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A Study on the Analysis of the Current Situation of the Target Site Using the Image of Unmanned Aircraft in the Environmental Impact Assessment

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Abstract

Small-scale environmental impact assessments have limitations in terms of survey duration and evaluation resources, which can hinder the assessment and analysis of the current situation. In this study, we propose the use of drone technology during the environmental impact assessment process to supplement these limitations in the current situation analysis. Drone photography can provide rapid and accurate high-resolution images, allowing for the collection of various information about the target area. This information can include different types of data such as terrain, vegetation, landscape, and real-time 3D spatial information, which can be collected and processed using GIS software to understand and analyze the environmental conditions. In this study, we confirmed that terrain and vegetation analysis and prediction of the target area using drone photography and GIS analysis software is possible, providing useful information for environmental impact assessments.

Keywords: *Environmental Impact Assessment, Drone, Drone Mapping, Terrain Analysis, Vegetation Analysis*.

1. INTRODUCTION

The environmental impact assessment system is a process of scientifically analyzing and evaluating the environmental effects of policies and development plans and presenting mitigation measures[1]. However, there is inherent uncertainty in the evaluation techniques and information, making it difficult to accurately predict future environmental impacts[2]. In particular, small-scale environmental impact assessments are difficult to conduct due to limited survey periods and evaluation resources, and most of the data is based on past information, making it difficult to understand the current situation. The regulations for preparing environmental impact assessments specify the use of literature, national databases, and other sources of information[3].

Using unmanned aerial vehicles (UAV) to capture images and videos can help assess environmental conditions, and with the recent expansion of the UAV market, drones have become more popular[4, 5]. The image data collected by drones can be used in environmental impact assessments through GIS analysis software, enhancing the accuracy and reliability of survey data and increasing economic efficiency[6, 7]. To this end, this study aims to explore the efficiency of environmental impact assessments using affordable drones and open-source software.

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2. RESEARCH METHOD

2.1 Study Area

As shown in Table 1, this study verifies the practicality of using drones in the actual environmental impact assessment process through field surveys and drone surveys of development projects, and analyzes and predicts topography and vegetation conditions using collected images.

Table 1. Location and overview of the study area.

Category	Area(㎡)	Type of development project	Note
YJ	107,319	Logistics Complex Development Project	planar
NA	26,550	Road Construction Project	Linear

2.2 Drone and Analysis Software

The drone used in this study is DJI's Mavic Pro, which is a low-cost and popular drone that is easily purchased is shown in Table 2. The RGB sensor (camera) built into the drone was utilized for data collection[8].

Table 2. Drone and Analysis Software

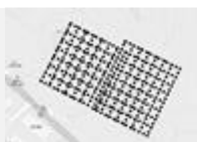
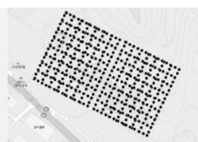
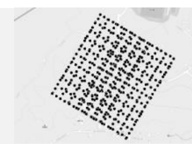
Category	Drone	Auto pilot	Mapping	Spatial Analysis	Segmentation
Name of product	Mavic Pro(DJI)	Pix4Dcapture	OpenDroneMap	QGIS 3.18	Orfeo ToolBOX

2.3 Field shooting

Each target area was defined through aerial photographs before field investigation, and videos were collected by conducting field investigations and shootings 1-2 times from September 2021 to April 2022 for each target area to compare temporal changes. The video collection method utilized the DJI Mavic Pro drone and its built-in RGB sensor (camera) that is widely available for purchase and easy to use. The automatic navigation mobile application (Pix4DCapture) that is linked with the drone was used for flight planning, way point setting, shooting altitude, camera angle, grid type setting, and for driving the drone during the field investigation[9].

Table 3 shows the automatic navigation information that was input for each target area.

