Geographical Data and Computational Tools for Determining Restoration Priorities in Mangrove Ecosystems

Ainur Smailova, Laura Valentina Sierra, Pablo Ramos-Henao, Saif Ur Rehman, Yan-Yu Lin

* Department of Computer Science, University of Liverpool

Abstract

Hello! This is Pablo testing the abstract. zzzz

Introduction

Mangrove forests are unique, highly productive coastal ecosystems characterized by salt-tolerant trees and shrubs that thrive in the harsh intertidal zones—the areas between land and sea where conditions fluctuate widely in salinity and water level. These forests are vital for global ecological balance, providing critical biodiversity services and supporting complex food webs. A primary function of mangroves is their significant role in global climate change mitigation. They possess an exceptional capacity for carbon sequestration, storing up to four times more carbon than comparable terrestrial forests [1]. Furthermore, ecologically, mangroves serve as natural coastal defense barriers, providing protection against tidal erosion and storm surges, while also functioning as critical nurseries and habitats for numerous species of fish, crustaceans, and birds, thus supporting coastal communities worldwide. Despite these indispensable benefits, mangrove forests are facing rapid decline. Deforestation is primarily driven by anthropogenic pressures such as urbanization, aquaculture expansion, and agricultural development, leading to reported loss rates of 1 – 2 percent of the total area per annum [1]. The complexity of developing effective preservation strategies is amplified by the sheer diversity of mangrove species and the vast range of global climate conditions they inhabit, necessitating comprehensive, globally available datasets and advanced analytical tools. To address the challenge of global mangrove monitoring, the Global Mangrove Watch (GMW) platform provides open access to remote-sensing data and analytical instruments. This platform delivers near real-time information on mangrove extent and global change dynamics Global Mangrove Watch. A key component of GMW is the mangrove loss alert system, which utilizes Copernicus Sentinel-2 satellite data processed at a 20-meter resolution. While Sentinel-2 typically provides weekly image acquisitions, the alert process is subject to delays caused by cloud cover and the requirement for multiple observations to confirm genuine ecosystem change. Consequently, an alert is typically transmitted approximately three months after a loss event occurs [2]. Despite having modern technology and open data access, achieving global conservation goals for coastal ecosystems has been difficult because we lack consistent, worldwide data on their past and present health. Now, access to resources like the decades-old Landsat satellite archive and newer, higher-resolution satellites allows us to analyze changes over long periods. This high-resolution data helps us accurately map scattered or fragmented ecosystems like mangrove forests. This new data is combined with powerful computing systems and cloud platforms (e.g., Google Earth Engine), allowing us to quickly process satellite data for the entire planet. This combination has encouraged many global-scale studies that can help answer critical questions for mangrove conservation.

Aim

The aim of this paper is to assess the status of the technologies and analysis techniques used in determining the conservation status and restoration needs of mangrove forests; as well as identifying research gaps.

Objectives

The first objective is to review and assess the current completeness and robustness of various available datasets. Several factors can affect data access and analysis, such as cloud cover and shadows when comparing satellite data. These limitations can hinder the consistency of images required for continuous change monitoring. [3] Secondly, we aim to identify the technologies used for mangrove identification and conservation, as well as the computational modules used to analyse these datasets and gauge their performance. Additionally, we aim to outline the current challenges of measurement tools and computational analysis methods to elaborate on the main existing research gaps.[4]

Methodology

The aim of this paper

PRISMA Chart

In the first stage of our scoping review, we identified records from five major databases. The initial search produced a combined set of studies, with the number of records obtained from each source presented in Figure X. Twenty-nine records were removed during initial organisation upon determining that Nature, being a publisher rather than a database, produced duplicated entries across our other information sources.

During screening, we identified a number of non-English records and further duplicates. Because our institution offers full-text access to all searched databases, none of the records were were excluded due to retrieval limitations.

The remaining studies were then divided among the research team, and each member screened titles and abstracts to assess their relevance to the research objectives. Studies were excluded if they did not involve geospatial data, if they relied solely on simple descriptive or statistical analyses, or if they did not use the modelling approaches central to our review, such as Random Forest or CNN-based methods, they fell outside the scope of this study.

Findings

This is the section for findings

Geological Survery Tools

This is the section for geological survery tools

Computational Analysis Techniques

This is the section for computational analysis techniques

Research Gaps

«add more here»>

Convolutional Neural Networks (CNNs) are the most widely used models in the field and are the foundation of most mangrove classification approaches. However, they struggle to detect small and fragmented mangroves resulting in incorrect classifications. [5]

Conclusion