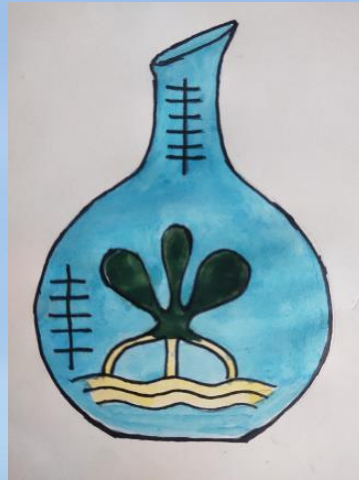


MID TERM REPORT



MEKONG DELTA LIVING LAB

AN OPEN AIR LABORATORY FOR COASTAL PROTECTION AND NATURE-BASED SOLUTIONS



Hanoi, July, 2025

The Mangrove Living Lab team

1. *Dr Le Hai Trung – Project Coordinate, TLU-ICE*
2. *Dr Phan Khanh Linh – Project member, TLU*
3. *Dr Truong Hong Son – Project member, TLU*
4. *Dr Dao Hoang Tung – Project member, HUNRE-ICE*

With cooperation with

Dr Phan Manh Hung – Project member, ICOE

Mrs Marjan Kreijns – Project Coordinate, Delft University of Technology

Ms Lindsey Schwidder – Project Coordinate, Delft University of Technology

Dr Bas van Maren – Project member, Supervisor, Delft University of Technology

Prof. Dr Thom Bogaard – Project member, Supervisor, Delft University of Technology

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1 Introduction

1.1 Project description and activities

The Living Lab project is going on in its second year of its process. The 2025 plan needs to take actions that assist what has been left out in the first year (Mission Report Sep 2024).

This fieldwork aims to achieve a view of engineering aspects on a location that has barely been impacted by artificial coastal measures, such as a permeable breakwater (the hollow piles – rocks), except for earthen sea dikes. The team has looked at hydraulics and mangrove aspects in this fieldwork campaign, including wave-flow and mangrove characteristics. The difference and improvement compared to the 2024 campaigns are that the first offshore-wave measurement had been deployed. Even though the results met the team's expectations, many challenges arose due to the real "laboratory conditions".

Table 1.1. Recall of measurements conducted since 2024 till now

| No. | Location | Time | Measured elements | | | | | | | |
|-----|------------------------------|---------|-------------------|-------|------|-----|---------|---------|----------|------------|
| | | | Water levels | Waves | Flow | SSC | Bed Sed | Weather | Sanility | Bathymetry |
| 1 | Phu Long, Cat Hai, Hai Phong | Mar/24 | x | x | x | x | - | x | - | - |
| 2 | Hoa Binh Wind farm, Bac Lieu | Apr/24 | x | x | - | x | - | - | - | - |
| 3 | Nha Mat, Bac Lieu | Aug/24 | x | x | - | x | - | x | x | - |
| 4 | Phu Long, Cat Hai, Hai Phong | Sept/24 | x | - | x | x | - | x | - | x |
| 5 | Hoa Binh Wind farm, Bac Lieu | Dec/24 | x | x | - | x | x | x | x | x |
| 6 | Ham Luong, Ben Tre | Mar/25 | x | x | x | x | - | - | - | - |
| 7 | Kim Son, Ninh Binh | Apr/25 | x | x | x | x | - | - | - | x |
| 8 | Vinh Chau, Soc Trang | Jun/25 | x | x | x | x | x | - | - | X |

Bed Sed: Bed sediment collection

1.2 Fieldwork description

The first two campaigns occurred in March and June 2025 at Ham Luong, Ben Tre* (Ham Luong river estuary) and Vinh Chau, Soc Trang*, respectively.

- Time and measurement duration

+ Ham Luong, Ben Tre: 25 March to 3 April, 2025; Measurement duration: 7 days

+ Vinh Chau, Soc Trang: 10 June to 21 June, 2025; Measurement duration: 7 days

- Location:

Ham Luong, Ben Tre: $9^{\circ}56'59.60''\text{N}$, $106^{\circ}37'21.80''\text{E}$.

Vinh Chau, Soc Trang: $9^{\circ}17'36.41''\text{N}$, $105^{\circ}58'33.36''\text{E}$.

Figures 1-1 and 1-2 are the maps of two provinces (after merging) where the measurement campaign occurred.

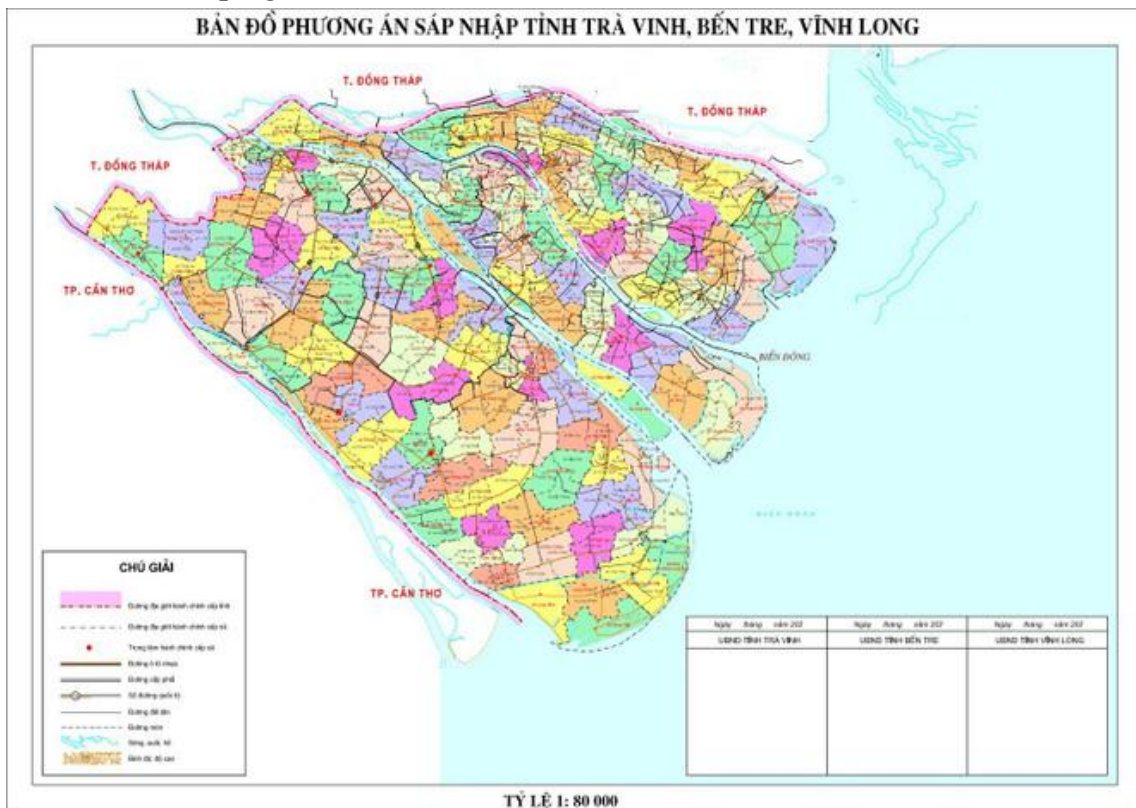


Figure 1.1. Map of new Vinh Long including Ben Tre province (Trung tâm Thông tin công tác tuyên giáo, 2025).

* Ben Tre and Soc Trang are belong to (new) Vinh Long and (new) Can Tho, respectively, after 1st July, 2025

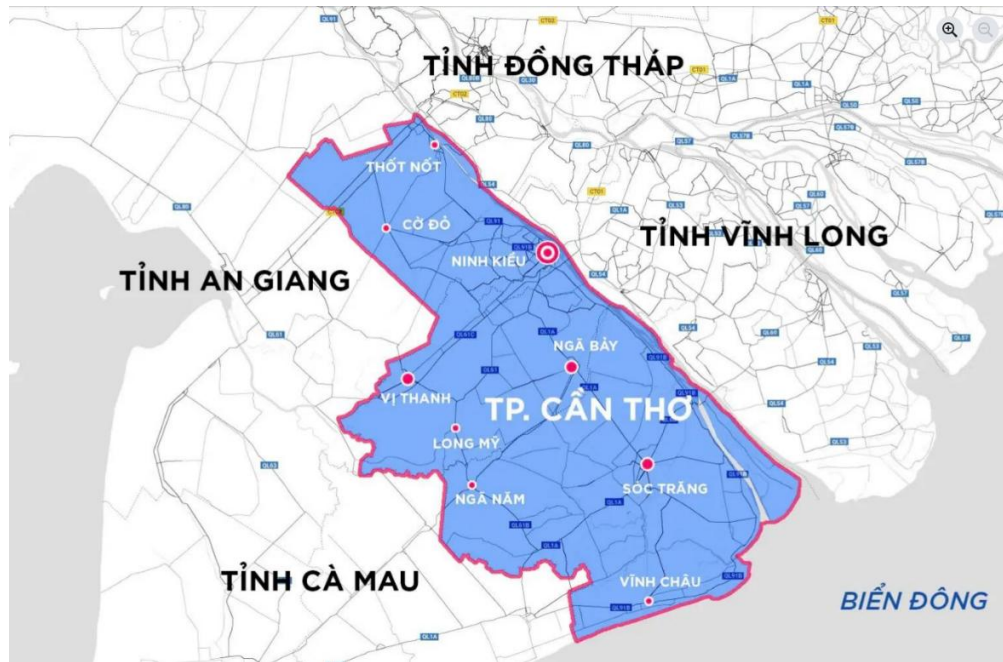


Figure 1.2. Map of new Can Tho city. Measurement locations are located in the south, named Vĩnh Châu (Governmental sources).

1.3 Equipment

The list of equipment is listed below:

Table 1.2. List of active equipment for the projects

| No. | Name | Description | Quantity |
|-----|---------------------------------------|--|----------|
| 1 | OBS-Wave buoy400 | Real-time full wave and sea surface temperature. Observational Buoy | 01 |
| 2 | Level Gauge | Real-time water level measurements using a highly accurate radar sensor. | 01 |
| 3 | Pressure-based Wave Gauge | Pressure sensor wired to power and telemetry module. Measure non-directional wave spectrum and bulk wave parameter. | 02 |
| 4 | Weather station | Comprehensive weather data comprising wind speed and direction, air temperature and pressure, solar radiation, rainfall, relative humidity, and lightning. | 01 |
| 5 | Rain gauge | Real-time gauge with 0.2 mm resolution. | 01 |
| 6 | CT Station (Water physical parameter) | All-in-one conductivity, temperature and salinity measurements. | 01 |
| 7 | Time-lapse camera | Real-time image capture. | 01 |

The equipment is developed by the Obscape company, Delft University of Technology. Measured data will be streamed to the Obscape servers with a high-speed internet connection installed inside the device. Every station is equipped with solar

power cells that can recharge in the sunlight. As a result, the installed devices can measure for up to a year without changing batteries.



(a) Wave buoy: OBS-Buoy 400



(b) Weather station



(c) Time-lapse camera



(d) Pressure-based wave gauge



(e) Level gauge Radar

Figure 1.3. Obscape devices.

Other than those devices, additional options for measuring water levels, water depth, waves and flows can be list in the table below.

