Assessment of the Carbon Sequestration Capacity of Mangrove Forest Plantation: Case study of Thailand

Wilailuk Niyommaneerat [1, 2, 3]

[1]Sustainable Environment Research Institute

[2]Center of Excellence on BCG Towards Sustainable Development, Social Research Institute

[3]Hub of Waste Management for Sustainable Development, Center of Excellence on Hazardous Substance Management

Chulalongkorn University, Bangkok, 10330 Thailand

kae.wilailuk@gmail.com;wilailuk.n@chula.ac.th

Mangrove Forests in Thailand

Introduction

- Total mangrove forest area: 229,618.56 hectares
- Found along Thailand’s coastline
- Vital for natural beauty and coastal ecosystem health

Jiayong Lai et al., 2022

Role in Climate Change Mitigation

Mangroves as a Carbon Sink

- Found in tropical and subtropical coastal regions
- Among the most effective ecosystems for **carbon sequestration**
- Store carbon in:
    - **Above-ground biomass** (trees and vegetation)
    - **Belowground biomass** (roots and rhizomes)
    - **Sediments** (main long-term storage)

Key Factors in Carbon Budget Analysis

Assessing Mangrove Carbon Storage

1. Sediment Carbon Stocks

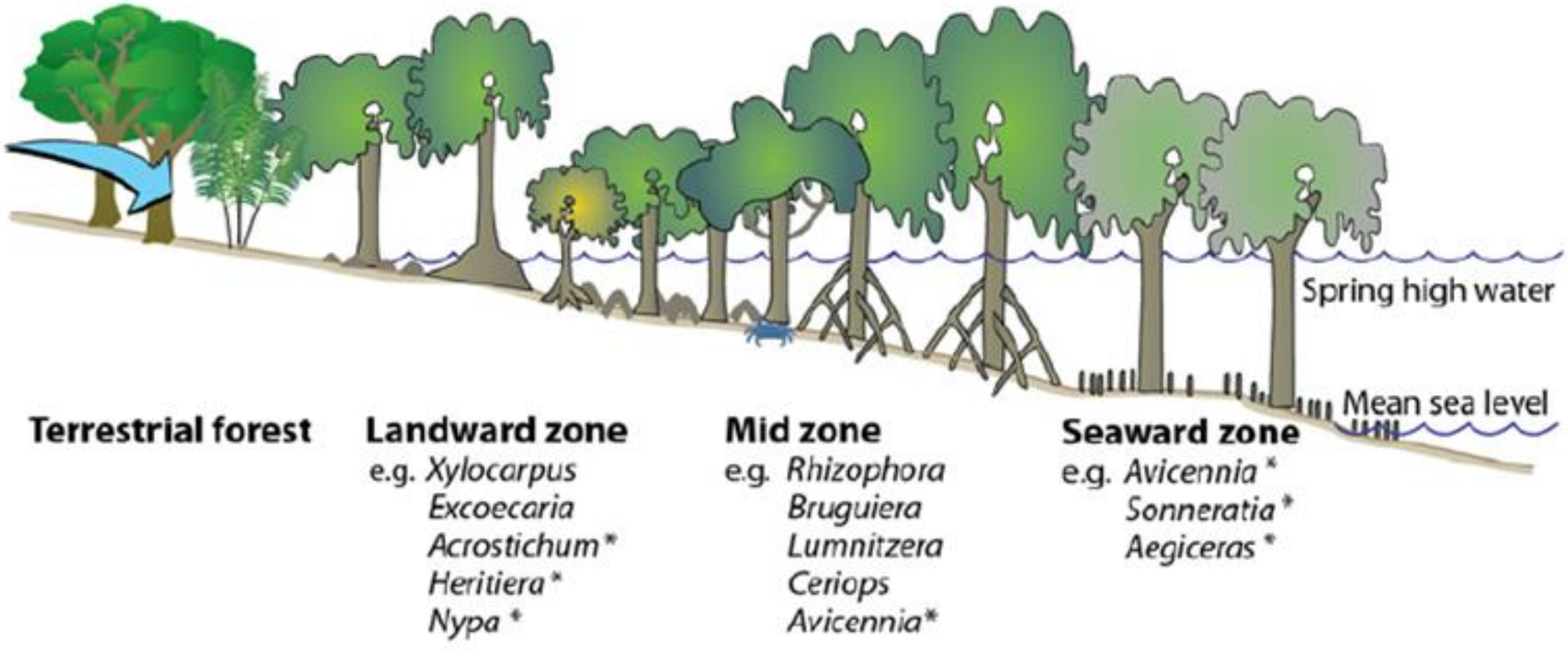
- Analyze sediment layers
- Field sampling and lab testing

2. Biomass Carbon Stocks

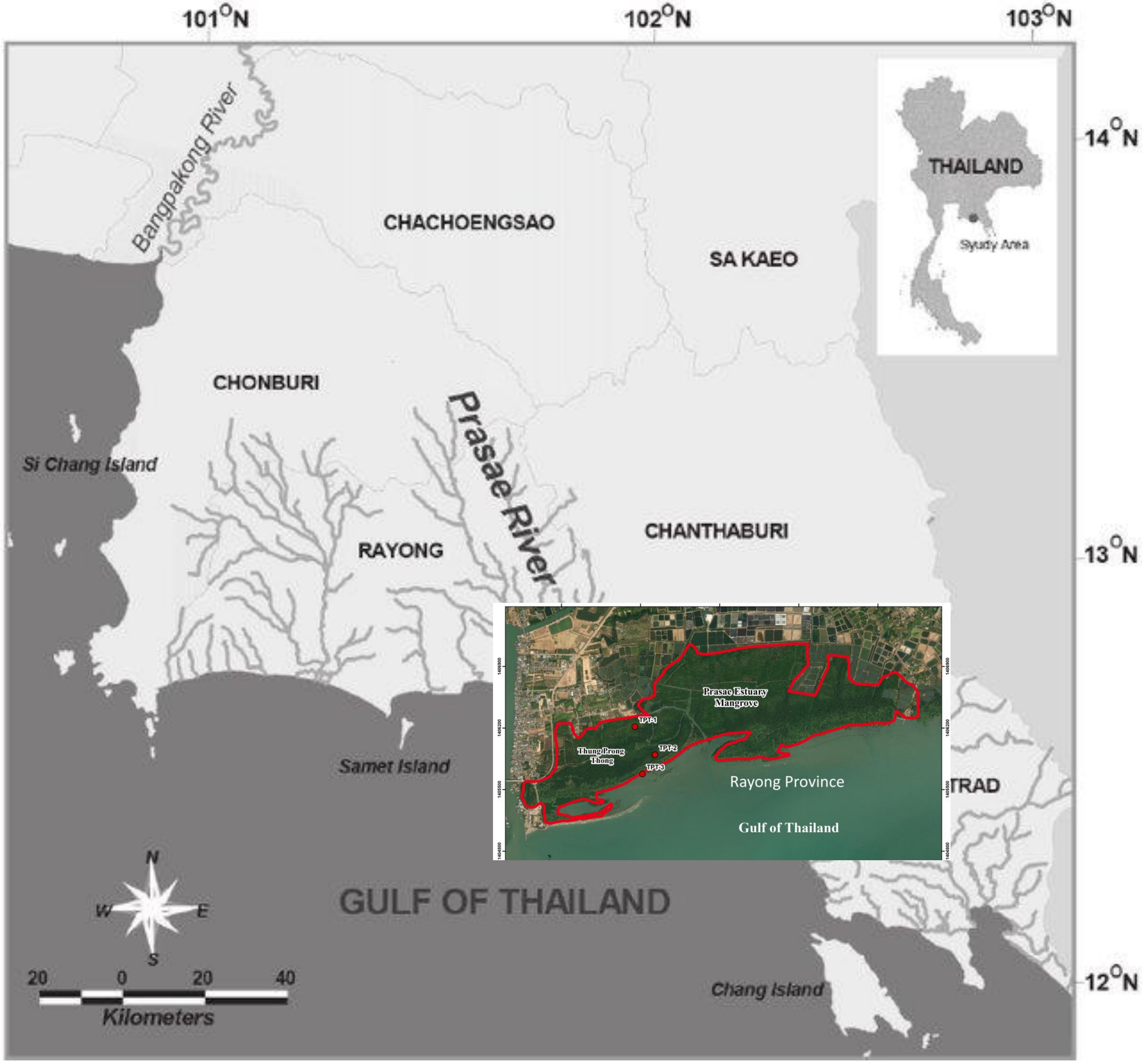
- Measure above-ground and below-ground biomass

