The Germany-CGIAR^{++} Science and Impact Hub

Research proposal:

Title of your proposal:

Land-Use Impacts on Mangrove Carbon Stocks and Economic Valuation: Evidence from Banyuwangi, Indonesia

Summary:

(give a brief summary of your research proposal, maximum 250 words)

This study examines the impact of land use change on mangrove carbon stocks and their economic value in Pangpang Bay, Banyuwangi, Indonesia. Focusing on three types of land use—restored mangroves, abandoned aquaculture, and protected mangroves—this study aims to measure total carbon stocks in soil and vegetation, while assessing their financial value within the framework of the global carbon market. Although mangroves play a crucial role in carbon storage, coastal protection, and local livelihoods, they are increasingly threatened by conversion to aquaculture, agriculture, and other development pressures. This study responds to the lack of regional carbon data in Indonesia, particularly in East Java, where mangrove restoration has grown rapidly in recent years but remains undermeasured and undervalued.

Using a global standard protocol (Kauffman & Donato, 2012), this study will measure above-ground biomass, below-ground biomass, fallen wood, and soil carbon to a depth of one meter. This study will then apply the carbon tax rates recommended by the World Bank to estimate the economic value of stored carbon, linking biophysical data with climate financing mechanisms. By combining ecological metrics with economic assessments, these findings will support evidence-based coastal land management, inform carbon market policies, and open up opportunities for blue carbon financing.

To conclude, the research contributes to climate mitigation, sustainable development, and improved livelihoods, positioning Pangpang Bay as a model for mangrove-based climate solutions in Southeast Asia.

Introduction:

(Maximum 300 words)

Mangroves have been proven to provide essential ecosystem services such as climate regulation (Murdiyarso et al., 2015), livelihoods (Mallick et al., 2021), tourism (Khakhim et al., 2021), water filtration (Kim et al., 2016), coastal protection (van Hespen et al., 2023), fisheries (Ickowitz et al., 2023), valued source of wood (Riungu et al., 2022). However, in a world of 2°C global temperature rise possibility, which leads to sea-level rise with significant global impacts (Friess et al., 2022), mangroves in the Southeast Asia region are also likely to experience extensive cyclone activity and become a global hotspot for human-induced pressures (Goldberg et al., 2020). Sagala et al. (2024) show how mangroves can lower the vulnerability of the coast, and conservation efforts provided by the local community in Banyuwangi have proven the increase of total areas of mangroves up to 23-46 % from 2015–2023 (Hidayah et al., 2024). Although global studies have examined the carbon storage and emission from mangroves as well as the impacts of land use and land cover change, limited data remains, specifically focused on extensive regional areas in Indonesia. Yet, the transformation of mangroves into aquaculture ponds, urban growth, and anthropogenic pressures have severely threatened their sustainability. Sasmito et al. (2019) revealed that up to 83% ± 37% or 72 ± 44 Mg C/ha of biomass were lost due to converting mangrove areas to an aquaculture pond.

Mangroves have significant economic value through carbon trading and global climate finance mechanisms (Murdiyarso et al., 2015). Assessing soil and vegetation carbon stocks provides a basis for conservation policies, supports rehabilitation priorities, and guides sustainable management (Jakovac et al., 2020). However, limited research has examined how land-use change affects carbon

stocks and their economic valuation. The findings of this project will reinforce the integration of carbon management with land-use considerations for sustainable decision-making.

Objective and research questions:

(Maximum 200 words)

This study seeks to assess total carbon stocks (soil and vegetation) across three land uses in Pangpang Bay, Banyuwangi, such as restored mangroves, abandoned aquaculture, and protected mangroves, as well as assess the economic value of these carbon inventories within the framework of carbon markets. Research questions:

1. How do total carbon stocks differ across land uses, and what environmental factors drive these differences?
2. What is the economic value of mangrove carbon stocks in each land use type when applying World Bank–recommended carbon tax rates?
3. How are the carbon stock levels correlated with ecological and environmental conditions in different land-use types?

Methodology:

(Maximum 300 words)

The study will be conducted in Pangpang Bay (08°28'28.13"N, 114°23'00.77"E), Banyuwangi District, East Java, Indonesia, which has various mangrove species that live in Pangpang Bay, such as *Bruguiera sp, Rhizophora sp, Avicennia sp., Sonneratia caseolaris*, etc. The total ecosystem carbon stock will be assessed by following the worldwide protocols from Kauffman and Donato (2012).

1. *Aboveground biomass*
   The carbon stock from aboveground biomass will collect data on diameter at breast height (DBH) and height. The conversion from the tree's DBH data to dry biomass and carbon will be calculated using allometric calculations from previous studies.
2. *Belowground biomass*
   In this study, the root biomass will be derived from the DBH value using the root-to-shoot ratio and then multiplied by 0.48 to obtain the root carbon.
3. *Downed wood*
   Following the protocol, the downed wood will be applied to each sub-plot, which will classify every dead wood into several ranges of size, such as fine pieces (<0.6 cm), small pieces (0.6-2.5 cm), medium pieces (2.5-7.6 cm), and large wood (>7.6 cm).
4. *Soil carbon*
   The soil carbon in this study will be assessed by collecting the soil at the midpoint of several classifications of soil depth: 0–300 cm. The soil organic carbon will be quantified utilizing the loss on ignition (LOI) method. Carbon stock losses and gains in the soil carbon pool will be estimated using the stock-difference approach by addressing fixed depth basis and fixed mass basis as described by Ellert et al. (2008).