Table 1.3. List of equipment deployed in all measurement campaigns

| No. | Name | Origin | Quantity | Team | Measured elements | | | | | | | |
|-----|-------------------|---------|----------|-----------------|-------------------|-------|------|-----|--------|---------|----------|------------|
| | | | | | Water levels | Waves | Flow | SSC | Bed Sd | Weather | Sanility | Bathymetry |
| 1 | Radar water level | Obscape | 1 | ICE | X | - | - | - | - | - | - | - |
| 2 | Divers | Vanesen | 4 | ICE(2), ICOE(2) | X | - | - | - | - | - | - | - |
| 3 | Wave buoy | Obscape | 2 | ICE | - | X | - | - | - | - | - | - |
| 6 | Pressure-based WG | Obscape | 4 | ICE(2), ICOE(2) | X | X | - | - | - | - | - | - |
| 7 | AEM213 | Japan | 1 | ICE | - | - | X | - | - | - | - | - |
| 8 | RTK | - | 1 | ICE | - | - | - | - | - | - | - | X |
| 9 | Low Range | - | 1 | ICE | - | - | - | - | - | - | - | X |

| No. | Name | Origin | Quantity | Team | Measured elements | | | | | | | |
|-----|-----------------|---------|----------|------|-------------------|-------|------|-----|--------|---------|----------|------------|
| | | | | | Water levels | Waves | Flow | SSC | Bed Sd | Weather | Sanility | Bathymetry |
| 10 | Weather station | Obscape | 1 | ICE | - | - | - | - | - | x | - | - |
| 11 | CT Station | Obscape | 1 | ICE | - | - | - | - | - | - | x | - |

1.3.1 Water levels and water depth

Level gauges use the method below, where d is the distance between the sensor and the water surface.

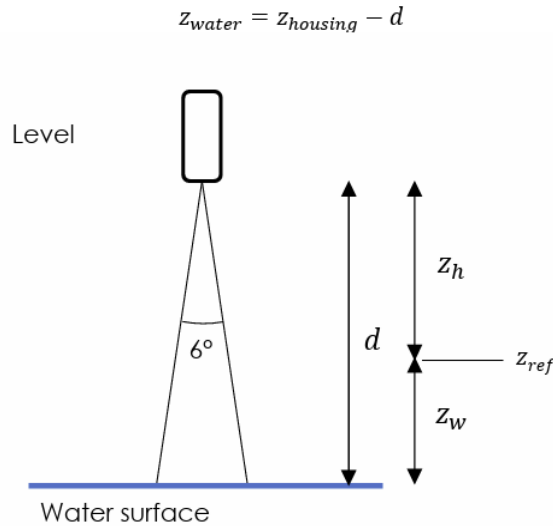


Figure 1.4. Level gauge radar principle.

1.3.2 Wave and flow

OBS-Buoy 400 can be installed at an offshore location so data can be obtained for model validation and calibration. Wave buoy uses 8 Lithium D-cells (3000mAh, 3.7 V), resulting in data recording up to 10-12 months. Data specifications are presented in Table 1-4.

Table 1.4. Wave buoy characteristics

| No. | Data specifications | Note |
|-----|------------------------------|--|
| 1 | Wave spectrum | Fully directional, including height and period, using the Maximum Entropy Method |
| 2 | Bulk wave parameters and SST | SST, H(m0, max), T(peak, m01, 02, 10, max), Dir(peak, mean) |
| 3 | Sample frequency | 6.25 Hz |
| 4 | Filtered frequency range | 0.05 – 1.00 Hz (~20 – 1 sec) |
| 5 | Bust duration | 30 minutes for each recorded data |
| 6 | Storage | Data portal, External storage |
| 7 | Communication modes | GSM (4G) |

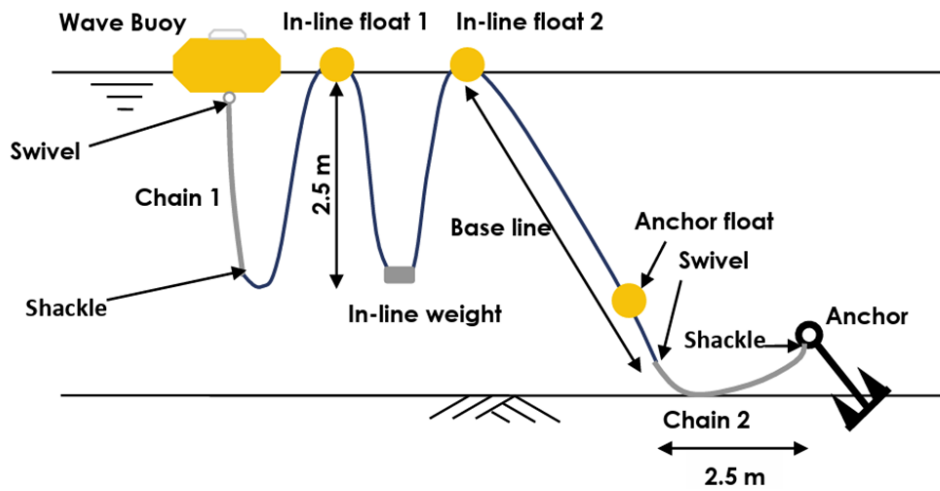


Figure 1.5. Measurement scheme of Wave buoy.

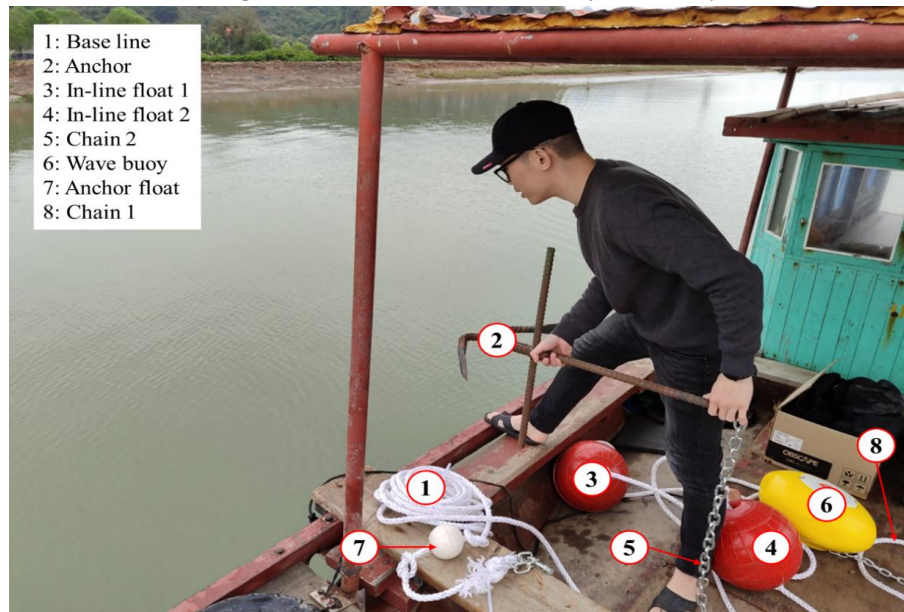


Figure 1.6. Wave buoy installation processes.



Figure 1.7. The wave buoy system has been installed. Two red balls on the left side are the in-line floating connected with easy-spot objects (flags and lights). The yellow spot on the right is the wave buoy. This system can work up to 12 months under normal conditions.

In the field, the wave buoy is vulnerable under strong wave conditions, so it should be observed and have daily checks during the measurement campaign. The team checks the buoy every 03 hours. The ideal time should be 7, 10, 13, 16, 19, and 21 hours, including several aspects, such as the general information, abnormal functions, data streaming portal, and device location. Figure 7 below shows the daily measurement and telemetry cycle.

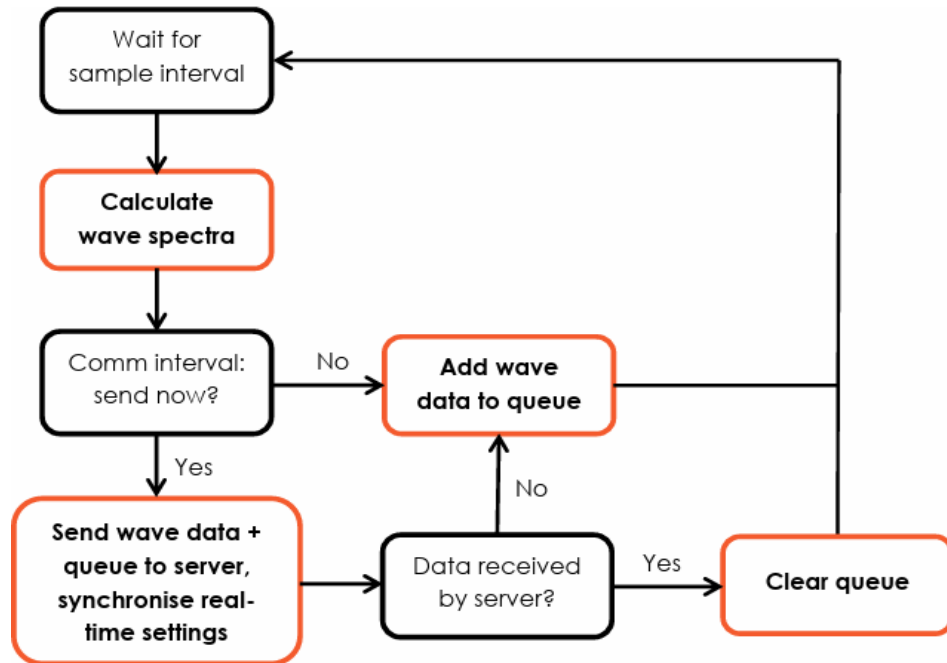


Figure 1.8. Measurement and telemetry cycle during the campaign.

Flow measurement

Flow measurements were conducted continuously throughout the survey period, with data collected at various layers. The number and location of measurement layers depend on the local depth (H) of the measurement site.

Flow measurement settings: readings were taken every 30 minutes. Each time, 10 values per flow parameter (velocity and flow direction at different layers) were recorded. Measurements were performed continuously over 7 days and nights.

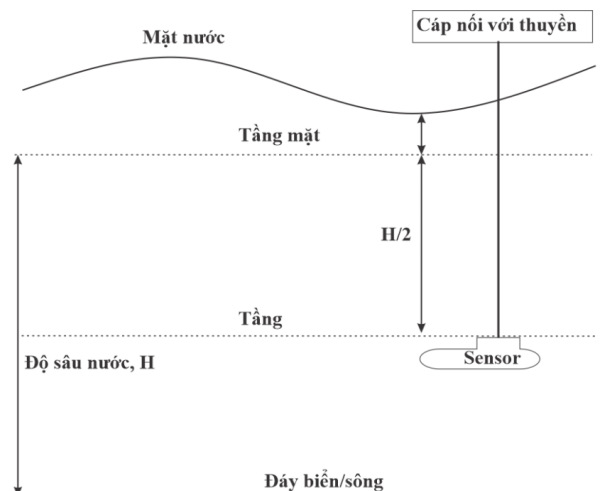


Figure 1.9: Layout diagram for flow velocity measurement at the flow measurement station

1.3.3 Sedimentation

Data will be collected from both mobile stations (extracting from the equipment) and manual. Within the field campaigns, the team collects sedimentation following the method.

Sedimentation data is collected at a frequency of 3 times per day at the current/flow or wave stations. Collecting toolkits include a 40-60cm diameter tube (See Figure 4) being collected at different depths by ropes. An ideal volume for each collecting time is designed by the supporters with metadata written, e.g., location, date and time.