3. Carbon Sequestration Rates

- Estimate carbon accumulation over time
- Based on sedimentation rates

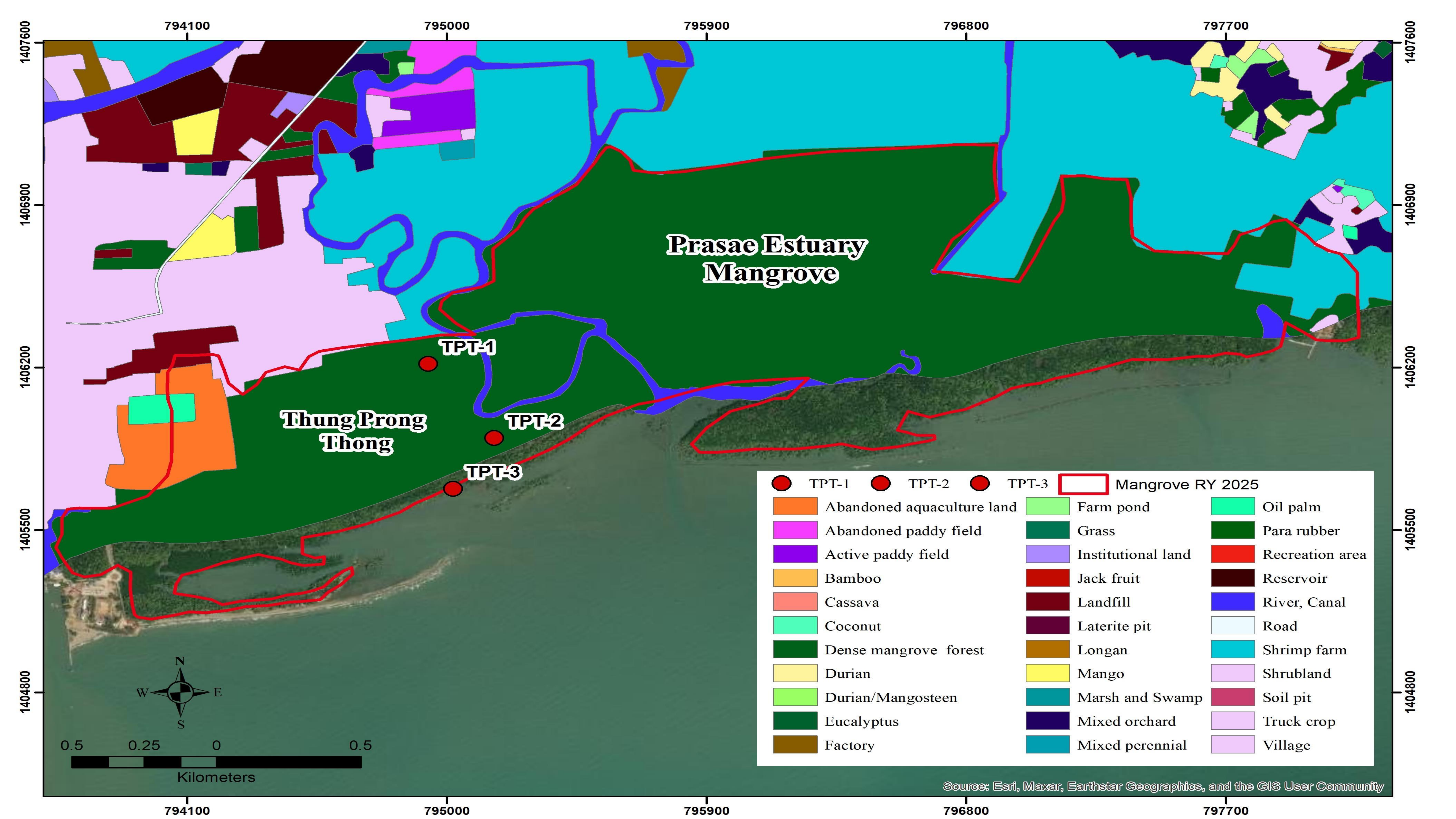


- **Three zones typical of mangrove habitats in the tropical Pacific, showing the differences in mangrove species typical of each zone.**

