Application of Web-Based Model on Land Pooling: A Case Study on Ganeshpur Village, Syangja

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Keywords: Land Pooling, Survey Department, GIS, Web-GIS, Leaflet, Django

Summary

In Nepal, agriculture plays a significant role, contributing around 31% to the GDP and engaging over 70% of the population. However, the uneven topography and sloping land have hindered the adoption of modern farming techniques, impeding agricultural development. Land pooling presents a suitable solution, replacing traditional methods with modern tools and addressing challenges such as irrigation, access to roads, low production, and unscientific cultivation practices. This article focuses on applying effective land pooling techniques in resolving the agricultural problems of Ganeshpur village in Syangja District, utilizing a web-based model to display information. Primary and secondary data collected through field surveys and the Survey Department were used to plan the plot and perform various analyses following land fragmentation guidelines. The final results, along with parcel and owner information, are displayed on a web-based platform. The web-based model serves as a common platform for visualizing and sharing data and information about the parcels. It allows users to access location and attribute information with a single click, and an admin login enables data management. Users can view different shapefiles and raster files of parcels and plots in various base layers. The system also connects farmers with users, allowing them to add products from their respective plots. Given the significance of land pooling, both government and private organizations can utilize this system for planning, updating, and visualizing plots in specific areas.

1 INTRODUCTION

1.1 Background

Agriculture is a vital sector in Nepal, with over 70% of the population engaged in agricultural activities. Land pooling, also known as land readjustment, is a technique that consolidates fragmented plots owned by different landholders and redistributes them in a planned manner. This project focuses on implementing land pooling to modernize agricultural practices, aiming to enhance productivity and bring in entrepreneurial expertise.

Land pooling offers benefits such as combined farming, where farmers pool their lands together to create larger plots. This approach allows for the adoption of modern tools and methods, increases productivity, and enables the development of crucial resources like irrigation canals and roads. The project targets indigenous farmers in sloping terrace farming regions, designing wide agricultural plots accessible for irrigation and road services. [2]

The project utilizes Geographic Information System (GIS) technology, including GNSS (DGPS), Android smartphones, and GIS software like QGIS and ArcGIS. These tools are employed for surveying, mapping, and designing land parcels during the land pooling process. Additionally, the project aims to develop a web-based GIS system to centralize and manage information related to land pooling, facilitating efficient data analysis and management. Integration with PostgreSQL/PostGIS database and programming languages like Python and JavaScript ensures accurate data management and successful implementation of land pooling projects.

1.2 Objective

The general objective of this project is to develop a web-based model for land pooling.

1.3 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 m^2. 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.

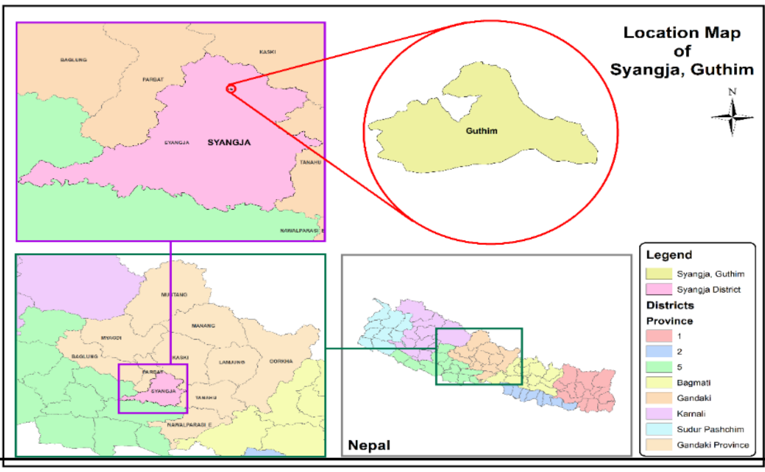

Fig 1 Location Map of Syangja, Guthim

2 METHODOLOGY AND RESULTS

In this study, ArcGIS, QGIS, Python, Javascript, Geo-Django were used as software packages. The spatial data were collected by using DGPS and existing cadastral maps. Then data was managed by database technique and finally, web-based GIS is created.

The detailed methodology of our project is described below:

2.1 Preliminary Study

Areas with urban expansion, 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.

