HARNESSING MULTIPLE BENEFITS FROM RESILIENT MANGROVE SYSTEMS: Biophysical mapping of mangroves

Biophysical mapping of mangroves is a key component to management and sustainable use of mangrove resources. It is also an essential tool for making informed decisions. This research used satellite image analysis and field survey to map mangrove extent, species composition, biomass and leaf area index (LAI) in Kim Trung and Thuy Truong communes in the Red River Delta.

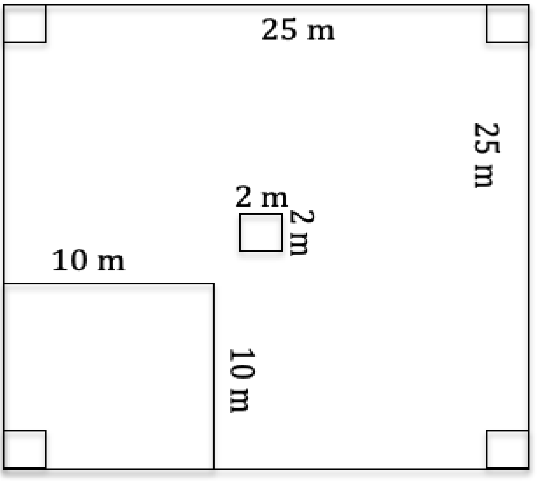
Mangrove Biomass is the biological material produced by mangrove plants as a result of photosynthesis. Mangroves accumulate CO_2 in both their biomass and in the soil. Mangrove forests with high biomass are believed to be effective at reducing greenhouse gases.

The **Leaf Area Index** (LAI) quantifies the amount of leaf material in the canopy and can be used to measure forest growth and productivity because photosynthesis occurs at the leaf surface. As a measure of net canopy photosynthesis, the higher the LAI the greater the ability of the forest for photosynthesis.

A **Mangrove Health Index (MHI) categorising forest from very poor to good health** was constructed to obtain an overall assessment of mangrove health based on biodiversity, biomass LAI, seedling and sapling regeneration, mangrove species composition, and tree appearance.

Grade	Description	Mangrove Health Index
1	Very poor	<100
2	Poor	100-200
3	Medium	200-300
4	Fair	300-400
5	Good	400-500

Field data were collected in survey plots established with different sizes within areas of different mangrove types

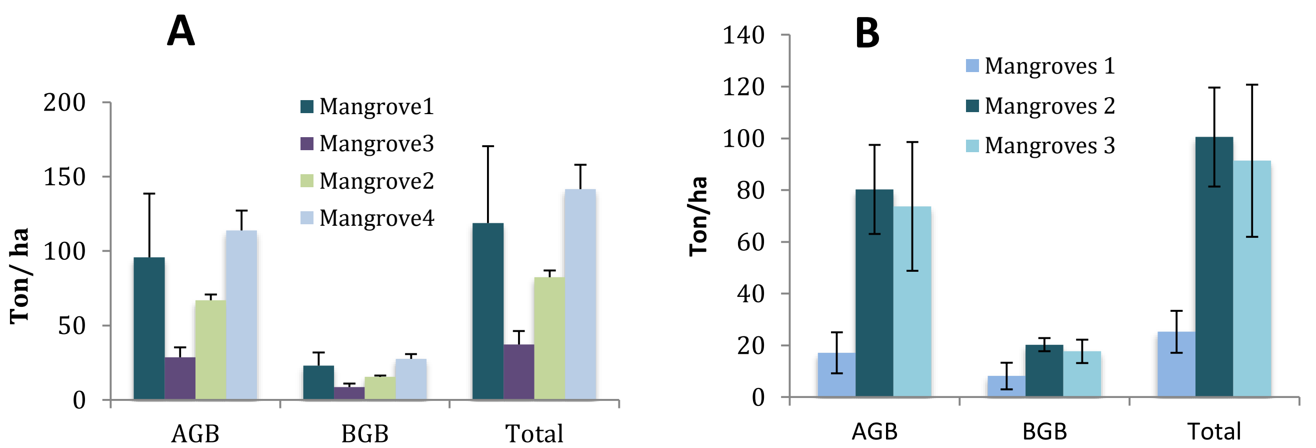


***Sonneratia caseolaris* density, height and diameter at breast height were measured in three 625m² plots. Density, height and stem diameter for other species was measured at 10% of tree height in three 100m² plots. Regeneration was measured in 15 plots measuring 4 m² or 25m² depending on seedling density. LAI was determined by direct measurement in nine 0.5m² plots for each mangrove type where 50-100g of leaves were collected to determine the relationship between leaf area and weight.**

Satellite data were sourced from Landsat-2 to 8, and SPOT-7 and Sentinel-1 to undertake remote sensing classification of mangrove age and species and conduct change analysis on mangrove extent. Images were obtained between 1975 and 2019 for every five years. The field measured data of mangrove ages and forest type were used for parameter calibration and validation of mangrove classification algorithms.