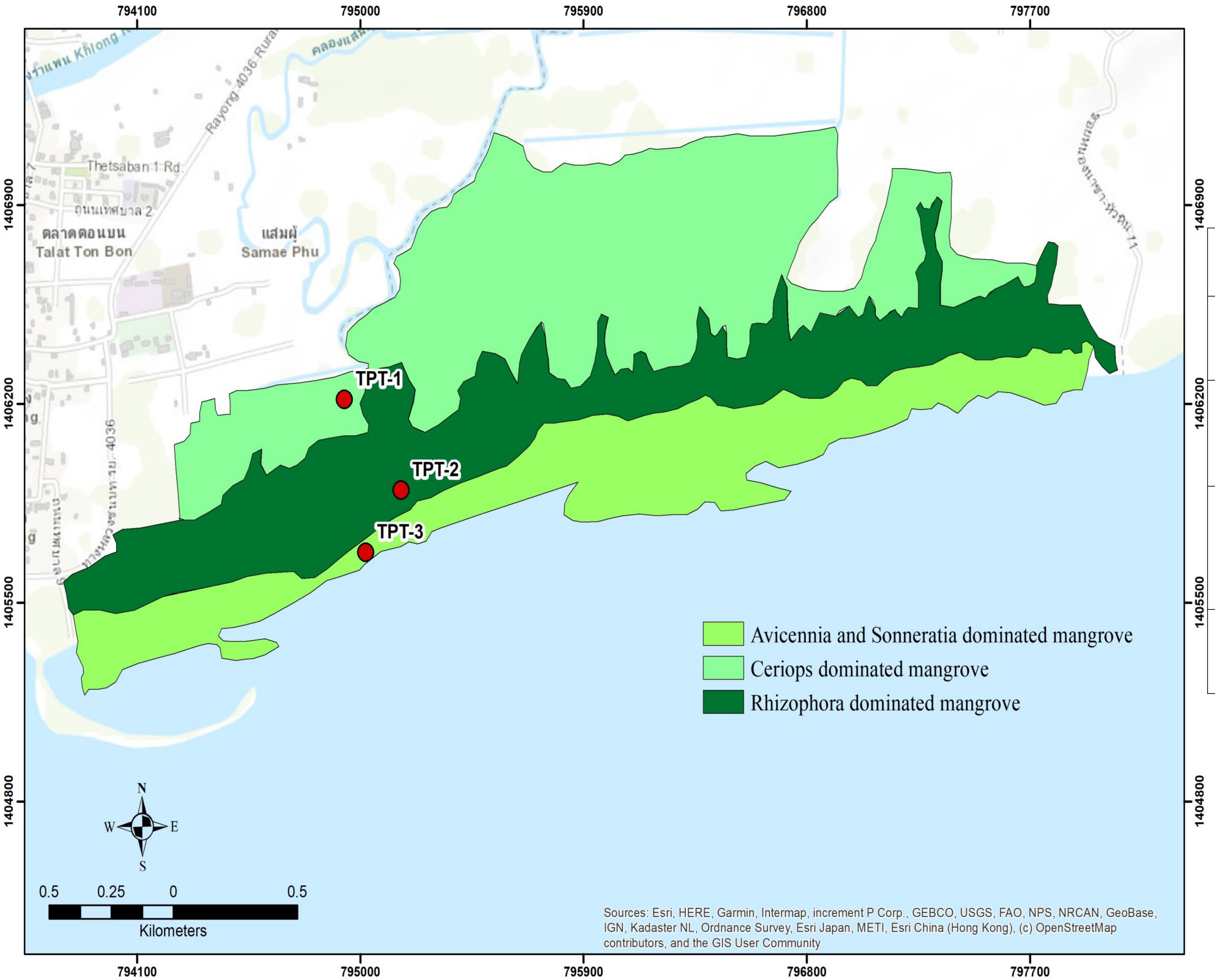


Sampling stations in Prasae River Estuary, Rayong Province, Thailand


Prasae Estuary
Mangrove
TPT-1
TPT-2
TPT-3
Thung Prong
Thong
Rayong Province
Gulf of Thailand
1406900
1406200
1405500
1404800
1406900
1406200
1405500
1404800
N

