Accuracy Assessment of Land Use Mapping Methods-Spatial Reference KDU Southern Campus

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Abstract— The development of land-use mapping is approached from a historical perspective. The southern campus was chosen as a study area because it has a water area, cultivation area, built-up area, and forest area needed to create a land use land cover map. With the most recent technologies, numerous methods for mapping land usage have been established. To assess the validity of these procedures, no comprehensive investigation has yet been carried out. As a result, it emerged to analyze the accuracy of land use mapping. The Global Navigation Satellite System was used as a ground data collection method to prepare a land use plan for the study area. Further, land use maps for the same area were prepared by using satellite images and drone images. Accordingly, the accuracies of the Remote Sensing product were compared with the output of the ground data collection method. According to this study, The Supervised Method of sentinel image has also received 88% accuracy, the semi-automatic Method of sentinel image has also received 88% accuracy and the unsupervised Method of sentinel image has also received 86% accuracy. The Supervised Method of drone image has also received 90% accuracy. Finally, when considering the comparison of all these results, it shows that drone images are suitable for creating land use land cover maps.

Keywords— **Remote Sensing, Drone Images, Image Classification**

I. INTRODUCTION

A land use map refers to a map based on the Land Survey techniques that depict the zoning and land classification of any current uses on all parcels of land within the survey area (Cavur et al., 2019). When creating a land use land cover map can use different kinds of data collection sources like ground Data Collection methods, spaceborne data collection methods, and airborne data collection methods. While that method airborne data collection method and spaceborne data collection method can be considered a remote sensing method.

In this research general objective is the accuracy assessment of land use mapping methods in digital image processing. General Sir John Kotelawala Defense University - Southern Campus has been selected as the study area for this purpose and a digital map of the study area was created by using AutoCAD software. This map was created using the observations taken by the ground-based data collection method. Also, these methods take much more time to complete the survey work and generate its final output. But the ground data acquisition method is a very accurate method. Therefore, the created land use map can be compared to the AutoCAD plan and the accuracy level of the land use map can be obtained.

However, satellite images can be used to create land use maps of the entire world or a portion of it. Using satellite imagery-based remote sensing tools, the mapping procedure for the preparation of land-use maps can be completed in a short amount of time (Bekanov et al., 2020). This method can be used to identify changes in land use on the Earth's surface. When producing maps of areas that can be viewed by satellite imagery, the accuracy of those maps varies on the spatial resolution of the satellite imagery.

In addition to that, for creating land use maps can use drone images using drone technology. Unmanned aerial vehicles (UAV) are among the low cost, have the resolution, and may be acquired at any time with few restrictions. This technology is particularly convenient, as it has previously established numerous classification approaches to extract terrestrial properties from UAV images. For this study, the Mavic 2 enterprise dual UAV was used to create an ortho-mosaic image. Then the ortho-mosaic image can be classified by using the supervised classification method and generating a land use map and comparing that map with the AutoCAD plan to check the accuracy of the land use map.

Nowadays most maps are prepared by using Remote Sensing methods. But the problem is still there is no proper accuracy assessment of those methods. So that assessing the accuracy of these techniques is very important. Therefore, considering this important this study is organized to determine the accuracy of those methods with respect to the ground data collection method. Therefore, through this study, maps depicting the current land use of the Southern Campus premises were prepared in various ways and their accuracy was analyzed.

II. METHODOLOGY AND EXPERIMENTAL DESIGN

A. Study Area

As for the study area, General Sir John Kotelawala Defence University - Southern Campus in Sooriyawewa, Sri Lanka was selected. The study area is shown in Figure 3.1. The university area covers 0.7044 km^2. The huge variation of geographical features inside the Southern Campus area is the main reason for selecting it as the study area. Cultivation areas, buildings, road networks, water bodies, and other variations can be found in this selected area. The land use maps related to such variations can be prepared very easily if data collection is conducted in this considered area.

