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Three-Dimensional (3D) Land Contour Modeling using QGIS Software on Topography Mapping in Buwit Village, Kediri District, Tabanan Regency, Bali

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Abstract

A topographical map is a map that contains information about the elevation of the land surface in a place to the mean sea level (Mean Sea Level), which is depicted by contour lines. Information from the coordinates and elevation of detailed land points as a result of land surveying can be used to create a three-dimensional model of the land surface on the map using the Quantum Geographic Information System (QGIS) software application. With a three-dimensional (3D) model, the objects on the map are seen more alive than they actually are in the field, so analyzing a topographic map can be done more easily. To support these activities, three-dimensional (3D) land contour modeling was carried out with QGIS software on topographical mapping in Buwit Village, Kediri District, Tabanan Regency, Bali.

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1 Introduction

In the development of Geographic Information Systems, many applications can be handled, including the field of natural resources for land use planning. A topographic map is a map that contains general information about the state of the land surface along with elevation information using contour lines The three-dimensional model makes it easier to read the contours of a place on the earth's surface because you can immediately see the height of each altitude line, rather than reading a two-dimensional model (Stevens et al., 2003; Freitas et al., 2010; Pratt & Chang, 2012; Yasada et al., 2022). To achieve this, the input data in the form of a topographic map is analyzed and processed to become a three-dimensional object model output. 3 (three) dimensional contour mapping is then used by many groups, including for spatial planning purposes. So to support these activities, three-dimensional (3D) land contour modeling was carried out with QGIS software on topographic mapping in Buwit Village, Kediri District, Tabanan Regency, Bali (Kusmiarto, 2017; Prahasta, 2001; Rostianingsih et al., 2004; Simbolon et al., 2017).

2 Materials and Methods

The research implementation is generally carried out in the form of information collection (secondary and primary data collection), field surveys, problem analysis, inventory formulation, and performance evaluation of digital data processing. The research work steps are outlined in the form of a research diagram that describes the complete stages from beginning to end sequentially to the end with a duration of one year of research. The complete research flowchart can be seen in the image below:

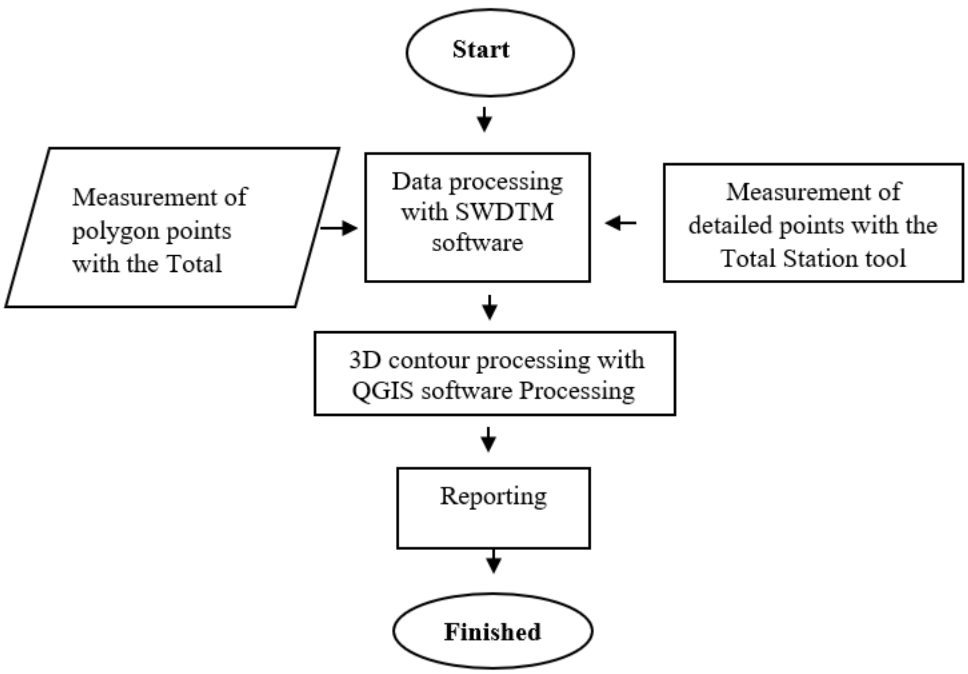

Figure 1. The complete research flowchart

Conduct field surveys, including among others

a) Topographical mapping planning
Before doing the mapping, we have to make a measurement plan by conducting an initial survey so that a plan for the number of horizontal control points/polygons can be made (Cintya et al., 2017; Panjaitan et al., 2019; Ramadhony et al., 2017). The development of measuring instruments is characterized by the number of points or positions that can be taken in one unit of time and their accuracy. The development of digital measuring instruments began with the emergence of the Electronic Distance Meter (EDM). The EDM measurement