Table 3. Automatic navigation input conditions

SITE		YJ		NA	
Date		21.10.17	22.03.09	21.11.12	22.04.17
Grid type		Double	Double	Double&Single	Double
Area Covered(㎢)		0.242	0.287	0.196	0.220
Altitude(m)		100	100	100	100
Camera Angle(°)		60	60	70	65
Overlap(%)	V	80	80	85	85
	H	72	72	77	77
Images		508	538	428	559
Location for shooting					

2.4 Image processing

As shown in Figure 1, the video data collected through the field survey were processed using WebODM. The video processing process was divided into two tasks: photo processing to align aerial images and terrain processing using the generated terrain information. The processing process consisted of photo alignment, GCP calibration, point cloud output, orthophoto generation, 3D mesh generation, and terrain information (DSM, DTM) generation[10, 11]. Table 4 also shows the analysis method for the current status of the study area.

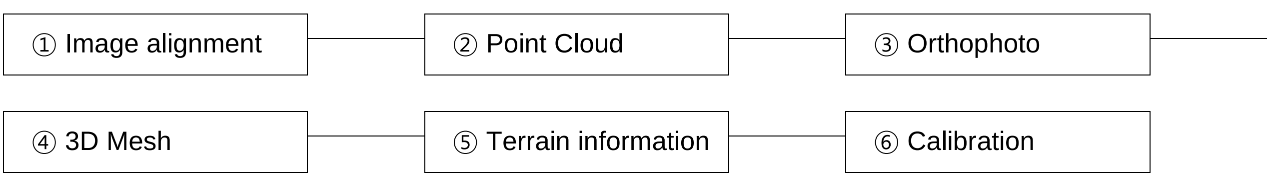


Figure 1. Image processing process

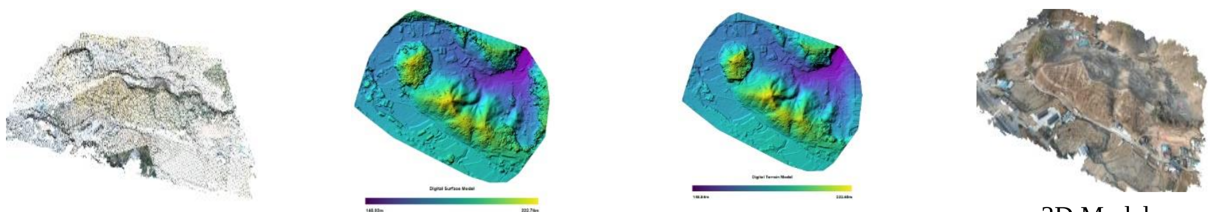
Table 4. Analysis method for the current status of the study area

Category	Terrain analysis	Vegetation analysis
Analysis method.	① DTM → Elevation, Slope analysis ② Construction site terrain model construction after construction ③ DTM → Terrain model after construction Prediction of earthwork volume and terrain changes	① DSM - DTM → nDSM ② Filtering of forest and non-forest areas ③ Construction of tree height distribution map ④ Segmentation ⑤ Image classification ⑥ Vegetation classification and calculation of damaged areas

3. ANALYSIS AND PREDICTION RESULTS

3.1 Construction of Terrain Spatial Information

The image data collected from each selected target area was spatially constructed through image processing and used as basic data for evaluating each criterion. Spatial information constructed by the target area is shown in Figures 2 and 3. As shown in Table 5, as a result of error analysis of the constructed spatial information, the X, Y errors showed a range of 0.066 to 0.401m, and the RMS ranged from 0.182 to 0.487m, indicating a relatively high level of accuracy.



Point Cloud DSM DTM 3D Model

Figure 2. Terrain spatial information(Site-YJ)

Point Cloud DSM DTM 3D Model

Figure 3. Terrain spatial information(Site-NA)

Table 5. Error analysis of 3D model

Site	3D	Mean	Sigma	RMS Error	Site	3D	Mean	Sigma	RMS Error
YJ (21.10.17)	X (m)	0.084	0.181	0.200	NA (21.11.12)	X (m)	0.137	0.349	0.375
	Y (m)	0.066	0.113	0.131		Y (m)	0.145	0.453	0.476
	Z (m)	0.126	0.361	0.382		Z (m)	0.401	0.982	1.061
	Total			0.182		Total			0.487

