High-Resolution Land Cover Classification Using Drone LiDAR for Climate Change Adaptation

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Background

1. Relationship between climate change and forests

- Forests influence the climate and are highly sensitive to climate change. Due to their long lifespan, trees are unable to adapt to rapid environmental changes, affecting forest structure and function.
- Forest land cover reflects structure, species and management results and serves as essential data for climate adaptation planning and vulnerability assessments. So, systematic and quantitative monitoring of forest land cover and structure is essential.

2. Forest survey using drone LiDAR

- Forest inventories in South Korea have been conducted through terrestrial surveys aerial orthophotos, but terrestrial surveys are costly and time-consuming, and orthophotos only capture the canopy.
- In contrast, LiDAR sensors can penetrate vegetation, making them useful for accurately estimating detailed forest stratification.

Objectives

We aim to identified the potential of drone LiDAR data for fine-scale forest land cover classification to support climate change adaptation planning.

Study Site

- location: Forest of the Folk Village within Yeungnam University, Gyeongsan-si, Gyeongsangbuk-do, Republic of South Korea
- Plot size: about 200m x 200m

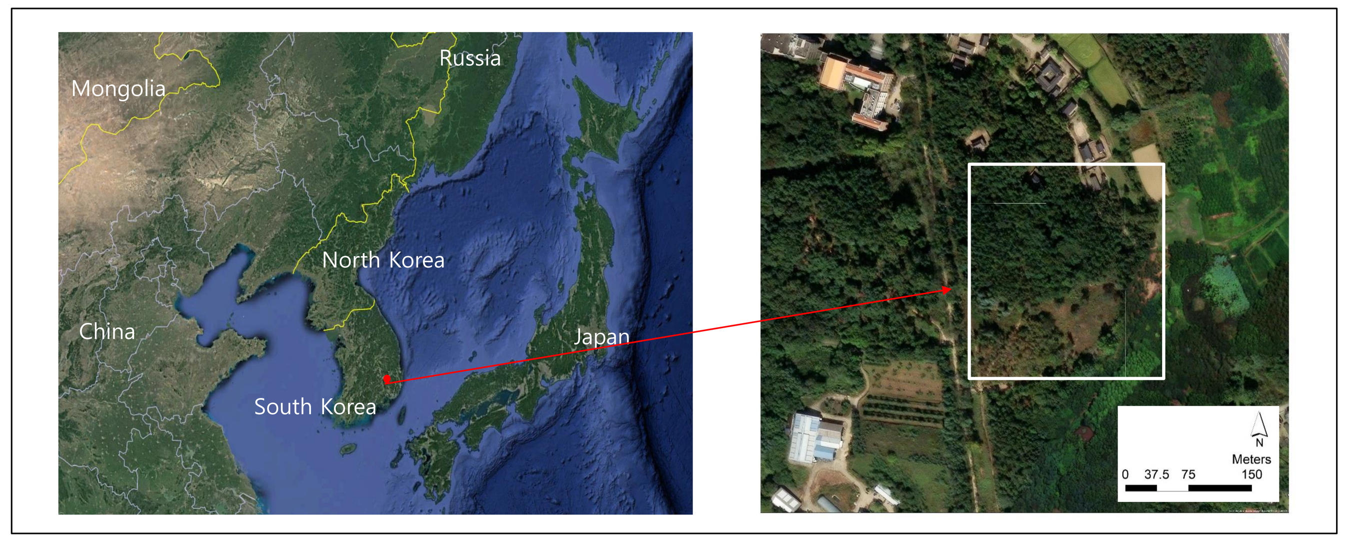

Figure 1. Study Site

Methods

1. Data Collection

- Platform: DJI Matrice 300 RTK + DJI Zenmuse L2

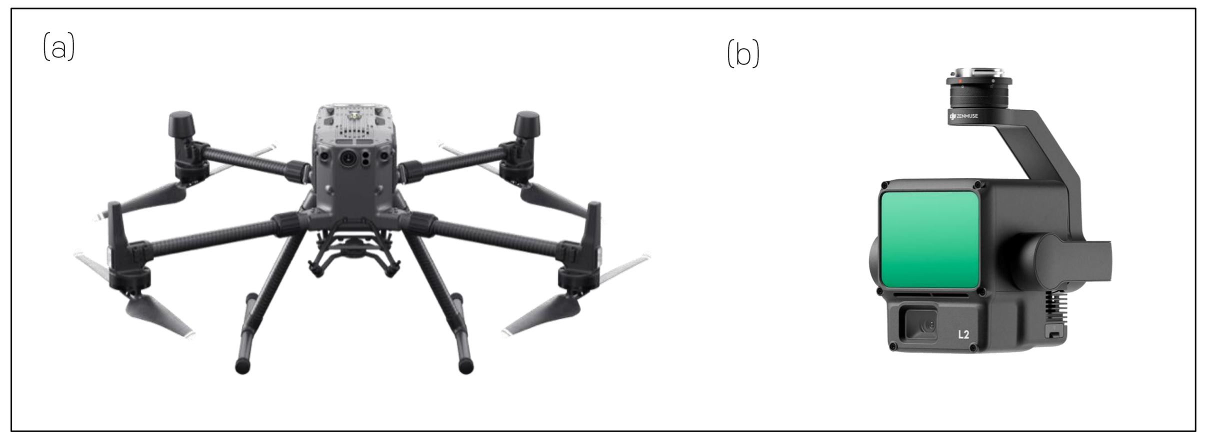

Figure 2. Using platforms. (a) DJI Matrice 300 RTK. (b) DJI Zenmuse L2

- Collection date and time: June 19, 2025, 11:30 AM ~1:30 PM
- Flight Settings

Table 1. Flight Settings

Point Cloud Density	580points/㎡	Side Overlap(LiDAR)	60%
GSD	1.88cm/pixel	Side Overlap(Visible)	69%
Terrain Follow	70m	Forward Overlap(Visible)	60%
Speed	7m/s	Return Mode	Penta

2. Data Preprocessing

- LiDAR data preprocessing was conducted using DJI Terra, CloudCompare and RStudio.
- Resolution: 0.25m