principle uses the travel time of the emitted electromagnetic wave multiplied by the speed of the emitted light. EDM was developed into a Total Station (TS) which has the principle of recording distance and angle data which is converted into x, y, and z coordinates using several calculations (Chang et al., 2003; Park et al., 2019; Ajaj et al., 2023; Lanca, 1998). The method used in measuring with TS to determine the elevation of an object is measuring detailed situations using the tachymetry method.

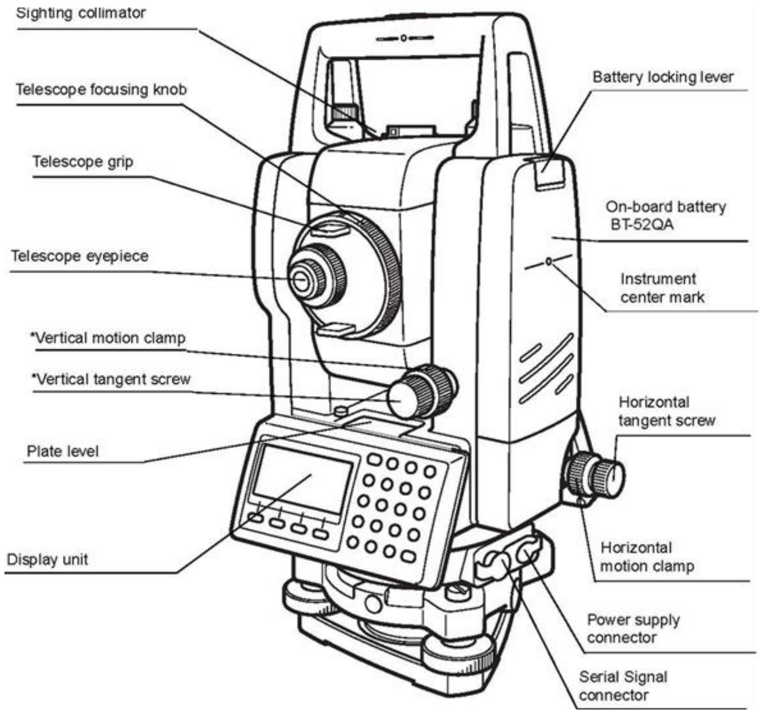

Figure 2. Digital measuring instrument

Every measurement must have corrections. Likewise with the data processing process, especially the registration process. The magnitude of the error is indicated by the RMSE (Root Mean Square Error) value. RMSE is the difference between the actual value and the measured value. The greater the RMSE value, the greater the error value of the measurement results relative to actual conditions. The following is the formula for calculating the RMSE.

$$RMSE = \sqrt{\frac{\Sigma (R - R_1)^2}{n}}$$

information:
RMSE: Root Mean Square Error
R: Value that is considered correct
R1: Measurement value
n: Many sizes are used

b) Collecting data by measuring polygon points and detail points in the field using a total station measurement tool.

Data processing, including among others

a. Transferring data from a total station device to a computer using the Topcon Link software
b. Perform measurement data processing with SWDTM software so that detailed points and polygons are depicted on the Autocad layer
c. Processing of 3 (three) 3-dimensional contour data using QGIS software

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Inventory

Inventory is the collection of data related to the location and the tools to be used.

Analysis

The analysis work carried out includes analysis as a unit. The analysis carried out includes:

a) Analysis of the tools used
b) Analysis of polygon point measurements and detail points
c) Analysis of the accuracy obtained in the depiction results.

Research sites

This research is located in Buwit Village, Kediri District, Tabanan Regency, Bali.

Figure 3. The research located

Tourism-based spatial planning to support development in Bali.