2.2 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:

2.2.1 Primary Data Collection

Primary data, collected firsthand, played a crucial role in the planning process. To obtain relevant data, Real-Time Kinematic (RTK) method using the Geomax Zenith 35 Pro GNSS Receiver was employed for on-ground data collection. The collected information underwent post-processing techniques for data refinement. ArcGIS and QGIS software were utilized for data analysis, including DEM preparation, different analysis purposes, and map creation. Additionally, a social survey was conducted to gather insights from the local community. The topographic survey was carried out to generate final maps at a scale of 1:3000 with a contour interval of 1m.

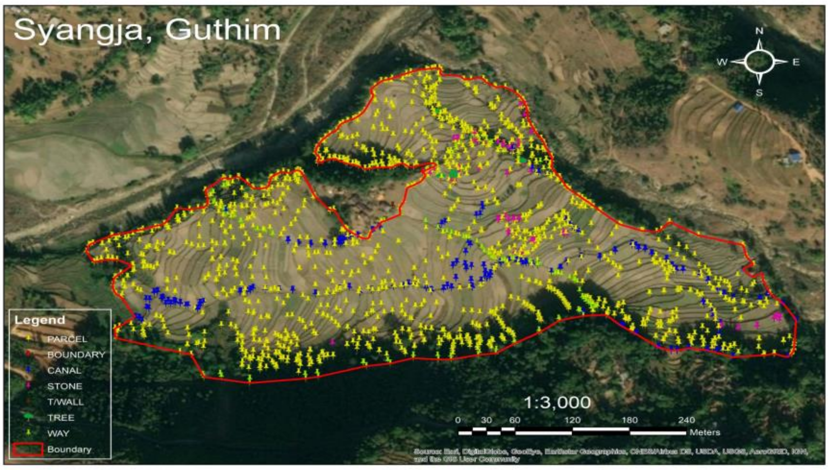

Fig 2 Primary Data Collected in the Field using DGPS

2.2.2 Secondary Data Collection

Secondary data, obtained from sources such as policies, acts, regulations, and the survey department, played a significant role in this project. Existing Cadastral Maps of the project area were accessed from the District Survey department in Syangja. However, landholding records from the District Land Revenue Office were not available due to confidentiality restrictions. As a result, dummy data was created to represent parcel ownership information for the project.

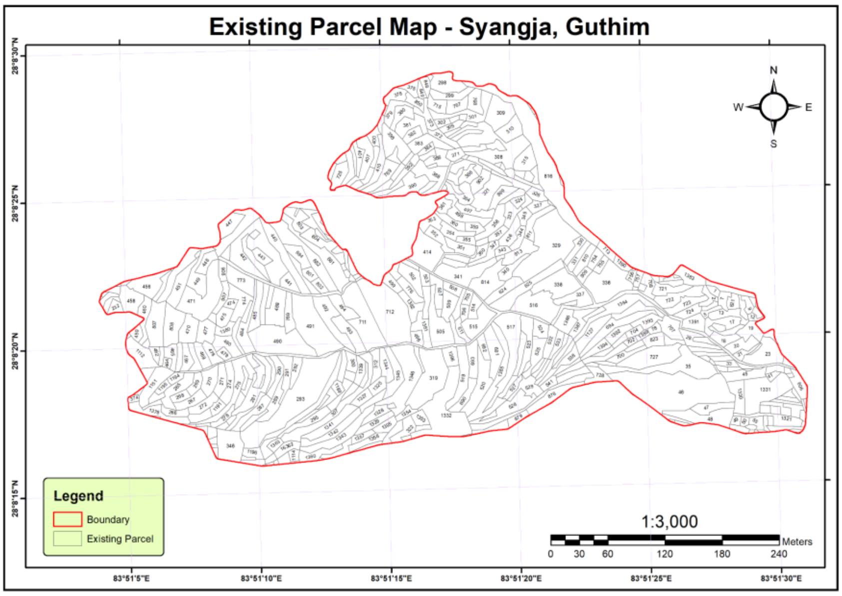

Fig 3 Existing Parcel Map of Syangja, Guthim from Secondary Source

2.3 Data Processing & Analysis

Data processing involves converting data into a usable form through a predefined sequence of operations, either manual or automated. Data analysis, on the other hand, involves inspecting, cleansing, transforming, and modeling data to extract valuable information, support decision-making, and enhance business operations. In this project, DGPS field data was processed for error correction and analyzed in ArcGIS for various purposes, including DEM generation, contour creation, slope analysis, network analysis, and georeferencing of new plots with existing parcels. Additionally, cut-fill analysis was conducted to determine the required volume of earthworks in the study area. The data processing and analysis tasks are described in detail below.