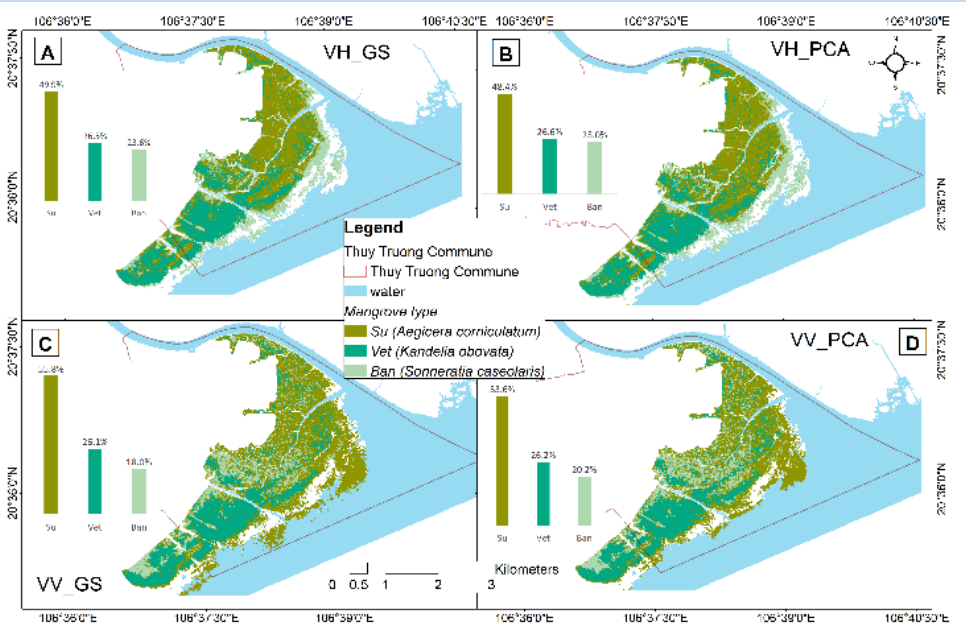
Key findings

Mangrove Health at Kim Trung commune was measured in four locations: two areas of mangrove on the seaward side of the dike, and two areas on the landward side. Mangrove health in all locations was fair. Forest located on the seaward side of the dike had lower biomass and regeneration ability, although saplings were present in one seaward area and not elsewhere. This young mixed mangrove plantation had the highest LAI. Mangroves of similar ages inside and outside of the outer dike showed differences in biomass, regeneration, and density, suggesting the dike has positively affected mangroves on the landward side, and negatively affected mangroves on the seaward side. However, mangrove regeneration inside the dike appears negatively affected. Mangrove forest is not enclosed within a dike at Thuy Truong. Mangrove adjacent to the dike is older than that further seaward, but its biomass is lower indicating potential degradation. Biomass recorded in *K.obovata* forest was lower than that recorded at Kim Trung. Mixed mangrove forests at Thuy Trung had higher LAI and better regeneration.



