LAND DEVELOPMENT FOR RESIDENTIAL AREAS USING UAV

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ABSTRACT:

This report outlines a comprehensive land development project aimed at systematically designing residential parcels of regular shapes through modern technological approaches. To minimize the problem of unmanaged urbanization due to the ever-increasing population, this project aims to prepare a land development plan for residential use using advanced tools like Unmanned Aerial Vehicles (UAVs) and Differential GPS (DGPS) to collect accurate and detailed data, streamlining the process. However, using the geo-tagged images only does not meet the need for locational accuracy. Thus, DGPS has been used, as another surveying method to enhance the reliability of the outputs.
The land development map obtained from this study divides the study area which is 4.5 Hectare located in Ward-4, Bhakundol, Dhulikhel, Nepal into several regular shaped residential plots, serviced plots, open spacesand canalsas well as designing road networks that touch all the parcels, all under the guidelines set by the governmental body. The result shows that among 4.8 Hectares of land 61% have been developed for residential plots, 25% for roads, 7% for serviced plots, 5% for open space and 2% for the canal. The report underscores the significance of systematic land development in promoting sustainable urban growth, contributing to improved community living conditions and ecological balance. Through the integration of modern technologies, this study showcases the potential for innovation to reshape land development practices, leading to well-designed and accessible residential areas that cater to both present and future needs.

1. INTRODUCTION

Background

Land development means the process of planning, design, and construction used to convert raw land to serviced building parcels that are ready for construction. Land development comprises changing a landscape to better meet the demands of people who wish to live there. The land development technique is the only program that will help with sustainable urban growth with suitable infrastructure and land consolidation without financial support from the government, the majority of land disputes will be resolved, and nobody will be evicted from their neighborhoods (Oli, 2010). While development can occasionally be seen negatively because it alters the landscape, increases traffic, and affects ecosystems and habitats, land development is necessary for a community to succeed because it can increase employment, improve curb appeal, minimize the land related issues, bring neighbors together, and maintain or raise home values (Construction and Land Development n.d.).

Using UAVs (Unmanned Aerial Vehicles) is an emerging tool for the development of residential areas. Land developers use drones to help them get accurate digital images of design concepts for new developments. Drone technology is the most cost- effective way for land developers to change their ideas and make changes before construction begins (Yunuset al., 2020). With a UAV, topographic data collection is quicker and also requires fewer human resources than with land-based techniques. Additionally, UAVs can collect data in inaccessible places too (Hermosilla et al., 2012). The establishment of control points is done using DGPS. Differential GPS (DGPS) is a system in which differences between observed and computed co- ordinates ranges (known as differential corrections) at a particular known point are transmitted to the user (GPS receivers at other points) to upgrade the accuracy of the users' receiver's position (Atabudhi, n.d.).

AutoCAD software, which has powerful drawing and vector editing functions, is used in land and planning departments widely but AutoCAD is weak in expressing and analyzing the relationship of spatial data whereas ArcGIS can gather geospatial data to process and express in a single model framework, as well as handle graphic data, model, analyze, and manage the existing spatial data. Hence ArcGIS is favored by more and more GIS enthusiasts due to its ease of use while handling geospatial data(Yeh & Li, 1998).

Objective

Primary Objective

- To prepare land development plan for residential purposes by systematically creating parcels of regular shapes.

Secondary Objective

- To prepare a topographic map using aerial imageries.
- To design proper building plots and road networks following the government guidelines.

2. METHODOLOGY

Study Area

The study area is located near LMTC, Dhulikhel-04, Kavre. The area covered during land development is around 5 hectares. The study area was at an altitude of around 1465m with geographic coordinates 27°37'10" N and 85°32'46" E. It is situated on the way to Dhulikhel Hospital around 200m due east of the LMTC and around 500m southeast of the junction of Kathmandu University and Land Management Training Centre (LMTC).

