Mangroves and aquaculture
in West Java, Indonesia
Image by T. Fisk (pexels.com)

MANGROVE POTENTIAL MAP

DIGISHAPE
DATASCIENCE
FOR
DELTAS

Deltares

Van Oord
Marine ingenuity

Witteveen + Bos

Introduction

Let’s get acquainted with the audience’s expectations and general understanding of mangrove growth physical processes.

Why did you sign up for this workshop?
What are your expectations of the workshop?

Goal of the Workshop

1) Background and rationale

2) Explore large-scale initiatives for identifying mangrove restoration potential areas.

3) Explore the Mangrove Potential Map platform and the underlying data.

4) Looking forward, what's next?

Agenda

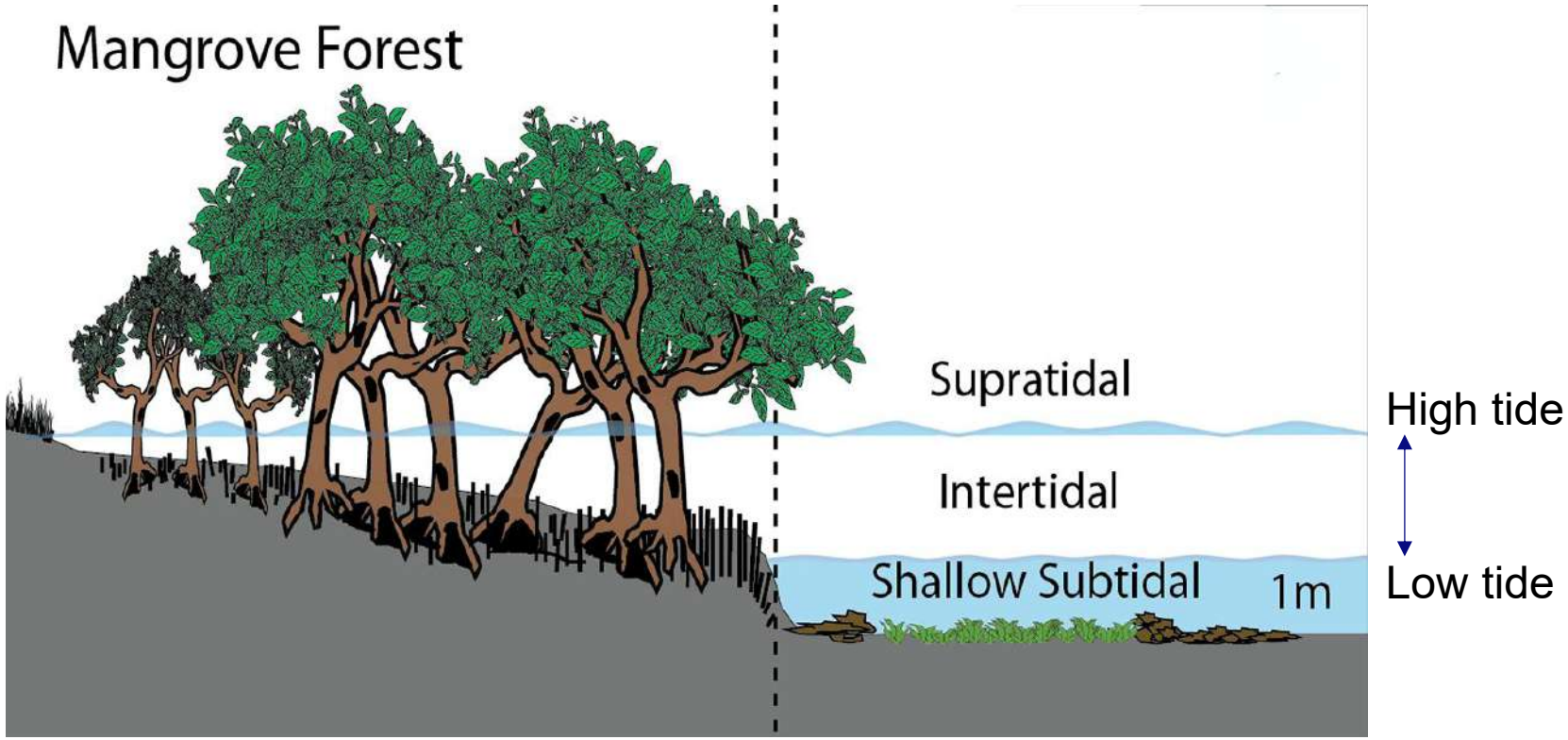
Background	**9:10 – 9:30**
Mangrove Potential Map Overview	**9:30 – 9:50**
Break	
Hands-on Exercise	**10:00 – 10:50**
Break	
What's Next	**11:00 – 11:30**

Background and Rationale

What is a mangrove forest?

~80 different species of mangrove trees

- Mangroves are of **trees and shrubs** that strive in the **coastal intertidal zone**.



Giraldes et al., 2020
in *PloS ONE*

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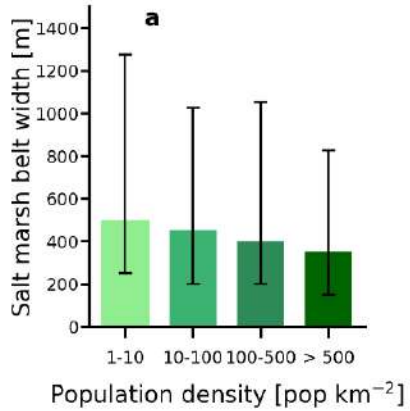
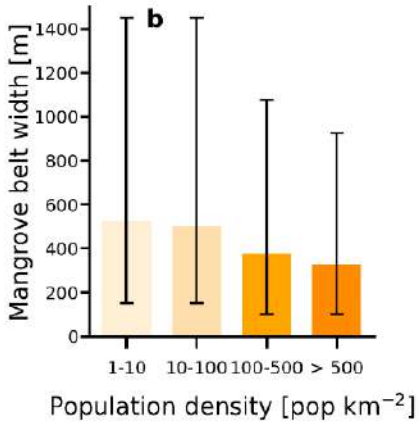
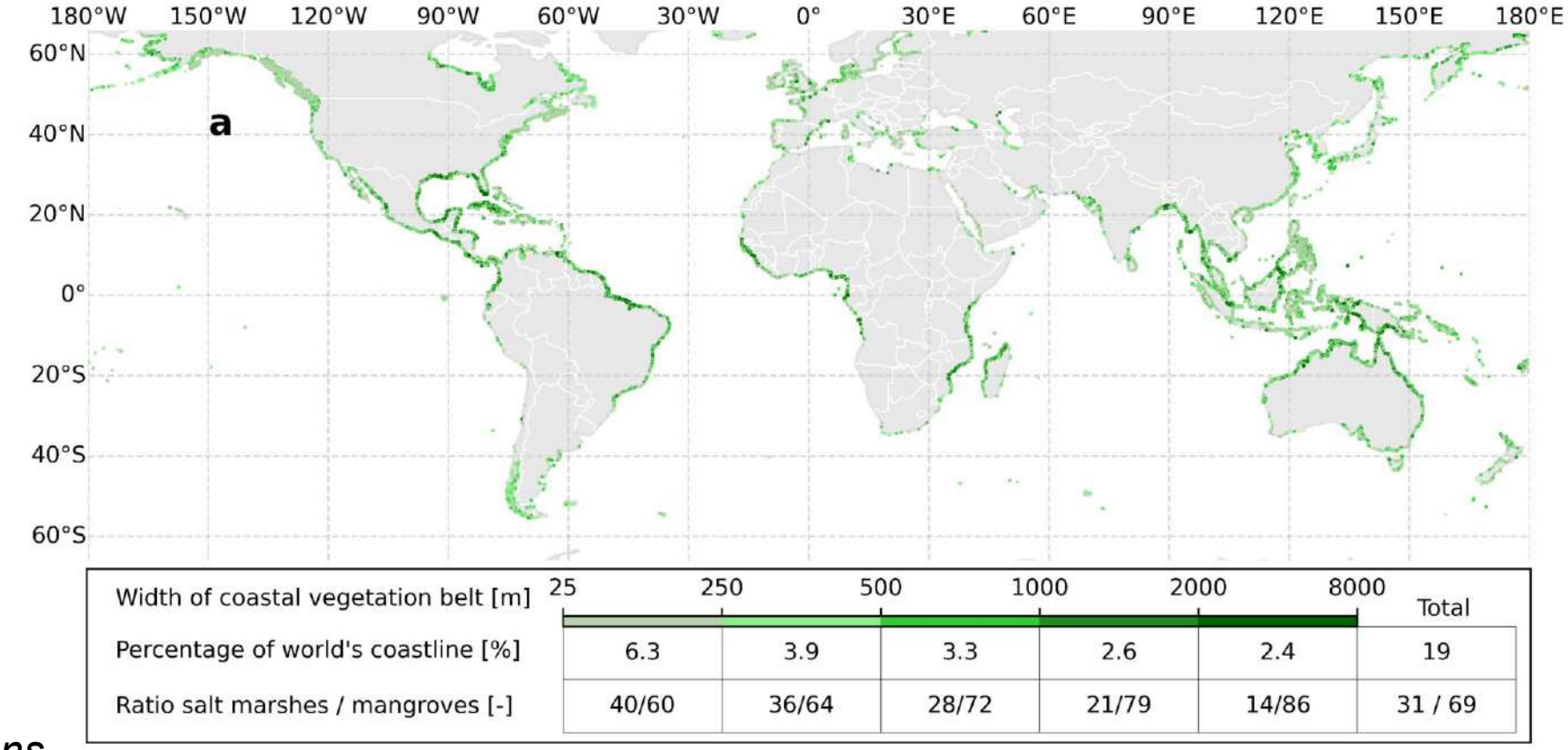
10% of the global coastlines are covered with mangroves







Van Zelst et al., 2021
in *Nature Communications*

~10 % of global coastlines covered with mangroves!