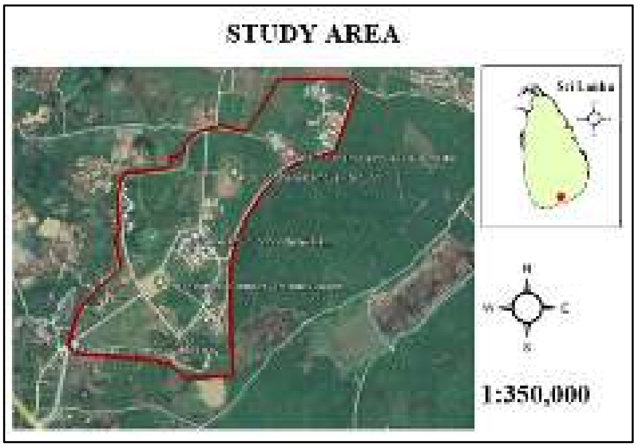

Figure 1. Study Area

This chapter described the process and design of the study expected to be done in this research work. The workflow of this study is shown in Figure 3.2. In this study, the data was collected in 3 ways:

1. Ground data acquisition method.
2. Spaceborne data acquisition method.
3. Airborne data acquisition method.

B. Methodology Applied

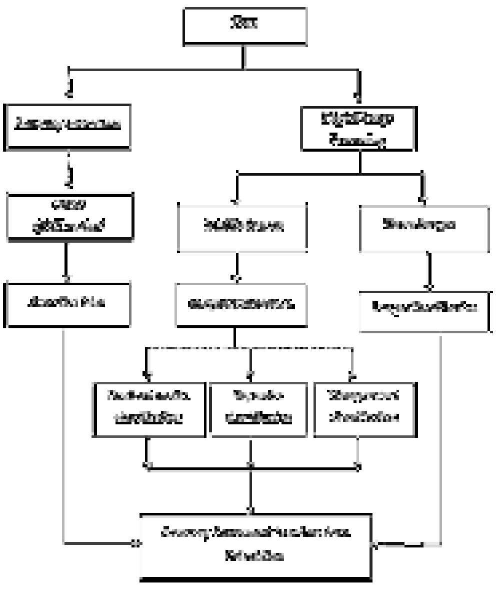

Figure 2. Workflow

1) Ground Data Acquisition Method

An improved surveying technique called Real-Time Kinematic (RTK) uses two (GNSS) antennas to measure relative positions in real time. Using RTK technology, the frequent mistakes in GNSS findings are identified and addressed (Insider, 2022).

The ground data acquisition method is taken as the base method for this research. GNSS survey technique is supposed to be used as ground data collection method for preparing a land use plan for the study area. The Kotelawala Defence University-Southern campus area was selected as the study area because it is consisting of the categories of hydro, building, land use, terrain, and transportation which were used to create a land use map. First, a reconnaissance survey was done and then the base was set up at GPS point KDUSC 10 and connected to the rower. Then the data were collected according to the categories of water, built-up, cultivation, and forest. After that collected data was exported as a dxf file and imported into the AutoCAD software and create the plan. Different colors and hatches were used to show the area and various categories as mentioned above. Finally calculated the area of those categories one by one.

2) Spaceborne Data Acquisition Method

This survey was conducted using satellite images. During this study, a Sentinel 2A image was used to obtain the accurate output, and only 2, 3, 4, and 8 bands were used. Therefore, before starting the analysis clear sentinel images with fewer clouds were selected. The satellite image selected was downloaded from the USGS Earth Explorer website including the Sooriyawewa area. The downloaded sentinel images were classified by using 3 different methods and QGIS software was used to create LULC maps.

1. Semi-Automatic Classification – Maximum likelihood
2. Supervised Classification – Maximum likelihood
3. Unsupervised Classification – Maximum likelihood

The bands 2, 3, 4, and 8 which are used to process a Sentinel satellite image were added to QGIS software. Before processing the satellite image, the errors of the image were removed through preprocessing and the required area was isolated by using the clipping function before conducting the preprocessing. After that, a virtual band with RGB values 4-3-2 was created. Then training signatures were selected for 4 categories which are water, built-up, forest, and cultivate. After that different colors were used to identify each one separately. Then the classification was done using training signatures and used spectral angle mapping tool for the processing. Then the map was clipped by using a shapefile of the campus boundary. After that an accuracy assessment was conducted and confirmed that 80% of users, producer, and then these relevant categories were selected, and areas were calculated.

