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Comparative Analysis of Total Station and Mobile Base Station Accuracy in Determining Land Plot Volume (Case Study of Metland Land Plot)

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ABSTRACT

Measurement of land using extraterrestrial methods has developed quite rapidly due to the increasingly sophisticated measuring instruments used in measurements using these methods. The problem lies in the long baseline that causes the rover to take a long time to reach a fixed solution. Mobile Base Station can be used as an alternative solution to the problem because it can bring the base station closer to the measurement location, thus increasing measurement efficiency. The purpose of this study was to determine the accuracy of the aspects of coordinate differences and differences in land area and to determine the efficiency of land area measurement time using Mobile Base Station South Type Galaxy G1. The research method used is a comparative experiment with a quantitative approach. The samples selected were 89 residential land parcels in 1 (one) block. Sample measurements were carried out twice, namely using Mobile Base Station South Type Galaxy G1 with extraterrestrial methods and using Total Station as comparison data. The analysis used is the t test with a significance level (α) of 5%. The results showed that there was a significant difference between the coordinates of the land plot measured by the Mobile Base Station and the coordinates measured by the Total Station. The length of time needed to complete the work in this study with the Total Station tool is 585 minutes or or 9 hours 45 minutes and for the Mobile Base Station South tool it takes 476 minutes or 7 hours 56 minutes. And based on the results of the calculation of the time efficiency of these measurements that have been carried out combined with the time efficiency with the implementation of measurements during practical work is 37.24%.

Keywords: land plane measurement, mobile base station, south galaxy G1.

INTRODUCTION

Currently, measurement tool technology is experiencing rapid development, such as the emergence of tools that use digital systems, so everything can be done electronically, quickly and accurately. Many types of modern sophisticated measuring instruments such as Total stations, Geodimeters, Echosonders, Laser meters, and others [1]-[4]. However, the use of Global Positioning System (GPS) technology and spatial data processing and analysis technology or Geographic Information Systems (GIS) is a significant advancement and is very helpful in topographic measurements that require a lot of time and higher costs. Despite the existence of these mapping technologies, the concept of land surveying is the basis and forerunner of these sophisticated measurement methods. There are various types of GPS and each has a way of use or application that is different from one another. However, the navigation type GPS is the most common and most readily available type, although one of the weaknesses of navigation GPS is its relatively lower accuracy [5]-[8].

Besides GPS, there's also a Total Station, a modern electronic instrument used in surveying to measure angles, distances, and heights. A Total Station is an improvement on the theodolite, offering considerable accuracy in recording and retrieving data in the field. The coordinates provided by a Total Station are derived from direct measurements taken in the field, unlike GPS, which provides information from remote satellite scanning. However, the height component of the three-dimensional coordinates provided by GPS is the height referenced to an ellipsoid or the average height above sea level [9]. Therefore, the height obtained with GPS is not the theoretical height, which refers to the geoid or general surface. Therefore, the height obtained from GPS should not be directly integrated with the height obtained from measurements using general flatness methods. This comparison must be considered because it can affect other calculations, such as the area and contour of the land obtained from measurements using these measuring tools [10]-[12].

GPS is currently expected to address the issue of point accuracy on the Earth's surface, especially at points that are difficult to obtain data from due to their relatively large distances and obstructions [13]. However, determining elevation using a Total Station to obtain elevation difference data remains the primary choice due to the high accuracy of the Total Station's leveling measurement tool, particularly compared to GPS navigation. Furthermore, the comparison of data collection results using the two tools is unknown [14]-[16].

This paper seeks to answer the first question: how does the accuracy of observations using the Galaxy G1 Mobile Base Station South compare to measurements using a Total Station? Second, how time-efficient is the measurement of agricultural land using the Galaxy G1 Mobile Base Station South compared to measurements using a Total Station?

This paper is supported by quantitative research, using a comparative experiment method. The data collection technique used in this study is direct field experiments, namely measuring land boundary points under open conditions.

RESEARCH METHODS

Data analysis was conducted in two stages. First, compare the data from the coordinate position measurement results (X and Y) of the land parcel boundary with the extraterrestrial method using the South Type Galaxy G1 with the comparative data from the coordinate position measurement results (X and Y) of the land parcel boundary with the terrestrial method using the Nikon Nivo 5C brand Total Station. The difference in coordinates (X and Y) is tested statistically using the t test. The difference in the area of the land parcel is tested with a tolerance of $\pm\frac{1}{2}\sqrt{L}$. Second, compare the length of time required in measuring the land parcel with the extraterrestrial method using the South Type Galaxy G1 with the comparative data of the length of time for measuring the land parcel with the terrestrial method using the Nikon Nivo 5C brand Total Station.