Research road map

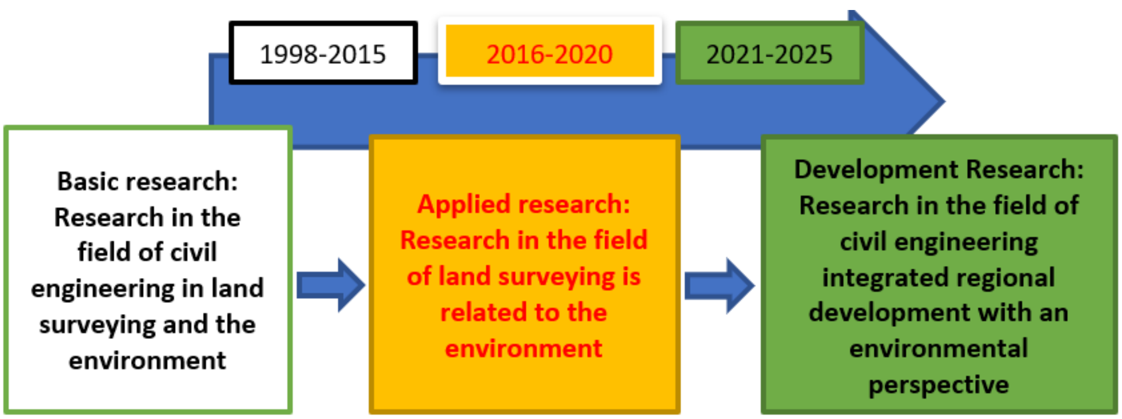

Figure 4. Research road map

3 Results and Discussions

Detailed polygon measurements and points in the field

Measuring polygons and detailed points in the field using a Topcon Total Station type GTS-102N to obtain UTM coordinates (x, y, and z). From the field measurement data, a drawing process was carried out using the AutoCAD program and the SWDTM program to produce a two-dimensional (2D) land contour image as shown in the image below:

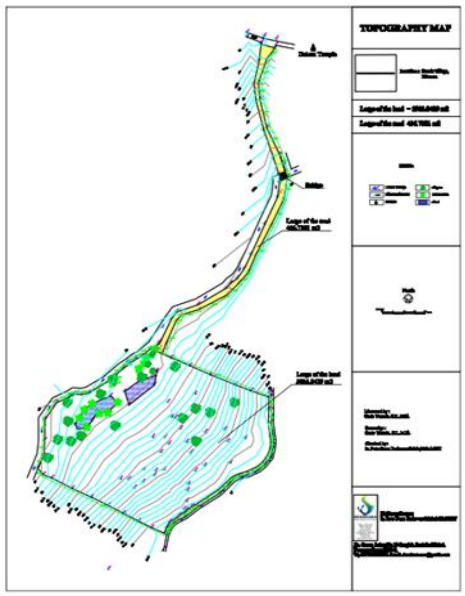

Figure 5. Two-dimensional (2D) land contour image

Table 1
Field measurement result data input to the QGIS program

Name	Easting (E)	Northing (N)	Elevation (Z)	Code
1	4999.992	5000.004	17.979	P1
1000	5000	5004.016	18.02	1000
100	5002.774	5004.604	17.833	B
101	4999.095	5004.232	17.973	G
102	4998.144	5000.583	18.051	G
103	4998.11	4998.511	17.8	B
104	4996.202	4995.561	17.833	B
105	4994.639	4992.449	17.837	B
106	4993.159	4989.191	17.879	B
107	4991.695	4984.118	17.882	B
108	4991.131	4980.543	17.882	B
109	4990.45	4967.483	17.7	B
110	4991.738	4968.052	17.814	J
111	4996.556	4968.368	17.785	J
112	4992.066	4978.87	17.958	J
113	4993.229	4984.942	17.942	J
114	4996.876	4994.083	17.927	J

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This section is a preview of some of the settings that have been made before. So that it can be ensured that there are no data format errors before the data is imported into QGIS (Molina-Navarro et al., 2018; Ellsäßer et al., 2020; Guo et al., 2022; Bazurto et al., 2019).