Supervised classification also performed as the same way of the semi-automatic classification. The only difference of the super classification, maximum likelihood tool is used to create classification map but in semi-automatic classification map used spectral angle mapping tool. Then the accuracy assessment was done and got 80% for the accuracy assessment. If the accuracy assessment is more than 80% it is proven that it has better accuracy.

Without the use of labeled training samples, each image in a dataset is classified as belonging to one of the innate categories existing in the image collection in a process known as unsupervised image classification. For this classification used Sentinel 2 satellite image in 2022. For this analysis Sentinel, 2 image was used due to the high resolution (10 m). Here 4 labeled training samples were used.

3) Airborne Data Acquisition Method

For this survey, used Mavic 2 enterprise dual drone. DJI pilot software was recommended for DJI UAVs. So used DJI software to fly the drone. First The study area was separated into a few parts by considering the battery power of the drone. Then suitable places were selected to establish ground control points (GCPs) by referring to research papers. GCPs were established randomly. Side overlaps and frontal overlaps were 80% and altitude was taken as 60m. DJI pilot software has two methods such as manual flight and mission flight. Mission flight was used in this survey to create mapping routes because wanted to get 2D images. Then flew a drone and captured the images. The study area was separated into a few parts by considering the battery power of the drone.

Then the drone images were processed using PIX4D software and all the captured drone images were processed using the software. All drone images were processed at once to remove the overlapping errors when capturing the images during the drone survey. This processing was conducted according to 3 steps as,

1. Initial Processing
2. Point Cloud and Mesh
3. DSM, Or Ortho-mosaic and Index

Finally, the ortho-mosaic image which was the final output of the drone image processing was converted to a land use land cover classification map by using the supervised method in ArcGIS software.

III. RESULTS

Satellite images are widely available for use throughout the world from a variety of commercial and governmental sources. They are digital photographs of the Earth's surface created from spectral data gathered by sensors mounted on special-purpose satellites (Insider, 2022).

Drone photography is the process of taking still photos and moving pictures with a UAV, usually referred to as a drone or an unmanned aircraft system (UAS) (Insider, 2022).

Nowadays these technologies are used to do a survey as data collection methods but even today there is no analysis of the accuracy assessment of these methods. So, in this study, these methods were compared one by one, and the accuracy of these methods was checked. For this accuracy assessment, the AutoCAD plan was used as a base LULC map prepared by using the RTK method.

Below is the AutoCAD plan which is the base map used to compare the LULC maps created by using sentinel satellite images and drone images in this study considering four LULU types. These are Water, Cultivation, Forest, and Built-up. The result of this study is shown in Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7.

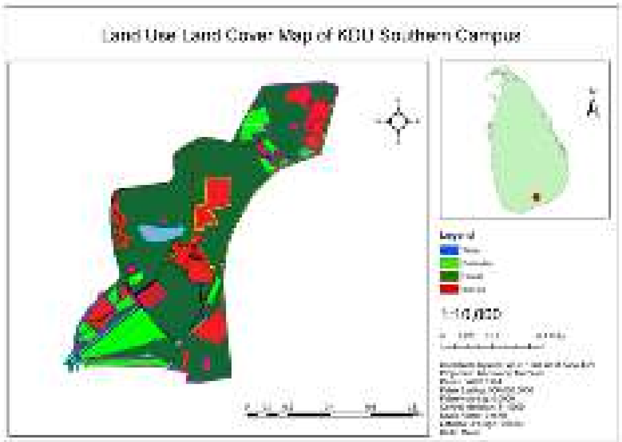

Figure 3. LULC Map of KDU Southern Campus – AutoCAD Plan (Real Time Kinematic Positioning Method)