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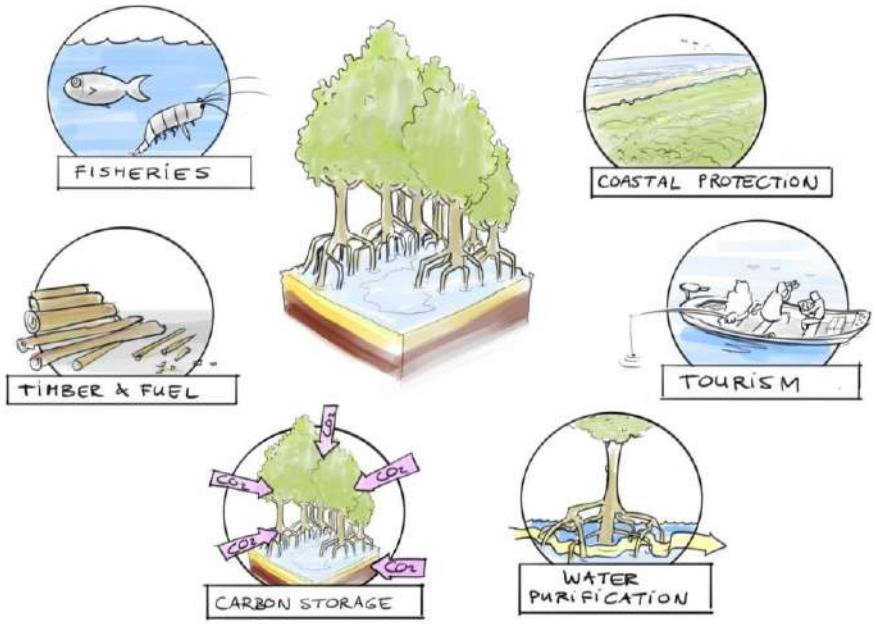
FAST
FORESHORE ASSESSMENT USING SPACE TECHNOLOGY

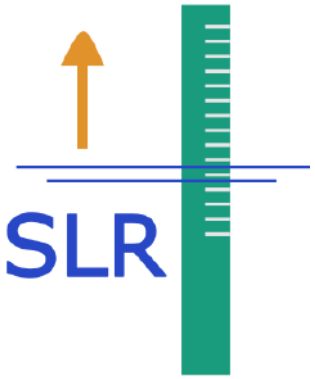
Services of mangrove forests

Additional ecosystem services

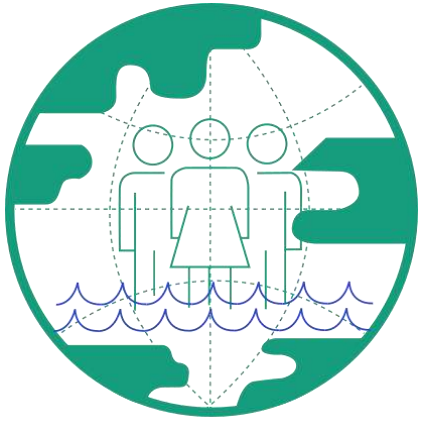


From Wilms, T., Van der Goot, F., Tonneijck, F., Nurhabni, F., Sembiring, L. (2020). Building with Nature Approach. Building with Nature to restore eroding tropical muddy coasts. Ecoshape technical report

Shoreline Adaptation & stabilization



Flood Risk Reduction



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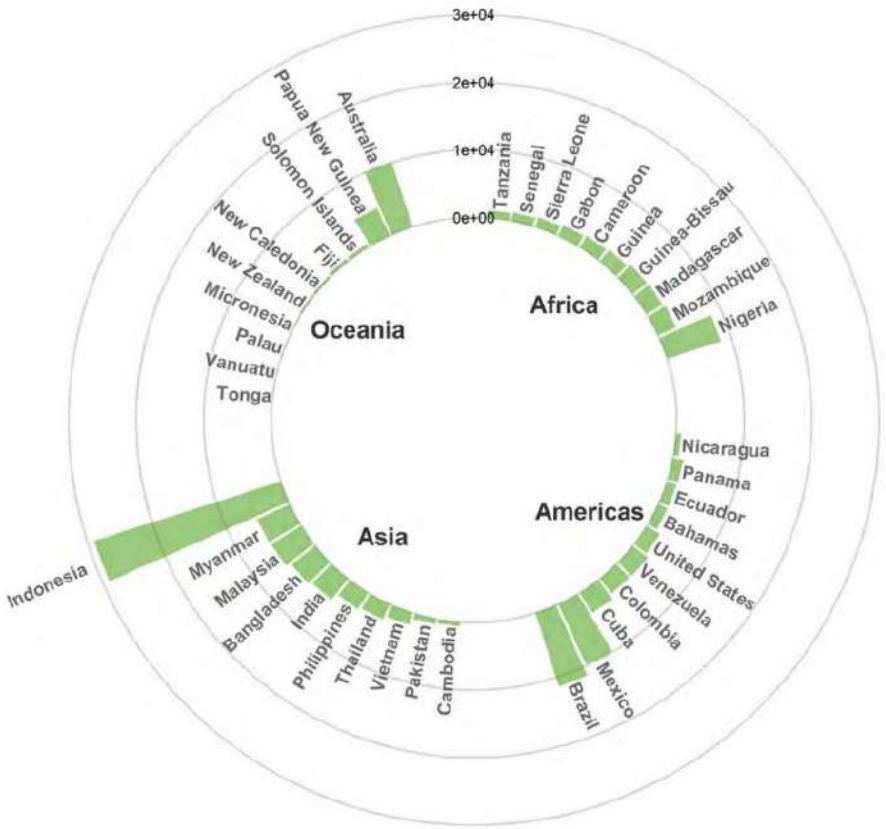
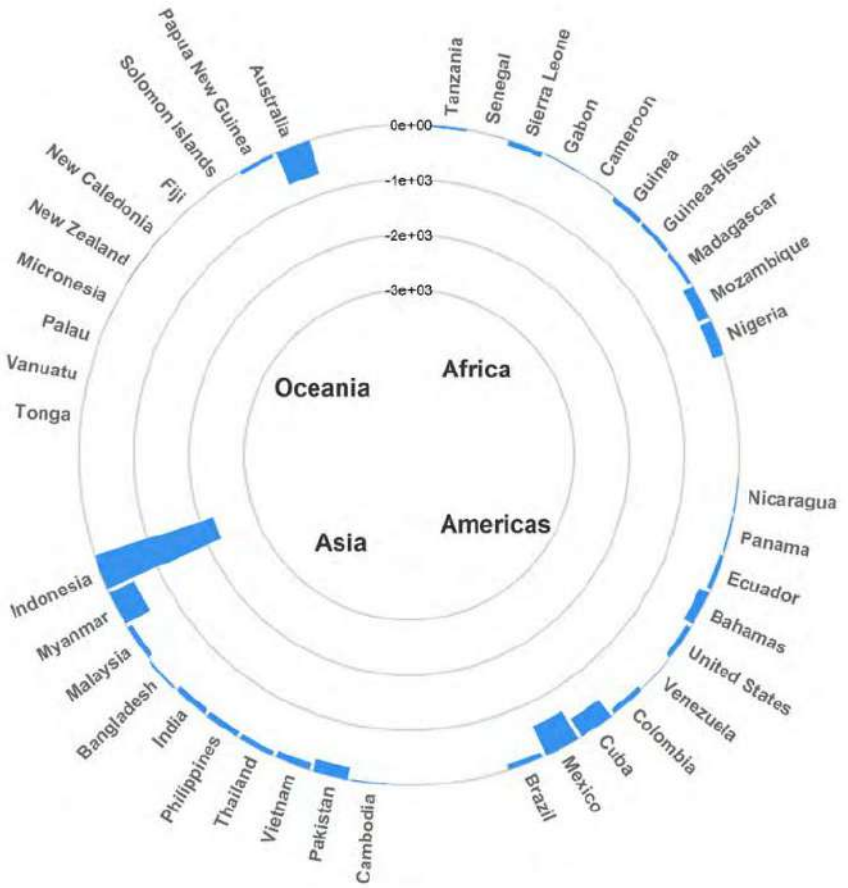
Mangrove extent and change

Extent year 2020 [km^2]



Change 2016-2020 [km^2]



From GMW v3.0

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OVER 50% OF MANGROVE RESTORATION PROJECTS FAIL..

(Lovelock et al., 2022 in *Plos Biology*)

OVER 50% C
RESTORATIC

(Lovelock et al., 2022 in *Plos Biolog*

Reasons of failure mangrove replantation/rehabilitation

Socio-economic:

- poor communication with locals and stakeholders
- poor awareness
- underdeveloped knowledge infrastructure
- poverty

Environmental:

- Plant wrong species (Rhizophora–is not pioneer),
- too little fresh water,
- location of planting is too wet (too low).

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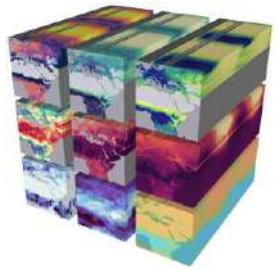
Planting the **wrong species** in the **wrong location**

Overview of global mapping initiatives

Initiative	Description	Years Covered	Resolution
Mangrove Restoration Potential (GMA)	Map showing restoration opportunities globally based on degradation and drivers	2018	Varies
Climate Smart Shrimp	Initiative linking sustainable aquaculture (shrimp farming) with mangrove restoration and climate mitigation	Ongoing	Project/site scale
Blue Carbon Initiative Maps	Mangrove carbon stocks and restoration potential (blue carbon focus)	2018–Present	Varies
Global Mangrove Watch (GMW)	High-resolution global time series of mangrove extent and change	1996, 2007, 2010, 2015–2020	~25 m (ALOS PALSAR)
Giri et al. / USGS Mangrove Dataset	First global baseline map of mangroves using Landsat imagery (~year 2000)	2000	30 m (Landsat)
World Atlas of Mangroves (UNEP-WCMC)	Global mapping and status of mangroves, with socioeconomic context	2009	~30–90 m (varies)

Promising insights, but not yet including e.g. accommodation space.
→ Recent developments.