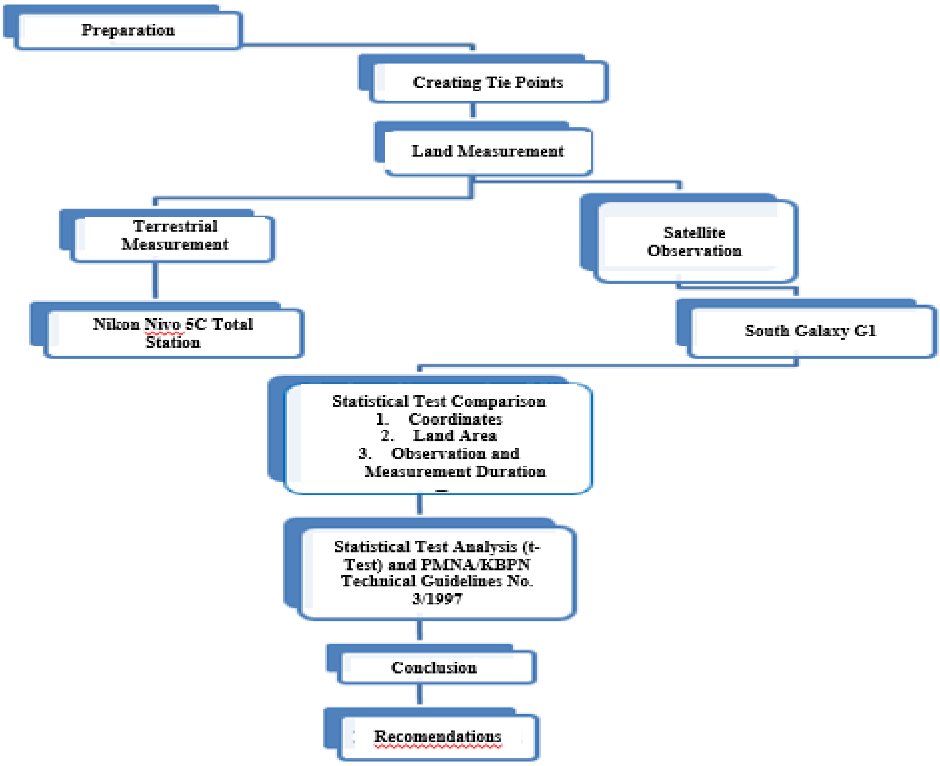

Figure 1. Flowchart of the Framework

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Methods

The method used in this study was a comparative experiment with a quantitative approach. The research was conducted in Petir Village, Cipondoh District, Banten Province. The location was determined based on the open conditions of the area and the flat topography. The population in this study was all residential land plots, while the sample used was 89 residential land plots measured using the Galaxy G1 and TS Mobile Base Station South.

The equipment used in this study included hardware and software, including:

1. A GNSS receiver used to measure points to serve as bases for extraterrestrial measurements and two starting points used to create closed polygons for terrestrial measurements. Tie point measurements were conducted using the static method.
2. A Galaxy G1 GNSS South receiver consisting of one base and one rover used for RTK-NTRIP measurements.
3. A Nikon Nivo 5c total station with autorecord function was used for terrestrial measurements.
4. A reflector or prism and reflector pole were used for terrestrial measurements.
5. A lite pole or pole was used for extraterrestrial measurements.
6. A tape measure was used to measure the height of the instrument during the measurements.
7. An iPhone 15 smartphone was used to calculate the duration of each activity stage.
8. An Asus laptop was used for data processing and research report preparation.
9. Autodesk Map 3D 2012 software was used for the drawing process.
10. ASCII File Generator software was used to convert job files (*JLX) into raw data files (*RAW File).
11. Microsoft Excel software was used for compiling and processing measurement data and statistical calculations.

Data Analysis

The analysis technique was carried out by comparing data obtained through different treatments of the specified samples. The first treatment involved measurements using a Total Station. The second treatment involved measurements using a Galaxy G1 Mobile Base Station South on the same sample.

Data analysis was performed on three components: the position of the land parcel boundary, the area of the parcel, and the observation period.

RESULTS AND DISCUSSION

Differences in Coordinates of Land Plot Boundary Points

The land boundary points were measured twice using different measurement methods: a total station and a South Galaxy G1 mobile base station. Based on the coordinates collected in the field, the difference in coordinates can be obtained using the formula $\Delta Li = \sqrt{((Xi - xi)^2 + (Yi - yi)^2)}$.

The differences in coordinate positions were then analyzed using a t-test. This involved comparing the abscissa (X) of the total station measurement with the abscissa (X) of the mobile base station measurement, and the ordinate (Y) of the Nikon Nivo 5c total station with the ordinate (Y) of the mobile base station measurement. The t-test used was a two-tailed paired-sample test with a significance level of 5%. A 5% significance level indicates a 95% confidence level in the research results. The t-test calculation was performed using Microsoft Excel [17].