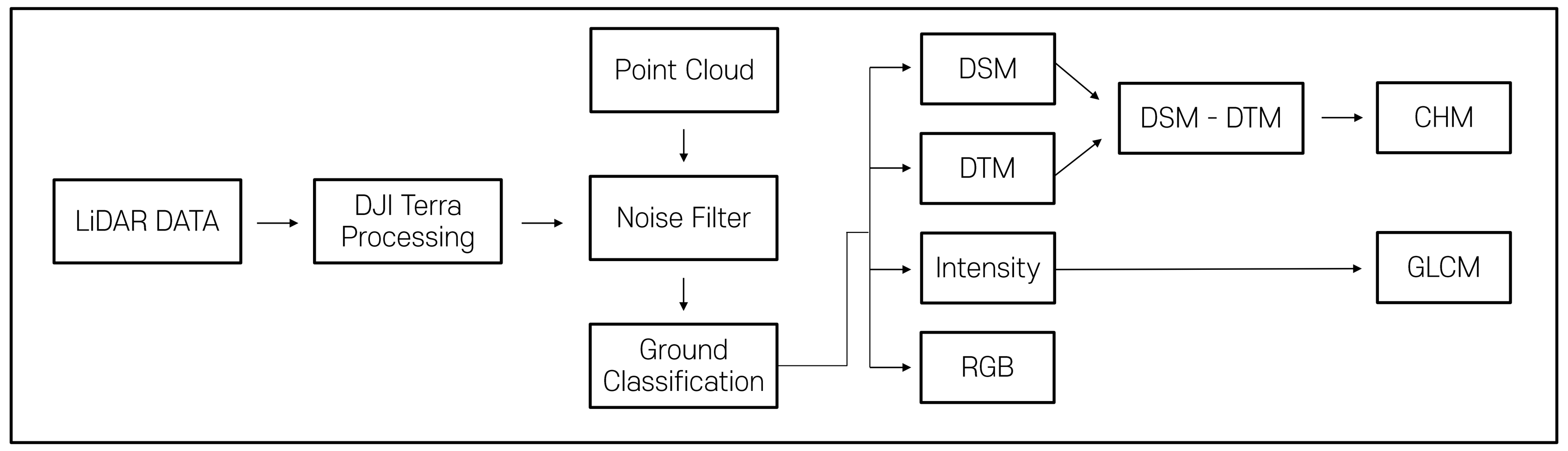

Figure 3. Data Preprocessing Flow

3. Vegetation and Non-Vegetation Classification

1) Classification Metrics

The Canopy Height Model(CHM) represents the height of trees and can be used to derive structural metrics. Intensity defined as the ratio of reflected to emitted light. To enable clearer object classification, the intensity was converted into Gray-Level Co-occurrence Matrix(GLCM) textures. RGB imagery was used to derive spectral measurements such as vegetation metrics.

Table 2. The extracted metrics from CHM, GLCM and RGB

Classification Type	Source	Metrics	Description
Land Cover Classification	CHM	CHM_mean	- Mean value of the pixel per plot
		CHM_max	- Max value of the pixel per plot
	GLCM	GLCM_contrast	- A measure analyses the image contrast
		GLCM_variance	- A measure of gray tone variance of the pixels within the plot
	RGB	nG	- Normalized G - G/(R+G+B)
		Brightness	- Mean Brightness - (R+G+B)/3

2) Classification Land Cover

- For forest stratification classification, we need to classify vegetation and non-vegetation areas within the plot.
- We used K-means algorithm, an unsupervised method that clusters data points based on their similarity.

Table 3. Detailed Land Cover Type of Vegetation and Non-Vegetation Classification

Class Type	Class	Detailed Land Cover Type
Land Cover Classification	Vegetation	Grassland, Tree, Shrub
	Non-Vegetation	Barren, Building

4. Height Interval Distribution of Point Cloud

- Height intervals were divided into 0–1.5 m, 1.5–3 m, and above 3 m to examine the point cloud distribution.