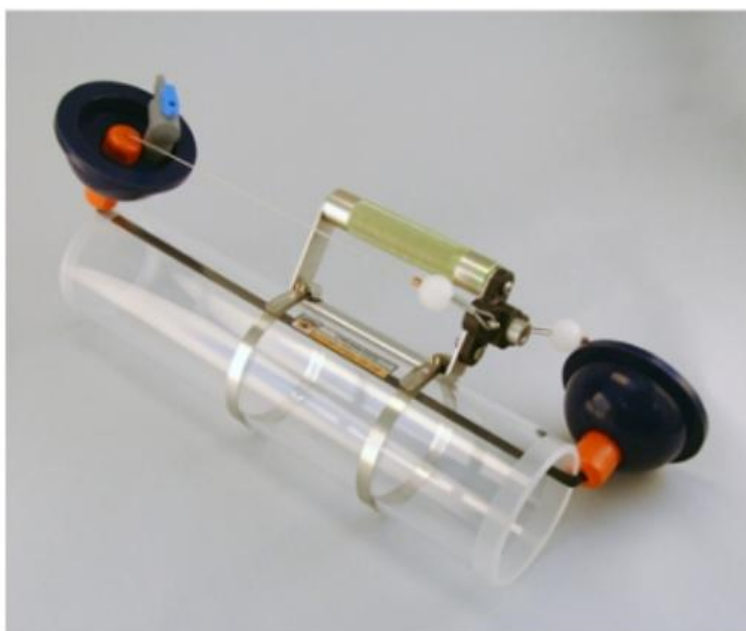


Figure 1.10. Sedimentation/Water quality collection toolkit

Every sample should be maintained in good condition before being brought to the laboratory for further analysis. Figure 5 presents the processes for sedimentation analyses.

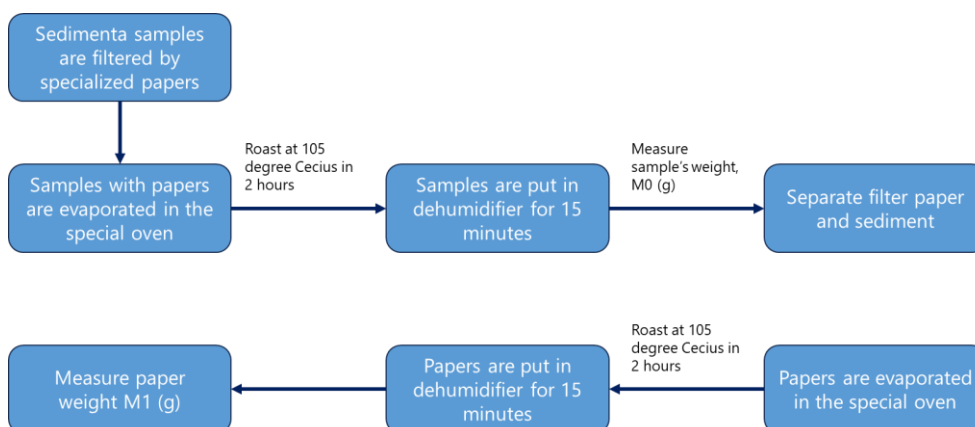


Figure 1.11. Analyzed processes for sedimentation

The sedimentation samples, including the filtered papers, are then brought to measure the secondary weights. The final result will be written in the field notes.

1.4 Participants and Partners

A list of partners and participants joining both campaigns is described below:

Table 1.5: Partners

| No. | Institution | Person in charge |
|-----|---|------------------------|
| 1 | Institute of Civil Engineering Thuyloi University | Assoc. Dr Le Hai Trung |
| 2 | Faculty of Water Resource Engineering College of Engineering Can Tho University | Dr Dinh Van Duy |
| 3 | Institute of Coastal and Engineering | Dr Phan Manh Hung |
| 4 | Hanoi University of Natural Resources and Environment | Dr Dao Hoang Tung |

Table 1.6: Participants

| No. | Name | Institution | Position |
|-----|-----------------|--------------|--|
| 1 | Đào Hoàng Tùng | HUNRE-ICE | Head of Technician team, Project members |
| 2 | Đỗ Tuấn Anh | HUNRE-ICE | Technician |
| 3 | Mai Duy Khánh | TLU-ICE | Technician |
| 4 | Trần Thị Lợi | TLU-ICE | Technician, Mangrove expert |
| 5 | Lã Phú Hiến | TLU-ICE | Technician |
| 6 | Phan Mạnh Hùng | ICOE | Head of ICOE team, Project members |
| 7 | Lê Nhật Minh | ICOE | Technician |
| 8 | Lê Hữu Nghĩa | ICOE | Technician |
| 9 | Đình Nhật Duy | Can Tho Uni. | Head of CTU team |
| 10 | Lê Hải Trung | TLU-ICE | Project coordinates |
| 11 | Trương Hồng Sơn | TLU | Project members |
| 12 | Phan Khánh Linh | TLU | Project members |

2 Ham Luong estuary - Ben Tre, the 1 st campaign of 2025

2.1 Campaign description

The fieldwork in Ham Luong, Ben Tre[†], occurs from 25 March to 3 April, 2025, which cooperates with a research project funded by the Viet Nam government (Dr Truong Hong Son is project manager at TLU). This campaign is one of the first in 2025 and partly links to the activities in the second package of the project.

Ham Luong River is a branch of the Mekong River in the Mekong Delta region, belonging to (old) Ben Tre province. This location contains interesting aspects in mangroves and flow due to the rich of nutrients and sediments from upstream flow. This study area is also highlights as the flow dominant for mangrove coasts, which is fit with the project activity aims.

2.2 Measurement settings

Measurement stations are chosen as shown in Figure 2.1, the team decides to have 01 offshore station for wave measurement and 01 nearshore station for wave, flow and suspended sediment concentration.



Figure 2.1. Measurement stations in Ham Luong.

Figures 2.2 to 2.3 illustrate offshore and nearshore stations, respectively. The offshore waves are recorded by a wave buoy, while the nearshore station includes water depth, flows and collecting sediment samples.

[†] Ben Tre is part of Vinh Long Province after 1st July, 2025



Figure 2.2. Wave buoy deployment in the field.



Figure 2.3. Wave gauge and Divers deployment. The diver in the left panel measured the water depth/level at the seaward location while the one in the right panel did the same job at the mangrove edge.

Table 2.1. List of devices and their locations

| No. | Device's name | Purposes | Lat/Lon | Note |
|-----|--------------------------------------|------------------|---------------------------------|--------------|
| 1 | WB2026 | Offshore wave | 9°57'26.40"N, 106°38'58.40"E | Full 07 days |
| 2 | Logger Divers Y6818 | Water depth | 9°56'59.60"N, 106°37'21.80"E | Full 07 days |
| 3 | Pressure-based Wave gauge PTM6005 | Wave | 9°56'59.60"N, 106°37'21.80"E | Full 07 days |
| 4 | AEM213 | Flow | 9°56'59.60"N, 106°37'21.80"E | Full 07 days |
| 5 | SSC | Sediment samples | 9°56'59.60"N, 106°37'21.80"E | Full 07 days |

Measure time: 25 March to 3 April, 2025; Measurement duration: 7 days

2.3 Data presentation

2.3.1 Water level

Water level can be converted from water depth that has already been collected by Divers. Figure 2.4 shows the water depth at two nearshore locations (see Figure 2.3).

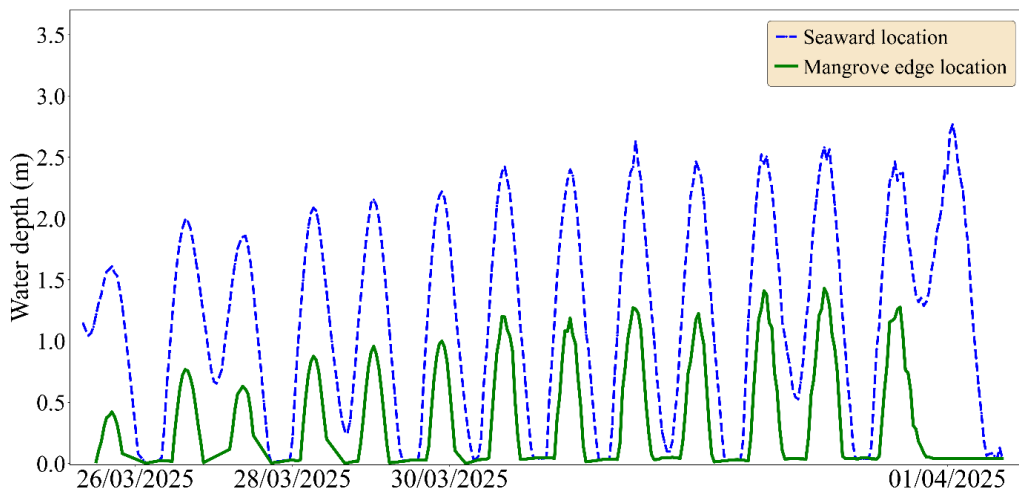


Figure 2.4. Water depth at two locations.

2.3.2 Wave

Wave characteristics are recorded and plotted from 2 stations, offshore (Wave buoy, Figure 2.2) and nearshore (Wave gauge, Figure 2.3). Data plots include significant wave heights, peak wave periods and wave direction (wave rose).

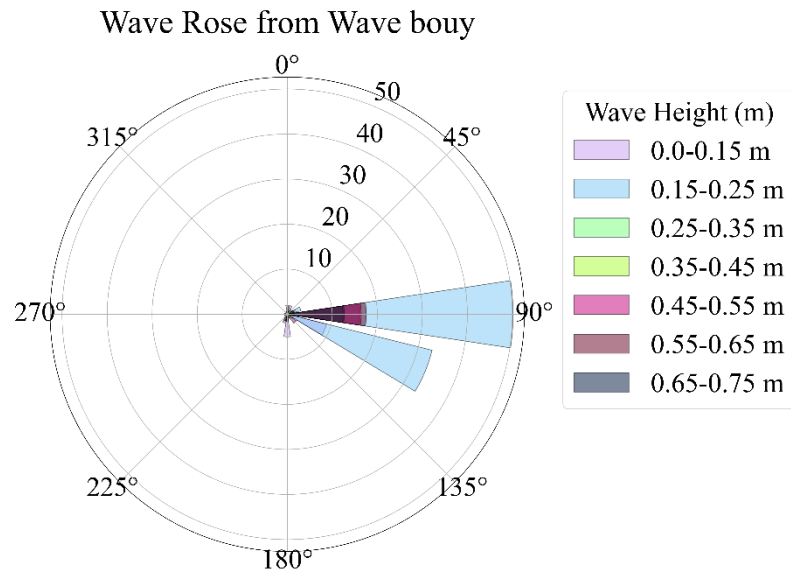


Figure 2.5. Wave rose for wave height at the offshore station recorded by the Wave buoy.

In Figure 2.5, wave directions are mostly from the East as the data recorded are still getting effective in the winter monsoon.