In addition to that, this study will also use a carbon tax valuation methodology to assess the financial value of the carbon stock based on its total CO_2 equivalent (tCO_2eq) with the carbon tax rate advised by the World Bank highly relevant in alignment with the Paris Agreement goals (World Bank Group 2017).

Expected results and envisioned impact:

(Maximum 200 words)

This study expects the carbon stock value from different land uses in the Pangpang Bay coast, as well as its significant influence on how the variability of both ecological conditions and economic worth affects the carbon within mangrove ecosystems. As the first study on mangrove carbon in Banyuwangi Regency, East Java, Indonesia, this study will provide a powerful and useful reference

and valuable input for stakeholders and decision-makers in determining better coastal land management strategies to prevent the loss of carbon, which contributes to mitigating climate change. In addition to that, by integrating the carbon data with economic valuation, this study provides a robust framework for leveraging mangroves in climate finance mechanisms, supporting both environmental and financial sustainability, and can inform policy frameworks, reinforcing the role of mangroves in global climate action and sustainable economic development while advancing the achievement of SDGs 13, 14, and 15. These powerful results will obviously link Indonesia's coastal ecosystems to valuable blue carbon assets and unlock carbon financing opportunities, strengthening community livelihoods and positioning Pangpang Bay as a model for sustainable mangrove management in Southeast Asia.

Work plan:

(please give a monthly schedule of your activities during your research stay at the CGIAR++)

During the first month, I will focus on orientation, meeting with supervisors, aligning with CGIAR research priorities, and refining the study plan, including field protocols and sampling. In the second month, I will handle field preparations by obtaining permits, coordinating with local partners, arranging logistics, and conducting trials to validate methods. The third month will be dedicated to full-scale field data collection, including soil and vegetation carbon sampling, ecological measurements, and data entry. In the fourth month, I will begin laboratory analysis of samples, process and validate field data, and integrate carbon stock measurements with spatial information. The fifth month will focus on economic assessment, applying carbon tax rates to estimate market value, running comparative models between land use types, and sharing initial insights with CGIAR researchers. In the final month, I will synthesize the results into technical outputs, including reports, a thesis, and potential journal manuscripts, then present the findings through an internal seminar while exploring opportunities for future collaboration and scalability.

Thematic link to development oriented agricultural research:

(Maximum 200 words)

Pangpang Bay in Banyuwangi Regency is currently facing significant development challenges, including rapid climate change and sea level rise, as well as unsustainable agricultural production, particularly of dragon fruit, soybeans, rice, and so on. A remarkable shift is needed in the understanding, knowledge, skills, and capacity of stakeholders at various levels so that they can take a collective approach and encourage a notable transition in land use, value chains, governance, and social protection, which appears to be necessary in order to achieve the Sustainable Development Goals (SDGs), especially given rapid climate change. In 2023, the agriculture, forestry, and fisheries sectors contributed approximately 27.67% to the Regional Gross Domestic Product (RGDP) and were therefore the focus of sustainable and inclusive development in Pangpang Bay. However, the conversion of mangroves to other land uses, such as aquaculture and agriculture, has been widespread and massive, resulting in carbon emissions into the atmosphere. Therefore, by understanding the biophysical limits and options for mangroves in the context of climate change, as well as exploring opportunities to generate greater income from ecologically sustainable mangrove-based systems, this study will determine whether such a transition can address not only climate change but also other development challenges in the region.

Thematic link to the hosting CGIAR++ research program/project:

(Maximum 200 words)

This study aligns closely with the CGIAR++ research program, particularly CIFOR-ICRAF's Blue Carbon Deck and the Sustainable Wetland Adaptation and Mitigation Program (SWAMP) by

integrating carbon accounting and livelihood-focused interventions. The assessment of carbon stocks across different land uses will also contribute to CGIAR++'s goals of enhancing nature-based climate solutions and promoting sustainable land-use practices that support ecosystem health and rural development. In addition to generating data-driven decision-making for land management, restoration planning, and resilience building in coastal and agricultural landscapes within the CGIAR++ framework, this research will also increase the capacity of local communities and stakeholders in terms of knowledge and skills by generating climate-smart agriculture/aquaculture and sustainable finance mechanisms under carbon market frameworks and protocols assessed by this research. To conclude, this research will provide actionable insights that integrate climate mitigation, ecosystem restoration, and socio-economic benefits, offering scalable models for sustainable land-use transitions and blue carbon initiatives that align with ongoing CGIAR research priorities.

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I hereby confirm to the best of my knowledge and belief that the information provided above is correct. Furthermore, I hereby confirm that no artificial intelligence was used to write the above proposal, and I am aware that any kind of deception may lead to immediate rejection of the application.

Göttingen, 15th November 2025 

Place and date	Signature