Assessment of agricultural land pooling using GNSS technologies and GIS software in Gandaki province, Nepal

Kshitij Raj Sharma, Ashmeera Dahal, Anish Chhetri, Surya Adhikari and Saugat Nepal

Center for Space Science and Geomatics
Pashchimanchal Campus, Institute of Engineering, Tribhuvan University
Gandaki Province, Pokhara, Nepal
061-440457, www.ioepass.edu.np
kshitij@wrc.edu.np, 73bge507@wrc.edu.np, 73bge504@wrc.edu.np, pas074bge040@wrc.edu.np, surya.adhik197@gmail.com

Abstract

To aid the planned development in the agricultural system and infrastructural linkage, this project introduces a modern and positive approach called land pooling technique which is initiated in Gandaki province, Nepal. An area of 782,407.11 m² in 5 different districts of Gandaki province is proposed for this initiation. This paper assesses the replacement of traditional ways of mapping and surveying with GNSS technology and mobile application for quick and reliable work. To provide agricultural plots linked with physical infrastructures like roads and irrigation, data are collected using GNSS technology. The agricultural plots are designed using geospatial software then land readjustment is done by remarking the point of interest in the field using GNSS technology and an android application called “Chaklabandi". This modern approach in agriculture helps to readjust and make it possible to employ infrastructural services in the existing small plots where there is difficulty in ploughing. After introducing land pooling in the agriculture system, productivity increases drastically which helps to achieve the SDGs target Zero Hunger. This practice supports the digital cadastral system and seeks to increase the economy of Nepalese farmers by supplying serviced plots for agriculture.

Keywords: agricultural land pooling, GNSS technology, physical infrastructure, chaklabandi, SDGs

1 INTRODUCTION

The economic growth of Nepal is determined largely by the growth of its agriculture sector, which contributes to one-third of the GDP. This project exhibits modern agriculture technique i.e., land pooling which plays a crucial role in the advancement and improvement of agriculture. Land Pooling, also widely known as Land Readjustment, is evaluated as one of the best land development techniques that mainly concerned with acquiring fragmented land parcels belonging to many landowners, consolidating the small land parcels into one large area in a planned manner providing all required infrastructures (road, water supply, drainage); subdividing the area and redistributing back to the owners as per agreed terms of land contribution. This project mainly concerns with 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.

2 OBJECTIVES

The main objective of the project is to promote agricultural and economic growth through the adequate distribution of "agricultural-plots" and to appraise the efficacy of GNSS technologies and mobile application in surveying and layout.

The secondary objective includes:

- To identify and check if the delineated area is appropriate physically, socially acceptable and financially viable for implementing land pooling projects.
- To prepare maps with block designs, master plans for infrastructure such as access roads, irrigation canal on land consolidated sites.

3 PROJECT OUTLINE

3.1 STUDY AREA

The total area of 782,407.11 m² (1537.93 ropani) land is proposed for land pooling in Tanahu, Kaski, Gorkha, Parbat and Syangja districts with a minimum area of 50 ropani to a maximum of 600 Ropani where the average slope is north facing of 20 degrees.

3.2 DATA SOURCES

Field survey, old cadaster, land ownership details, submitted proposal

3.3 SOFTWARE/ DEVICES

GNSS device: Geomax zenith 35 pro, H 8 mm + 1 ppm V 15mm + 1ppm (RTK), H 3mm + 0.5ppm V 5mm + 0.5 ppm (static)

Desktop software: QGIS, ArcGIS, custom-developed a Python toolbox on ArcGIS for the plot cut fill calculation: facilitates the volumetric analysis of cut and fill based on the pixel value. It assists in excavation analysis and rate analysis.

Mobile software "Chaklabandi": It is an android based mobile application which is developed particularly for this project to carry out layout works which includes staking out points, line and polygon in the field. This mobile software makes construction work easier and also enables users for proper 3D visualization of the plots.

4 METHODOLOGY

After completion of all the legal procedures, technical work for land pooling is carried out. First of all, topographic surveying of the project area is carried out. Field data is collected using a DGPS applying RTK technique. During this process, a base station is established in the project site and another GNSS receiver is used as a rover for the topographic survey.

The collected data are then extracted from the receiver (RINEX format) using the Geomax windows-based software. The extracted data are preprocessed to convert into our usable format (CSV format). The processed data is then loaded in a GIS software for designing of the plot plan. For the best design of the plot the contour map, slope map and aspect map of the field are

taken into account. These map analysis help in determining the threshold such as the minimum area of each plot, elevation difference for each plot etc. for designing plots. In the design, every plot has access with the road and irrigation canal which is the basic requirement for each agricultural field/plot. Water flow accumulation analysis is performed for irrigation so that there is smooth flow and distribution of water in every plot. The amount of earthwork in the excavation is determined. A custom model is developed which helps in the estimation of the volume of cut and fill in each plot. This volumetric analysis plays a crucial role in determining the cost and feasibility of the project.

