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THE INTEGRATION OF GEOGRAPHY INFORMATION SYSTEM (GIS) AND GLOBAL NAVIGATION SATELITE SYSTEM-REAL TIME KINEMATIC (GNSS-RTK) FOR LAND USE MONITORING

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ABSTRACT: Limited open space area requires accurate monitoring to maintain changes in land use that is not suitable with city spatial planning. The difference between spatial planning and existing land Use should be minimized. Currently, land Use monitoring using Global Positioning System (GPS) and processed by Geography Information System (GIS) but the result has a deviation from the existing land Use. Within GNSS-RTK as a new approach will correct the result of GPS become more precise map of land Use. This research will test a GNSS-RTK that is applied to the land Use belongs to the campus of Universitas Indonesia. The land use will be divided as built up area and open space. The method used is quantitative experimental integrated with Geographic Information Systems (GIS). The results are, 1) the difference of land Use area with GPS and GNSS-RTK, 2) GNSS-RTK can get more accurate data than GPS. Base on the result, the conclusion is through GNSS-RTK and GIS, land use monitoring can be more effective because the highly precision of land area.

Keywords: GNSS-RTK, Land Use Monitoring, Geography Information System

1. INTRODUCTION

The use of various tools to facilitate positioning for survey and mapping have been growing and have the high speed and accuracy. One development of satellite-based technology is GNSS-RTK which operates by several satellites and operated for 24 hours as a reference in positioning both in real time and post-processing.

GNSS-RTK (Global Navigation Satellite System) is a constellation of currently satellites such as GPS (Global Positioning System-USA), GLONASS (Russia), Galileo (Europe), BeiDou (China), and QZSS (Japan), that transmitting signals for navigation and positioning applications, anywhere on the surface of the earth.

Generally GNSS-RTK has been widely used by various groups to support the data processing models included in urban studies. Accuracy of measurement and data processing method in a study in urban becomes very important that the Use of GNSS-RTK into one solution to increase the accuracy of the data. In urban area study, signal problems become obstacles for determining the position and navigation due to some problems such as shadowing and multipath effects [1].

Satellite navigation tools such as the Global Positioning System (GPS), which is often used as a means of positioning has disadvantages signal if the area is covered with high-rise buildings and also have the imprecision in determining the position should be. Some experimental researchs in the field of urban trying to compare between the GPS to GNSS-RTK to see the level of accuracy each tools (Case Urban Canyon) [2]. Besides the accuracy in the application of navigation system also depends on the availability of accurate references. At this time generally the availability of high map accuracy rate is less enough. The level of map accuracy standards used (for the metropolitan area) ranging between 5-20 meters [3].

In relation to the land Use GNSS-RTK monitoring is also used to reconstruct the boundaries of plots of land. Use of GNSS-RTK-based technology Continuous Operating Reference System (CORS) can be applied to dynamic cadaster, geodetic framework that is as dynamic and has a homogeneous accuracy so it can be used as a reference in the connective point position changes and limit land parcels that have been measured [4]. This dynamic cadaster concept which is then tested at the University of Indonesia, located in Depok, West Java on land use / land cover. Land use / land cover will be given for making land Use monitoring system. Land cover is an important factor in the analysis of the environment and spatial planning physically because it is a dynamic variable, which reflects the socio-economic interaction and regional environmental change [5].

Data retrieval land use / land cover done using GPS which is then corrected by taking the connective point using GNSS-RTK. Geo-data base and integration of satellite data is processed, and analyzed by technical Geographic Information System (GIS) to map the more accuracy and precision.

GNSS-RTK-RTK GNSS-RTK is using QZSS satellites developed by Tokyo University. University of Indonesia is one of the universities in Southeast Asia are getting antenna and Receiver GNSS-RTK RTK from Tokyo University's education and research activities base on navigation system.

2. METHODOLOGY

2.1 Mapping UI using UAV

Aerial image data was gathered between May 12th 2016 to May 14th by using Phantom 3. Detail specifications of Phantom 3 are: 2-megapixel camera resolution, maximum 2 kilometers of flight distance and GPS system for navigation and image reference coordinate. Image gathering was spread into 4 regions in 333 hectares of Universitas Indonesia. The result was 1500 sets of image which merged using Agisoft. The result of a single image still shows some area outside Universitas Indonesia region. Therefore, the image was cropped using ArcMap. The Final results was aerial image of Universitas Indonesia.

Imagery of Universitas Indonesia was acquired by drone. Consideration chosen drone to be process imagery mode is the resolution, image resolution is 8 centimeters. All imagery must be taking in same weather characteristic. Because it can reduce sun exposure differentiation, so we can get the same quality of imagery.

First process of imagery is area orientation. It is useful to make flight track. Because we set up drone on automatical mode. We can refer to google earth imagery for finding coordinate reference. From imagery we can get photos coordinate from default GPS system in drone.