3.2 Terrain Analysis(Site-YJ)

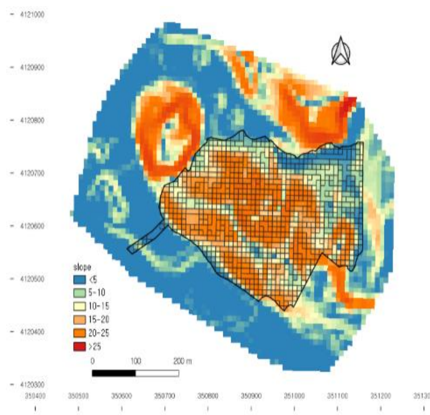
3.2.1 Slope Analysis

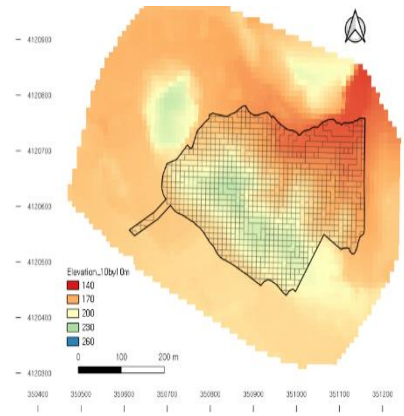
As shown in Table 6, as a result of the analysis, the highest elevation of the target area is 223.7m, and the lowest elevation is 151.7m, showing an elevation difference of 72.9m. Areas with a slope of less than 20 degrees within the target area accounted for 52.5%, and the average slope was analyzed to be 20.4 degrees.

The elevation analysis results showed similar results to the environmental impact assessment results. In the case of slope analysis, the distribution ratio of the slope over 25 degrees was analyzed to be 25.9%, which was relatively higher than the analysis results of 11.7% and 16.8% in the evaluation[8].

Table 6. Summary of Slope Analysis Result

Slope(°)	Area(㎡)	Ratio(%)
Total	107,319.0	100.0
<5˚	5,162.8	4.8
5˚ ~ 10˚	12,191.5	11.4
10˚ ~ 15˚	19,121.8	17.8
15˚ ~ 20˚	19,862.0	18.5
20˚ ~ 25˚	23,160.1	21.6
>25˚	27,820.7	25.9
Average	20.4˚	



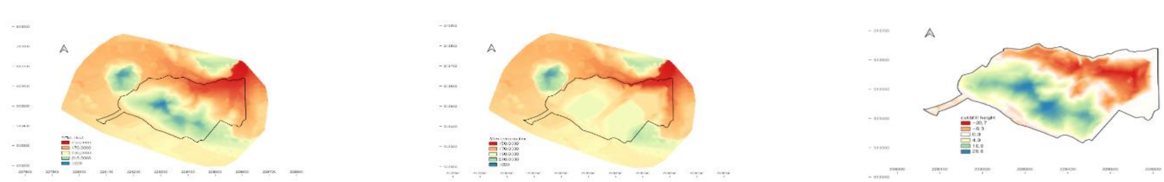


3.2.2 Prediction Earthwork Volume

As shown in Table 7 and Figure 4, the site development plan was converted into a 3D drawing, and the terrain was simulated by predicting the terrain after completion. The difference in topography between the current terrain model obtained through drone image processing and the predicted post-construction topography model was analyzed using QGIS to predict the soil and rock excavation depths, and the total volume of soil excavation was estimated based on the excavation depth and area of each pixel. According to this study, the predicted amount of soil excavation was found to be 88.6% of the amount estimated in the environmental impact assessment, indicating an 11.3% reduction in soil excavation[12].

Table 7. Prediction Earthwork volume

Category	Cutting	Banking	Note
Volume(㎥)	579,992	373,391	Max. Cutting (H) 30.2m Max. Banking (H) 21.8m
Total(㎥)	953,383		
Topographic change index1)	8.69		



Current st atus　　After the development project　　Cutting&Banking

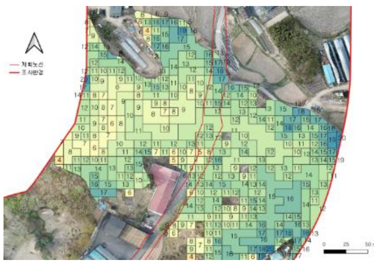
Figure 4. Prediction of Topographic Change

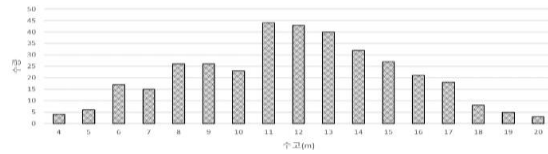
3.3 Vegetation Analysis(Site-YJ)