Table 1. Results of the Difference Test (t-test) for Coordinate Differences [17]

Difference in values X		Difference in values Y	
Average ΔX	0.41	Average ΔY	0.39
α	0.05	α	0.05
df	139	df	139
T_{table}	1.97717772	T_{table}	1.97717772
T_{count}	11.83215957	T_{count}	11.83215957

(Source: Author's Data, 2025)

Differences in Land Plot Boundary Point Coordinates

The number of land plot samples in this study was 89 (eighty-nine). To determine the difference in land area between terrestrial measurements using a Nikon Nivo 5c Total Station and extraterrestrial measurements using a South Galaxy G1 mobile base station, the area of each plot was calculated. The tolerance for each plot was then calculated according to PMNA/KBPN Technical Instructions Number 3 of 1997 using formula (6).

The calculation results show that all differences between the land area measured using the Nikon Nivo 5c Total Station and the area measured using the South Galaxy G1 mobile base station for 89 plots meet the tolerances stipulated in PMNA/KBPN Technical Instructions Number 3 of 1997 concerning Land Registration Measurement and Mapping Materials, where all differences in the tested land area are $\leq \frac{1}{2}\sqrt{L}$.

Comparison of Measurement Time

In this study, the efficiency criterion focuses on the time required to measure land plots of the same area and shape (the same object). The time required for each method is calculated from the start of the measurement or data collection process to data processing, which includes mapping the plot, creating a measurement drawing, and creating a land plot map [18]. The results of this processing can be found in the appendix (terrestrial and extraterrestrial measurement drawings) and the appendix (terrestrial and extraterrestrial land plot maps) [19]. The time required to complete this work for each method can be seen in the following table:

Table 2. Time Required for Measurements Using a Total Station

No	Activity Type	Speed Unit	Time Required (Minutes)
1	Tie Point Measurement	10 Minutes	10
2	Land Area Measurement	5 Minutes x 89	445
3	Land Area Image Processing		60
4	Land Area Map Creation		70
	Total		**585**

(Source: Author's Data, 2025)

The table shows that the total time required to complete the work process was 585 minutes, or 9 hours and 45 minutes. The longest time required was for data collection in the field, namely for measuring the tie points and measuring the land area, which took 455 minutes, or 7 hours and 35 minutes.

Table 3. Time Required for Measurements Using a Mobile Base Station

No	Activity Type	Speed Unit	Time Required (Minutes)
1	Tie Point Measurement	10 menit	10
2	Land Area Measurement	4 menit x 89	356
3	Land Area Image Processing		50
4	Land Area Map Creation		60
	Total		**476**

(Source: Author's Data, 2025)

The table shows that the measurement process using the Galaxy G1 Mobile Base Station South took 476 minutes, or 7 hours and 56 minutes, to complete, and process, the data. The longest measurement time with this tool was for the tie point measurement and the land area measurement, which took 366 minutes, or 6 hours and 6 minutes.

Table 4. Difference in Measurements from the Two Tools

No	Activity Type	Speed Unit (minutes)
1	Measurement process with a total station	585

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No	Activity Type	Speed Unit (minutes)
2	Measurement of tie points with a mobile base station	476
	Time difference required	**109**

(Source: Author's Data, 2025)

The table above shows that measurements using the Nikon Nivo 5c Total Station took longer than measurements using the Galaxy G1 Mobile Base Station South, with the difference in measurement time between the two devices being 109 minutes, or 1 hour and 49 minutes. The time efficiency calculated from these measurements, combined with the time efficiency of measurements taken during the practical work, was 37.24%.

CONCLUSION

The results of the land area measurement test using the South Mobile Base Station type Galaxy G1 meet the tolerances set by the Ministry of Agrarian Affairs and Spatial Planning / National Land Agency according to the Technical Instructions of the Regulation of the Minister of State for Agrarian Affairs / Head of the National Land Agency Number 3 of 1997 where all differences in the area of the land tested are ≤ ½ √L. The use of the South mobile base station type Galaxy G1 for measuring agricultural and residential land areas is more efficient in terms of time required compared to measurements using the terrestrial method using the Nikon Nivo 5c Total Station. The length of time required to complete the work in this study with the Total Station tool is 585 minutes or 9 hours 45 minutes and for the South mobile base station tool it takes 476 minutes or 7 hours 56 minutes. And the time difference from using the two tools is 109 minutes or 1 hour 49 minutes. Based on the results of the calculation of time efficiency from the implementation of field measurements, it is 21%. And based on the results of the time efficiency calculations from this measurement that has been carried out, combined with the time efficiency of carrying out measurements during practical work, it is 37.24%.

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