2.3.1 DEM Creation & Contour Generation

In this project, the field data collected with x, y, and z values was processed in ArcMap. The boundary of the study area was digitized using the collected data and a base map. The Topo to Raster feature in ArcMap was utilized to create a raster Digital Elevation Model (DEM) of the area, which was then clipped by the area boundary to obtain the DEM for the specific region of interest. The clipped DEM was further used to generate contours with a 1-meter interval using the Contour feature in ArcMap.

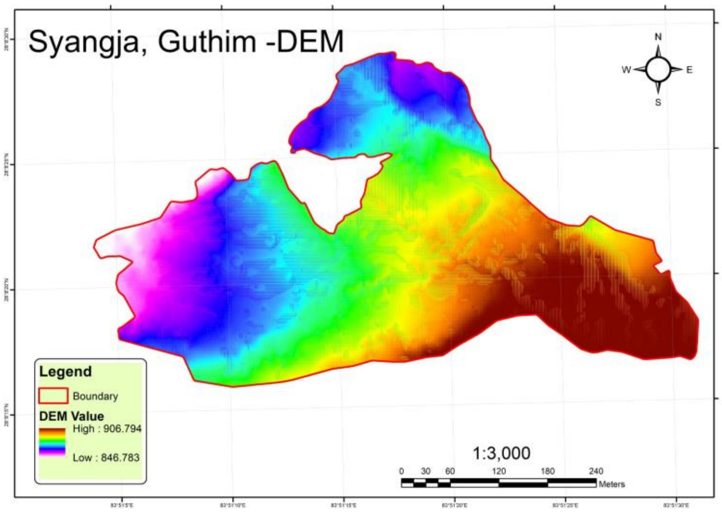

Fig 4 DEM generated using collected data

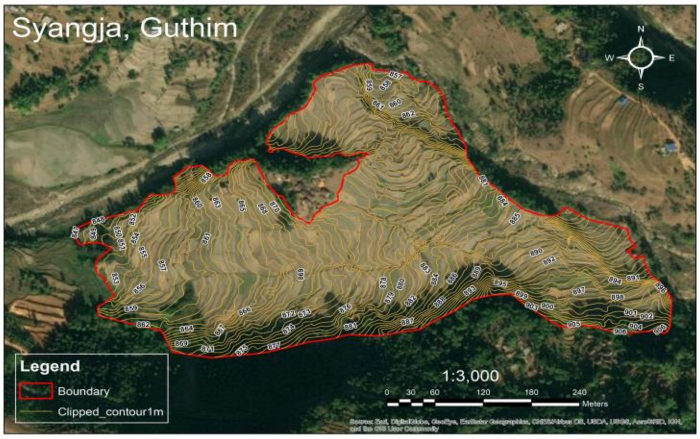

Fig 5 Contour generated using DEM

2.3.2 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.

2.3.2.1 Slope analysis:

Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. 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.

2.3.2.2 Network analysis:

Network analysis is an analysis that 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.