3.3.1 Analysis of Tree Heights

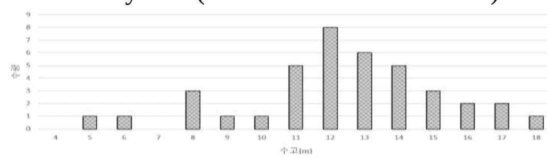
The tree height distribution of the forest vegetation within the survey area (within 150m on either side of the road centerline) was analyzed to range between 4-20m. The average tree height was analyzed to be 11.8m, with trees of 11-13m height range accounting for 36.7% of the total distribution. In contrast, the planned route area had trees with a height range of 4~18m, with an average height of 12.3m.

As shown in Figure 5, the average tree height was 8~9m as a result of the height analysis, which was 4.8~5.8m, which is lower than the result of the environmental impact assessment. In addition, it was found that the area affected by forest vegetation was considerable at 705 ㎡[12].





Survey area (within 150m on either side)

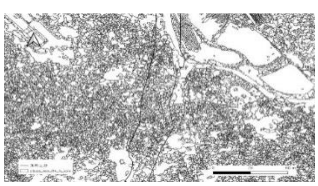


Planned road within the study area

Figure 5. Distribution map and proportion of tree height in forest vegetation

3.3.2 Prediction of Forest Vegetation Damage Area

Using the spectral and spatial information of the orthocorrected image constructed by photographing forest vegetation with a drone, a vector layer was created through segmentation and the elevation value of nDSM was delivered. Image classification was performed by inputting training data. Vegetation was extracted as shown in Figure 6 by filtering areas recognized as less than 4m above sea level and non-vegetated areas, and the final forest vegetation boundary was created through image processing such as merging the same classified areas as shown in Figure 7 and Table 8[13].



Segmentation

Extraction of forest vegetation

Forest vegetation - orthophoto overlay

Figure 6. Extraction of forest vegetation

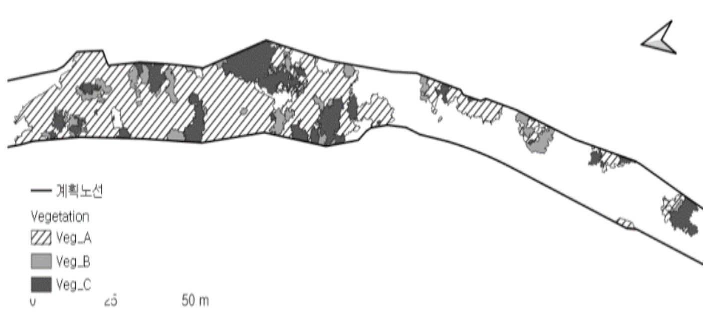


Figure 7. The current status of forest vegetation inclusion within the planned road.

Table 8. Prediction of forest vegetation damaged area

Category	Veg. A	Veg. B	Veg. C	Total
Training image				
Area(㎡)	1,806	266	458	2,530

As shown in Table 9, the density of trees in forest vegetation was applied to calculate the amount of tree damage, and as a result of the on-site vegetation survey, it was estimated that 455 trees were damaged due to the destruction of forest vegetation during the road opening during the environmental impact assessment[12].

Table 9. Prediction of the tree damage amount

Category	Damaged area(㎡)	Tree density1)(Number/100 ㎡)	The number of damaged trees(Number)
Planned road	2,530	18	455

1) The on-site surveyed tree density applied in the environmental impact assessment

4. CONCLUSIONS

In this study, it was confirmed that precise spatial information of the target area and its surroundings can be established and analyzed in a short period of time using low-cost drones and open-source software for environmental impact assessments based on drone-based optical imagery. Additionally, it was found that when combined with field surveys such as GCP and vegetation surveys, precise soil analysis, terrain change prediction, vegetation distribution status, landscape change prediction, and analysis can be achieved.