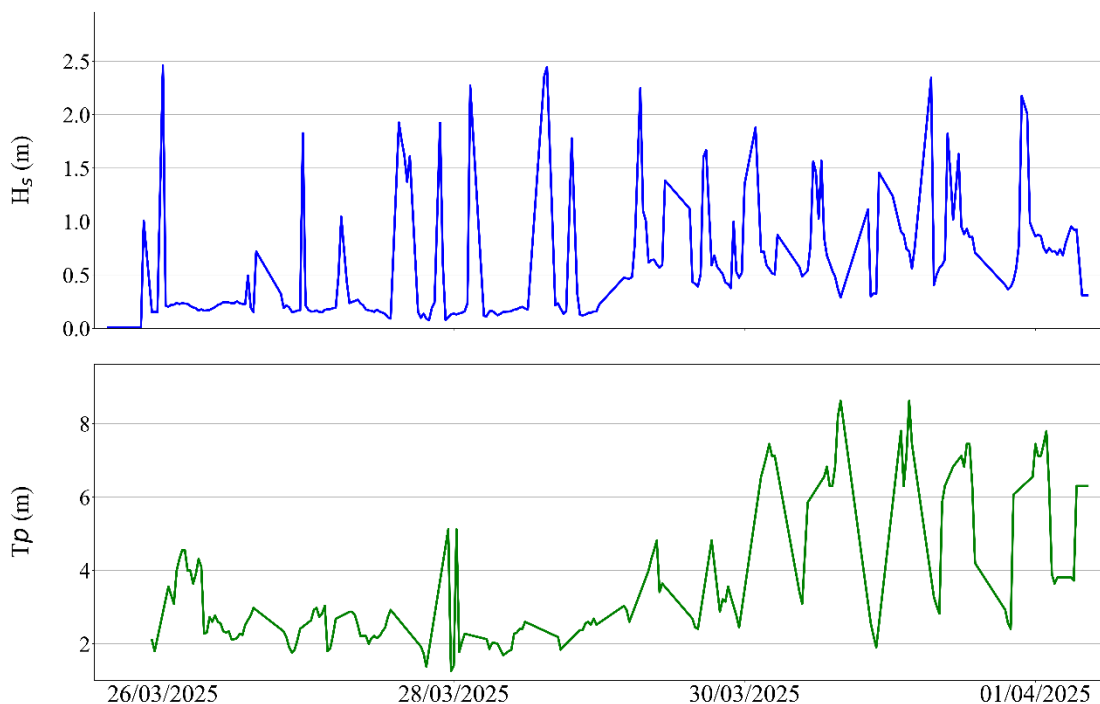


Figure 2.6. Significant wave height and peak wave period from the offshore station.

In Figure 2.6, maximum wave heights are quite high some of the time, but mostly averaging around 0.8 to 1.2 m. There are larger waves recorded from 31 March to 01 April due to the high wind event.

2.3.3 Flow

Flow velocities are plotted in Figure 2.7 with time. The average value is approximately 0.15 m/s and reaches a peak at high water level, at a maximum of 0.77 m/s.

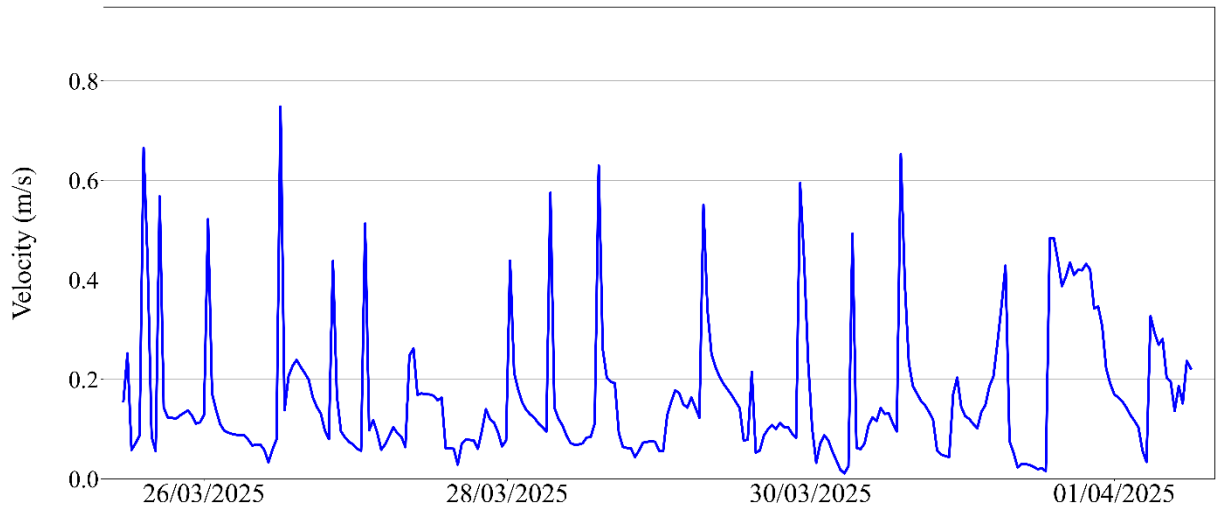


Figure 2.7. Flow velocity at the mangrove edge

Flow direction-value distributions show that the maximum value of velocity is about 0.15 m/s, and the majority follow the North-East direction.

Flow Rose from AEM213 at Mangrove edge

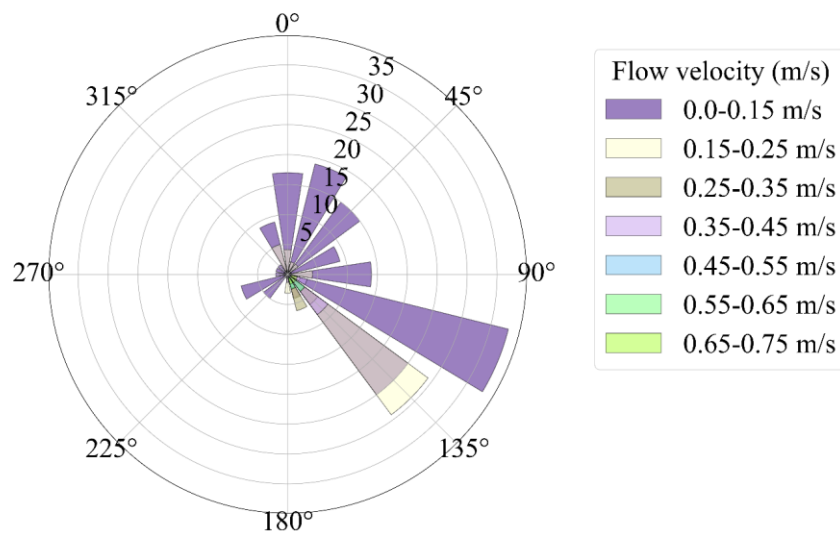


Figure 2.8. Velocity rose from flow data.

2.3.4 Suspended sediment concentration

Suspended sediment concentration is calculated from the weight of sediment in a 1.5-litre sample. The data changes over time and follows the water elevation during the day. The highest SSC shows at over 1.0 g/dm³ at the deep water (1.4 m). On average, the mean SSC ranges at around 0.2 g/dm³.

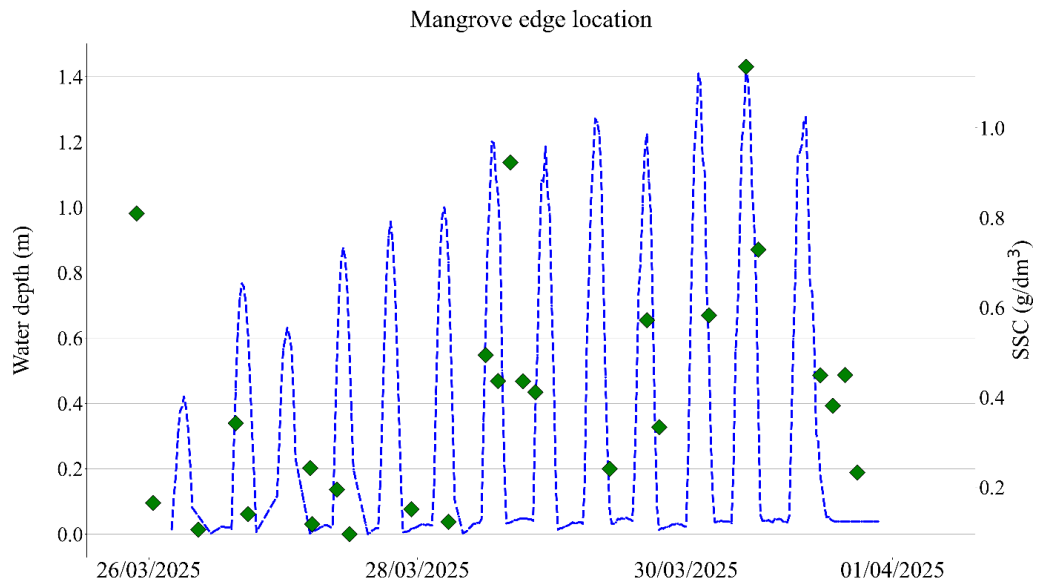


Figure 2.9. Suspended Sediment Concentration (SSC) at the mangrove edge.

3 Vinh Chau - Soc Trang, the 2nd measurement campaign of 2025

3.1 Campaign description

The Vinh Chau-Soc Trang fieldwork occurs at the time the team finds that there is an interesting phenomenon happening along the Vinh Chau coast. There is also a necessity to start activities at the shore where mangroves are healthy and less susceptible to human intervention. More importantly, the Vinh Chau mangrove coast can be set as a laboratory where the team can fix the boundary for further measuring.

This measurement starts on 10 June and ends on 21 June, including many activities, i.e., measuring offshore and nearshore waves, obtaining offshore flow, and collecting SSC and bed sediment samples. Bathymetry and mangrove surveys are also carried out.

3.2 Measurement settings

The team has decided to use devices/equipment that can measure nearshore and offshore measurements. Wave buoy (WB2006, Obscape) and Sentinel-V20 (Acoustic Doppler Current Profilers – ADCPs, US) were installed in an offshore location. The Logger TWR2050R-RBR for waves and Divers – Vanessen for water levels. The team also set up Radar Water Level (PTM6003) for water level at the Hoa Binh Wind farm. Other than those collection methods, technicians collected samples, including suspended sediment and bed sediment samples, manually. The list of devices is shown below.

Table 3.1. List of devices and stations

| No. | Device's name | Purposes | Lat/Lon | Note |
|-----|---------------------|--------------------------|---------------------------------|--------------|
| 1 | WB2026 | Offshore wave | 9°15'35.80"N, 105°57'23.90"E | Full 07 days |
| 2 | Sentinel-V20 | Offshore wave & flows | 9°15'35.80"N, 105°57'23.90"E | Full 07 days |
| 3 | Logger TWR2050R-RBR | Nearshore wave | 9°17'21.99"N, 105°58'27.19"E | Full 07 days |
| 4 | Logger Divers Y6818 | Water depth | 9°17'21.99"N, 105°58'27.19"E | Full 07 days |
| 5 | PTM6003 | Water level | 9°9'23.85"N, 105°42'29.58"E | Full 03 days |



Figure 3.1. Locations of stations. The left figure includes the nearshore and offshore wave-flow stations (WB and Flow). The right figure consists of a nearshore wave station (WG01), Suspended Sediment Concentration (SSC01 and SSC02), Bed Sedimentation (BSd-011 to BSd-033), Standard Mangrove Measured Size (OTC-01 to OTC03) and Cross-shore profiles (yellow lines). Vinh Chau Fishery Port is located in the north, where the team works with partners.