Next processing is mosaic process after all imageries have been cached by drone. Agisoft software has used. First step we input all images into agisoft work layer after that we can find flight track from all images. Next step is aligning photos. We choose high accuracy for getting the best result from this processing. After align photos we move on to input Ground Control Points (GCP) to be references coordinates. Next step is building dense point clouds, for option we use ultra-high quality. The last step is orthofoto processing for joining all images, JPG is the kind of image photo that used for the next processing. From agisoft processing we got 2 images, one is northeast University area and second one is southeast University area, final step, we join these images by Arcgis mosaic processing.

We divided Universitas Indonesia (UI) area into 2 part because the different of characteristics. Southeast UI area is dominated by buildup area, on the another hand northeast area is the central of forest conservation area. The final imagery can be seen in Fig. 1.

Fig.1 UAV imagery of Universitas Indonesia

2.2 Geometric Correction using GNSS-RTK Data and GPS Data

Default GPS system that included in drone has several weaknesses. Limit of accuration become a challenge for application aerial photos for mapping purposes, especially in detail mapping activity. GNSS-RTK is one of technology that has developed to fix this problem.

There is location bias in aerial image which influenced by GPS accuracy in the platform. Therefore, to increase the image accuracy, geometric correction was needed. This geometric correction could reduce bias value from the image. Some Ground Control Points (GCP) was needed in geometric correction to bind the true location so that they could reduce bias value. For high resolution image, it needs 40 to 60 minimum points which spread in the entire area of image. In this research, there are 42 GCPs, as shown in the figure 1. These points was obtained by using U-blox, a GNSS-RTK tools, by recording data from satellite. Duration of recording was around 10 minutes.

Control Points (GCP) was converted to excel Format that include coordinates of GCP. From recorded coordinates around 10 minutes must be combined into a single point. We can get more than 1000 unique coordinates. Simple average statistic was used to measured average values from recorded coordinates.

Ground Control Points (GCP) must be distributed well (Fig 1.), it can affluence the accuration and precision of correction. For synchronization between aerial image and GCP, choose attractive spot is better for reducing misinterpretation. Street lights, street cross section and tree are example of attractive spots. Another fundamental thing is the GCP must be unmovable.

Base on locational characteristic, we can divide UI into 2 pat of area, southeast area with high level of built up area and northeast with the majority of forest and conservation area.

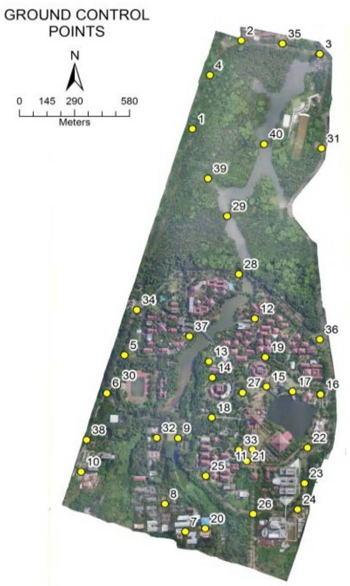

Fig.2 The locations of GCPs

Result of correction process will show the differentiation between GNSS-RTK and GPS system. The accuration both GNSS-RTK and GPS can be estimated by correction process. It is important for measuring error in mapping process. RMSE value of geometric correction should be an indicator in correction process. Application for estimation RMSE is ArcMap, that can automatically measure RMSE error from GNSS-RTK and GPS.

The RMSE value of geometric correction should be concerned. A good RMSE value ranged between 0 - 1. If RMSE value was more than 1, then the geometric correction is not good enough and couldn't be used to further processing. The result of RMSE value in this research is 2.68×10^{-5}, which was satisfy for further process.

2.3 Conversion Raster Data to Vector Data

From the result of aerial image that had corrected geometric can be a Base map for Interpretation land use change. Aerial image has raster format must be converted into vector format, so we can analysis easily. Vector data format is Shape File. Conversion was using manual digitization. Manual interpretation has several advantage, it can reduce error because the identic of spectral values.

Vector data features are acquired by following point, line, or polygon which identified manually (like forest of building) from aerial image in vector mode. The accuracy and spatial information of the features depend on the spatial resolution of the aerial image. Spatial resolution of the image is 0.083 meter, which should be able to map detailed scale up to 1:500.

However, manual digitation has some weakness. It required a lot of works and concentration. It also a tedious work, especially if there are a lot of features. Therefore, manual digitation is susceptible with human error. Furthermore, lots of buildings and features in Universitas Indonesia were covered by trees so that it makes feature identification harder.

2.4 Universitas Indonesia 2016

Result of digitization will be divided into 3 classes. Built up area, vegetation area, water body. Built up can be classified into parking area, building and road and vegetation can be classified into conservation forest and park. Universitas Indonesia (UI) is a unique place for research area, especially for land use monitoring. Because UI isn't only an area for educational activities but also the center of conservation and city forest in Jakarta and Depok city. It makes UI has big influences for ecosystem balance, water conservation and carbon management in this area. The high level of land use change in the city area should be the factor to implement land use monitoring system in Universitas Indonesia.