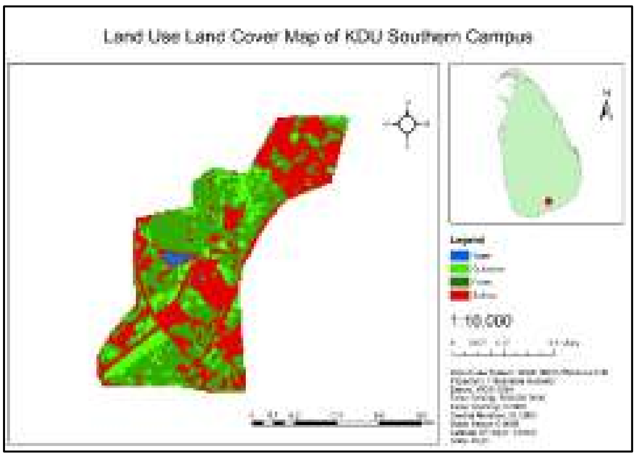

Figure 4. LULC Map of KDU Southern Campus - semi-automatic classification (Maximum Likelihood method)

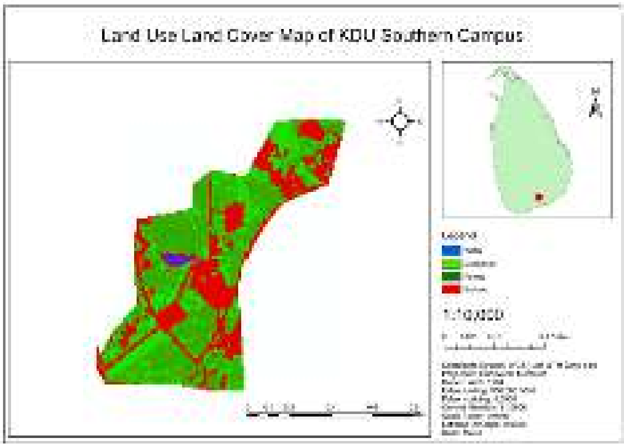

Figure 5. LULC Map of KDU Southern Campus - Supervised Classification (Maximum Likelihood method

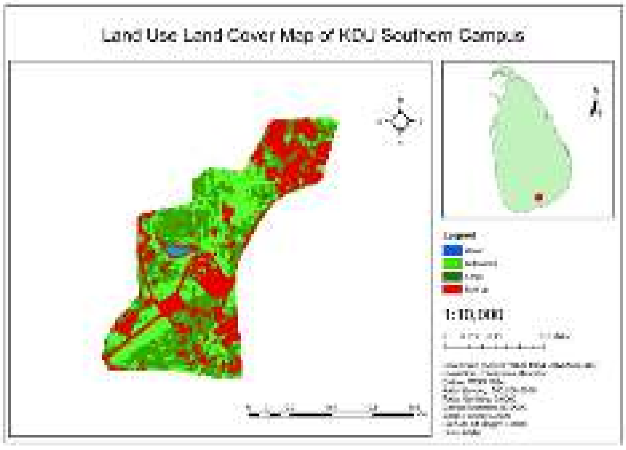

Figure 6. LULC Map of KDU Southern Campus- Unsupervised Classification (Maximum Likelihood method)

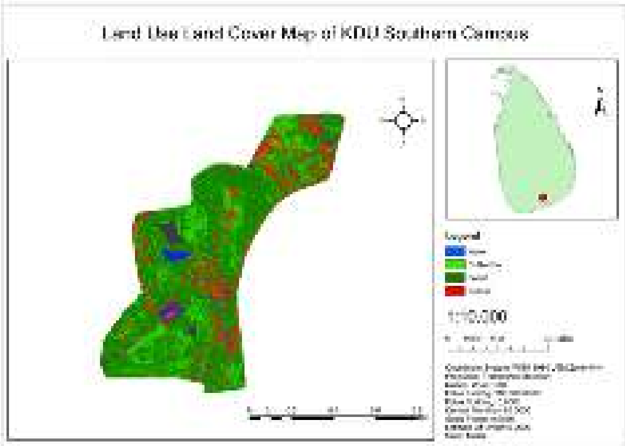

Figure 7. LULC Map of KDU Southern Campus- Unsupervised Classification (Maximum Likelihood method)

A. Land Use Land Cover Map– Real Time Kinematic Positioning Method

The table 1 shows the selected four LULC types and their calculated areas according to the data taken from the RTK survey. The areas were calculated using the prepared AutoCAD plan.

