USE OF UAV-BASED CANOPY HEIGHT MODELS FOR FOREST THINNING PROPOSAL AND SKIDDING TRAILS LAYOUT IN THAI TEAK PLANTATION

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Abstract

Suitable skidding trail layout is important in sustainable forestry system, thus can minimise the damages to trees and economical losses. Image data for certain plots of teak plantation in Thong Pha Phum were captured with unmanned aerial vehicle DJI Mavic Pro and further processed in Agisoft Metashape software. On obtained orthophoto single trees were distinguished and understory trees for thinning from below were identified on Weighted Voronoi diagram base. On Kernel Density Estimation base a tree density estimation raster output were created. Considering irregular teak spacing a subjective approach for skidding trail layout design was applied, with emphasis to shorten skidding distances and reducing the possible damages to remaining trees and soils.

Keywords: teak, plantation, Weighted Voronoi diagram, Kernel Density Estimation, thinning

INTRODUCTION

One of the many causes of destruction or damage to forest stands is timber skidding. This can be mitigated by pre-planning and careful control over skidding operation, together with following Reduced Impact Logging (RIL) principles. Well-arranged skidding trails can accelerate the time needed for wood extraction and can reduce possible harm to timber and ecosystem itself.

This paper merges new approach in Weighted Voronoi diagrams (Aakala et al., 2013) use with well-known technology of UAV and deals with skidding trails layout in irregularly spaced teak plantation and evaluates its success.

METHODOLOGY

The study site is a teak plantation in western part of Thailand, Huai Kayeng subdistrict, Thong Pha Phum district, Kanchanaburi Province, bordering Myanmar. In this area teak (*Tectona grandis*) and rubber tree (*Hevea brasiliensis*) are grown. For paper purposes only teak plantation is being considered, with total of 6 different-age plots. Final number of thinning cuts will be established according the suitability of each plot during the time, but in this thesis 2 thinning in 10 and 20 years with main felling in 30 years are assumed. If needed, 3 thinning in 15, 20, 25 years can be performed, with harvesting in 30 years. In Thong Pha Phum plantation tree felling and timber processing is performed motomanually. It is closely followed by transportation of tree stem to the roadside with a ground-based skidding system. Skidded timber is usually 15-20 m long, skidded from the stump to a roadside landing using farm tractor with logging chokers. This type of tractor must drive to each felled tree.

Image capturing was planned and set in a free flight planning app Pix4D Capture, available for iOS and Android, and performed using UAV DJI Mavic Pro Platinum. With a respect to Thai laws, maximum flight high of 90 m was used, with 80-85% image overlaps and flight speed regulated to 5 m/s. This low speed was used

to make amend to electronic shutter, which can cause image distortion. Images were processed into the DSMs, DTMs and orthomosaics in Agisoft Metashape software. Detailed processing workflow is described in Petrovičová (2019).

Canopy height models (CHM) have been created by subtracting of DSM from DTM and serves for trees identification performed using the Inverse Watershed Segmentation method (Edson and Wing, 2011). The CHM smoothing using Focal Statistics is the crucial step within trees identification. The function of focal statistics calculates the maximum of all CHM encountered in circle neighbourhood of 2 m radius for each raster cell). The optimum radius was determined experimentally, and the best results were achieved using radius of 2 m. This radius strongly depends on the canopy diameter. Tree height from CHM was assigned to each identified tree.

Inasmuch as the plantation is situated in a flat land, DTM based skidding trails layout is unreasonable. Hence, laying-out was carried out on the proximity thinning and tree density base with emphasis on high extraction productivity and minimum environmental damage. Thinning proposal was performed using the Weighted Voronoi diagrams (WVD), which in forestry stands for "*novel competition index, representing a spatial structure description of a tree neighbourhood*" (Aakala et al. 2013, Krejza et al., 2015). An inverted tree height was applied as the weight in ET Surface, a plugin for ArcGIS. Thinning from below was aimed to trees, which were represented by smallest area of the Voronoi diagram, based on the assumption that its local density is high, and its local height is low. Resulting raster of Kernel Density Estimation (ESRI, 2019). serves as base-map layer for skidding trails layout. If possible, the skidding trails were proposed from forest hauling roads or existing skidding trails to centres of thinning with emphasis to avoid locations with high tree density. Although, the main priority within layout creation was limitation of maximum deflection angle of 25°. This angle is recommended to follow when skidding 15 m or longer timber.