Here are photos from the fieldwork for device installation:



Figure 3.2. Wave buoy (left) and Sentinel-V20-ADCP (right panel)



Figure 3.3. AEM213 installation

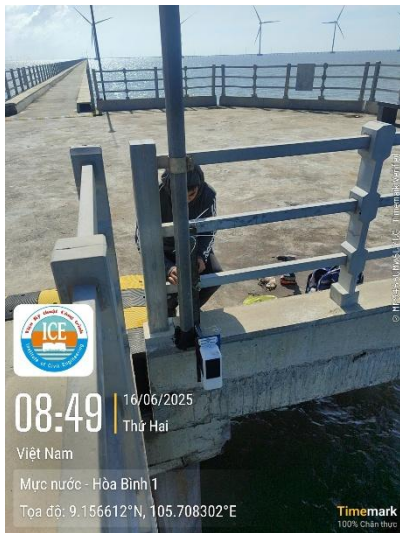


Figure 3.4. Radar water level PTM6003 (left), Logger RBR (middle) and Divers (right)

Nevertheless, suspended and bed sediment samples are collected in a traditional way at chosen locations based on the actual situations. In Figure 3.5, suspended sediment samples are collected at two locations, near the shore and offshore. Samples are kept in a plastic bottle (01 Litre) and filtered with special papers, date and time are carefully recorded for later analyzing. Bed sediment samples are collected manually at chosen locations along the chosen cross-shore profile (Figure 3.1). The figures below present actual activities in the field.



Figure 3.5. Suspended Sediment samples are collected and kept in a plastic bottle at the offshore station.

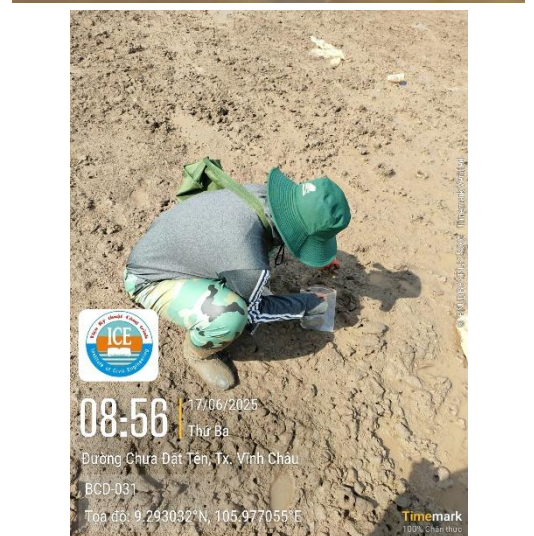
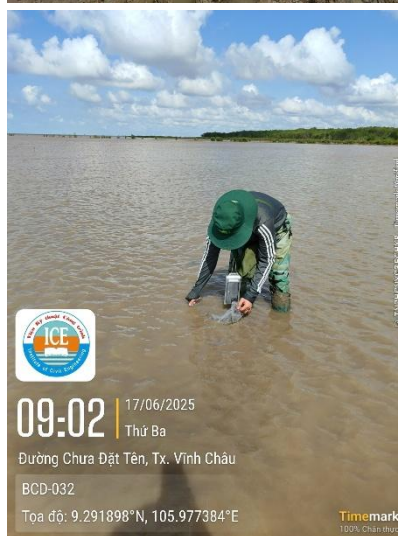
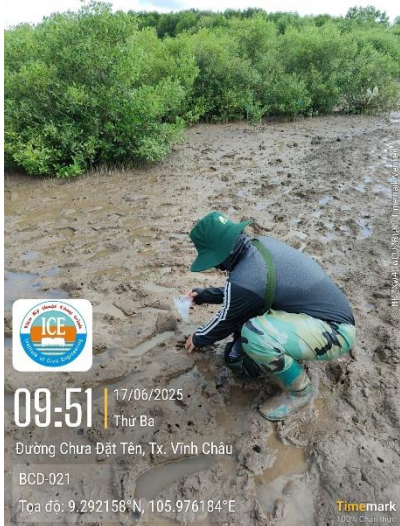


Figure 3.6. Collecting bed sediment samples

3.3 Data presentation

3.3.1 Water level and depth

Water level and water depth are collected at offshore and nearshore stations. As seen in Figures 3.7 and 3.8, water elevations follow the movement of tidal motions. At the nearshore location, water depth reaches 1.0 m as the deepest value, while water depth at the offshore station averages around 3.0 m.

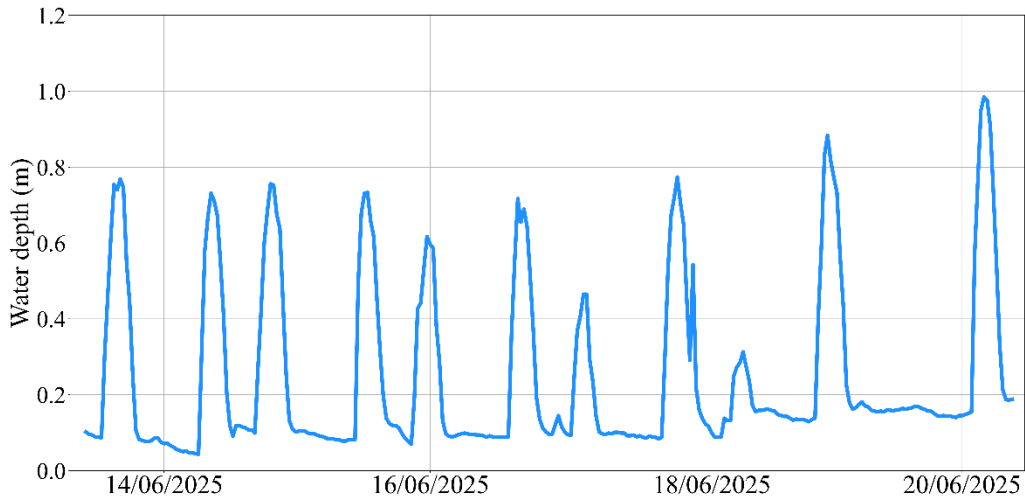


Figure 3.7. Water depth from Divers at nearshore location (See Table 3.1 and Figure 3.1)

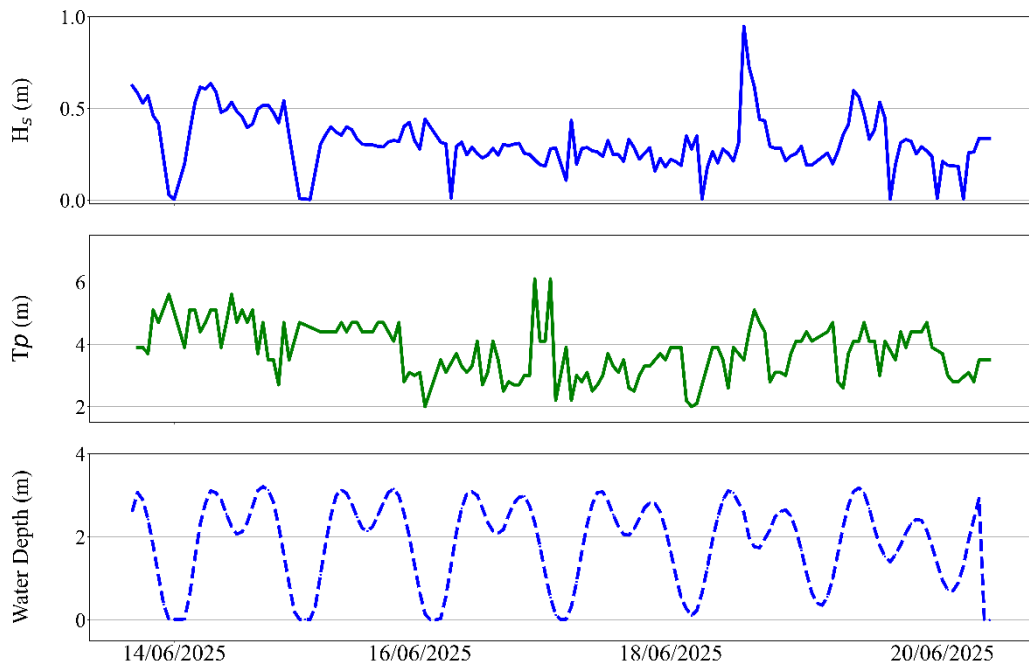


Figure 3.8. Wave data records from Sentivel-V20 at the offshore location, including water depth (bottom panel).

3.3.2 Waves

Figure 3.9 presents the wave heights, wave periods and water depth at the nearshore station. As seen in it, wave heights are quite small and dependent on water elevation. The largest wave has over 0.4 m of height, and the mean height is around 0.1 m. Due to the gentle forshore, waves are relatively small, with wave periods are only around 1.6 seconds.

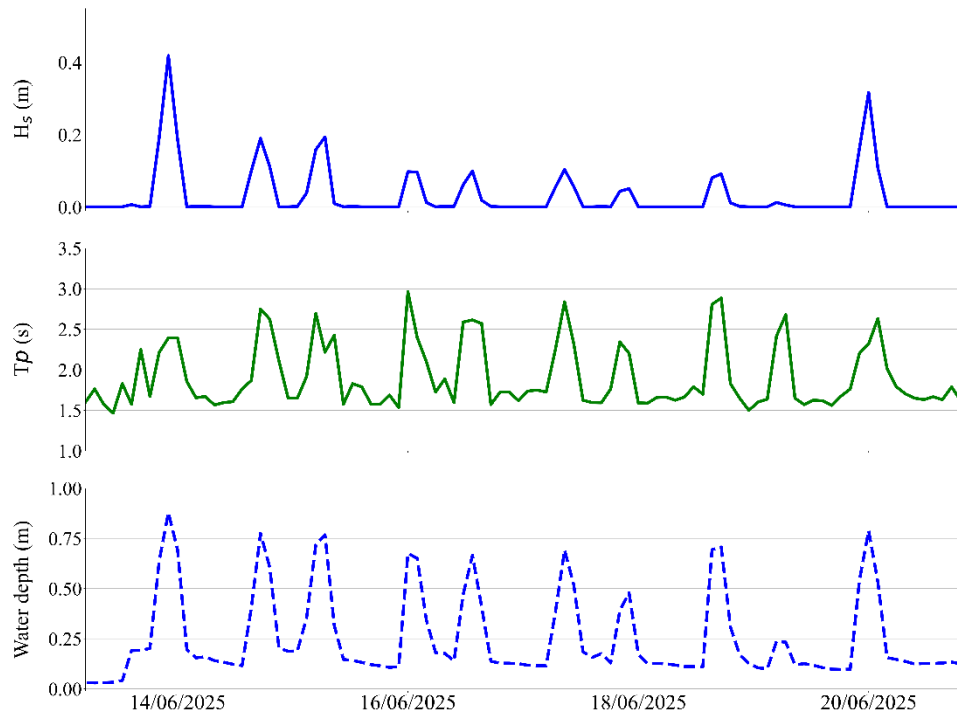


Figure 3.9. Wave characteristics at nearshore location, including significant wave height (H_s), peak wave period (T_p) and water depth.