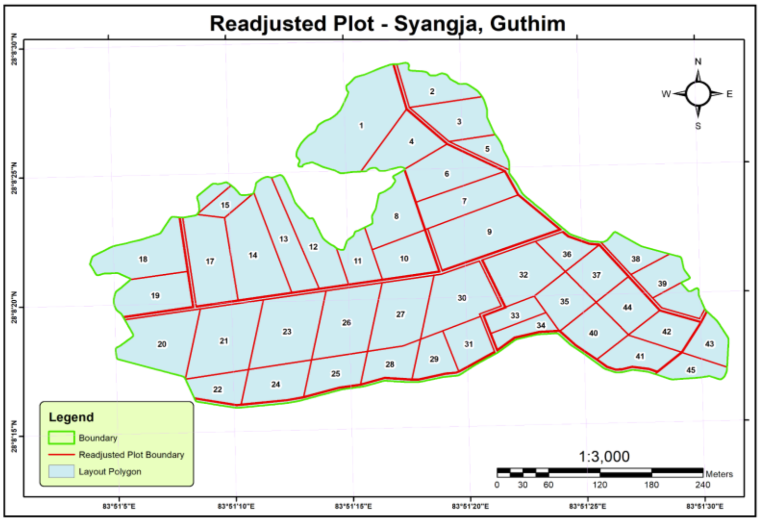

Fig 6 Readjusted Plot Map of Syangja, Guthim

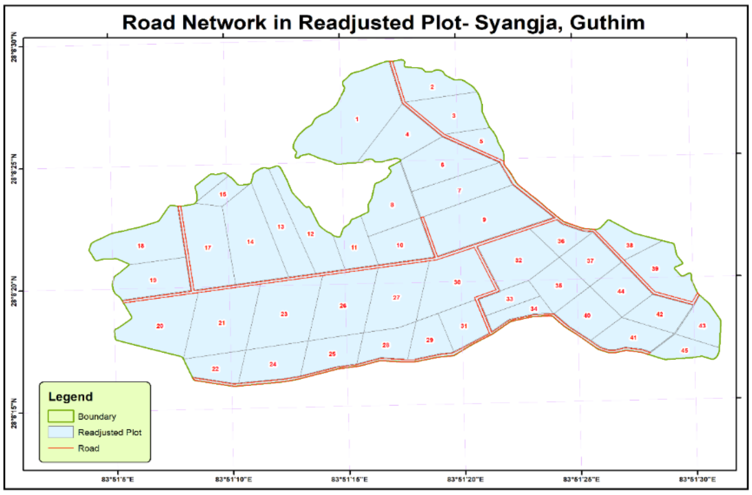

Fig 7 Road Network in Readjusted Plot- Syangja, Guthim

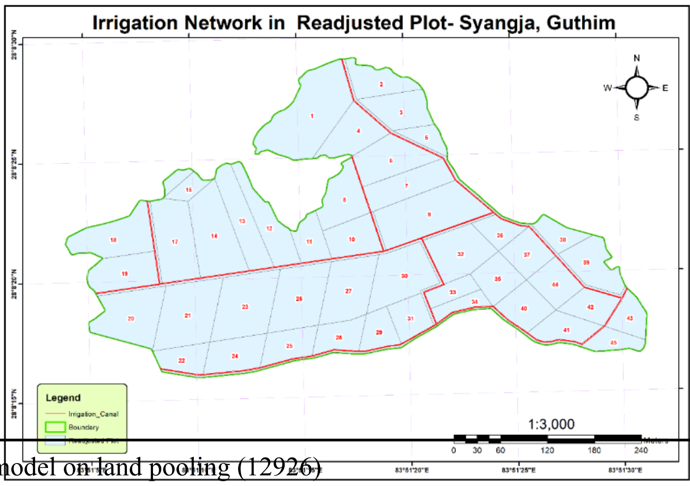

Fig 8 Irrigation Network in Readjusted Plot- Syangja, Guthim

2.3.3 Generating POI

A point of interest (POI) is a specific point location that someone may find useful or interesting. A point of interest specifies, at minimum, the latitude, and longitude (Easting or Northing) of the POI, assuming a certain map datum. A name or description for the POI is usually included, and other information such as altitude may also be attached. 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.

2.3.4 Calculating Zonal Statistics & DEM after Land Zoning

A zone is all the cells in a raster that have the same value, whether or not they are contiguous. 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.