Objective

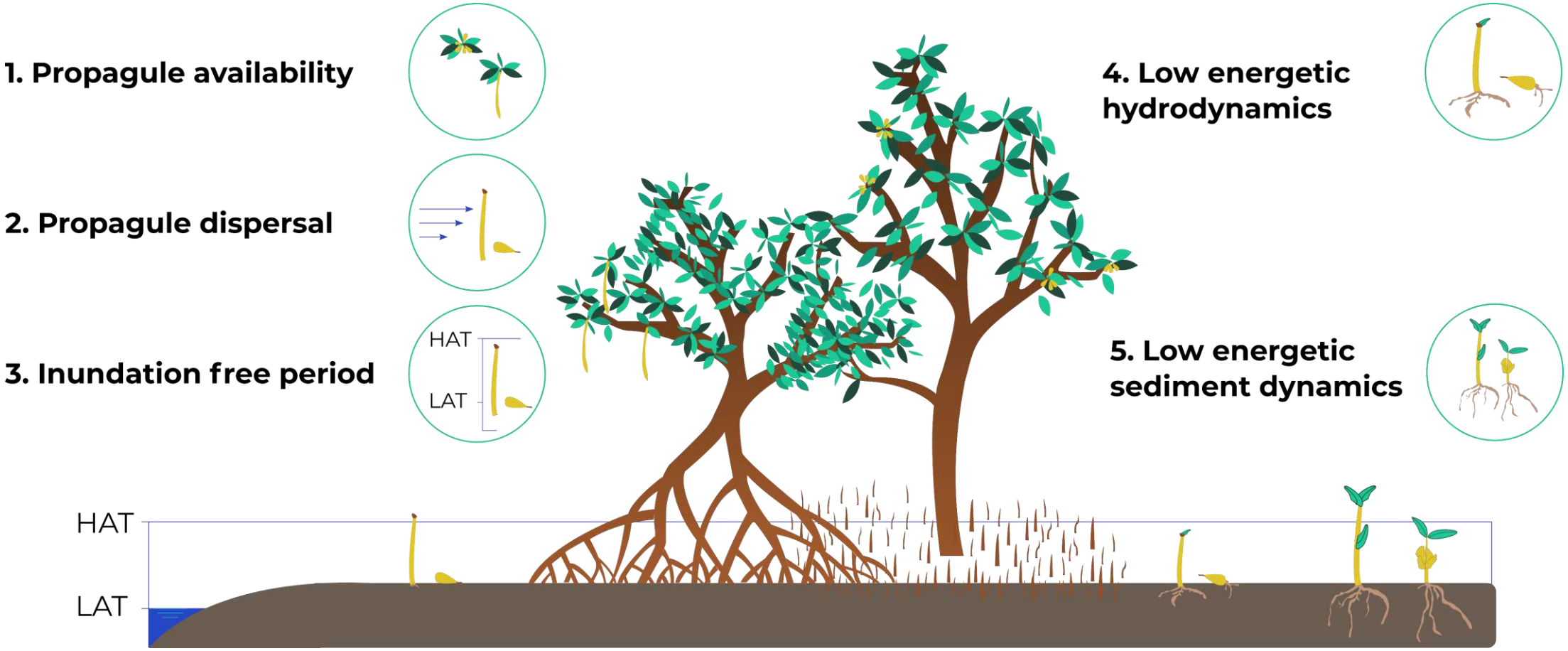
Identify high potential mangrove restoration areas,

with a special focus on aquaculture areas,

and quantify associated flood risk reduction benefits

by using global data layers and numerical modelling

What are important barriers and enablers for mangrove restoration (at different scales)?



Modified from Balke et al. 2011 in *Marine Ecology Progress Series*

Mangrove Potential Map

Workshop 15 October

Mangrove Expert Commission



➢ **Collaborative Process**

- Developed jointly with partners to ensure data relevance.
- Team: Dutch experts in mangrove consultancy & research (South Asia & South America).
- Defined key info to identify areas suitable for mangrove growth.

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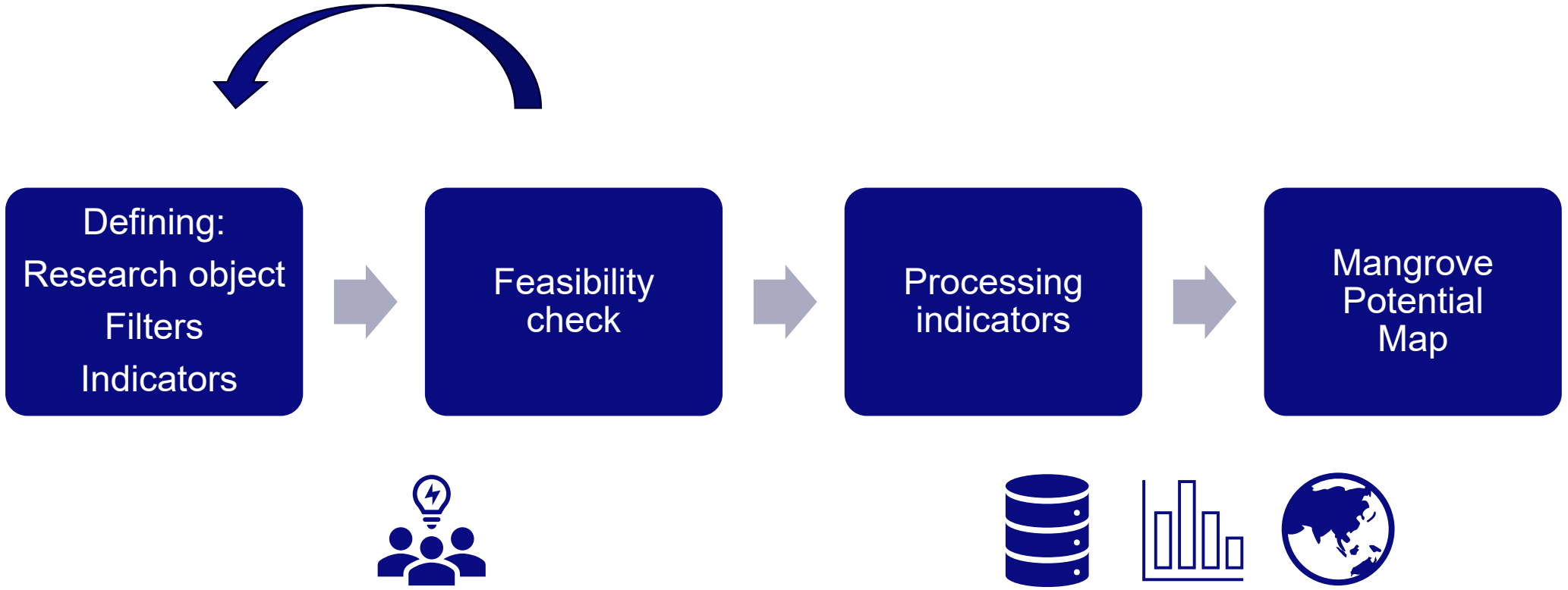
Process



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Overview indicators

RESEARCH OBJECT	FILTERS
GLOBAL COASTLINES IN PROXIMITY OF AQUACULTURE PONDS	1. LATITUDE 2. PERMANENT WATER 3. URBAN AREA 4. DISTANCE TO COASTLINE

SUITABILITY INDICATORS

- historical mangrove cover (general suitability indicator)
  - proximity to histroical mangroves (GMW1996)
  - years since mangrove loss
- proximity to present mangroves (seedling availability)
- elevation w.r.t. tidal range (accommodation space)
- distances (relevance and connectivity)
  - proximity to the coastline
  - proximity to (major) rivers
- subsidence
- aquaculture pond presence