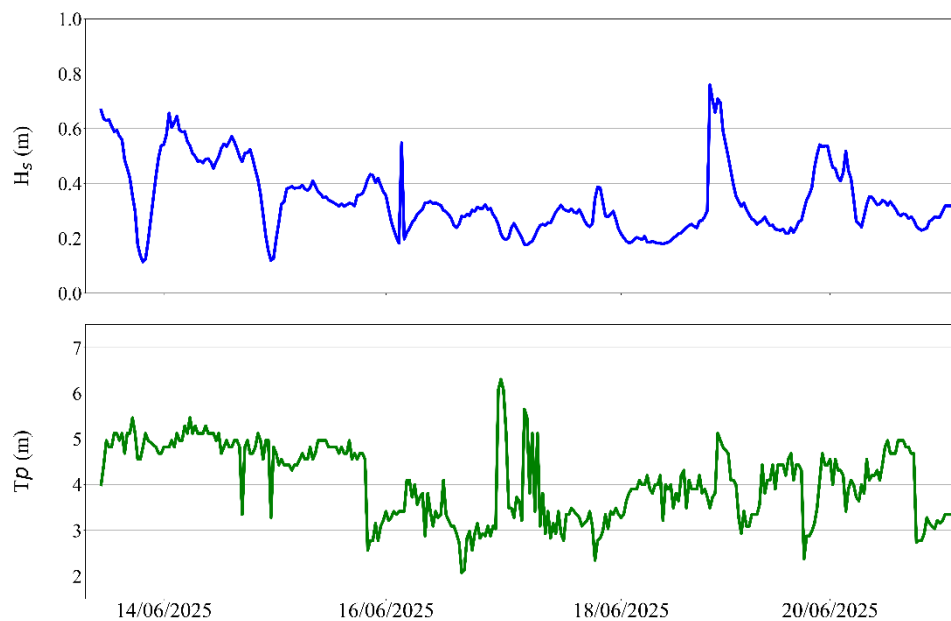


Figure 3.10. Wave characteristics at the offshore station.

The time of this fieldwork is during the summer monsoon; therefore, waves are relatively small even at the offshore station. The largest wave is recorded as 0.8 m on 19 June, but the period is relatively small at 5 seconds.

Wave directions in the summer monsoon are mainly SE, and the data show relatively close to the theory. Figure 3.11 shows the main direction is SE and secondly E, with the wave heights ranging from 0.25 to 0.35 m.

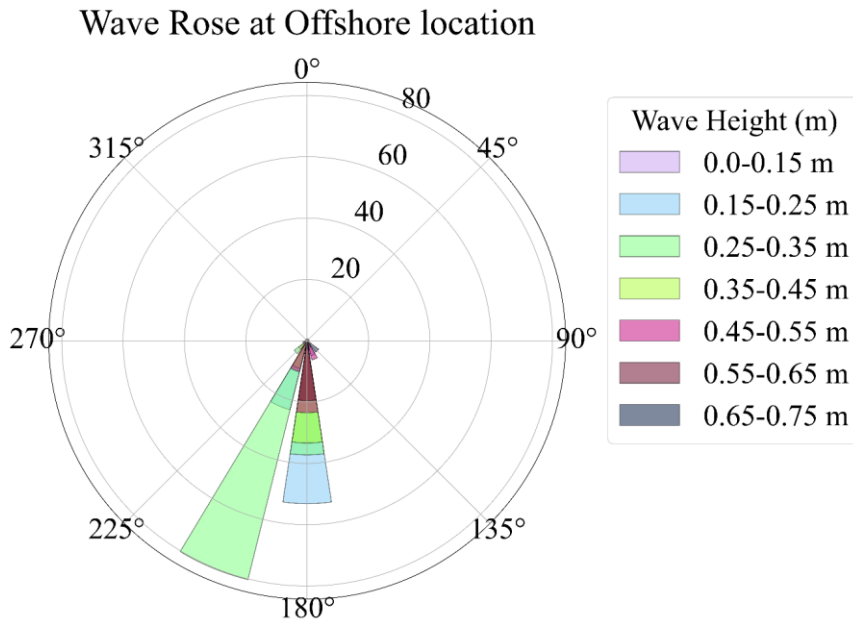


Figure 3.11. Wave direction contribution analyzed from the Wave buoy at the offshore location.

3.3.3 Flow

The support of colleagues from Can Tho University brings out the Sentinel-V20, which allows the team can record flow at different depths. In Figure 3.12, flow velocity at the vertical axis (from the top of the sensor, see Figure 3.2) is shown, which indicates to tell the flow velocity follows the tidal motions.

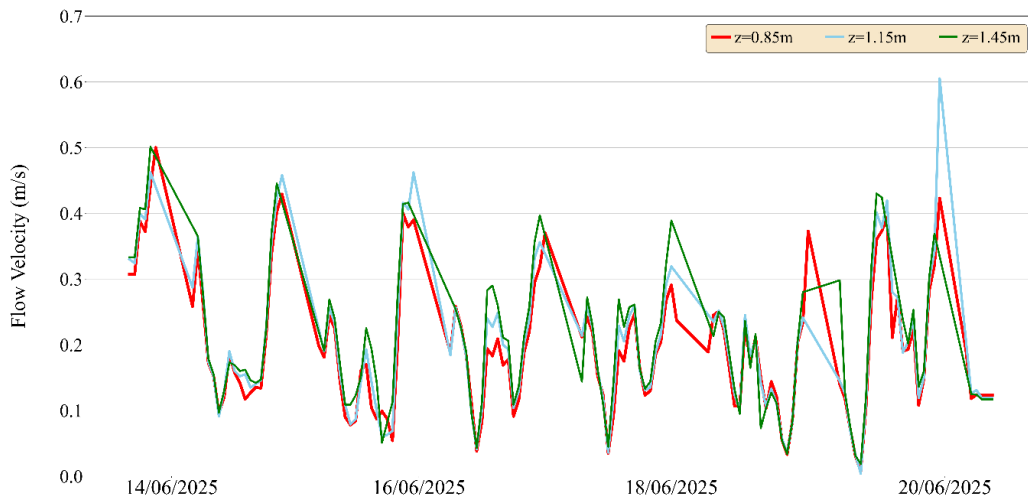


Figure 3.12. Flow velocity at offshore stations. Data is recorded at three vertical axes that are calculated from the device sensor.

Figure 3.13 presents flow velocity contribution with directions at the offshore station. The graph shows the SE flow with velocity of 0.15-0.20 m/s are the majority while lower velocities from S and SEE directions are ranging from 0.10-0.15 m/s. Higher velocities are only shown less than 10% of recorded data.

Flow Rose at the offshore station

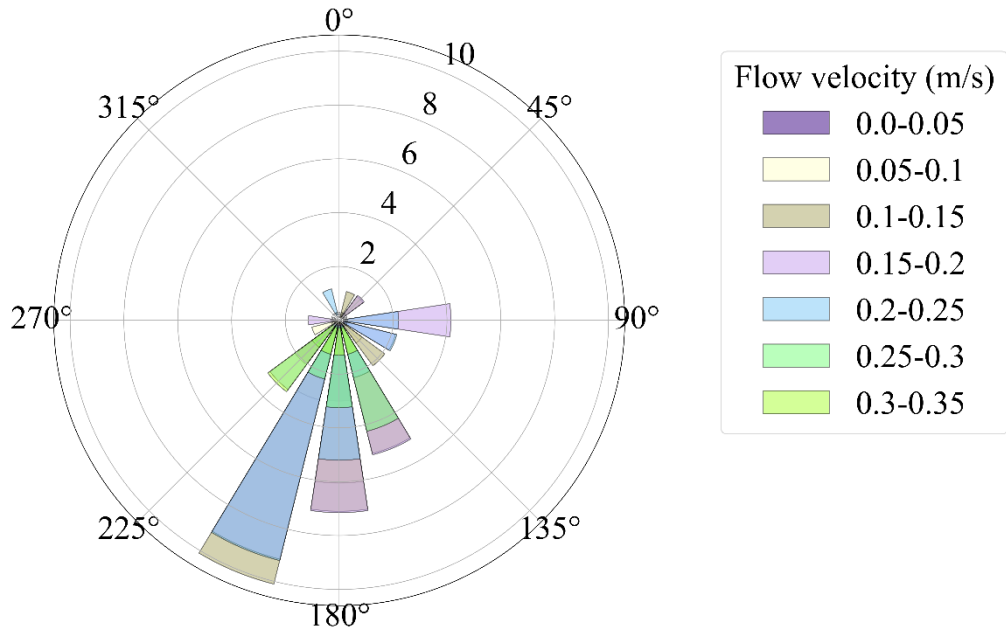
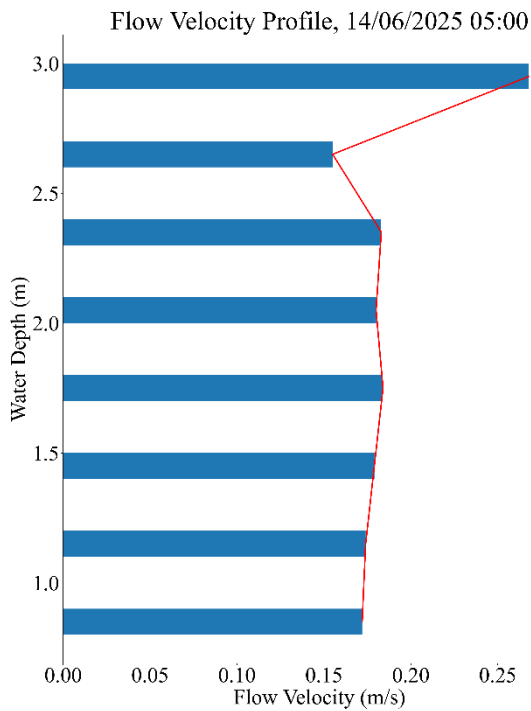
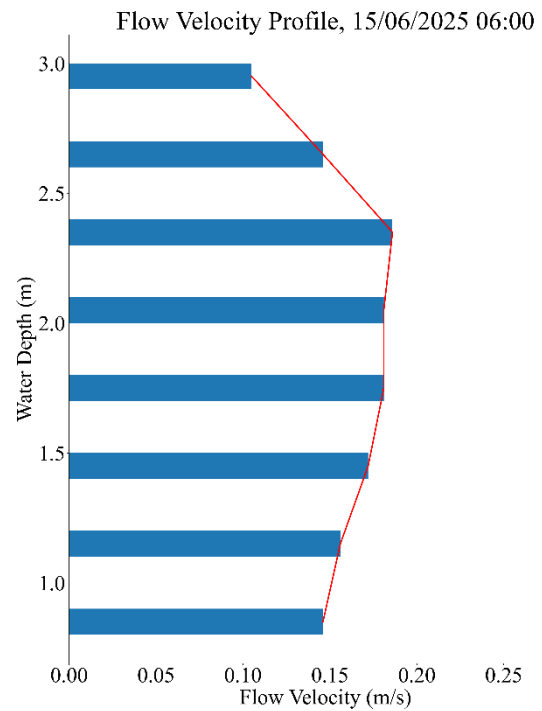


Figure 3.13. Flow velocity distribution at $z = 0.85$ m (close to sensor of Sentinel-V20)