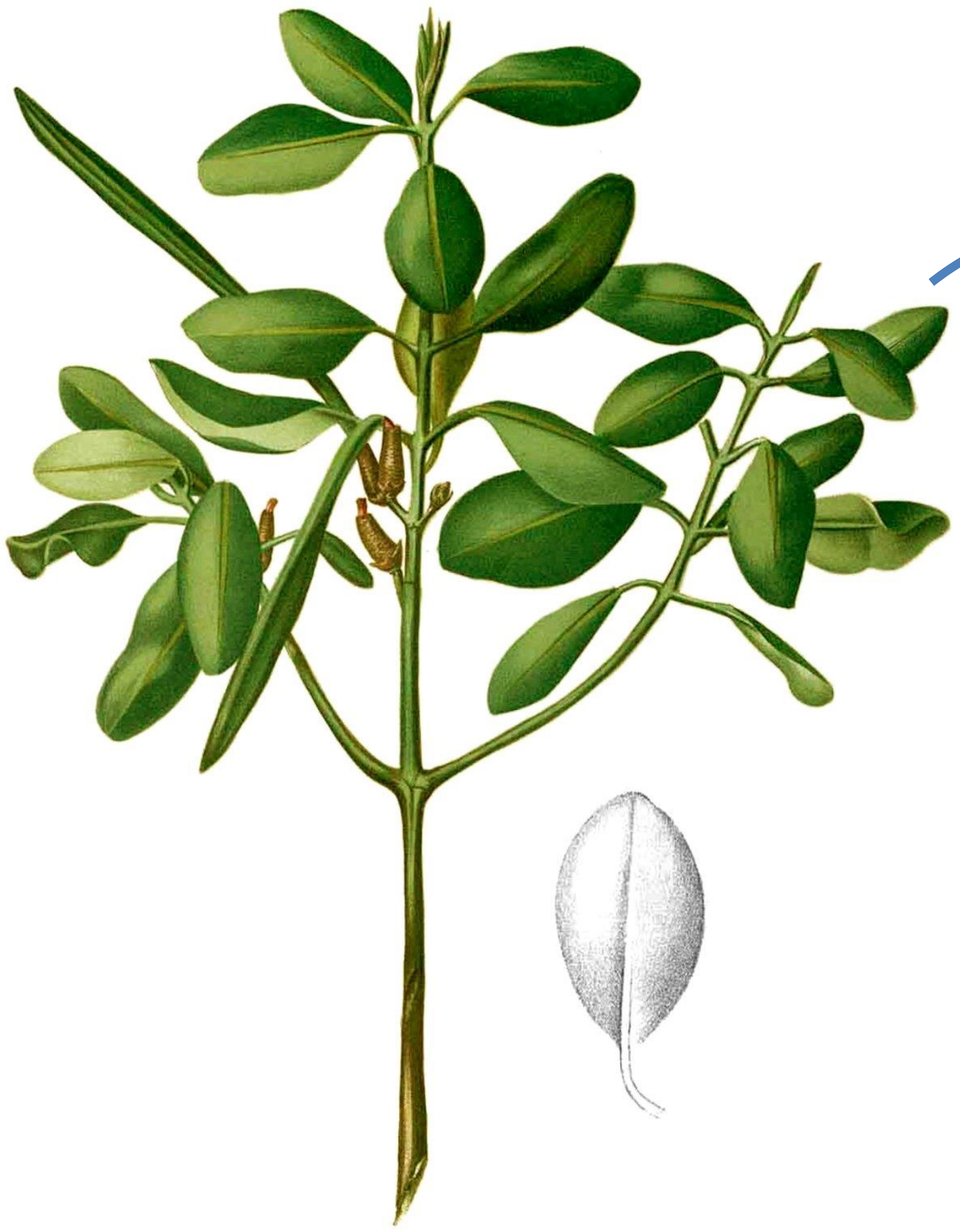


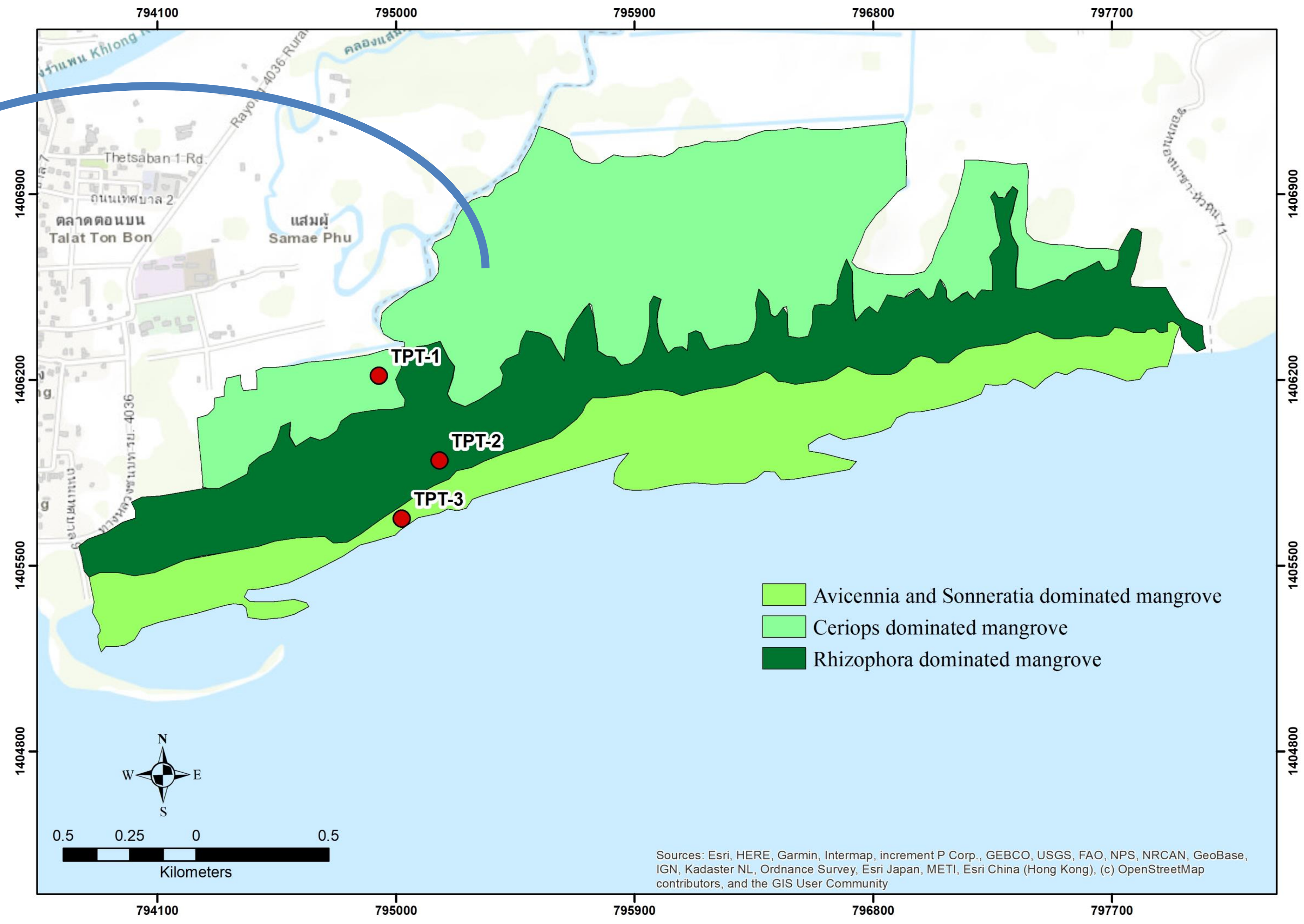
794100
795000
795900
796800
797700
1407600
1406900
1406200
1405500
1404800
Prasae Estuary Mangrove
Thung Prong Thong
TPT-1
TPT-2
TPT-3
Mangrove RY 2025
Abandoned aquaculture land
Abandoned paddy field
Active paddy field
Bamboo
Cassava
Coconut
Dense mangrove forest
Durian
Durian/Mangosteen
Eucalyptus
Factory
Farm pond
Grass
Institutional land
Jack fruit
Landfill
Laterite pit
Longan
Mango
Marsh and Swamp
Mixed orchard
Mixed perennial