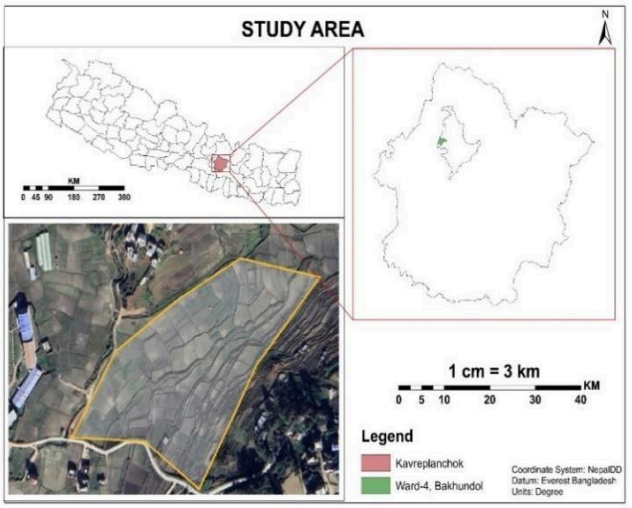

Figure 1. Study Area

Work Flow

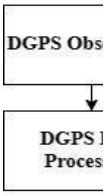

Figure 2. Workflow

Planning, Reconnaissance, Monumentation

Good planning is considered half-work done. The study area, software, and instrument selection, including the choice of digital camera and UAV platform types, are all part of this phase. Determining parameters and specifications for flight plan considering the precautions such as flight height, ground sampling distance, number of photos to be taken, storage capacity, time for battery backup, weather conditions and other parameters. Digital photogrammetric software like PIX4D was selected to process the digital aerial picture and create an orthomosaic of the study area. For better accuracy, DGPS survey was selected for the establishment of ground control points. Literature reviews of various projects and existing guidelines for land development were studied before proceeding with the project.

Field visit and reconnaissance was done and various features such as existing roads, parcels, drainages, buildings, electric poles and so on were observed and established six control stations, well distributed in the area.

Data Source Description

Data Used

- Ground Control Points (GCPs) were obtained from DGPS.
- Aerial imageries were captured from UAVs
- Google Maps as a base map

Instrument Used

- Unmanned Aerial Vehicle (DJI Mavic Pro 2)
- DGPS (Stonex)
- Measuring Tape

Software Used

- StaticToRINEX
- Trimble Business Center
- DJI Pilot
- PIX4DMapper
- AutoCAD
- ArcGIS

Specification used for DGPS and UAV

Table 1. Specification for DGPS

Specification for DGPS	
• Working mode:	Static
• Cut angle:	15 degrees
• Time interval:	15 sec
• PDOP Threshold:	3
• Number of Stations:	6
• Observation time	
□ For Base:	2 hr 15min
□ For Rover:	30 min
□ Time overlap:	10 min

Table 2. Specification for UAV

Field Work

DGPS Observation

Three sets of DGPS were used. A base and two rovers were used simultaneously. Base station was kept for about 2 hr 15 min whereas rovers were placed about 30 min with 10 min overlap for better accuracy. It was made sure that the base was operating until the very end till we finished our observation. The working mode was static with a cut angle of 15 degrees and PODP threshold 3. Altogether 6 stations were studied which covered the whole area.

UAV Flight

GCP markers of size 30*30 cm were used to mark the stations in the ground exactly above the wooden pegs. The flight height was set to 70 m. For better accuracy, end lap and side lap were kept high i.e. 80% and 70% respectively. For better resolution, GSD was maintained at 1.92 cm/pixel. These parameters resulted in 163 photos being taken to cover the entire area in 7 min 7 sec flight time. The weather was clear and wind velocity was also bearable.