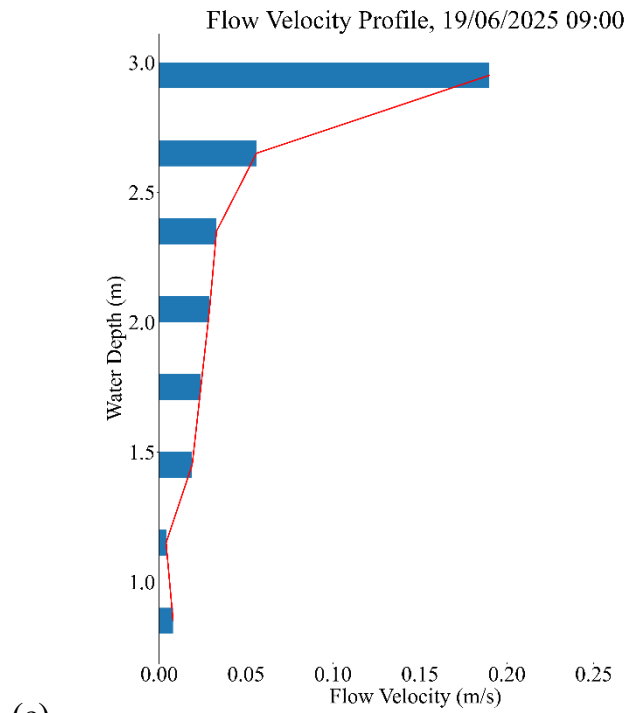
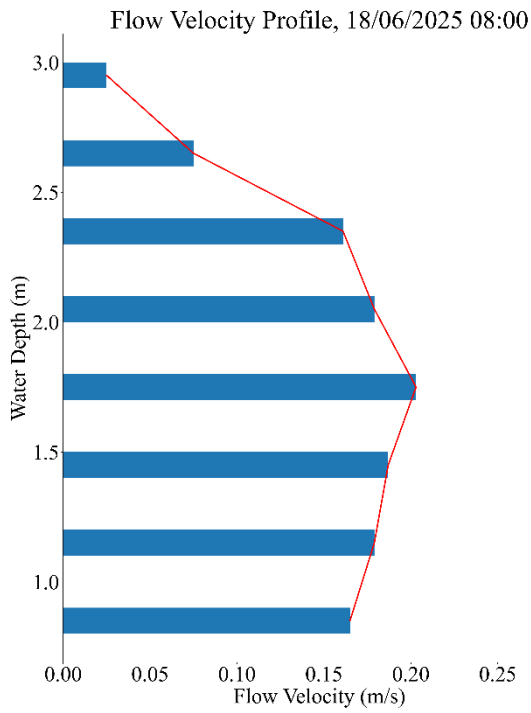
The average flow velocity is around 0.2 m/s and reaches 0.4 to 0.5 m/s in some cases. In Figure 3.14, flows over depth are illustrated, giving an idea of wave structures.



(a)



(b)



(c)

(d)

Figure 3.14. Flow velocity profile recorded from ADCP at offshore stations.

3.3.4 Suspended sediment concentration

Figures 3.14 and 3.15 present the SSC with water depth at two stations, near and offshore. In general, SSC on the shore are much larger and more dense than in the seaward location. The average of SSC in the offshore station is around 0.2 g/dm^3 , but this number in the shore is nearly triple.

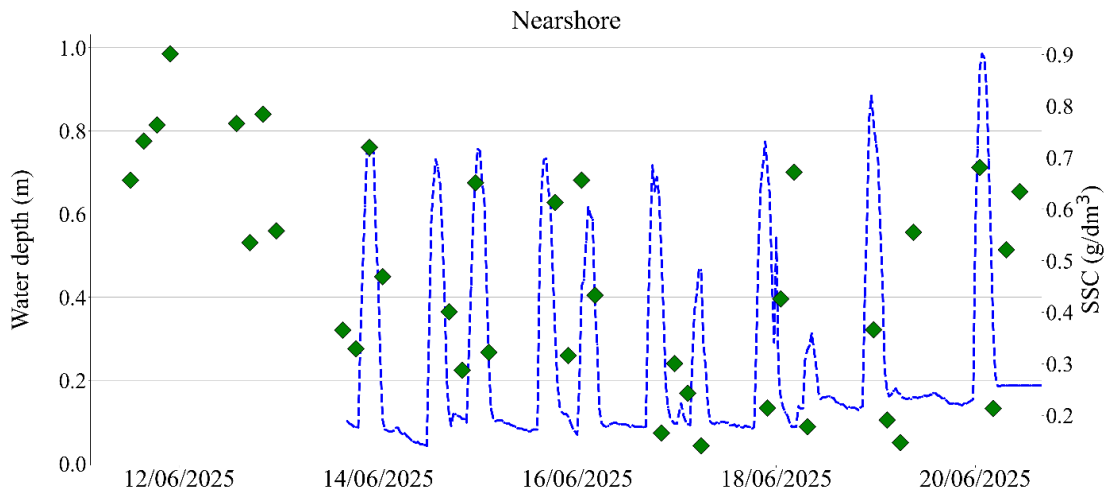


Figure 3.15. SSC at nearshore location

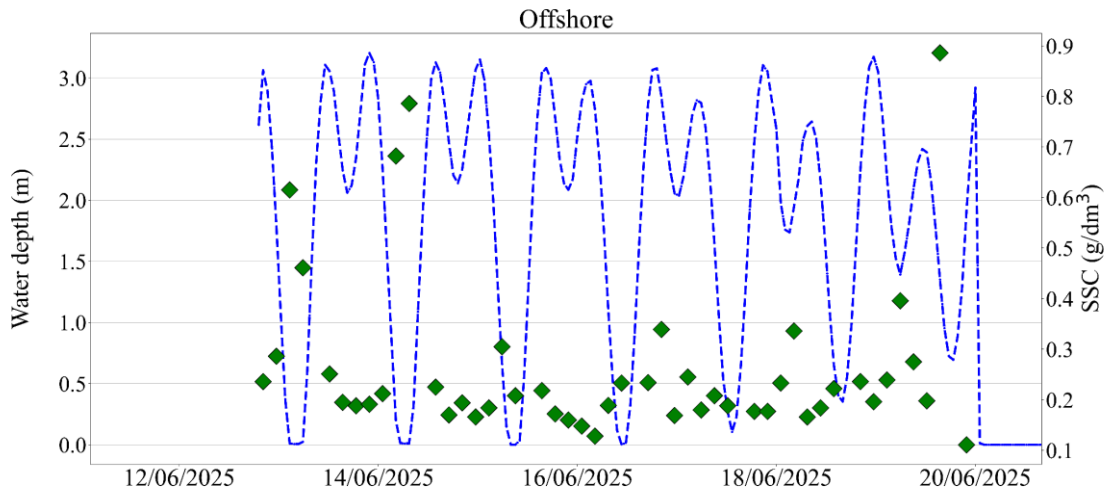


Figure 3.16. SSC at the Offshore station.

3.3.5 Bed sediments

Bed sediments are analyzed to have grain sizes as D50 and D90. In general, the grain size increases with the distance seaward. In Figure 3.16d, there are a total 09 bed sediment samples representing three standard sediments of the coast. Sand will be distributed more at the location further offshore, then finer sediments are at closer mangroves.

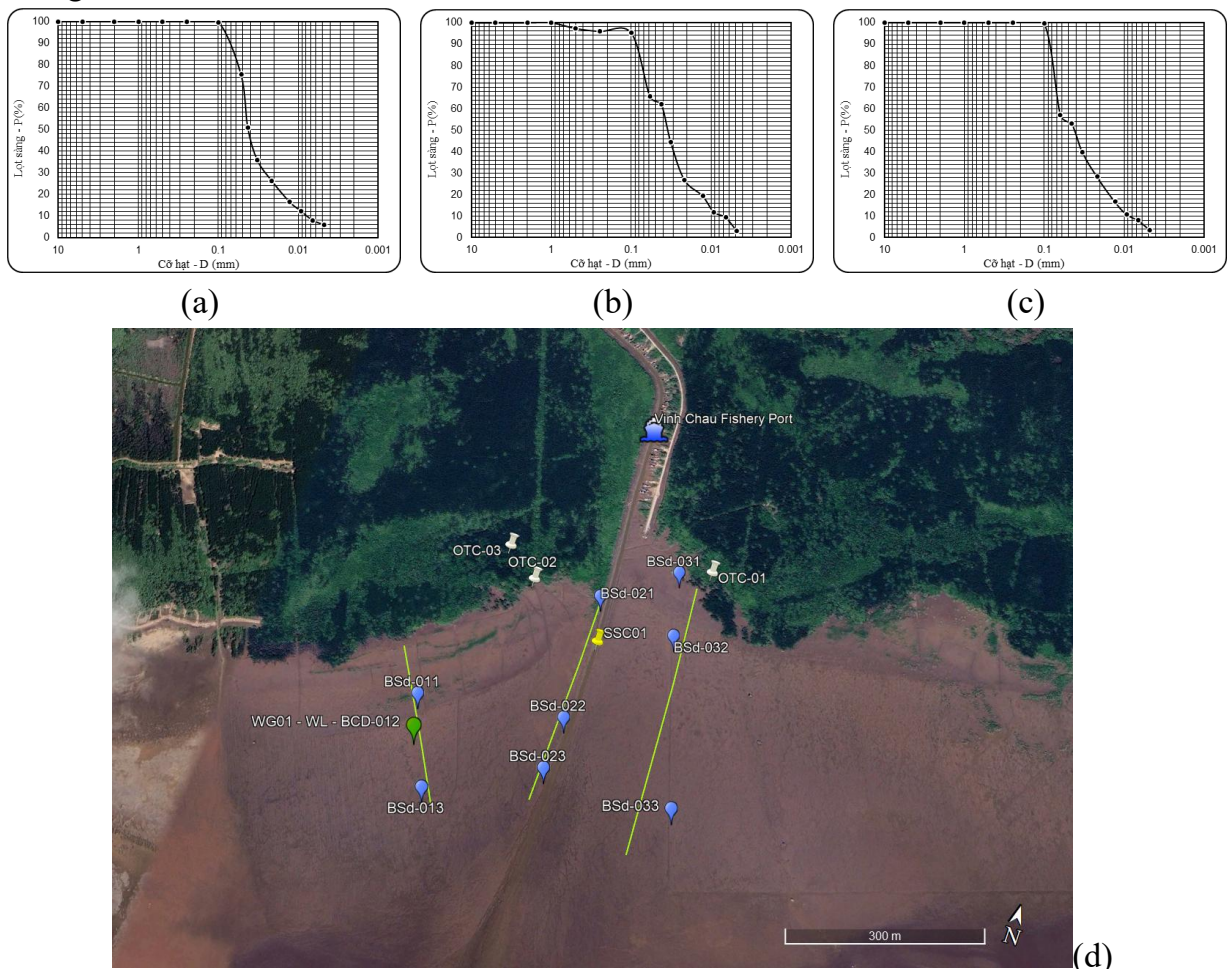


Figure 3.17. Bed sediment diameter contribution (a, b, and c in the left panel) and sample locations (d). Note that BSd is Bed Sediments

3.4 Bathymetry measurement

3.4.1 Settings

Bathymetry measurements are set to cover an area with a 4km in length and 700m in width as shown in Figure 1(left). Devices used for this task including the RTK and Fish-radar LowRange (See Figure 3.17).