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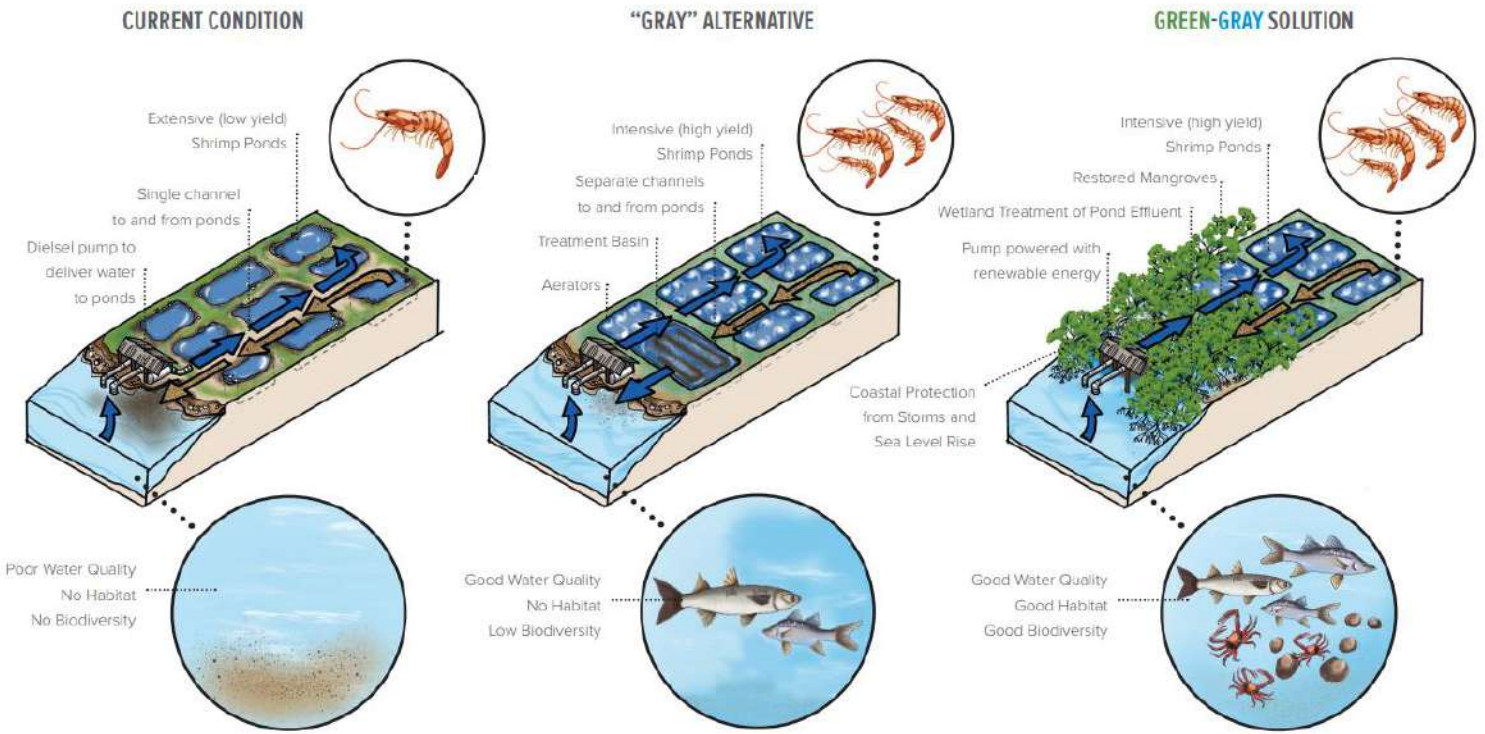
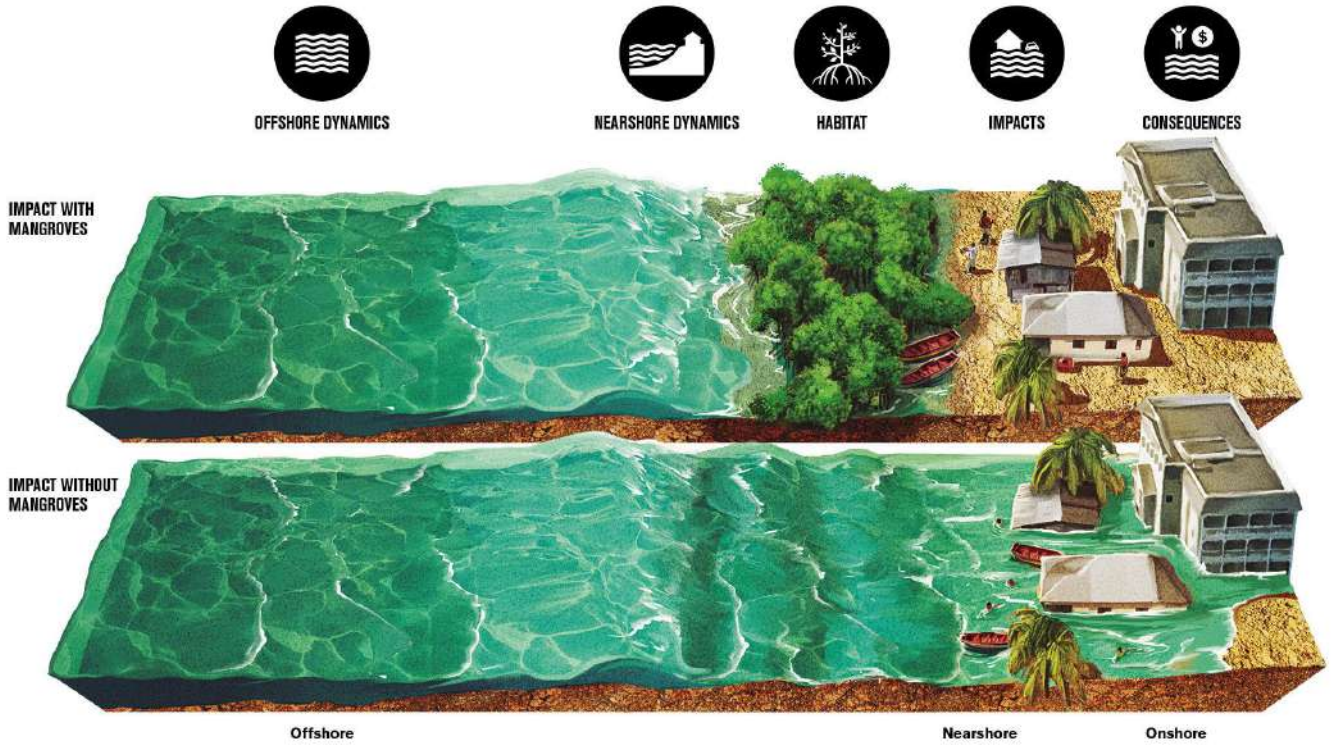
Focus on aquaculture ponds. Why?



https://www.conservation.org/docs/default-source/publication-pdfs/climatesmartshrimp_fact_sheet_200309.pdf?sfvrsn=30cea3b4_2

Initiative: Climate Smart Shrimp Tool

Focus on coastal areas. Why?



https://phys.org/news/2020-03-mangrove.html

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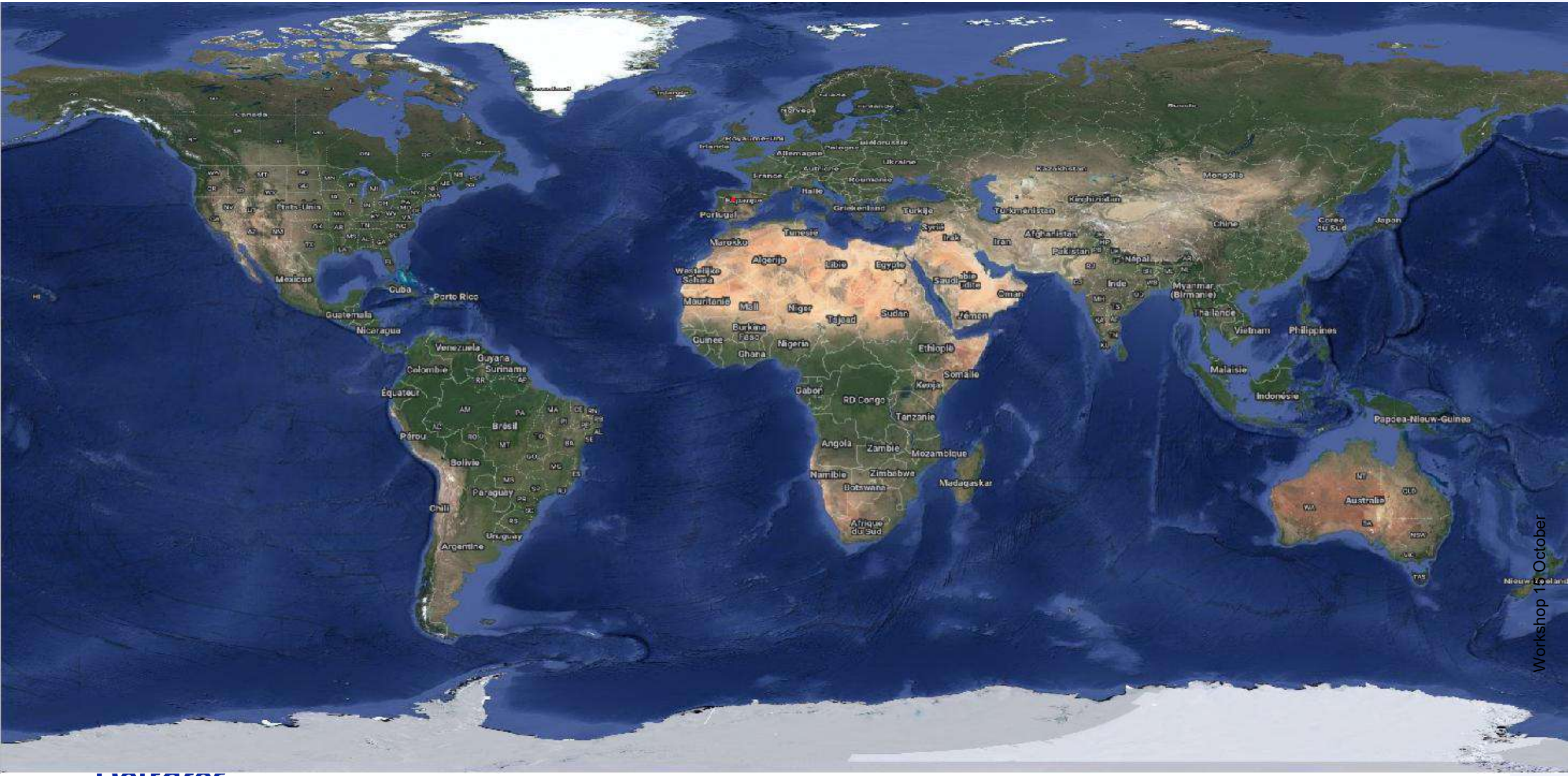