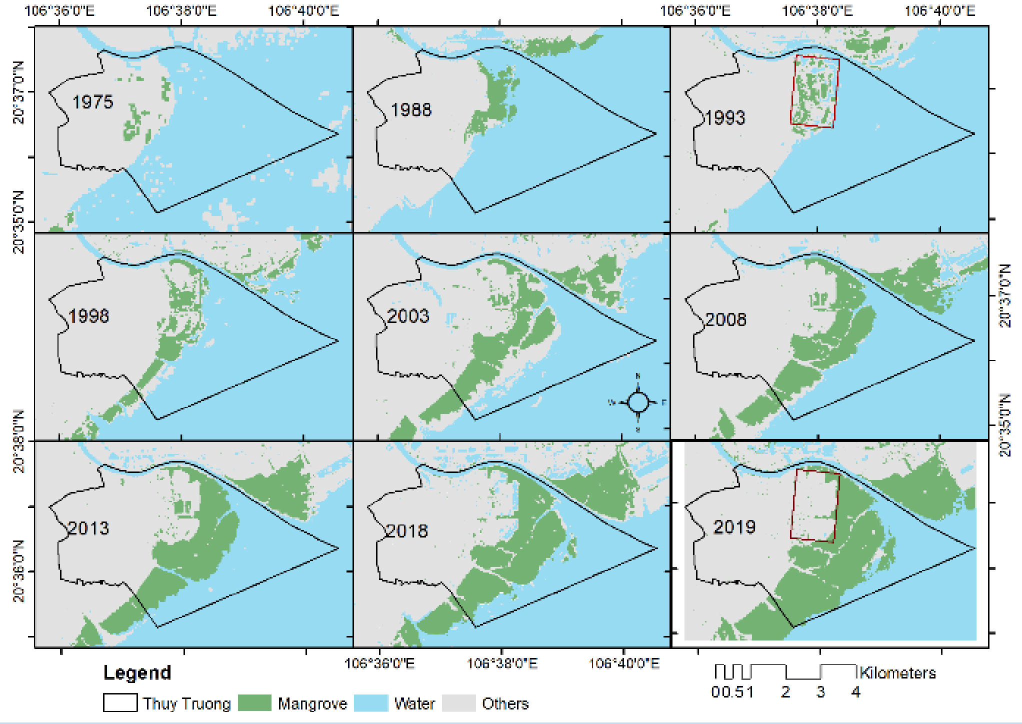
Mangrove biomass in Kim Trung (A) and Thuy Truong (B). AGB = above ground biomass; BGB = below ground biomass. In Kim Trung, mangrove 1 and 4 were located inside the dike, Mangrove 2 and 3 was on the seaward side of the dike . In Thuy Trung, Mangrove 3, 2 and 1 were located further in land, respectively.

Accurate **mangrove age and species classification** was achieved by fusing SPOT-7 and Sentinel-1 images and applying the support vector machine classifier



Classification of *Sonneratia caseolaris, Aegicerasasas corniculatum,* and Kandelia obovata **at Thuy Truong was achieved with an accuracy greater than 80% using the image fusion method of Gramschmidt and VH polarization of Sentinel-1 image (A), Principal component analysis and VH polarization (B), Gramschmidt and VV polarization (C), and Principal component analysis and VV polarization (D).**

Extracting **mangrove extents** between 1975 and 2019 showed the forest has expanded approximately 80m/year to about 3.5 km seaward in Thuy Truong commune and surroundings.



Mangrove extent change analysis using the iterative self-organizing data analysis technique (ISODATA) unsupervised classifier for nine Landsat-2 to 8 datasets from 1975 to 2019 generated results with 80% accuracy compared to the field measured data. The results of all Landsat image classifications were used for mapping mangrove extent changes in this research project.

Application of our remote sensing technique for mangrove monitoring and managing

Remote sensing presented an effective tool to extract useful information about mangrove extent and species. Data collected from standard plots in mangrove communities was used to improve the reliability and accuracy of the estimates of the biophysical mapping of the mangrove forest including above ground biomass estimation, forest classification and estimates of the forest age. In addition, information on mangrove biomass and age could be derived from remote sensing data which is also strongly correlated with mangrove health. The applications outlined in this research provide an example that can guide the incorporation of biophysical mangrove data in sustainable mangrove forest management.

This work was funded by:

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL — Newton Fund — NAFOSTED National Foundation for Science & Technology Development

Participating institutions in Vietnam and the UK:

UNIVERSITY OF LEEDS — UNIVERSITY OF HULL — ĐHQGHN — VNU ĐẠI HỌC QUỐC GIA HÀ NỘI Vietnam National University, Hanoi — CRES — VNSC Liftoff your Dream — HNUE HANOI NATIONAL UNIVERSITY OF EDUCATION TRƯỜNG ĐẠI HỌC SƯ PHẠM HÀ NỘI

For further information about the project, please contact:

UK: Dr Claire Quinn: c.h.quinn@leeds.ac.uk

Vietnam: Dr Hue Thi van Le: thivanhue@gmail.com

@Mangroves4Dev