The forester, the form and the geometer: An accuracy analysis of mangrove tree heights measured using forestry techniques, UAVs and hypsometers

Saliu Ibrahim Sunkanmi[1], Dahdouh-Guebas Farid[1,2], Satyanarayana Behara[1,3], Wolswijk Giovanna[1], Lucas Richard[4], De Cannière Charles[1], Otero Viviana[1] and Bin Fisol Muhammad Amir[3]

[1] Université Libre de Bruxelles, Laboratoire d'Écologie des Systèmes et Gestion des Ressources (ULB), Avenue F.D. Roosevelt 50, CP 169, 1050 Brussel, Belgium
E-mail: ibrahimsaliu297@gmail.com
[2] Mangrove Management Group (VUB-MMG), c/o Laboratory of General Botany and Nature Management, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium
[3] Mangrove Research Unit, Institute of Oceanography and Environment (INOS) Universiti Malaysia Terengganu (UMT), 21030 Kuala Terengganu, Malaysia
[4] Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences University of New South Wales, Kensington, Australia

Tree height is a fundamental measurement in forest inventory studies and a critical variable for the assessment of vegetation biomass, carbon stock and site productivity that authorities use in decision-making. However, measuring tree height is often a challenging task, especially in the mangroves, and may generate significant errors. Mangroves are one of the most productive ecosystems in many tropical and subtropical coastlines. Irregular forms of trees in these intertidal forests pose a major challenge to measuring structural parameters necessary for evaluating its status. This study conducted an accuracy analysis of tree height estimation through different methods ranging from traditional (thumb rule and pole) to geometric and trigonometric equipment (SUUNTO clinometer, Nikon 550 laser rangefinder, Blume-Leiss 60 altimeter), and advanced technologies (Unmanned Aerial Vehicle or UAV – DJI Phantom 3 professional, Leica distometer). These measurements were carried out in natural and urban vegetation settings (mangrove vegetation at Matang as closed canopy and on UMT campus as open canopy). In total, 173 mangrove trees (open canopy-146; close canopy-54) were measured from the both sites and grouped into different stem diameter size classes (0-20 cm, 20-40 cm and 40-60 cm). Height measurements obtained from the Leica distometer were considered as control. This was achieved by shooting the Leica distometer at a UAV flying at the tree's canopy level.

Using percentage errors, our results show that height measurements obtained from the DJI drone (3.5%), rangefinder (7.1%), pole (7.4%), altimeter (7.5%), clinometer (7.7%), stick method (14.8%) and thumb rule (15%) were from most to least accurate in that order. This trend was consistent regardless of the sites and size class being considered. Our next step of analysis is aimed at investigating how the angle of inclination affects the accuracy of tree height.

Keywords: Height; Accuracy; Mangrove; UAV; Hypsometer