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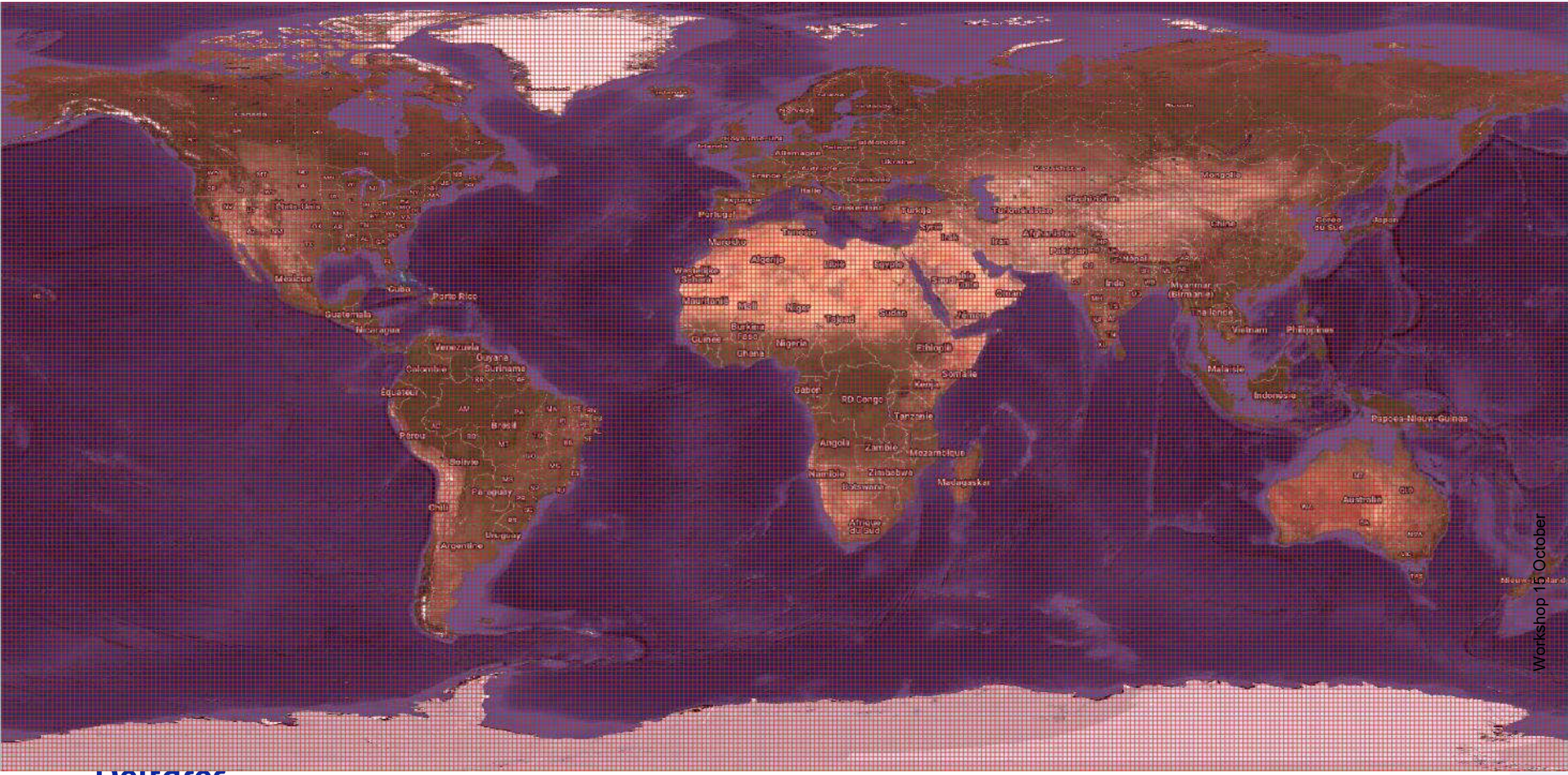

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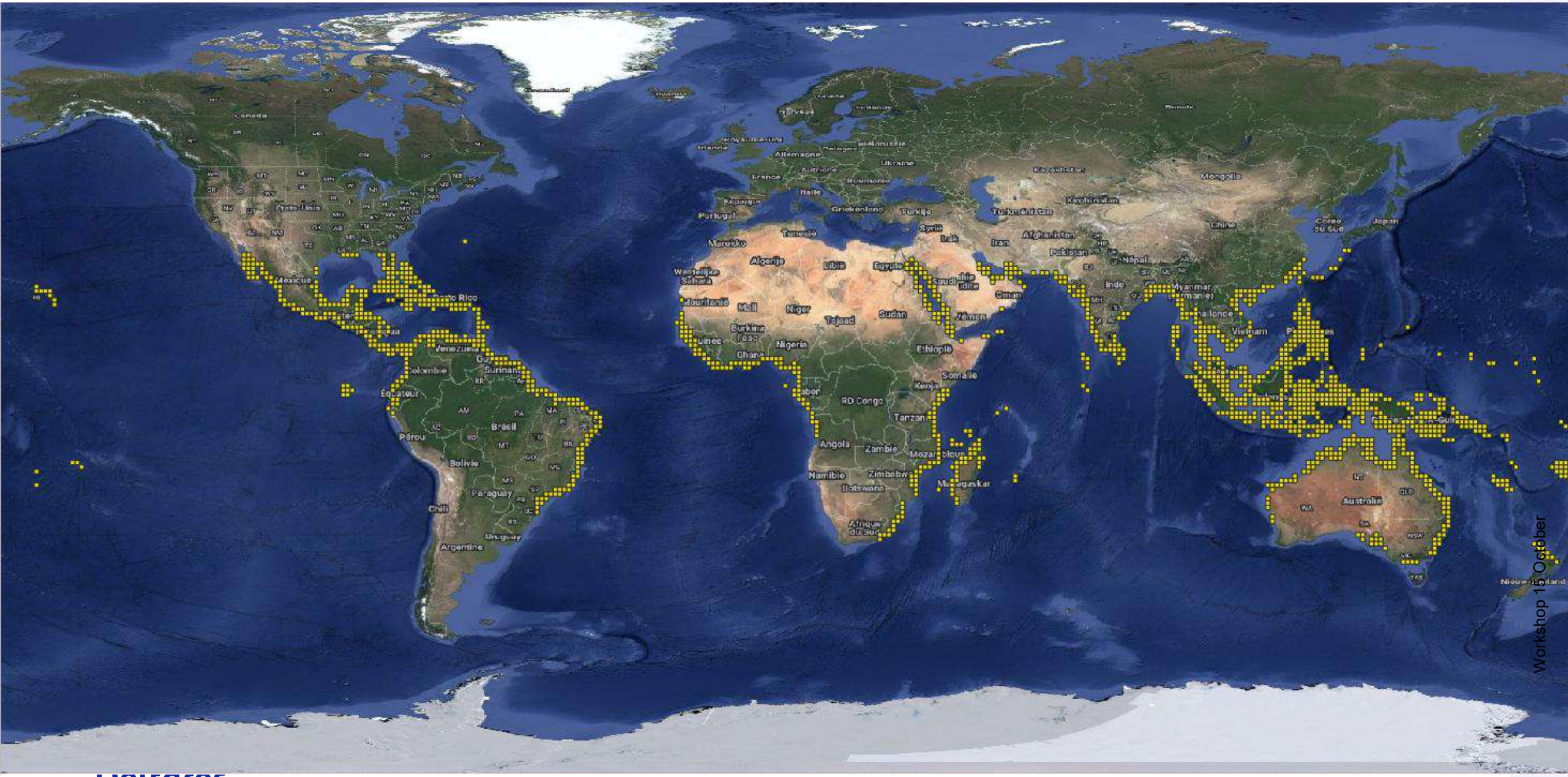

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Canada
Russie
Mongolie
Kazakhstan
Turkménistan
Chine
Corée du Sud
Japon
Turquie
Syrie
Irak
Iran
Afghanistan
Pakistan
Népal
Inde
Myanmar
Thaïlande
Vietnam
Philippines
Libye
Egypte
Arabie Saoudite
Oman
Yémen
Niger
Tchad
Soudan
Nigeria
Ghana
Guinée
Burkina Faso
Ethiopie
Kenya
Venezuela
Guyana
Suriname
Colombie
Equateur
Pérou
Brésil
RD Congo
Tanzanie
Angola
Zambie
Mozambique
Zimbabwe
Namibie
Botswana
Afrique du Sud
Nouvelle-Zélande

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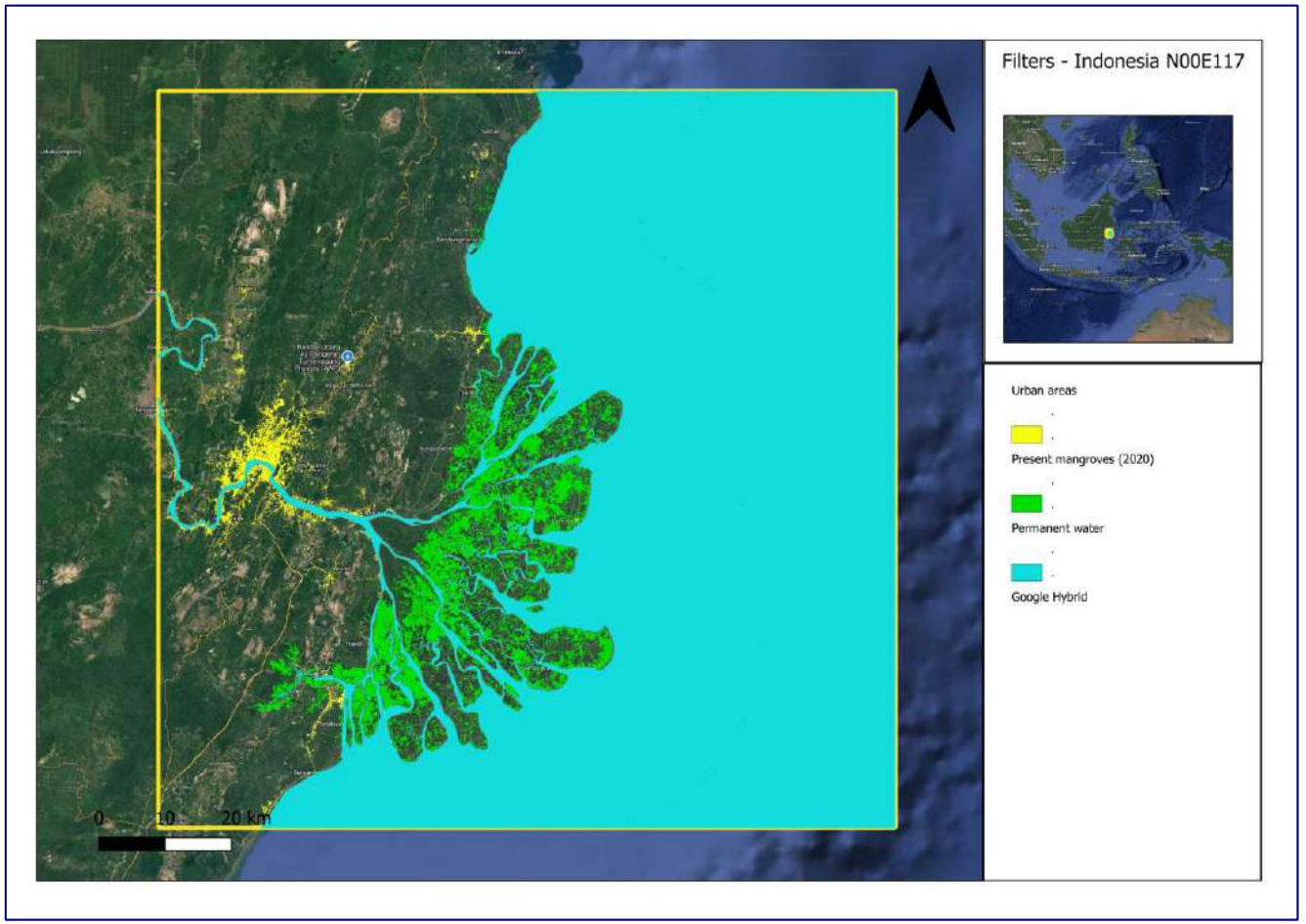
Filters

Filters indicate areas that are masked in the final Mangrove Opportunity Wheel Map.