Figure 6. Imported data into QGIS

QGIS 3D terrain visualization (Raster TIN)

To get a 3D visualization in QGIS, create a new 3D map view

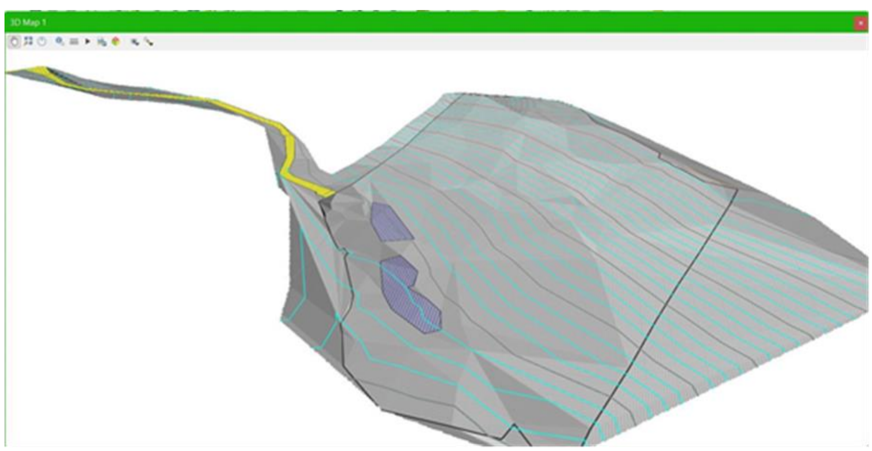

Figure 7. New 3D map view

QGIS vector data 3D visualization (Extrusion)

After the terrain is visualized in 3D, proceed with visualizing point vector data (trees).

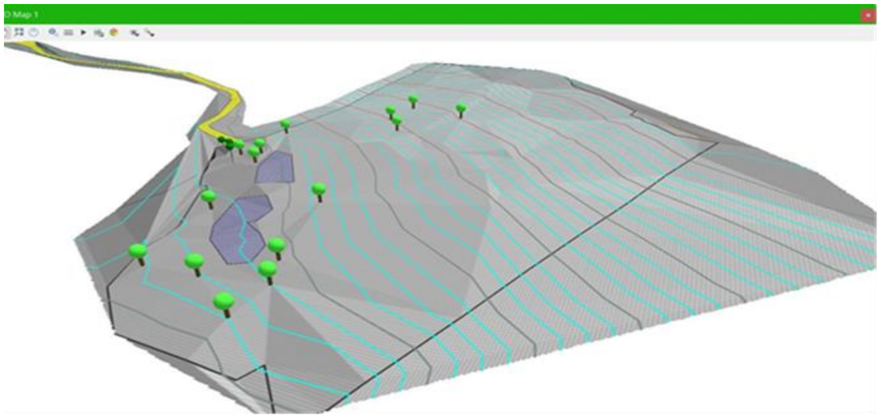

Figure 8. QGIS Vector Data 3D Visualization (Extrusion)

3D Road Image View

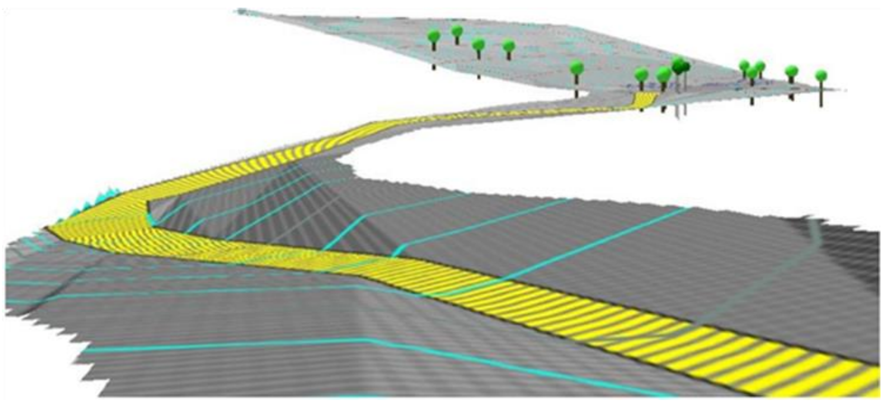

Figure 9. 3D road image view

4 Conclusion

The conclusions from the study of Three-Dimensional (3D) Land Contour Modeling with QGIS Software on Topographic Mapping in Buwit Village, Kediri District, Tabanan Regency, Bali are:

a) With a three-dimensional (3D) model, the objects on the map are seen as more alive as they are in the field, so analyzing a topographic map can be done more easily.
b) QGIS software can display the position of trees and other objects on the map.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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