Oil palm
Para rubber
Recreation area
Reservoir
River, Canal
Road
Shrimp farm
Shrubland
Soil pit
Truck crop
Village
N
W
E
S
0.5 0.25 0 0.5
Kilometers
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



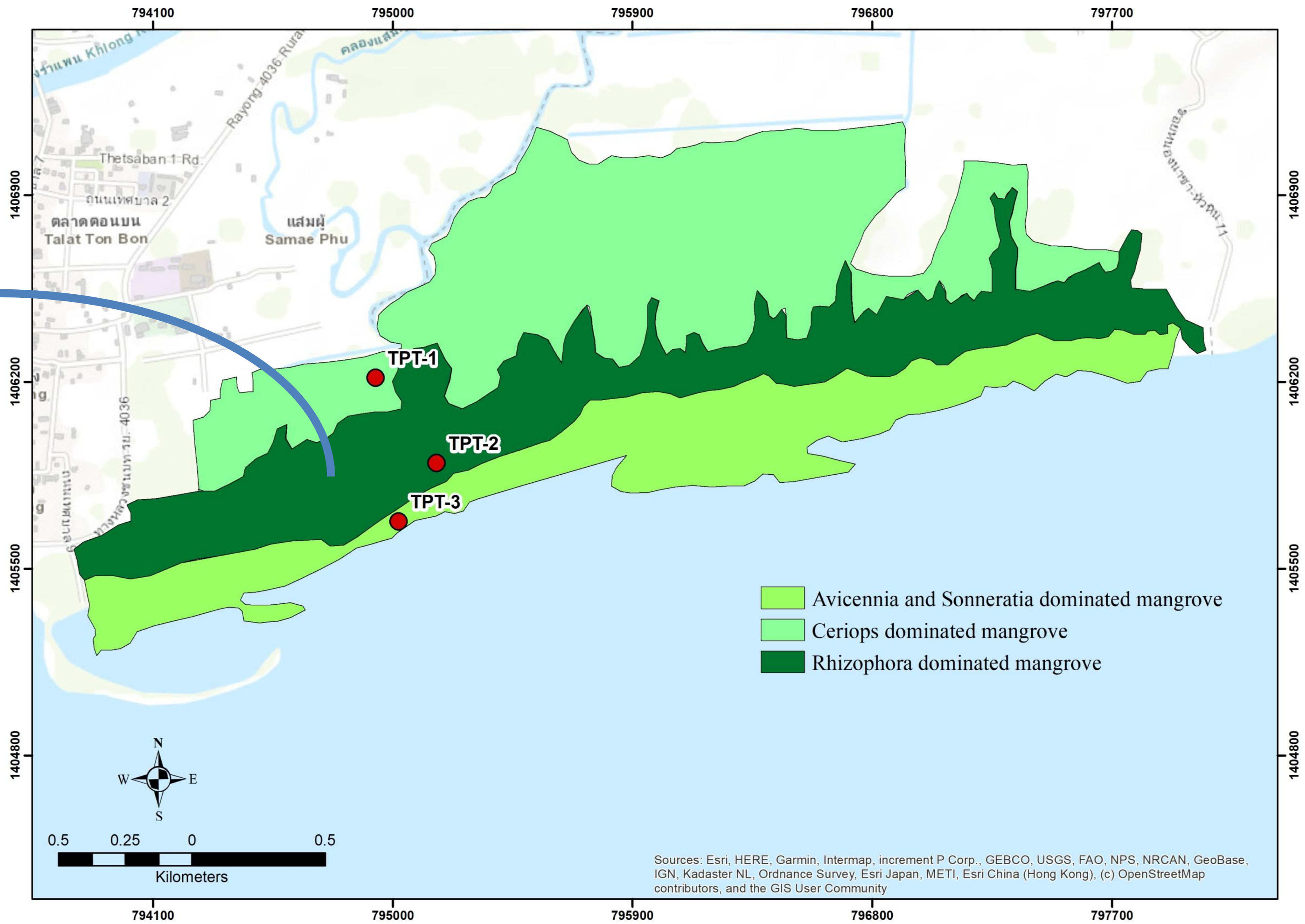
Details	Area (km2)	Area (Hectares)
Total Area of Thungprongthong (Mangrove forests)	3.66	361.00
Ceriops dominated mangrove (ต้นโปรง) TPT-1	1.61	161.00
Avicennia and Sonneratia dominated mangrove (ต้นแสม) TPT-3	0.84	84.00
Rhizophora dominated mangrove (ต้นโกงกาง) TPT-2	1.20	12.00