- **Non-tropical areas** (GMW tiles ranges)
- **Permanent water areas** (Pekel et al., 2016)
- **Urbanized areas** (ESA WorldCover)
- **Areas beyond 7.5 km from the coastline** (Modified from Wessel and Smith, 1996) except for areas within 2.5 km from rivers and 2.5 km from present mangroves.
- **Existing mangrove areas** (GMW 2020)



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Mangrove Potential Map

Addition of indicators

- ✓ Indicators are combined using equal weights.
- ✓ The final indicator ranges from 0 to 1, where 1 represents areas meeting all selected criteria for mangrove growth.
- ✓ A value of **1** is assigned only if the area was a recently lost mangrove site, is close to existing mangroves, lies within the high intertidal zone, is near the coastline or rivers, has a low risk of subsidence, and is identified as a pond area."

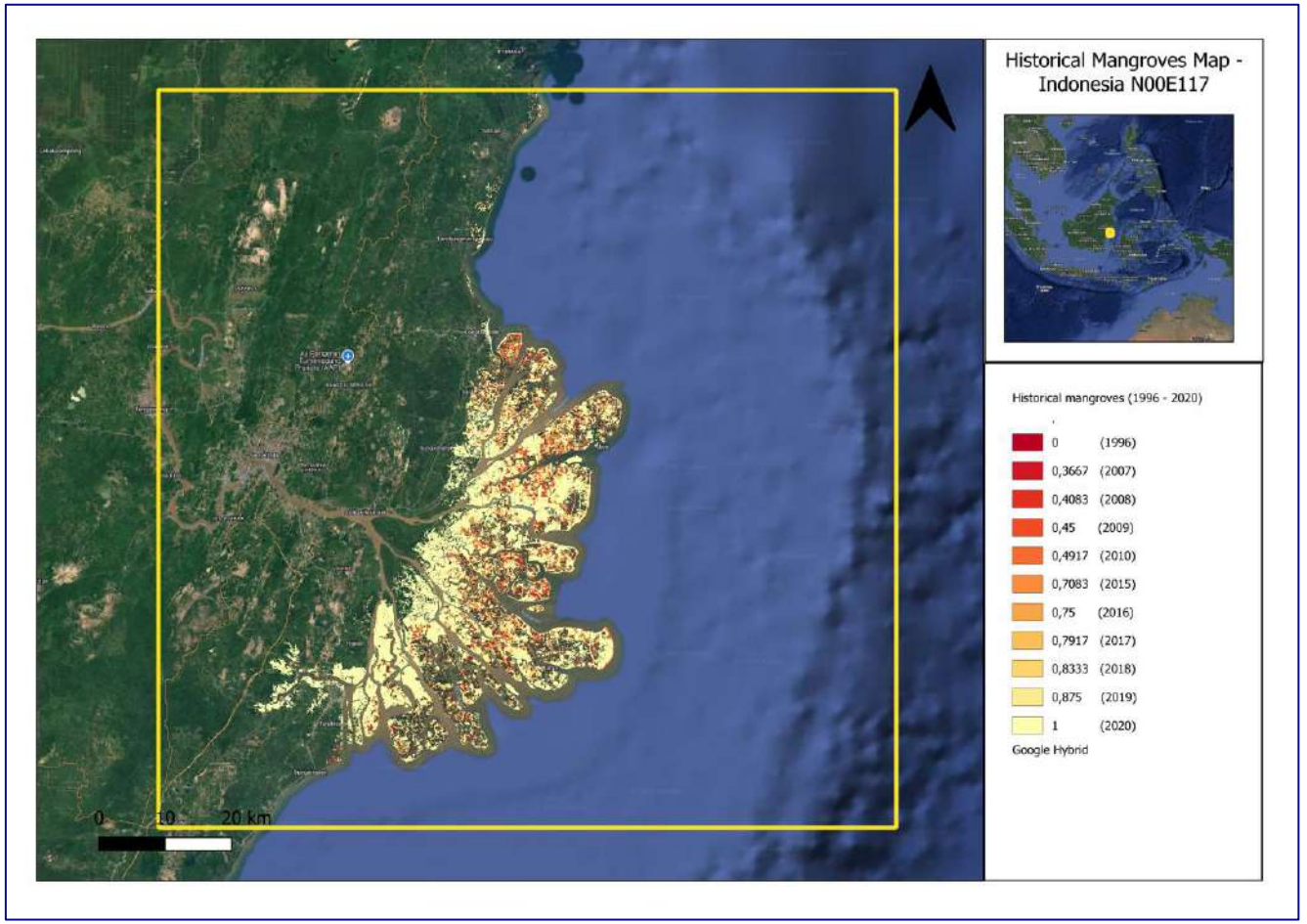
$$Opportunity\ score\ = \sum_{i=1}^{n} indicator_i * weight_i = indicator_1 * weight_1 + indicator_2 * weight_2 + \cdots + indicator_n * weight_n$$

$$weight_1 = weight_2 = weight_n = {}^{1}/_{n}$$

Suitability indicator: Historical mangrove cover

Mangrove potential growth based on areas of (recent) loss.

- Derived from **Global Mangrove Watch (1996–2020)**, indicates per pixel the last year mangrove cover was recorded.
- **Recent loss areas** are highlighted as mangrove potential growth hotspots
- Areas with **permanent changes** (e.g., urbanization, permanent water) are later filtered out.



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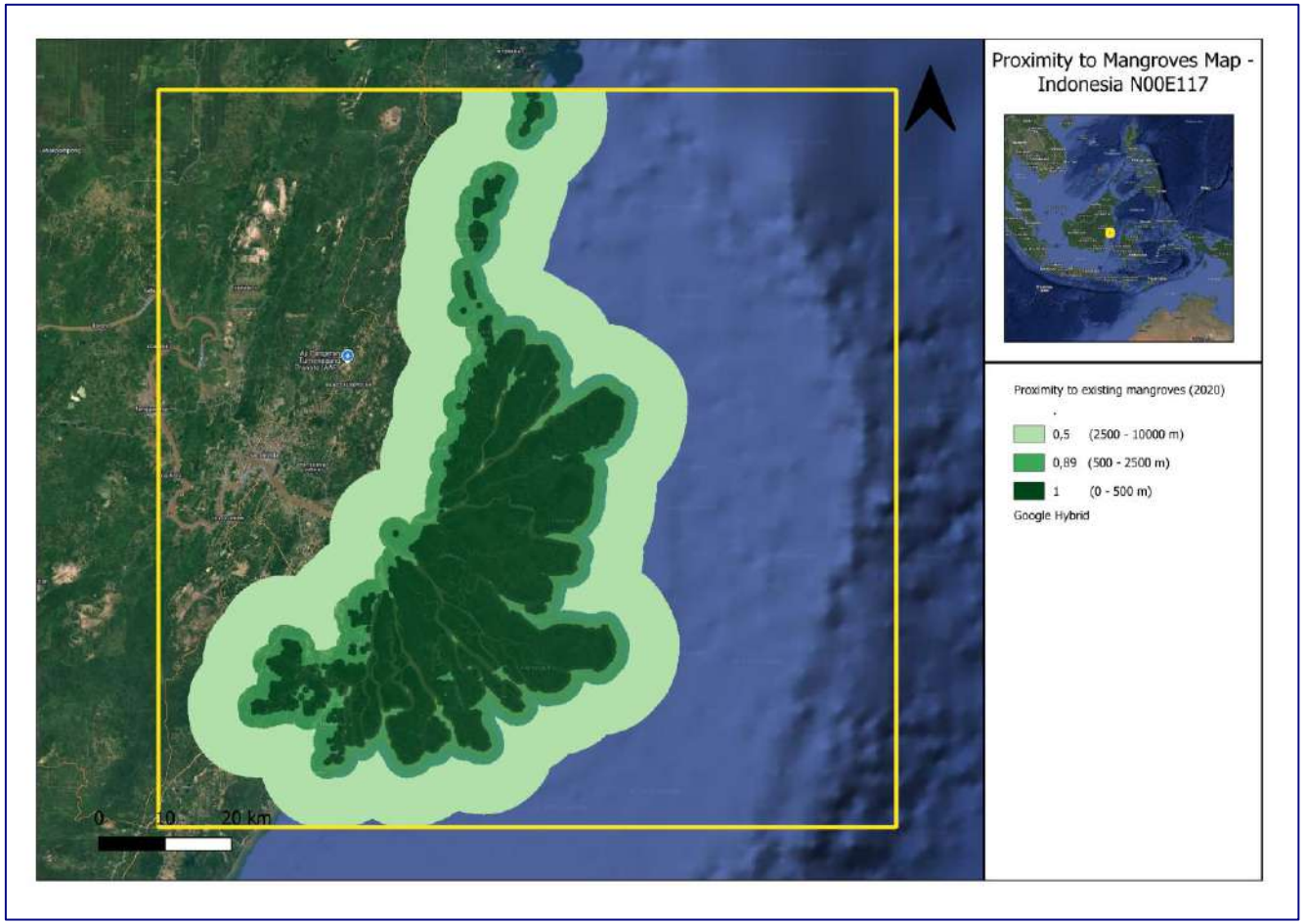
Suitability indicator: Proximity to present mangroves

Seed availability based on proximity to existing mangroves

- **Proximity from existing mangroves** (GMW 2020) used as proxy for seed availability.
- Identifies areas near existing mangroves as **seed dispersal hotspots**.
- **Distance buffers:** 0–500 m, 500–2,500 m, 2,500–10,000 m (no seed dispersal assumed beyond 10 km).