Results

1. Data Preprocessing Results

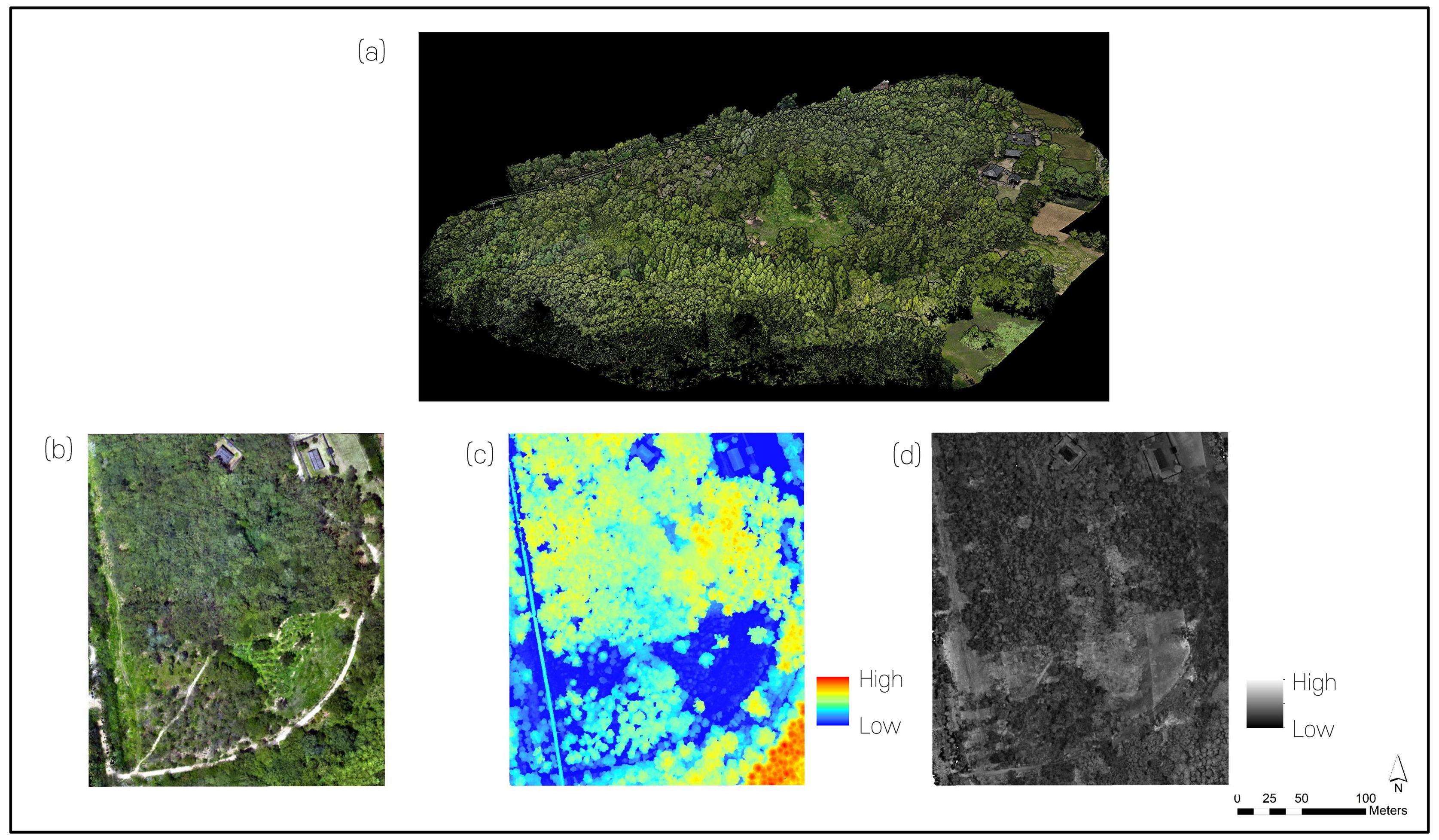

Figure 4. Data preprocessing results. (a) 3D Point Cloud (b) RGB (c) CHM (d) Intensity