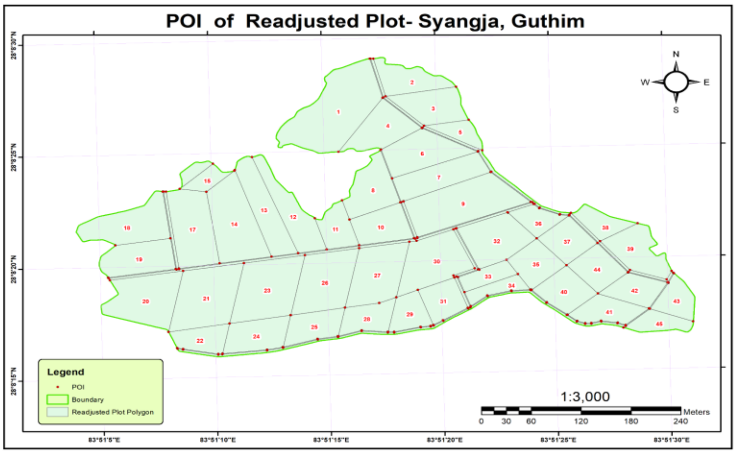

Fig 9 POI of Readjusted Plot – Syangja, Guthim

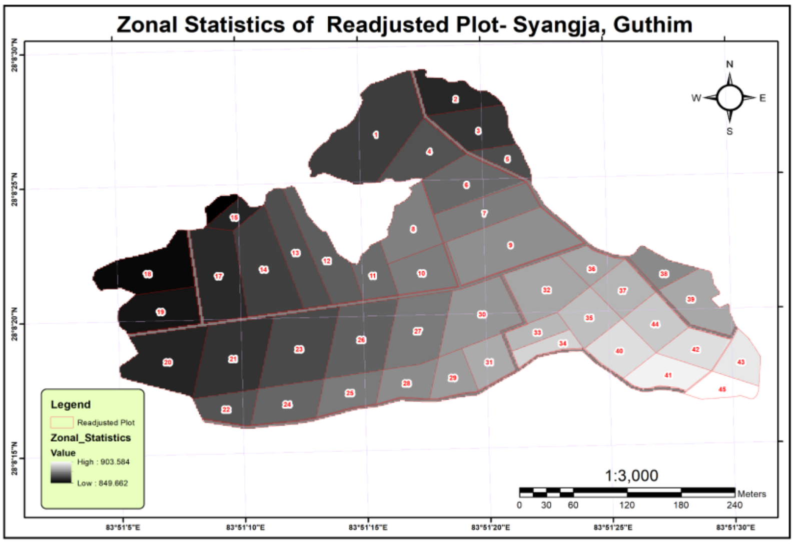

Fig 10 Zonal Statistics of Readjusted Plot- Syangja, Guthim

2.3.5 Cut Fill Analysis

A cut-and-fill analysis is a procedure in which the elevation of a landform surface is modified by the removal or addition of surface material. 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.