The following are the major research results obtained through this study:

The current status of the target area was analyzed using DTM and DSM data for terrain analysis (elevation and slope analysis), and it was found that when analyzing the slope, the proportion of slopes over 25° was relatively high due to the reflection of protruding and buried unknown terrain within the analyzed pixel when using drone imagery. Short-term estimation of soil volume for the target area is possible when constructing and utilizing DTM data and 3D development plans, and it was found that there was an 11.8% difference compared to the total soil volume data produced for environmental impact assessments. This can be used to predict the maximum vertical cut and fill height, maximum vertical cut and fill slope height, and terrain change index.

The tree density of the forest vegetation in the target area was analyzed using DSM and DTM data obtained by drones. The vegetation and vegetation community boundaries were extracted using image segmentation and object classifiers of the captured ortho-images, and the extent of forest vegetation damage caused by development projects was quantitatively calculated. It was found that it is difficult to calculate the tree density of forest vegetation using low-cost drones with built-in RGB sensors, but it is possible to conduct vegetation surveys and create existing vegetation maps using tree height analysis, image segmentation, and classification.

REFERENCES

[1] M. J. Lee et al, “Subtitle Establishment of Spatial Information Application System for Advanced Environmental Impact Assessment,” *Korea Environment Institute*, 2018.

[2] Y. J. Jin and S. Y. Lee, “Reviewing Feasibility of Applying of Drones and BIM in Environment Impact Assessment,” Korea Environment Institute, pp. 10-18, 2019.

[3] Ministry of Government Legislation, Korean law information center(http://www.law.go.kr), Regulations regarding the preparation of Environmental Impact Assessment reports and related documents.

[4] Y. J. Jin, “Application of Drones Modeling in Environment Impact Assessment,” 2020 Korea Academia-Industrial cooperation Society a collection of papers on spring academic presentations, 2020.

[5] I. Y. Hong and B. A. Chun, “Participatory Mapping Using Low-cost Drone and Open Source Software,” *The Korean Cartographic Association*, Vol. 20, No. 1, pp. 25-36, 2020.

[6] M. K. Park, “Comparison of Accuracy between Analysis Tree Detection in UAV Aerial Image Analysis and Quadrat Method for Estimating the Number of Trees to be Removed in the Environmental Impact Assessment,” *J. Environ. Impact Assess*, Vol. 30, No. 3. pp. 155-163, 2021.

[7] 7 S. W. Son, D. W. Kim, J. H. Yoon, H. J. Jeon, Y. E. Kang, and J. J. Yu, “3D Model Construction and Evaluation Using Drone in Terms of Time Efficiency,” Journal of the Korea Academia-Industrial cooperation Society, Vol. 19, No. 11, pp. 497-505, 2018. DOI: https://doi.org/10.5762/KAIS. 2018.19.11. 497

[8] Y. J. Kim and Y. G. Yu, “A Study for River Change Analysis using Spatial Information and Drone Photogrammetry,” *Journal of Korean Society for Geospatial Information Science*, Vol. 28, No. 3, pp.29-37, 2020.

[9] K. H. Kim. et al., “Applicability of Drone Image and Image Detection Technology for Constructing Invasive Plants Distribution,” Korea Environment Institute, 2019.

[10] K. M. Kim, et al.(2016). “Utilization of Remote Sensing Data for Advancing Clinical Diagnosis,” *National Institute of Forest Science*, 2016.

[11] H. C. Sung, Zhu, Y. Yan and S. W. Jeon, “Study on Application Plan of Forest Spatial Information Based on Unmanned Aerial Vehicle to Improve Environmental Impact Assessment,” J. Korean Env. Res. Tech, Vol. 22, No. 6, pp. 63-76, 2019. DOI: https://doi.org/10.13087/kosert.2019.22.6.63

[12] Strategic Environmental Impact Assessment for the Yangji Logistics Complex in Yongin, 2020. https://www.eiass.go.kr/

[13] B. H. Yoo, “QGIS 3.4 OrfeoToolBox(OTB)Machine learning-based drone image analysis,” Korea National Park, 2019.

[14] M.K. KIM, D. Y. KIM, and D. K. Hwang, “Study on the Application of Environmental Impact Assessment for Railway Development Based on Unmanned Aerial Vehicle,” *Journal of the korean society for railway* , Vol. 23, No. 7, pp. 625-636, 2020. DOI: 10.7782/JKSR.2020.23.7.625