Table 1: Area calculation -Real Time Kinematic Positioning Method

LULC Types	Area (km^2)
Water	0.0095
Cultivation	0.0797
Forest	0.4535
Built-up	0.1617
Total	0.7044

B. Land Use Land Cover Map - Semi-automatic Classification Maximum Likelihood method

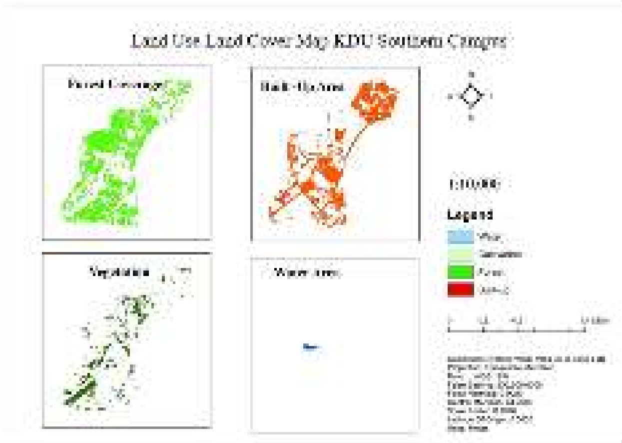

Figure 8. LULC Map of KDU Southern Campus - Semi-automatic Classification

The Table 2 shows the selected four LULC types and their calculated areas according to the LULC map shown in Figure 8, using semi-automatic classification – maximum likelihood method.

Table 2: Area calculation - Semi-automatic Classification Maximum Likelihood method

LULC Types	Area (km^2)
Water	0.0051
Cultivation	0.0942
Forest	0.3342
Built-up	0.2628
Total	0.6963

C. Land Use Land Cover Map - Supervised Classification Maximum Likelihood method

The Table 3 shows the selected four LULC types and their calculated areas according to the LULC map shown in Figure 9, using supervised classification – maximum likelihood method.

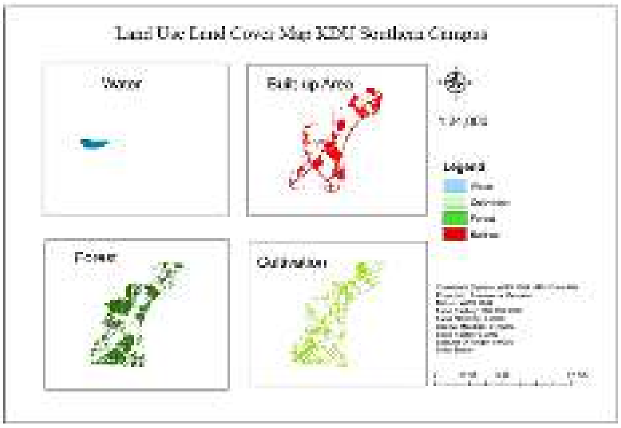

Figure 9. LULC Map of KDU Southern Campus – Supervised Classification

Table 3: Area calculation - Supervised Classification Maximum Likelihood method

LULC Types	Area (km^2)
Water	0.0052
Cultivation	0.1977
Forest	0.278
Built-up	0.2154
Total	0.6963

D. Land Use Land Cover Map – Unsupervised Classification Maximum Likelihood Method

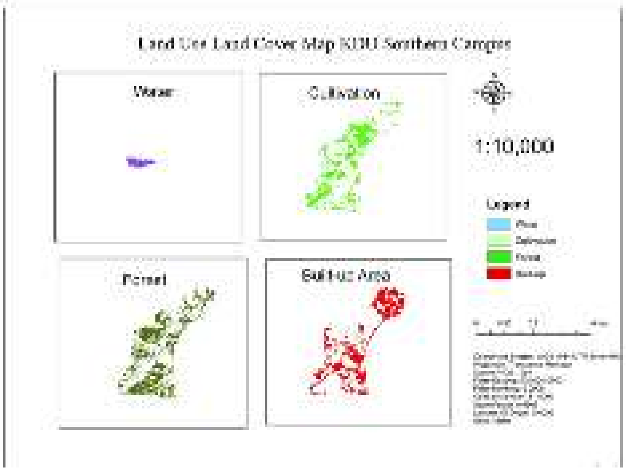

Figure 10. LULC Map of KDU Southern Campus – Unsupervised Classification

Table 4: Area Calculation - Unsupervised Classification Maximum Likelihood Method

LULC Types	Area (km^2)
Water	0.0045
Cultivation	0.2058
Forest	0.2624
Built-up	0.2250
Total	0.6977

The Table 4 shows the selected four LULC types and their calculated areas according to the LULC map shown in Figure 10, using the unsupervised classification – maximum likelihood method.