TPT-1 Zone*: Abundance of Ceriops tagal*



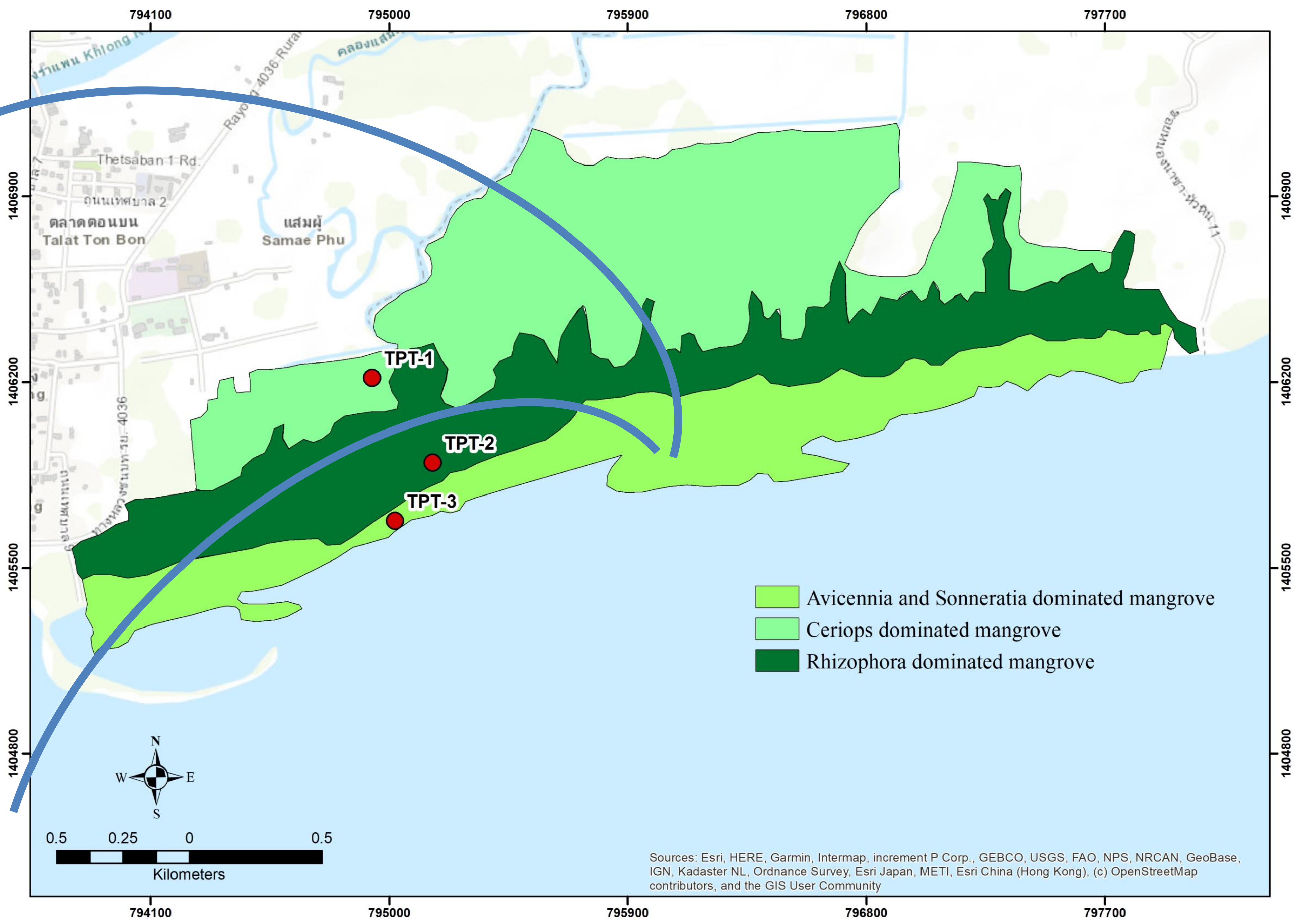


TPT-2 Zone: *Rhizophora dominated mangrove*

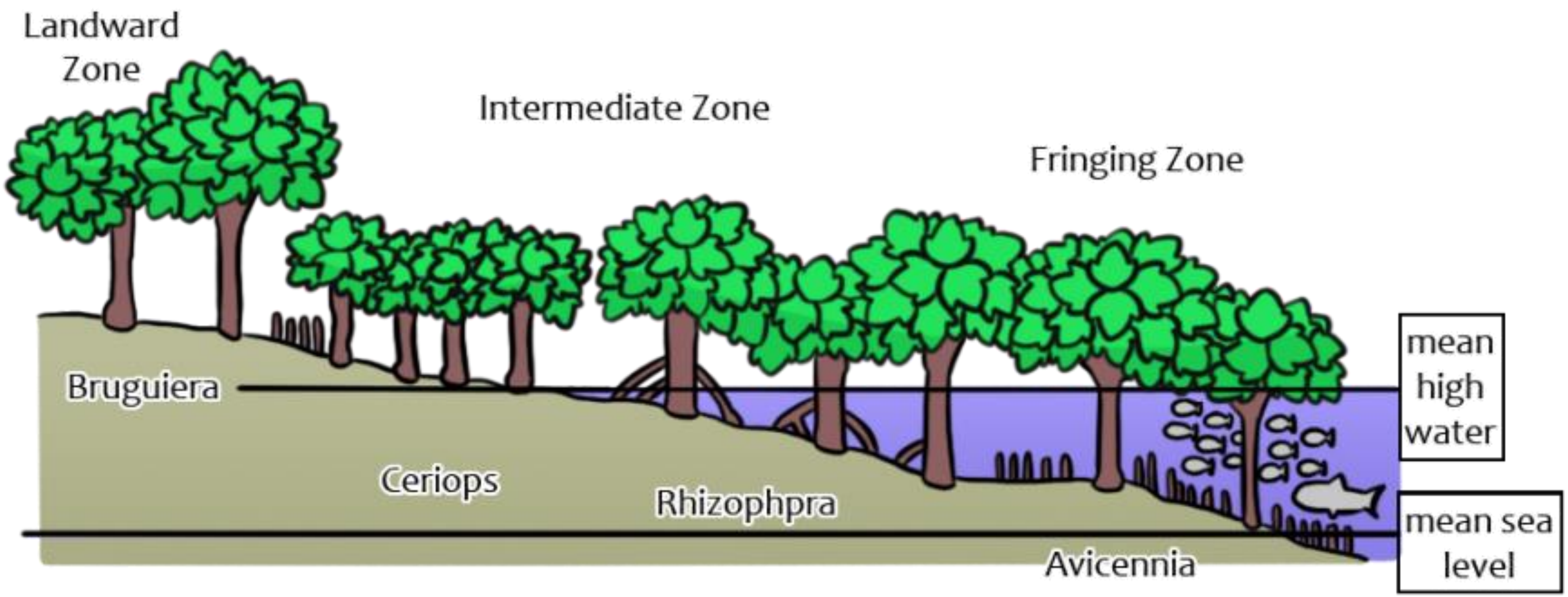


TPT-3 Zone: *Avicennia and Sonneratia dominated mangrove*

Sonneratia



Mangrove Species Zonation



Land

All increase towards shore

Sea

Salinity

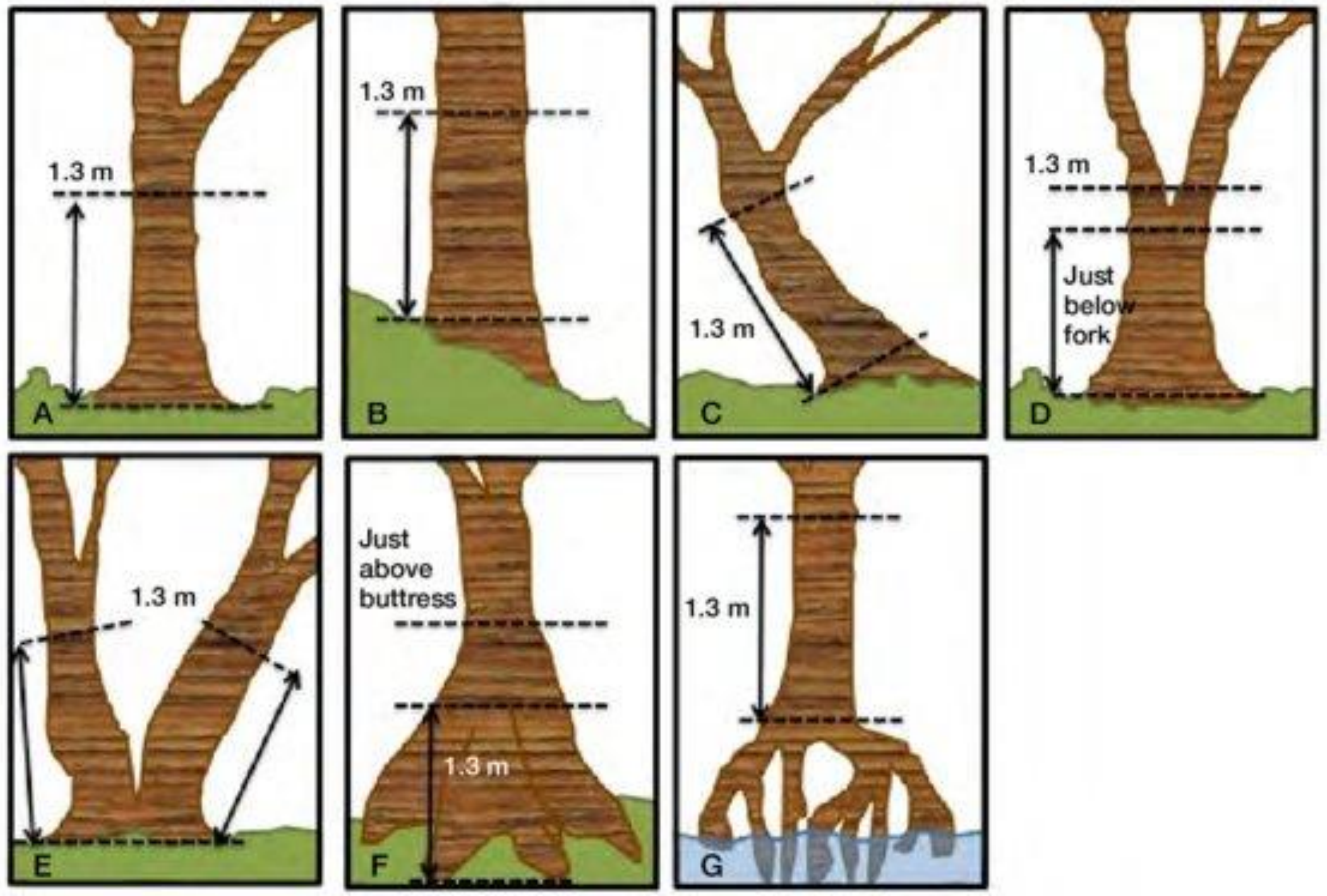
Inundation

Decreasing Soil Stability

Sedimentation Rate

Field Measurement for carbon stock in Mangrove plantation

- Measure a few basic properties of trees including the Diameter at Breast Height (DBH) and height.
- To measure diameter, we use a DBH tape, a common tool for on-the-ground forest measurements.
- To measure height, we use a clinometer and a range finder.