After the completion of designing work of plots, the layout is carried out. The final layout design is uploaded in the mobile application software and the corner points of the plots are imported as POI in the GNSS receiver. During the layout process, the POIs are first staked out by the mobile application using mobile phone GPS and eventually by GNSS receiver for higher accuracy. After staking out corner points of plots and roads in the field, proper counselling and map knowledge is provided for excavators so that the work could be executed as per the design norms and values.

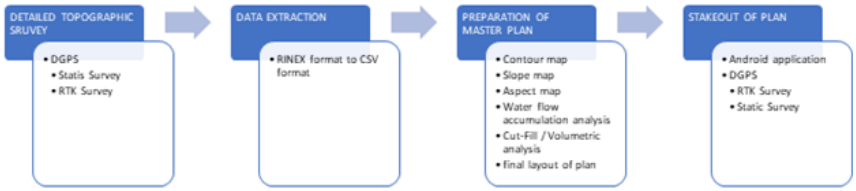

Figure 2. Methodology Chart

5 RESULT AND DISCUSSION

The data from the field survey using DGPS is initially plotted and interpolated for spatial reasoning in the design of the plot in ArcGIS. The surveyed data have the horizontal accuracy 5mm and vertical accuracy of 10mm. The master plan design for the plot includes roads & drainage accessible to each plot and average plot height to maintain for each during a readjustment. The road width is maintained at 4m and irrigation canal width as 1m. The height difference between the two plots is maintained below 4m so the risk of the landslide on the edge of the plot is prevented. The plot is maintained high as 6 ropani (1 ropani=508.72 m^2) and low as 1 ropani. The flat slope surface area is merged into a big size plot and steep surface are merged into a small size plot based on elevation difference.

The drainage assessment/flow accumulation is done for the design of the plot so that water gets available and distributed to each plot. Furthermore, the volumetric cut-fill analysis for the plot is calculated by the toolbox created on ArcGIS. Using the cut fill data & district rate, cost estimation is also included in the output. Use of GNSS Receiver along with Mobile application results in almost 20% faster approach for staking out design in the field. Depending upon the sloppiness of the field, the average 10-15 ropani area per hour is the time taken for surveying.

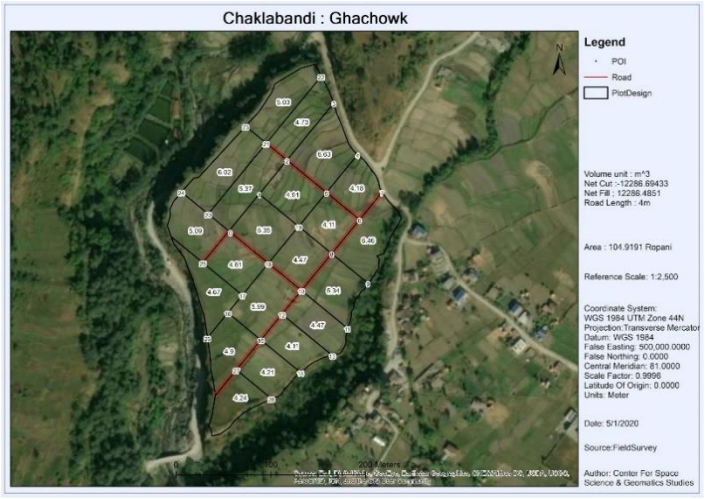

Figure 3. Land Pooling Site: Ghachok with block plan, Gandaki Province, Kaski, Nepal (51 Ropani)

Table 2. Labour, Manpower and Time Estimation before and after Land Pooling

	Before Land pooling (2018)	**After Land pooling (2019)**
Total Manpower required (Number)	249	150
Total Cost (RS)	198600	116000
Per Ropani Cost (NRS)	3894.117647	2274.509804
Cost difference Percentage (%)	- 41.59113797	
Manpower difference Percentage (%)	-39.75903614	
Time (days)	7	3
Time Difference Percentage (%)	-57.14285714	

1 Ropani = 508.74 Square meter

6 CONCLUSION

As seen from above table our research shows that after the agricultural land pooling performed in Ghachok we find out the cost has been decreased by 41.59 %, the number of manpower has been decreased by 39.75 % and the time has been decreased by 57.14% which is a great result in terms of agriculture. From the above statistics, we can conclude that land pooling has a great impact on agriculture in terms of labour, manpower as well as time. Furthermore, the result shows a drastic increase in productivity and also strongly supports achieving SDGs goal no. 2, Zero Hunger. This could be a revolutionary initiation in the field of agriculture.

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Acronyms

3D: 3-Dimensional

ArcGIS: Aeronautical Reconnaissance Coverage Geographic Information System

CSV: Comma- Separated Values

DGPS: Differential Global Positional System

GDP: Gross Domestic Product

GNSS: Global Navigation Satellite System

GIS: Geographic Information System

GPS: Global Positioning System

POI: Point of Interest

RINEX: Receiver Independent Exchange Format

RTK: Real Time Positioning

SDGs: Sustainable Development Goals

QGIS: Quantum Geographic Information System

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