Data Processing and Analysis

a) First of all data acquired from DGPS (i.e. in .dat format) were converted to RINEX format using StaticToRinex software as .dat extension files are not supported by Trimble Business Center(TBC). All the converted files were imported into TBC where baselines were processed, network adjustments were performed, reports were generated and coordinates were extracted.

b) Aerial images obtained from UAV were imported into Pix4D software. All we had to do was provide the strips of images, import the GCPs obtained from DGPS software and address the GCPs in related images. It took almost 3.5 hrs to process the images in standard quality. The software resulted in the outputs, Ortho-mosaic image and DTM.

c) Thus produced Ortho-mosaic was then exported to ArcGIS where the digitization of required area was done so that the existing condition of the ground layout could be known and could be compared with the newly designed layout after the land development. Finally, a topographic map of the study area was prepared by digitizing the Ortho-mosaic.

d) To design the new residential plots and development features, mostly AutoCAD was used. First of all, the boundary of the study area was

exported to AutoCAD from GIS. Then the design was prepared for the residential purpose. Then afterward GIS software was used to create various layers, define the coordinate system, specify the feature type (polyline, polygon, point), and apply different cartographic elements like suitable color, labels, scale, north arrow, legend and so on. Finally, a land development map was exported in JPEG format. The following factors were considered during the development of a residential plan.

- The plot's side must be perpendicular to the road touching it.
- Plot size must be of regular shape as far as possible.
- Plot size must be at least 130 m^2 i.e. 4.09 Aana
- The minimum width of the plot must be greater than 6 m and length must not exceed breadth by 4 times.
- Road access to the project area must be min 8m and the developed roads must be min 6m.
- The area covered by road, open space, residential plots, and serviced plots was as per the specification and guidelines of land development act.
- The area for open space must be in such a place that it should be easily accessible to every resident of the area.

3. RESULT AND DISCUSSION

Ground Control Points from TBC

Table1: Adjusted Grid Coordinates Obtained From TBC

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
1000	356399.295	3055791.279	1473.216
1001	356424.541	3055888.72	1472.880
1002	356503.861	3055835.472	1476.490
1003	356471.648	3055956.338	1474.697
1004	356556.731	3055884.366	1477.751
1005	356592.031	3055991.366	1476.424

Maps

The overlay of Orthomosaic map obtained from pix4D with a base map is shown below. The Orthomosaic map has been georeferenced with the coordinates resulting from DGPS survey. As a result of georeferencing of orthomosaic, it has been overlayed over the base map perfectly.

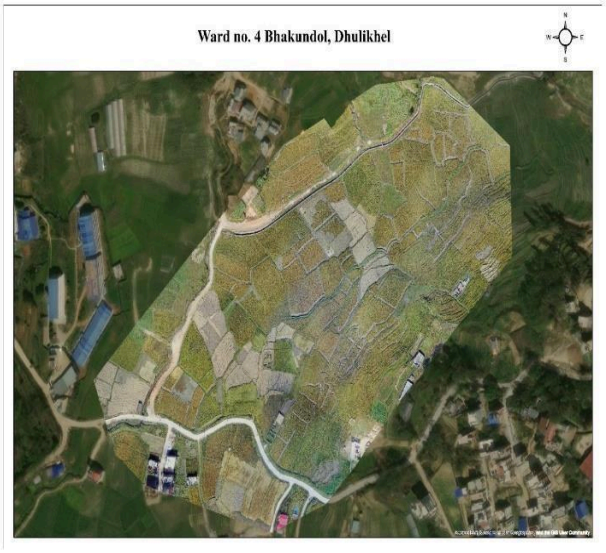

Figure 3. Overlay of orthomosaic

Using the orthomosaic as a backdrop, we digitized the existing parcels and features. Digitization of orthomosaic resulted the following map which shows the irregular parcels where there is no connectivity of road networks and no open space.

Specification for UAV

- GSD: 1.92 cm/ pixel
- End lap: 80 %
- Side lap: 70%
- No. of Photos: 163
- Area: 54064 m^2
- Altitude: 70 m
- Speed: 5.5 m/s
- Flight time: 7 min 7 sec.

Figure 4. Existing parcels before land development

Using the contours, a topographic map is prepared in a GIS environment, which is shown below.