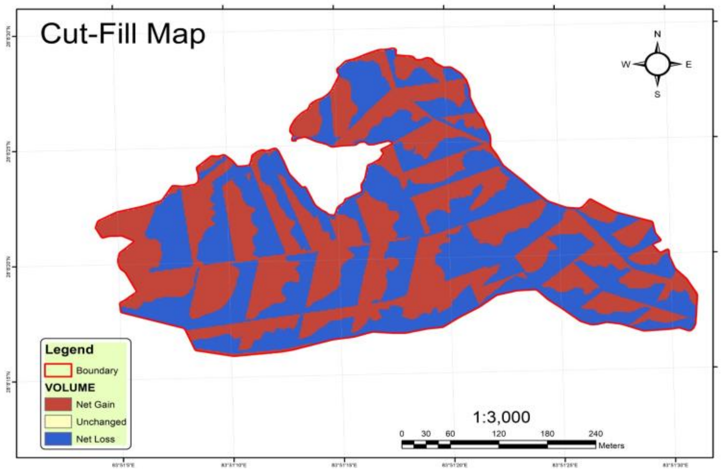

Fig 11 Cut-Fill Map of Study Area

2.3.6 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

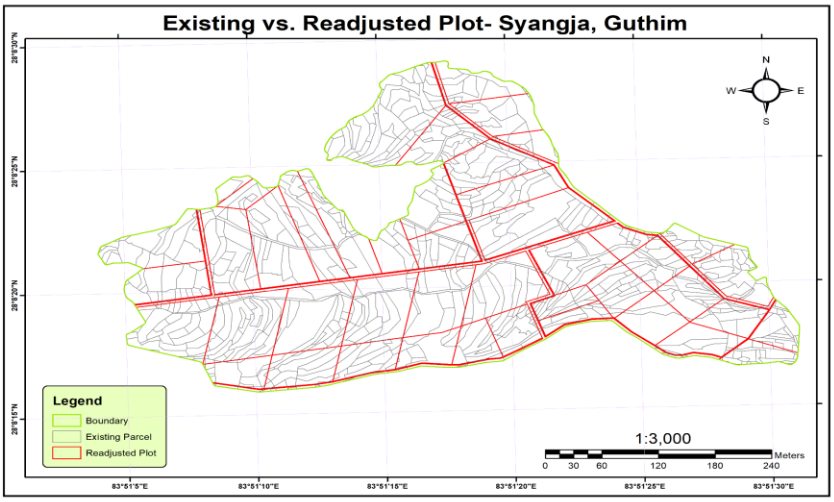

Fig 12 Existing vs. Readjusted Plot- Syangja, Guthim

2.4 Database Preparation & Area Calculation

After determining the contribution ratio, the final cadastral map was prepared in consultation with the landowners, specifying the exact sizes of plots to be returned to them. New plot numbers and areas were assigned, and Field Books were prepared alongside the new map. A database was created using PostgreSQL, PostGIS, and MS-Excel. The map was plotted with dimensions, and individual parcel areas were calculated. The new land records were reviewed and adopted, and a new database was created based on the proportional distribution of land to each parcel, considering the areas covered by infrastructure like roads and irrigation canals. The database related to original parcels and distributed plots were exported from ArcGIS to PostGIS, and additional relational databases were prepared through pgAdmin using query language, serving as the backend for the application.

2.5 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).

The following image shows the basic interface of the project.

Fig 13: Basic Interface of Web-application

3 SWOT ANALYSIS

It stands for Strength, Weakness, Opportunity, and Threat. The strength of our project is that a common platform is developed for designing, analyzing, planning, and executing infrastructures regarding land pooling projects as projects of national pride. The following table represents the SWOT analysis of our project:-

S.N	Strength	Weakness	Opportunity	Threat
1.	Various spatial and non-spatial cadastral data will be unified in one database system.	Due to lack of particular attribute data, information regarding the attribute may generate errors.	It makes designing, analyzing, planning and executing of the infrastructures and land policies common and easier across the country.	The system may not be able to process large volumes of relational data fastly.
2.	All the data is organized in a common platform. It makes data easier to fetch and maintain data security.	Control points with a certain degree of error may transfer the error to the surveyed points.	DGPS, Drone, etc. can be used to produce fewer error data.	Internet connection is compulsory for maintaining a quick access system for servers and clients. Server error may be encountered.
3.	Data can be modified by the admin of the system easily. Maintaining the database is easier.	Land disputes between owners may prolong the detailing of parcels.	This system can be reliable in preparing cadastral maps.	It may be difficult to convince the owner of the land about the land pooling policy.
4.	The valuation of the land is determined by the consent of landowners and public administration at a local level and is same throughout all plots.	Landowners with land across different plots may not agree in utilizing the same area in a single plot.	Widening of land, irrigation, road facility, increasing agriculture products, crops selection. This helps in uplifting the economic conditions of the people.	Disputes may lead to slow implementation of the project.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

In Nepal, traditional agriculture practices prevail in most areas, particularly in the hilly regions where agricultural land is narrow and lacks irrigation facilities. Productivity is low, and farmers often lack knowledge about appropriate crop selection. The concept of land pooling in agriculture offers numerous advantages, particularly for middle- and low-class farmers. Land pooling in agriculture is a priority project in several Nepalese state governments. This project focuses on developing a common working platform for methodology, planning, and land acquisition design. The web-based GIS system visualizes both old parcels and newly prepared plots in the study area. It allows for the analysis of multiple shapefiles and raster files simultaneously, providing a significant advantage for utility components. Users can access information about different features and their spatial positions, and the system offers various base maps for visualization. It enables remote access to information, making it useful for the general public, farmers, and administrators. The system can be further upgraded to include maintenance routines and additional functions.

This thematically layered system serves as an essential tool for performing a wide range of analysis functions and tasks conveniently. It provides up-to-date information and supports visualization and decision-making processes. The technology employed in the system allows for the integration of data from any area, converting it into useful information and disseminating it to all stakeholders. Given the importance of land pooling in Nepal, this system aligns with the country's trends and can be extended to other sectors beyond the study area.

