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Remote Sensing to Study Mangrove Fragmentation and Its Impacts on Leaf Area Index and Gross Primary Productivity in the South of Peninsular Malaysia

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Abstract: Mangrove is classified as an important ecosystem along the shorelines of tropical and subtropical landmasses, which are being degraded at an alarming rate despite numerous international treaties having been agreed. Iskandar Malaysia (IM) is a fast-growing economic region in southern Peninsular Malaysia, where three Ramsar Sites are located. Since the beginning of the 21st century (2000–2019), a total loss of 2907.29 ha of mangrove area has been estimated based on medium-high resolution remote sensing data. This corresponds to an annual loss rate of 1.12%, which is higher than the world mangrove depletion rate. The causes of mangrove loss were identified as land conversion to urban, plantations, and aquaculture activities, where large mangrove areas were shattered into many smaller patches. Fragmentation analysis over the mangrove area shows a reduction in the mean patch size (from 105 ha to 27 ha) and an increase in the number of mangrove patches (130 to 402), edge, and shape complexity, where smaller and isolated mangrove patches were found to be related to the rapid development of IM region. The Moderate Resolution Imaging Spectro-radiometer (MODIS) Leaf Area Index (LAI) and Gross Primary Productivity (GPP) products were used to inspect the impact of fragmentation on the mangrove ecosystem process. The mean LAI and GPP of mangrove areas that had not undergone any land cover changes over the years showed an increase from 3.03 to 3.55 (LAI) and 5.81 g C m⁻² to 6.73 g C m⁻² (GPP), highlighting the ability of the mangrove forest to assimilate CO₂ when it is not disturbed. Similarly, GPP also increased over the gained areas (from 1.88 g C m⁻² to 2.78 g C m⁻²). Meanwhile, areas that lost mangroves, but replaced them with oil palm, had decreased mean LAI from 2.99 to 2.62. In fragmented mangrove patches an increase in GPP was recorded, and this could be due to the smaller patches (<9 ha) and their edge effects where abundance of solar radiation along the edges of the patches may increase productivity. The impact on GPP due to fragmentation is found to rely on the type of land transformation and patch characteristics (size, edge, and shape complexity). The preservation of mangrove forests in a rapidly developing region such as IM is vital to ensure ecosystem, ecology, environment, and biodiversity conservation, in addition to providing economical revenue and supporting human activities.



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1. Introduction

Changes in the extent of mangrove cover has resulted in fragmentation that can greatly affect its functions and services to the environment and human kind [1]. Fragmentation of mangrove areas refers to the sub-division of a continuous landscape into smaller units,