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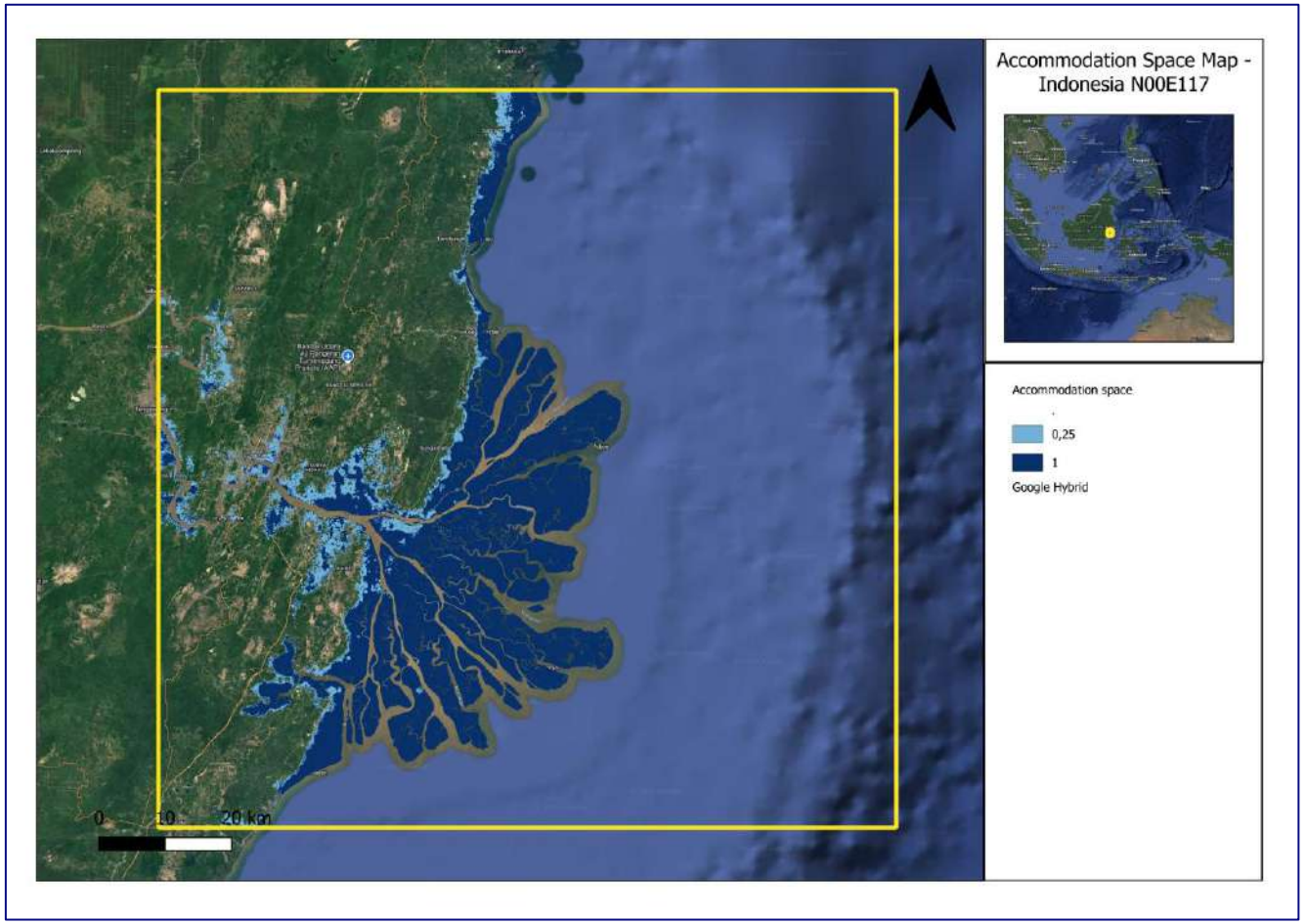
Suitability indicator: Accommodation space

Accommodation Space (Mean Sea Level to Highest Astronomical Tide + 1m)

- Derived from **DeltaDTM elevation** and **GSTM tide data**, with corrections for mangrove height overestimation and pond areas identified as permanent water.
- **Identifies high intertidal zones suitable for mangrove growth.**
- **Uses nearshore tides data.**



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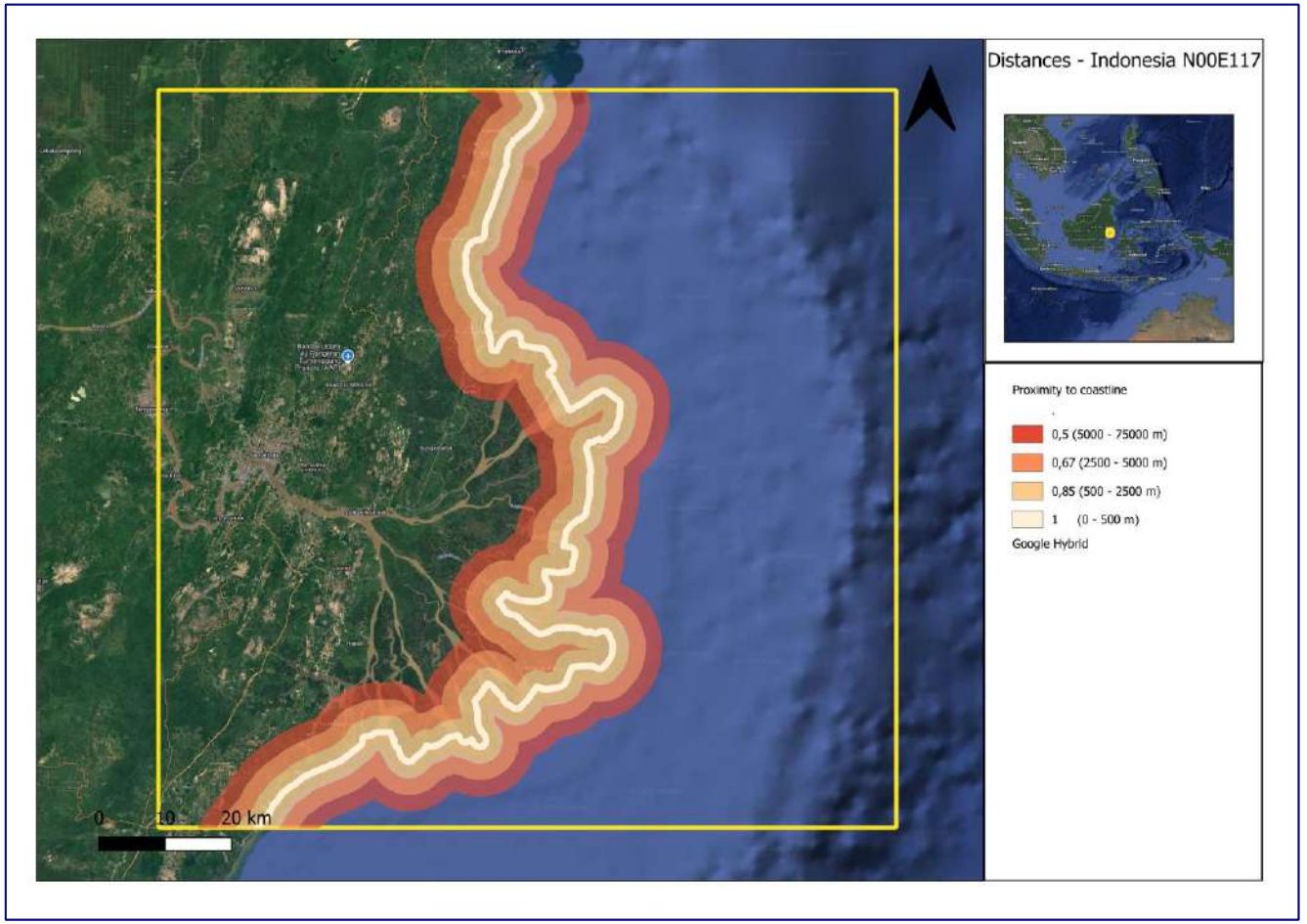
Suitability indicator: Proximity to coastline and rivers

Distances to coastline and rivers

- Derived from global shoreline (Modified from Wessel and Smith, 1996) and global rivers dataset (Lin et al., 2019) (rivers with Q > 1000m/s)
- **Highlights areas near the coastline and rivers as areas with high benefits for flood reduction measures.**
- **Distance buffers:**
  - From coastline: 0–500 m, 500–2,500 m, 2,500–5,000 m, 5,000–7,500 m
  - From rivers: 0–250 m, 250–500 m, 500–2,500 m