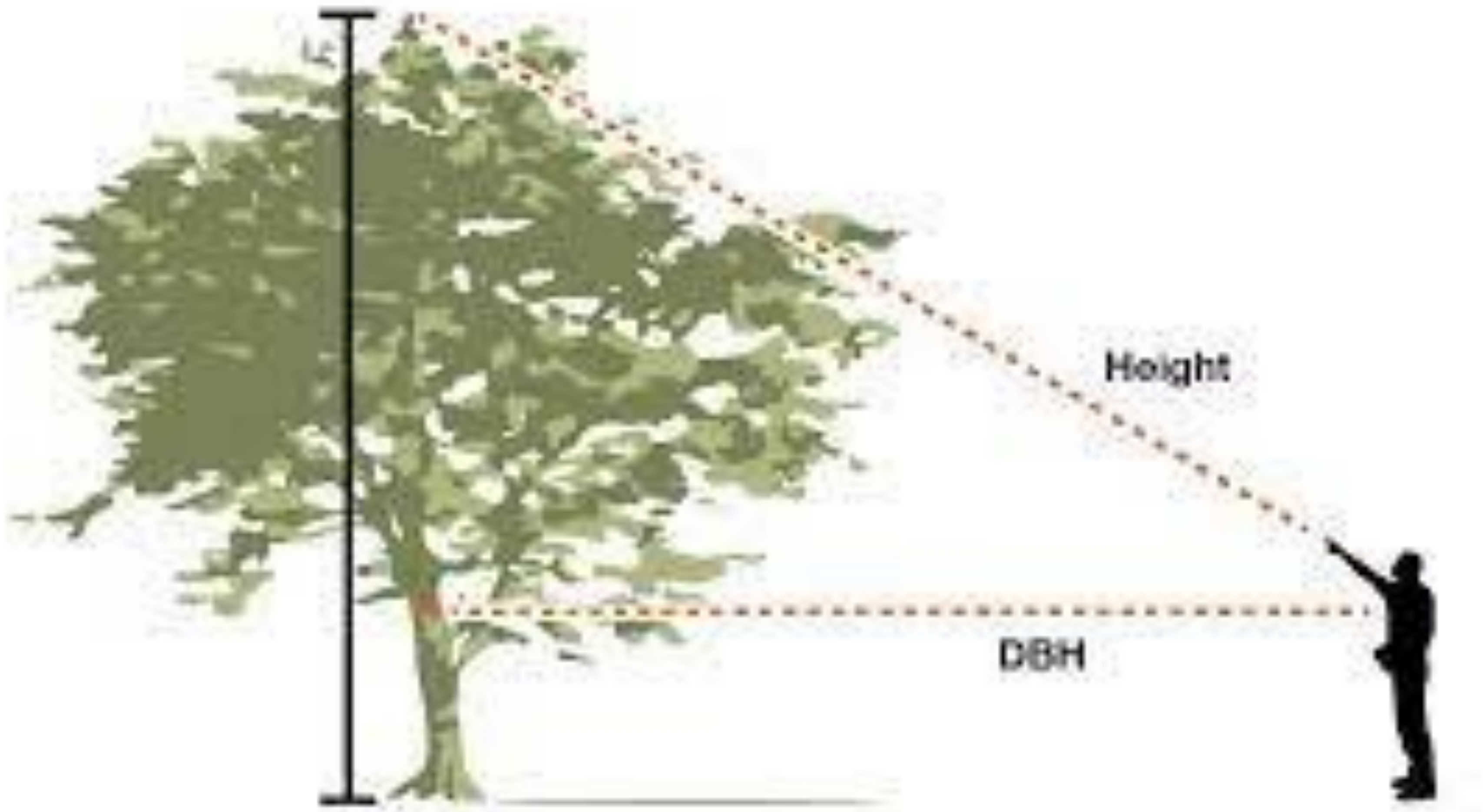


Table 4. Allometric equations using tree height and diameter for computing biomass of mangrove trees

	N	D_{MAX}	Max H	Equation	R^2
General equation	84	42.0		$B = 0.0509 * \rho * (D)^2 * H$	
Bruguiera gymnorrhiza	325	132.0	34	$0.0464 * (D^2H)^{0.94275} * \rho$	0.96
Sonneratia alba	345	323.0	42	$0.0825 * (D^2H)^{0.89966} * \rho$	0.95
Rhizophora apiculata	193	60.0	35	$0.0444 * (D^2H)^{0.96842} * \rho$	0.96
Rhizophora mucronata	73	39.5	21	$0.0311 * (D^2H)^{1.00741} * \rho$	0.95
Rhizophora spp.	265	60.0	35	$0.0375 * (D^2H)^{0.98626} * \rho$	0.95
Lumnitzera littorea	20	70.6	19	$0.0214 * (D^2H)^{1.05655} * \rho$	0.93
Xylocarpus granatum	115	128.5	31	$0.0830 * (D^2H)^{0.89806} * \rho$	0.95
Rhizophora mangle	26	15.4	11	$125.9571(D^2H)^{0.8557}$	0.99

B = biomass (kg), H= height (m), D = diameter at breast height (cm), ρ = wood density (g cm-3), D_{MAX} = maximum diameter of sampled trees (cm) and Max H = maximum height of sampled trees.

Notes: Parameters of diameter (dbh) and height are used for species-specific equations, and diameter and wood density are used for the general equation.

The general equation is from Chave *et al.* (2005), and includes all aboveground biomass. Individual species equations were modified from volume equations in Cole *et al.* (1999). These are equations of total wood mass and do not include leaves or stilt roots. To calculate total aboveground tree mass using these equations, leaves, and in the case of *Rhizophora*, stilt roots would also have to be calculated using separate equations such as those provided by Clough and Scott (1989). The equation for Rhizophora mangle is from Cintron and Schaeffer-Novelli (1984) and is suitable for use in dwarf mangroves. Additional equations for structural features of this species can be found in this manuscript.

Additional equations can be found in Komiyama *et al.* (2008), and Smith and Whelan (2006)

No	Allometric Equations	Explanation	Source
1	$Y = 0.1848 \times DBH^{2.3524}$ $R^2 = 0.9839$	Specific for *Avicennia marina*	Dharmawan, 2010
2	$Y=0.1466 \times DBH^{2.3136}$ $R^2=0.936$	Specific for *Rhizopora mucronata*	Dharmawan & Siregar, 2008
3	$Y=0.0275 \times DBH^{3.22}$	Specific for *Rhizopora apiculata*	Pambudi, 2011
4	$Y=0.251\dot{\rho} \times DBH^{2.46}$	Specific for *Avicennia*	Komiyama *et.al* (2005)
5	$Y=0.105 \times DBH^{2.68}$	Specific for *Rhizopora*	Komiyama (2008)
6	$Y=0.186 \times DBH^{2.31}$	Specific for *Brugueira*	Komiyama (2008)
7	$Y=0.186 \times DBH^{2.34}$	Specific for *Ceriops*	Komiyama (2008)

Allometric equations using tree height and diameter for computing biomass of mangrove trees


2025/03/08 10:59

2025/03/08 13:38


2025/03/07 15:28


2025/03/07 15:33

Carbon Sequestration of Mangrove Forest

	Total Area	Total Area	Carbon Sequestration of Mangrove Forest (2025)	
			CTREE	CTT=CTREE*(44/12)
	Km2	Rai	Ton CO2	Ton CO2eq
Ceriops tagal	1.614	1,008.981	3,970.234	14,557.524
Rhizophora	1.201	750.462	25,364.003	93,001.345
Avicennia and Sonneratia	0.841	525.674	4,528.468	16,604.382
		Total	33,862.705	124,163.251

Blue Carbon Stock

For Real-world Impact

- 100,000 tons CO_2e is roughly equivalent

~to the annual emissions of21,700 cars or carbon emitted from ~11 million gallons of gasoline.

- It represents a significant climate mitigation value and highlights the importance of preserving or restoring mangroves.

Conclusion & Call for Action

Protecting Mangroves for the Future

- Mangroves play a key role in mitigating climate change
- Conservation is essential to maintain their carbon benefits
- Further research is needed to improve protection strategies

Conclusion & Call for Action

Policy Recommendation

1.Incorporate Mangroves into National Climate Strategies

- Recognize mangroves as natural carbon sinks in Nationally Determined Contributions (NDCs).
- Include mangrove conservation and restoration under national REDD+ programs (Reducing Emissions from Deforestation and Forest Degradation).

2.Establish Legal Protection Zones

- Designate mangrove-rich areas as protected areas under environmental law.
- Impose moratoriums on mangrove conversion in high-carbon-storage zones.