4.2 Recommendation

In Nepal, the agricultural lands in hilly regions often suffer from narrowness, barrenness, and inadequate infrastructure. To tackle these challenges and drive agricultural development, Firstly, municipalities and local governing bodies should establish their own landowner databases to effectively plan and manage land attributes. Secondly, the central government should develop a web-based model for a land pooling system, enabling storage, analysis, and visualization of land features and promoting a common platform for land acquisition. Agreements between locals, concerned authorities, and the government should be made prior to land pooling to minimize disputes. Proper documentation of parcel attributes by the survey department is crucial, and further enhancements to the system can make it more useful for farmers, users, and the government. Implementation coordination between the Survey Department and Land Revenue Office of Nepal can play a vital role in decision-making processes related to land pooling.

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BIOGRAPHICAL NOTES

Er. Ashok Shrestha is a dedicated and accomplished Survey Officer currently serving at the Survey Office Parsa, Nepal. With a robust academic background in geomatics engineering, Mr. Shrestha has consistently demonstrated his expertise in the field of land surveying and geospatial sciences. Mr. Shrestha is deeply committed to continuous learning and professional development. He actively participates in workshops, conferences, and training sessions to stay at the forefront of the latest developments in the surveying field.

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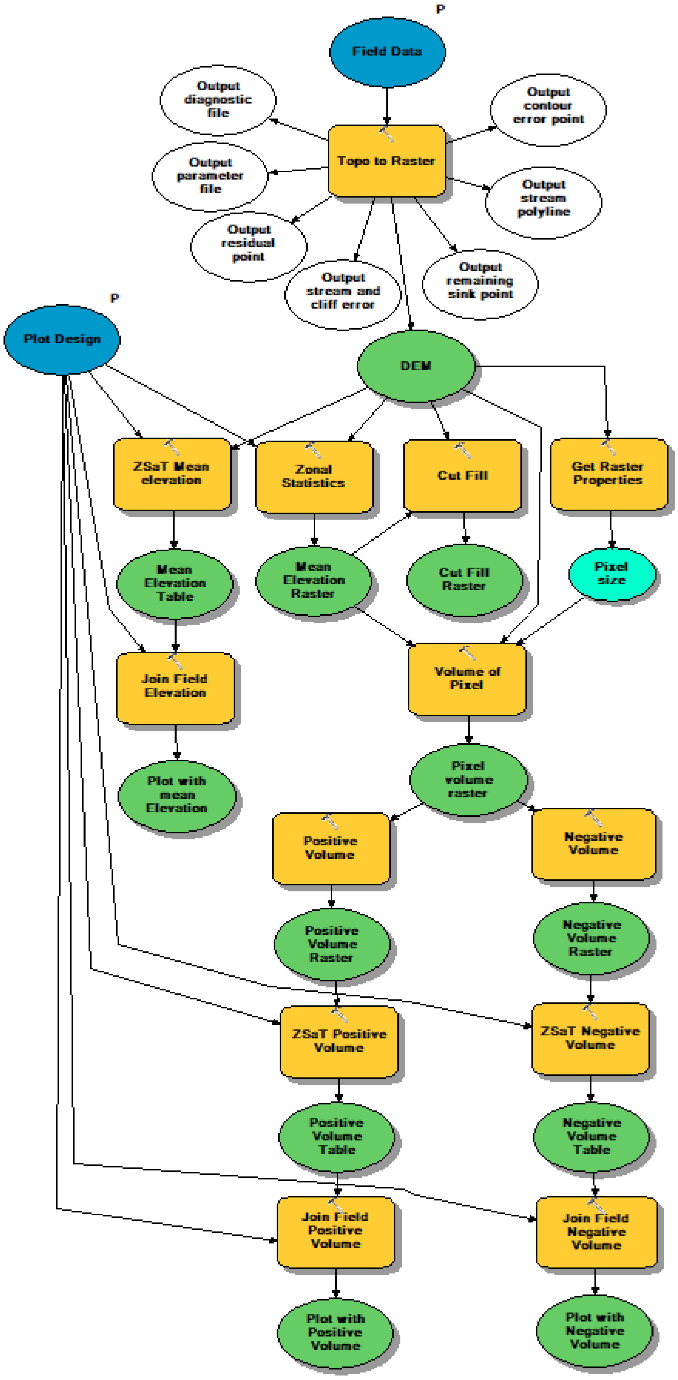
APENDIX I

Model

Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input. So, we have also prepared a model that runs sequences of geoprocessing tools that is required for land pooling for our desired output. The prepared model is shown as below:



Flowchart : Workflow model in ArcGIS for Land Pooling