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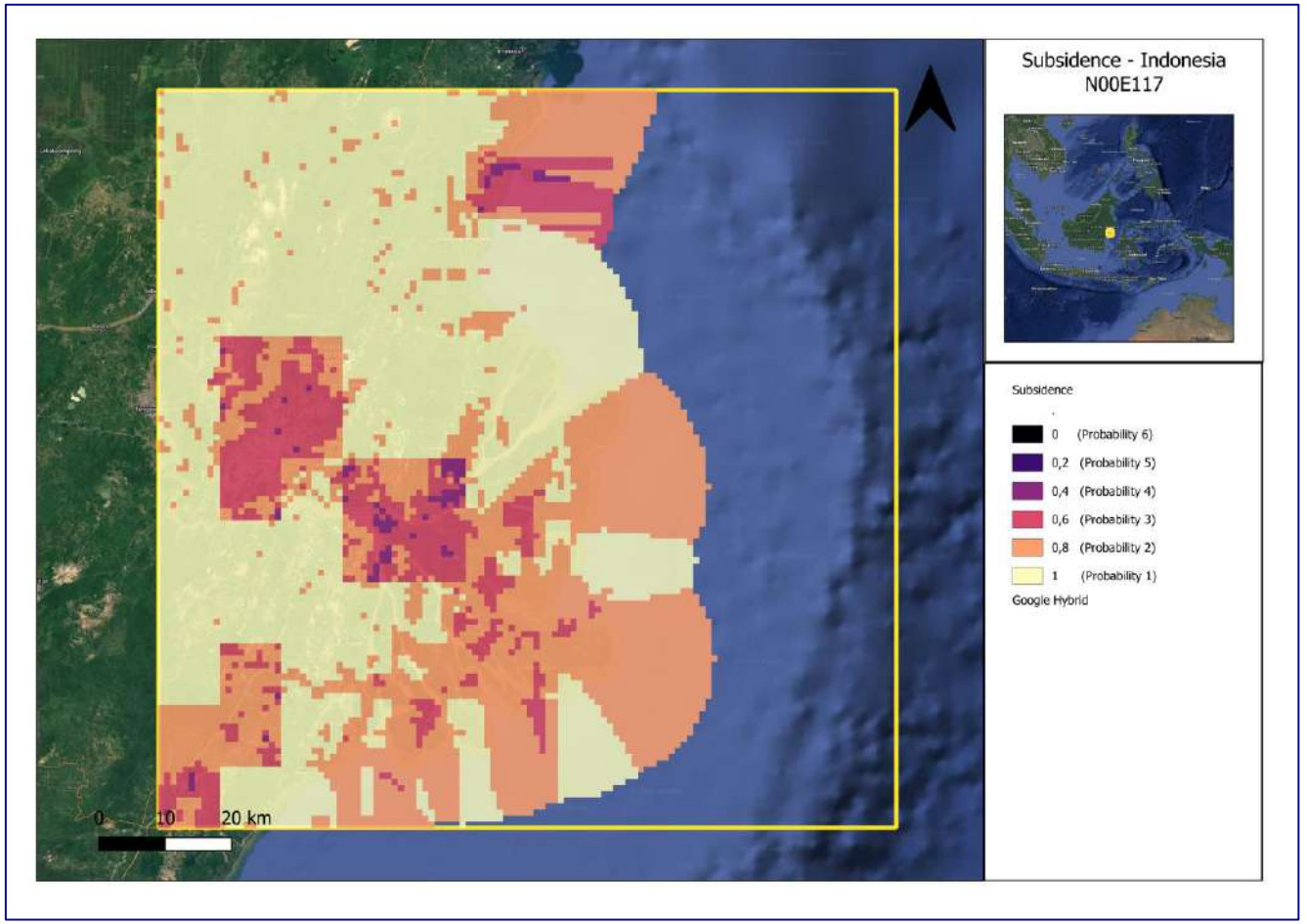
Suitability indicator: Subsidence

Subsidence probability

- Derived from global subsidence probability dataset (Herrera-García et al, 2021)
- **Highlights low-subsidence zones suitable** for mangroves.
- Probability scale: 1 (lowest) → 6 (highest).
- Averages for 2010 & 2040 used for analysis.



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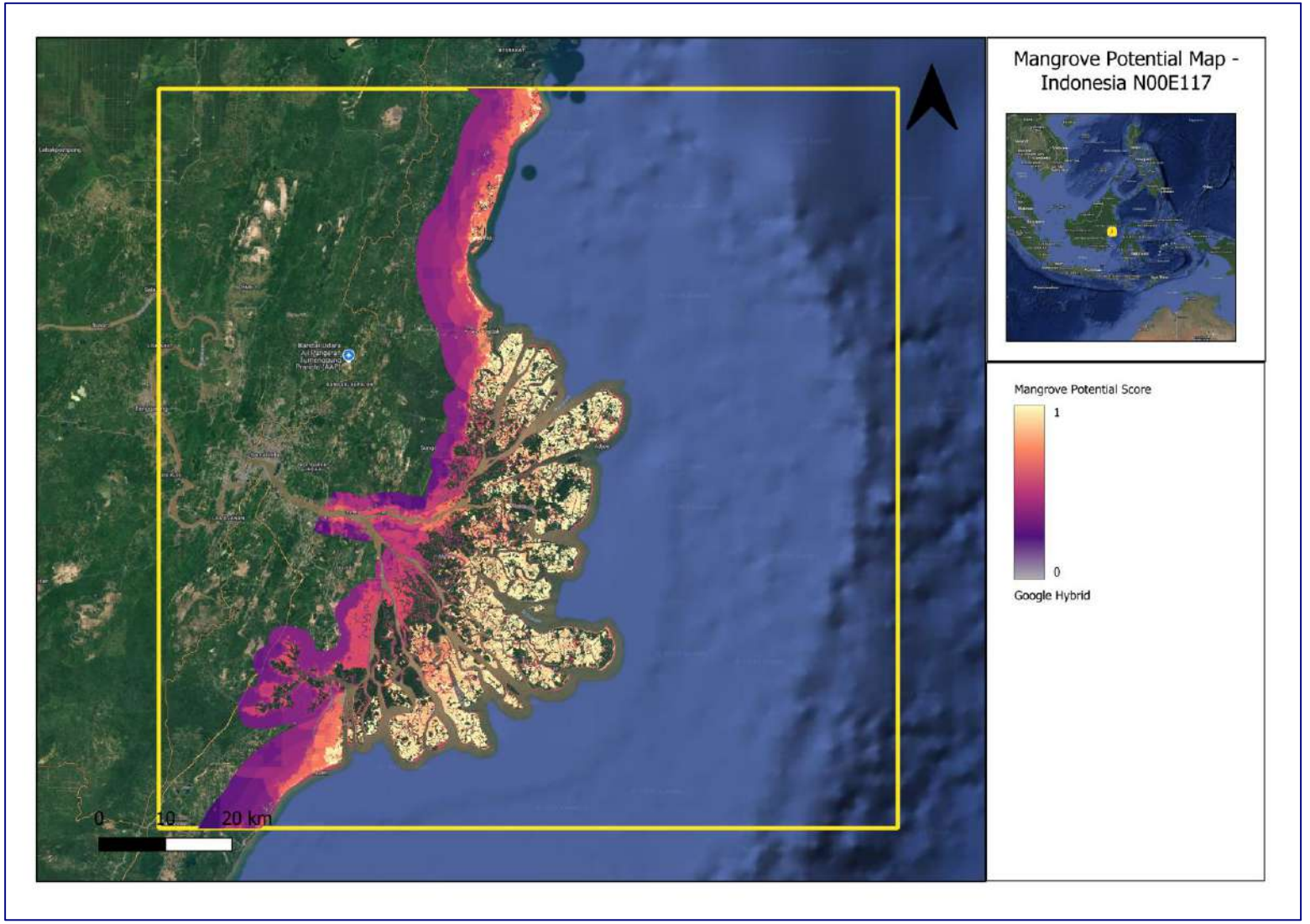
Research object

Aquaculture Areas

- Derived from (Clark 2022), showing aquaculture locations across multiple tropical countries.
- Includes all types of aquaculture—abandoned, intensive, and semi-intensive—without distinction.
- Used to highlight areas with high mangrove growth potential that are currently or were previously used for aquaculture.

Mangrove Potential Map



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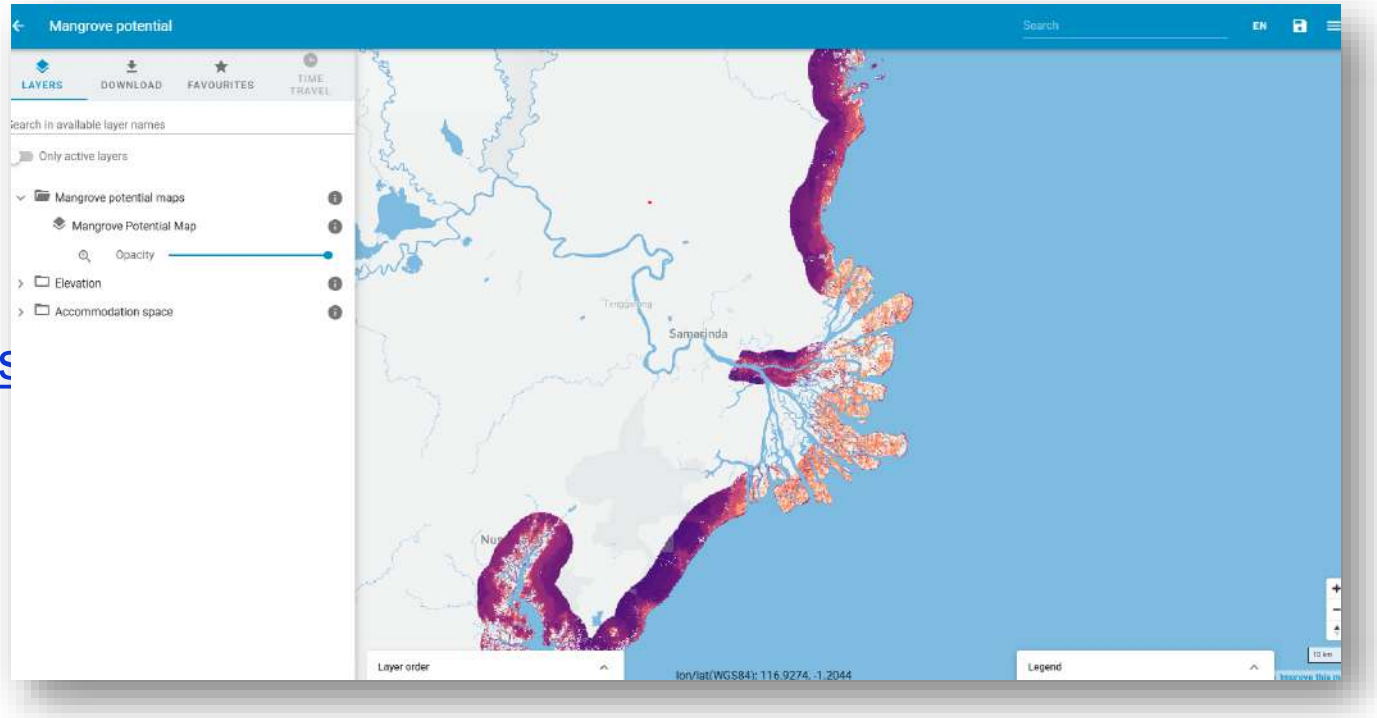
Viewer and storage

The Mangrove Potential map is open-access:



- Viewer: Mangrove potential
- Storage: https://s3-console.deltares

- https://data.openearth.nl/mangrove-potential-map

Thank you!