3. RESULT

Aerial image has converted into land use classification data, with total size each classes show in Fig. 3 and 4. Fig. 3 is land use data that converted from aerial image that was corrected by GPS ground control points and Fig. 4 shows land use classification after correction by GNSS-RTK.

The result shows that most of land use in the campus filled with vegetation cover (Fig. 2) which divided into conservation forest (115 Ha) and scattered trees along roadways and faculties (109 Ha). Built-up area of the campus consists of Buildings (24 Ha) and Parking Area (9 Ha), while Water Body consist of Lake (21 Ha) and Pond (0 Ha). Based on land use map (Fig. 2), northern part of the campus was dominated by Vegetation Cover, while the southern part was filled with Built-up Area.

Final analyses, we used aerial image to identify Universitas Indonesia boundaries. As a purpose to compare the total area of Universitas Indonesia that measured by terrestrial survey with area from aerial image by GPS and GNSS-RTK correction. Universitas Indonesia official published total area of Universitas Indonesia is 333 Ha. Comparation between GPS, Terestrial Survey and GNSS-RTK can be seen in table 1

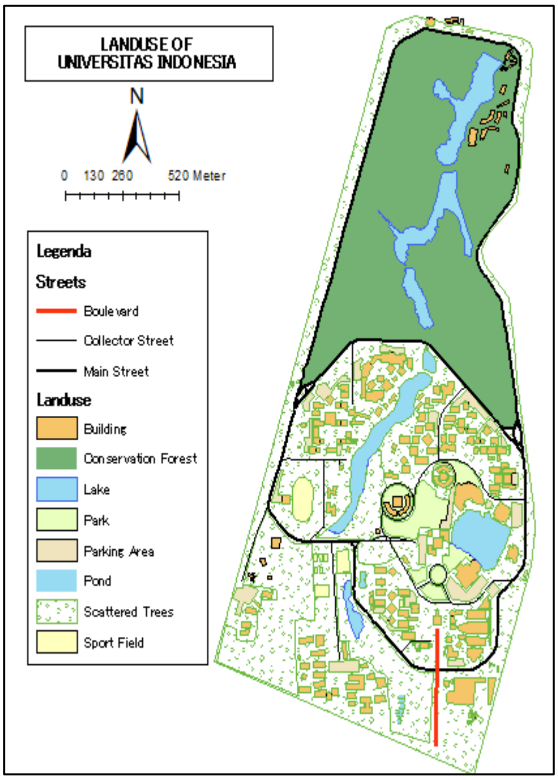

Fig.2 The Land Use Map of Universitas Indonesia

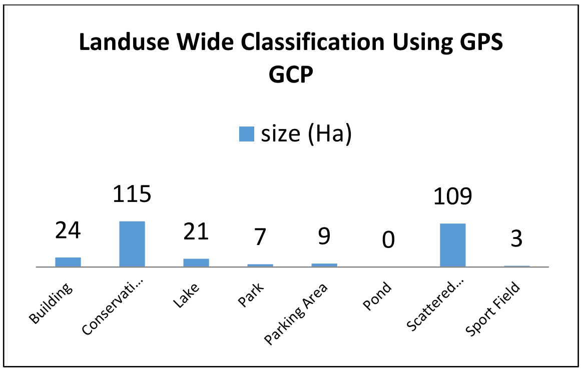

Fig.3 Land use Wide Classifications using GPS ground control points

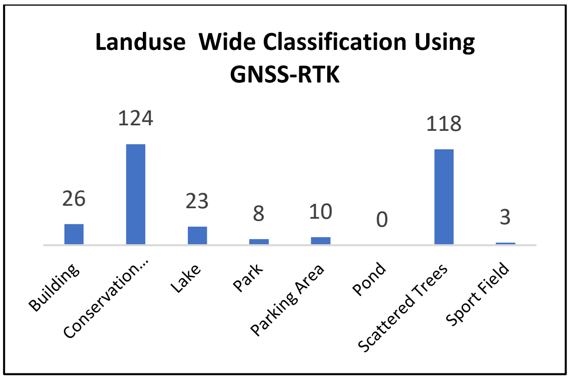

Fig.4 Land use Classification

Table 1 Total of Land Use Size Universitas Indonesia

Land use	Terrestrial survey	GPS	GNSS-RTK
Size	320 Ha	280 Ha	311 Ha

4. CONCLUSION

The difference of GPS and GNSS-RTK is the process of mapping. Several differences are the process of acquiring location coordinate and tools. So the coordinate result both GPS and GNSS-RTK are different. Based on the result of area estimation survey by terrestrial survey and aerial image that corrected by GPS and GNSS-RTK, we can conclude from the comparation that GNSS-RTK has more precise than GPS. The area similarity between GNSS-RTK and terrestrial survey has nearer than GPS and terrestrial survey.

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