E. Land Use Land Cover Map – Drone Survey

Figure 11. Ortho-mosaic image create by using Pix4D software

Above Figure 11 shows the ortho-mosaic image created using collected drone images.

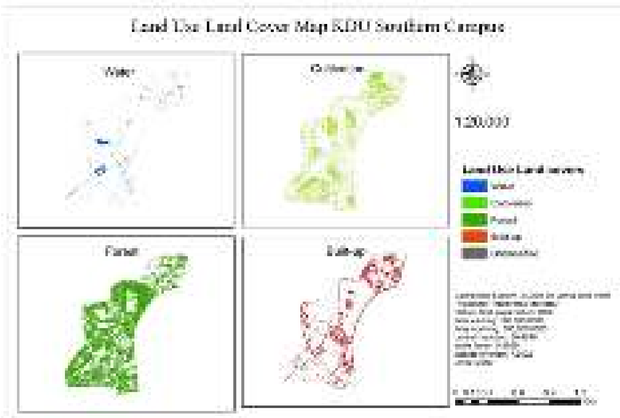

Figure 12. LULC Map of KDU Southern Campus – Supervised Classification

Table 5: Area Calculation – Drone Survey -Supervised Classification

LULC Types	Area (km^2)
Water	0.0250
Cultivation	0.1573
Forest	0.3986
Built-up	0.1145
Total	0.7055

The Table 5 shows the selected four LULC types and their calculated areas according to the LULC map shown in Figure 12, using drone survey.

Table 6: Accuracy Assessment

Image Clasification	Accuracy Assessment
Semi-automatic classification in sentinel image	88%
Supervised classification in sentinel image	88%
Unsupervised classification in sentinel image	86%
Supervised classification in drone image	90%

According to this study, The Supervised Method of sentinel image has also received 88% accuracy, the semi-automatic Method of sentinel image has also received 88% accuracy and the unsupervised Method of sentinel image has also received 86% accuracy. The Supervised Method of drone image has also received 90% accuracy. In comparison of all these results, the drone survey is suitable for the creating land use land cover map.

IV. DISCUSSION AND CONCLUSION

Currently, several methods are used to create LULC maps, but no comparison of the accuracies of those methods has been done so far. The current methods for preparing LULC maps are supervised, unsupervised and semi-automatic classification of sentinel-2A satellite images, by using GNSS RTK surveying technique and through supervised classification of drone images. These methods were identified by going through previous studies conducted regarding preparation LULC maps.

From above mentioned methods, the supervised classification of drone images was identified as a suitable method in aerial photogrammetry for land use mapping by going through previous studies conducted by researchers. So, this method was used in this study in order create LULC maps through digital image processing and compared the accuracy of the LULC maps prepared by drone images with the LULC maps prepared by Sentinel 2A satellite images from supervised, unsupervised, and semi-automatic classification. Then the overall accuracies of these LULC maps prepared by these two methods were determined by using the data obtained through GNSS RTK surveying technique.

Based on above comparisons the accuracy assessment for the Supervised Method of drone images is 90%. According to the results, the drone survey is suitable for creating a land use land cover map.

Some of the images captured by the drone were removed while processing because those drone images are erroneous due to the roll, pitch, and yaw of the drone. During this study, satellite images of 10m resolution were used for the comparison of satellite images with drone images. By using a satellite image with a higher resolution value, we can get a more accurate result.

The accuracy between LULC created from drone images and satellite images should be compared by establishing GCPs according to a grid while taking drone images. The accuracy between the point cloud classification of the drone image and the supervised classification of the ortho-mosaic image should be compared in area calculation.

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