RESULTS

The example of thinning proposal and skidding trails layout are shown in figure 1.

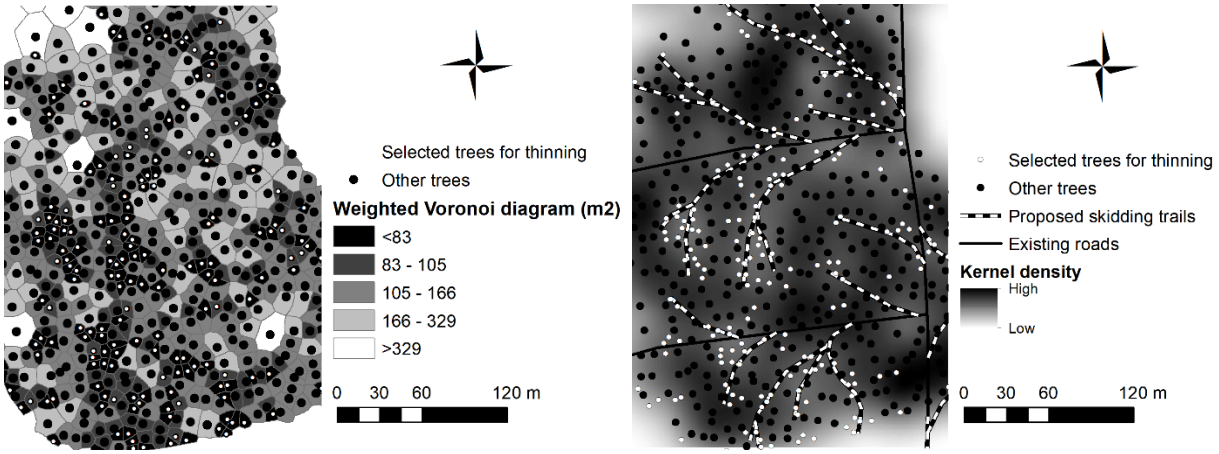

Fig. 1. Plot 3 – thinning proposal and skidding trails layout

The overview of proposed thinning parameter and proposed characteristics of forest road network is shown in table 1.

Table 1. The overview of proposed thinning and parameters of forest road network

Plot ID	Area (ha)	Number of detected trees	Number of selected trees for thinning	WVD area threshold for thinning (m^2)	Length of existing road (m)	Density of existing roads (m/ha)	Length of proposed trails (m)	Density of all roads (m/ha)
1	9,82	934	310	80,01	1 266	128,98	2 040	336,81
2	10,32	834	278	86,76	837	81,10	2 123	286,82
3	10,13	841	280	84,24	960	94,75	2 624	353,74
5	16,23	1 299	433	89,55	1 695	104,41	3 486	319,13
6	10,60	955	318	82,00	715	67,44	3 411	389,15
7	14,12	1 019	340	88,43	1 403	99,37	3 215	327,06

The length of proposed skidding trails is related to number of identified trees and even strongly with number of trees intended for thinning. It is also related to plot area. Forest road network correlates with the number of trees proposed for thinning. The threshold of Weighted Voronoi diagram area is correlated to the thinning intended trees and the length of proposed skidding trails.

This paper can contribute in higher effectivity in providing access to forest stands, improve quality of skidding and reduce damage to standing trees and timber itself. This approach doesn't include a field survey, thus lacks assessment of the health and quality of the trees but can be considered as a base for accelerating timber marking process. In temperate forests of Europe or especially Czech Republic this approach could be eventually suitable for use in plantations of willows (Salix sp.), poplars (Populus sp.) or princess trees (Paulownia tomentosa), since UAV provide quick data in short time periods. Its main benefit is UAV offers possible cheaper alternative to airborne laser scanning and can perform reliably in open canopy forest stands (Iglhaut et al., 2019).

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