3.Promote Mangrove Restoration

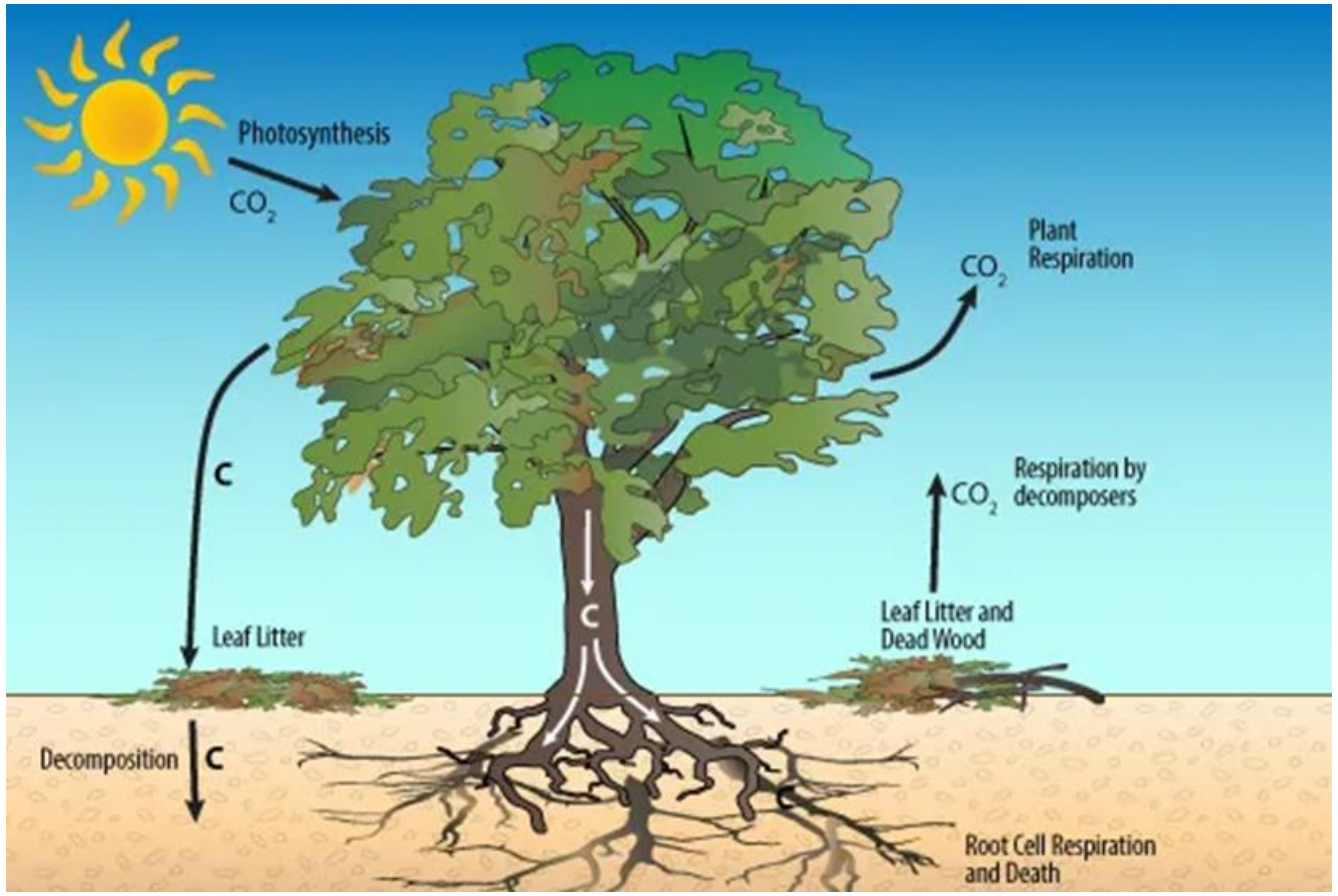
- Launch community-based restoration programs, providing funding and training for local stakeholders.
- Use native species and ecosystem-based approaches to maximize biodiversity and carbon benefits.

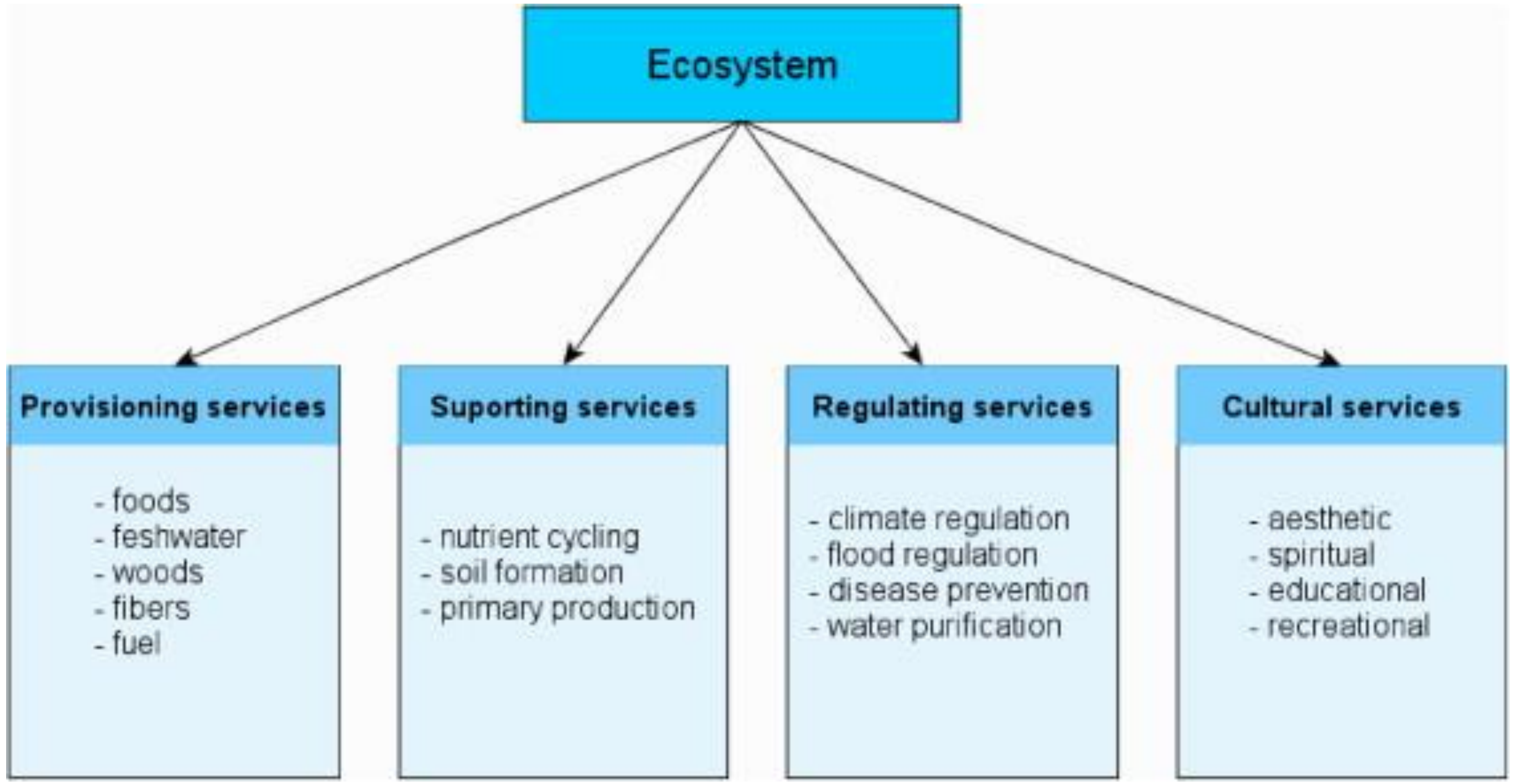
4. Strengthen Monitoring and Data Systems

- Invest in remote sensing and field-based monitoring to track mangrove extent and carbon storage.
- Create a national mangrove carbon inventory, updated regularly.

Ecological Service of Mangrove Forest

What Tree can do for You?





Let’s continue the conversation!

Message me your questions or comments in the IAIA25 app.

Wilailuk Niyommaneerat [1, 2, 3]

[1]*Sustainable Environment Research Institute*

[2]*Center of Excellence on BCG Towards Sustainable Development, Social Research Institute*

[3]*Hub of Waste Management for Sustainable Development, Center of Excellence on Hazardous Substance Management*

Chulalongkorn University, Bangkok, 10330 Thailand

wilailuk.n@chula.ac.th