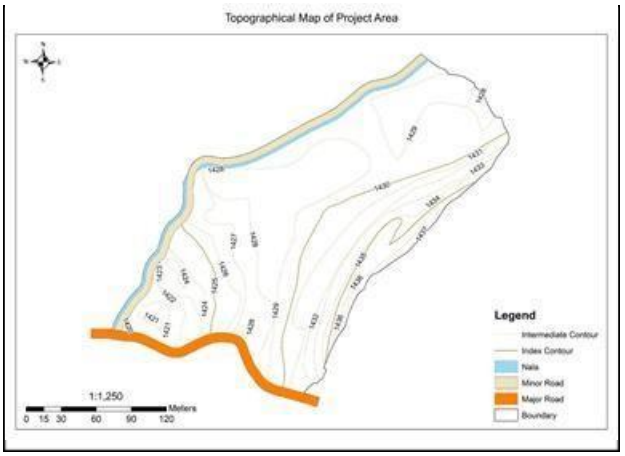

Figure 5. Topographic map of the project area

The boundary of study area is exported to AutoCAD environment. Land development plan is done using AutoCAD software where we make different layers for different features. It's quite easy to design plans in AutoCAD rather than in ArcGIS. Thus designed land development plan is later on exported to ArcGIS to get the map in desired format. The final output of project, a land development plan for residential purposes by systematically creating parcels of regular shapes is given as.

Figure 6. Final Land Development Plan

Figure 7. Before vs after land development

Project Summary

The area contained by a particular plot type along with features like road and canal is given below. The mentioned area coverage do not violate the land development guidelines. It follows the guidelines of local authority for the land development.

Table 3. Area Contained

Particulars	Description	Percentage (%)
Total Area	48045.95 m^2 (4.8 Hectare)	100
Open Space	2454.287 m^2	5
Road	12193.163 m^2	25
Service Plot	3260.588 m^2	7
Residential Plot	29308.03 m^2	61
Canal	960.919 m^2	2

Further details along with the number of each plot type as well as the width of different road types of the land development plan are given below. According to the land use regulations 2022, the government has barred the plotting of residential areas if the area of such land is less than 130 square meters (4 aana 1 daam). Hence considering this rule all the developed plots are greater than 130 square meters.

Table 4. Details of Land Development Result

Particulars	Description
Location	Ward-4, Bhakundol, Dhulikhel
Major Road	8 meter
Minor Road	6 meter
Minimum Plot Size	130 m^2 (4 Aana 1 Daam)
Number of Residential Plots	157
Number of Service Plots	9
Number of Open Space Parcels	3

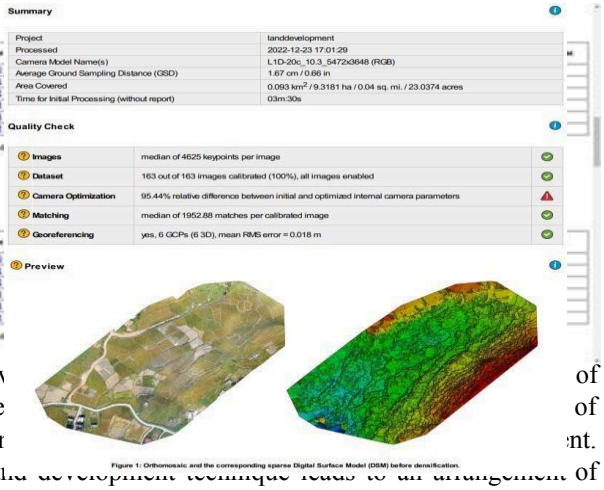

Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

irregular plots into regular plots which are suitable for housing and for accessibility. The rapid infrastructural developments in an unplanned way can be managed and minimized by using land development approach by using modern techniques. Land development not only helps to solve the unmanaged expansion of residential areas but also minimizes land-related issues, maintains the ecological balance, increases the value of land as well as enhances sustainable development.

5. REFERENCES

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6. APPENDIX

a) Baseline processing report from Trimble Business Centre

b) Network adjustment report

c) Image processing report from Pix4D