2. Vegetation and Non-Vegetation Classification Results

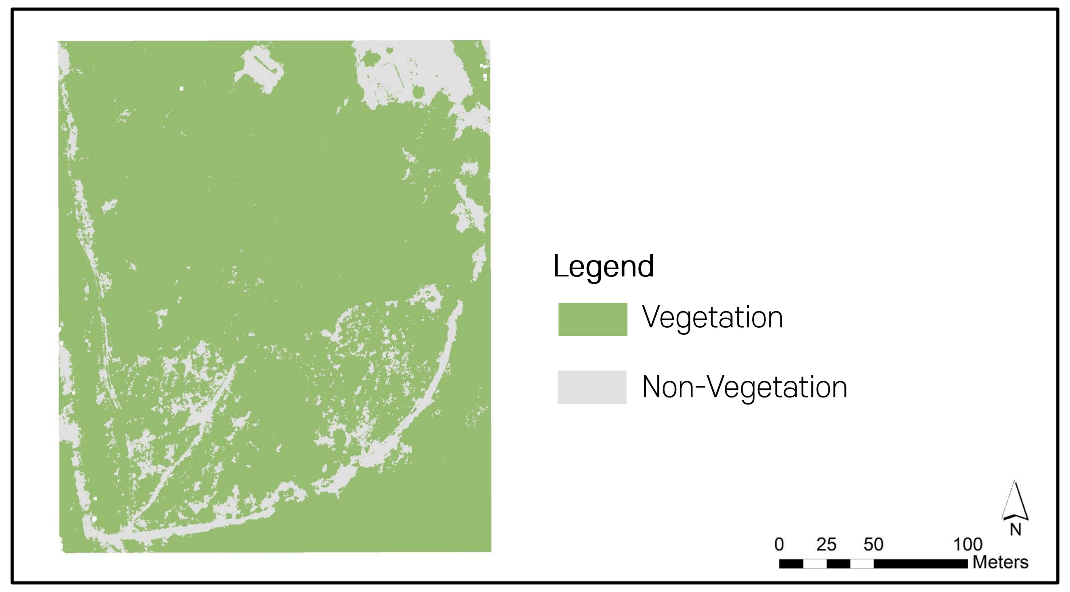

Figure 5. Results of Vegetation and Non-Vegetation Classification

3. Height Interval Distribution of Point Cloud

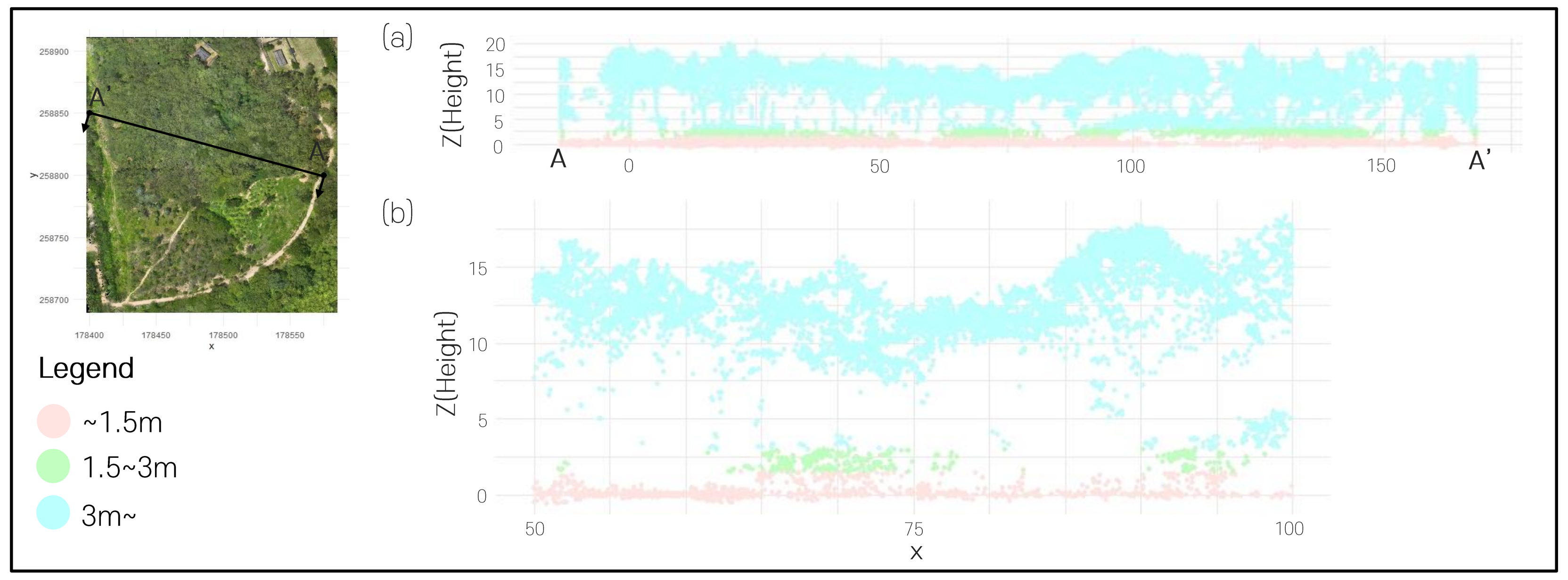

Figure 6. Cross Section of Point Cloud Distribution by Height Interval. (a) Example of Cross Section. (b) Cross Section with randomly sampled points from (a)

Conclusion

- This study didn't conduct field survey and accuracy assessment of the classification. Also, despite the importance of analyzing vertical forest structure, a full structural classification was not performed.
- In further studies, classifying specific forest stratification - such as single, double and triple layered forests - can support more detailed climate change adaptation strategies.