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Performance of Sentinel-1 and 2 imagery in detecting aquaculture waterbodies in Bangladesh

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ABSTRACT

In this study, we evaluated the use of synthetic aperture radar (SAR) and multispectral data to detect aquaculture waterbodies in Southern Bangladesh to quantify fish production on a national scale. For this purpose, we developed an object-based framework comprised of three sequential stages: 1) water detection, 2) feature segmentation, and 3) feature classification. Techniques such as Edge-Otsu for binary thresholding, edge detection with convolution filters, and various supervised and unsupervised machine learning methods were used as part of a workflow. We found that ensemble products combining individual subproducts resulted in higher overall accuracy for water detection (overall detection rate around 60%) and waterbodies classification (overall accuracies up to 79%). Moreover, we showed that SAR data and shape indices played important roles in better-discriminating waterbodies. However, limitations in edge detection outcomes affected the identification of small and isolated aquaculture waterbodies, especially those integrated into rice fields, or in areas with trees.

1. Introduction

Aquaculture is a rapidly growing food production activity that provides for millions of people around the world (Little et al., 2016). Global aquaculture accounts for 48% of all fish production, projected to reach 53% by 2030, with aquaculture production in Asia vastly surpassing that of any other continent (FAO, 2020). For Bangladesh, the fifth largest aquaculture producer in the world (FAO, 2020), aquaculture output increased 75% between 2002 and 2020, from 1.47 million metric tons to 2.58 million metric tons (DoF, 2020, 2002). While aquaculture has provided income and nutritious food for vast numbers of people in Bangladesh (Belton et al., 2012), its rapid growth has created competition with crop production in coastal and arid lands (Paul and Rashid, 2017; Yu et al., 2020). Moreover, national statistics are thought not to have kept pace with aquaculture growth (Belton and Azad, 2012). This confluence of land use competition, food security concerns, and patchy data creates an urgent need for new aquaculture identification methods.

Currently, there are two viable methods for identifying aquaculture ponds. The first option is to conduct extensive ground surveys. Surveys are expensive and time-consuming, especially when considering large regions (Rhodes et al., 2015), but they provide very accurate and specific information. The second option is utilizing remote sensing for aquaculture waterbody identification. This is a newer method with many benefits (e.g., low cost) and some shortcomings (e.g., low accuracy). Many remote sensing products are free and can be used to analyze large areas quickly. In recent years, there has been a significant increase in the use of remote sensing products to support aquaculture management (Ottinger et al., 2016). Applications include site selection and mapping (Anand et al., 2020; Ottinger et al., 2022), long-term monitoring (Duan et al., 2020b; Gusmawati et al., 2018; Luo et al., 2022; Stiller et al., 2019), aquaculture inventory (Prasad et al., 2019; Travaglia et al., 2004; Virdis, 2014), and assessment of large-scale environmental and economic impacts of aquaculture practices (Al Sayah et al., 2020; Ottinger et al., 2018).

In general, three types of products are used for aquaculture infrastructure detection: synthetic aperture radar (SAR), medium-resolution

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