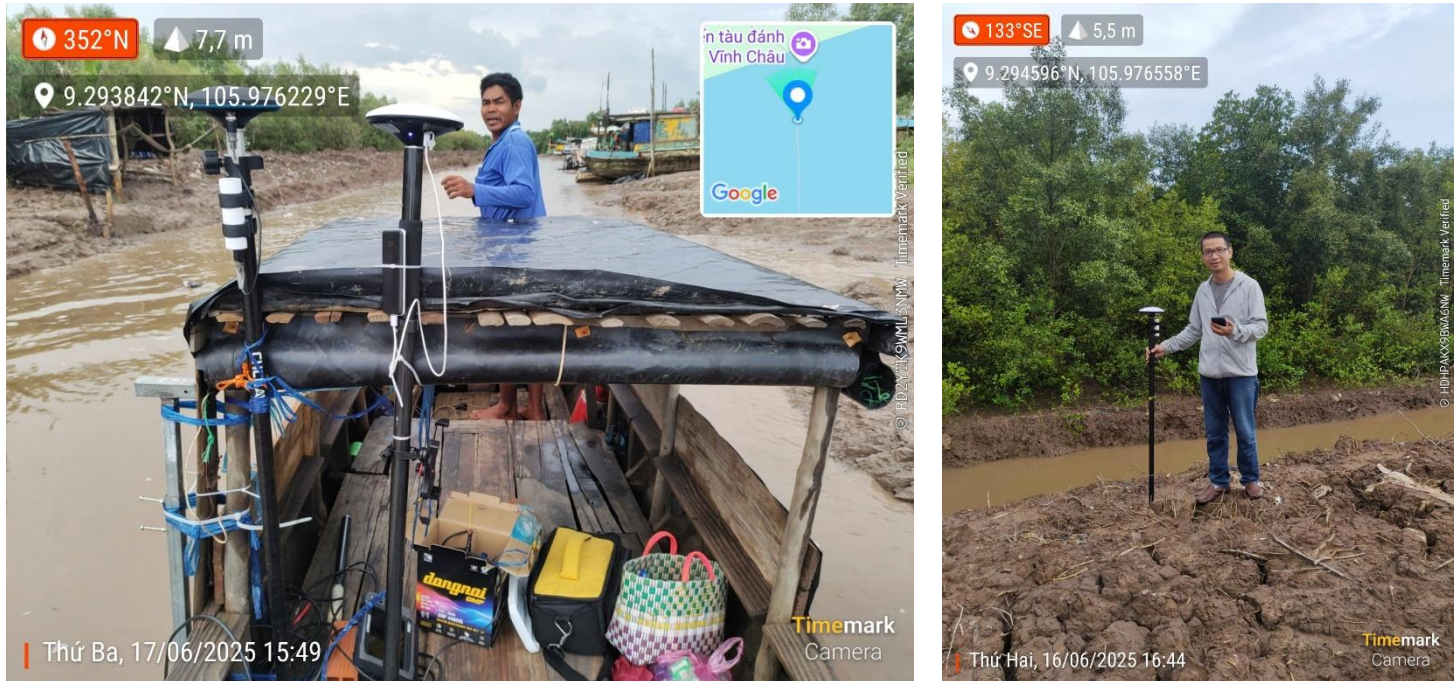


Figure 3.18. Equipment settings for bathymetry measurement

3.4.2 Data available

The data received after the fieldwork are presented in Figure 3.18.

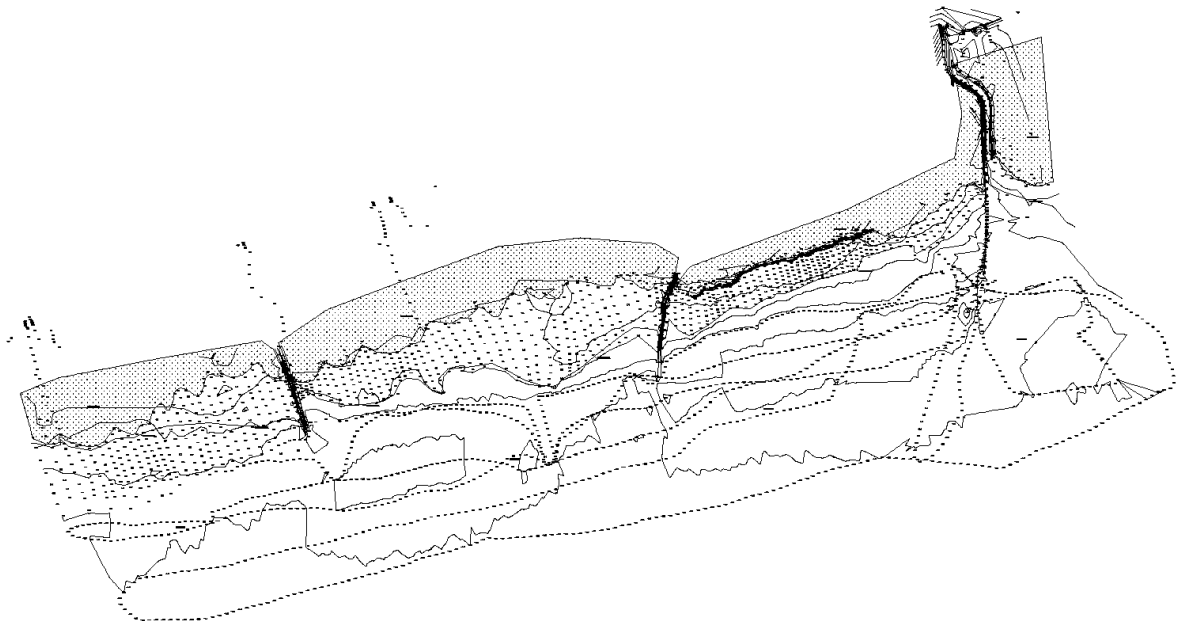


Figure 3.19. Bathymetry maps (raw) collection.

3.5 Mangrove survey

3.5.1 Settings

Mangrove surveys can be done within a sampling plot shown in Figures 3.19 to 3.21 and located in Figure 3.16d. The composition of mangrove species in the sampling plots are identified. After choosing the plots, experts will count and measure all necessary mangrove aspects, including the diameter of bodies, trunks and roots. More importantly, experts and volunteers need to define mangrove species in order to draw conclusions about their relation to the hydrodynamics.

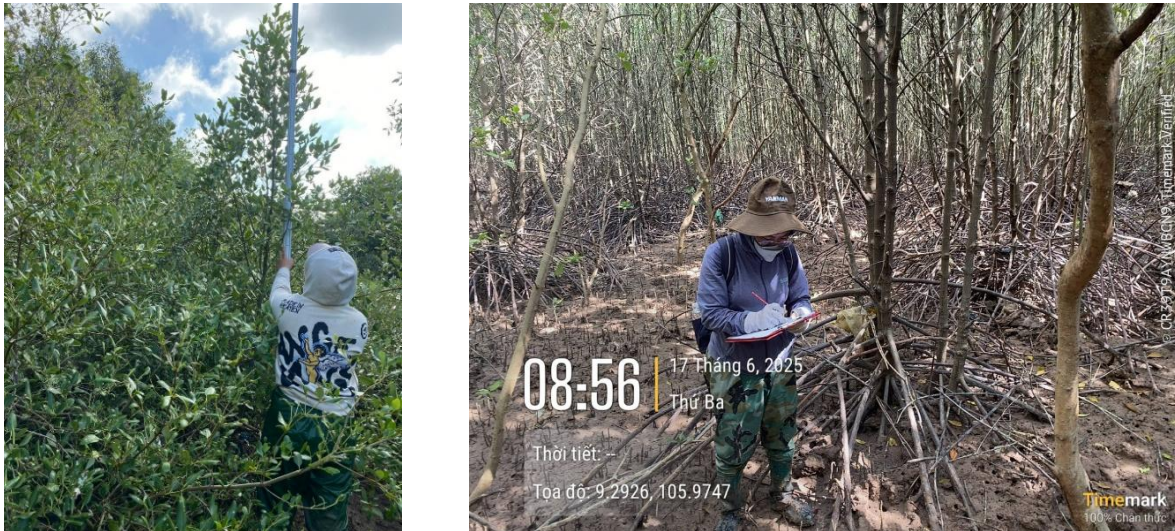


Figure 3.20. *Avicennia marina* in plot 1 (left panel), *Rhizophora apiculata* in plot 2 (right panel)

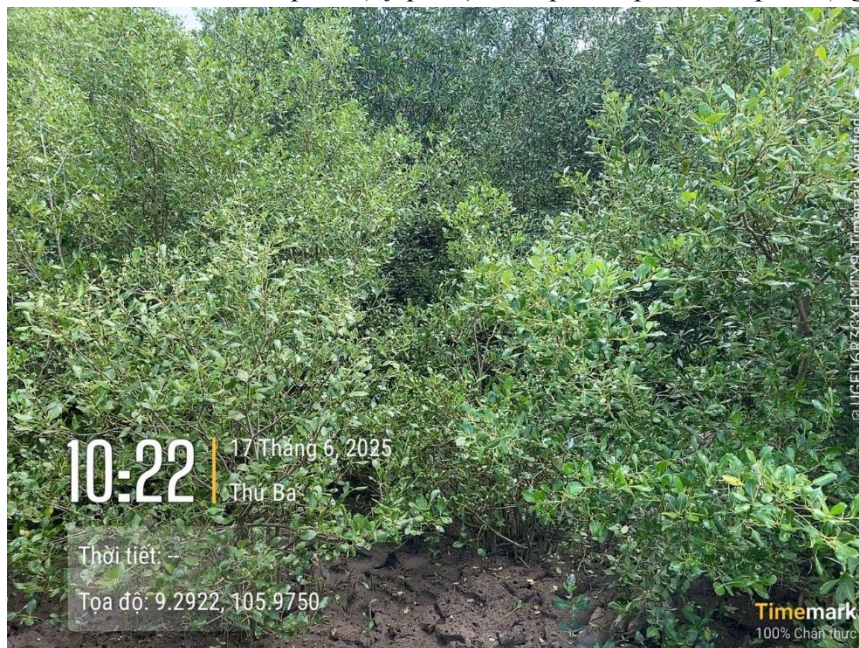


Figure 3.21. *Avicennia marina* in plot 3



Figure 3.22. Natural regeneration of mangroves on alluvial plain (left panel), *Avicennia marina* seedlings in plot 3 (right panel)

3.5.2 Data availability

Mangrove growth in sample plots is described below:

Table 3.2. Mangrove description in Vinh Chau

| Plot | Dominant species | Species | Hvn \pm SD (m) | Do \pm SD (cm) | D1.3 \pm SD (cm) | Dt \pm SD (m) |
|--------|---|---------|------------------|------------------|--------------------|-----------------|
| Plot 1 | Mixed <i>Avicennia marina</i> + <i>Rhizophora apiculata</i> (Planted) | Am | 3.03 \pm 0.96 | 4.0 \pm 1.8 | 2.2 \pm 1.5 | 1.54 \pm 0.56 |
| | | Ra | 3.29 \pm 0.52 | 3.4 \pm 1.3 | 2.6 \pm 1.7 | 1.23 \pm 0.35 |
| Plot 2 | Mixed <i>Rhizophora apiculata</i> (Planted) + <i>Avicennia marina</i> (Natural) | Ra | 7.11 \pm 1.27 | 6.1 \pm 1.7 | 5.3 \pm 1.5 | 2.34 \pm 0.75 |
| | | Am | 6.23 \pm 1.83 | 8.4 \pm 4.7 | 6.4 \pm 3.6 | 1.87 \pm 1.20 |
| Plot 3 | Mixed <i>Avicennia marina</i> + <i>Rhizophora apiculata</i> (Natural) | Am | 3.67 \pm 1.27 | 5.2 \pm 3.1 | 3.3 \pm 2.65 | 2.02 \pm 0.96 |
| | | Ra | 5.25 \pm 1.77 | 9.9 \pm 1.5 | 5.7 \pm 0.8 | 3.50 \pm 0.56 |

Other than the data collected from the field, data from geographical images can also assist the project. Figure 3.22, mangrove distribution over the Vinh Chau coast can be shown in different colours. The majority of species are *Rhizophora apiculata*; however, nearly half of the area is still under discovering.

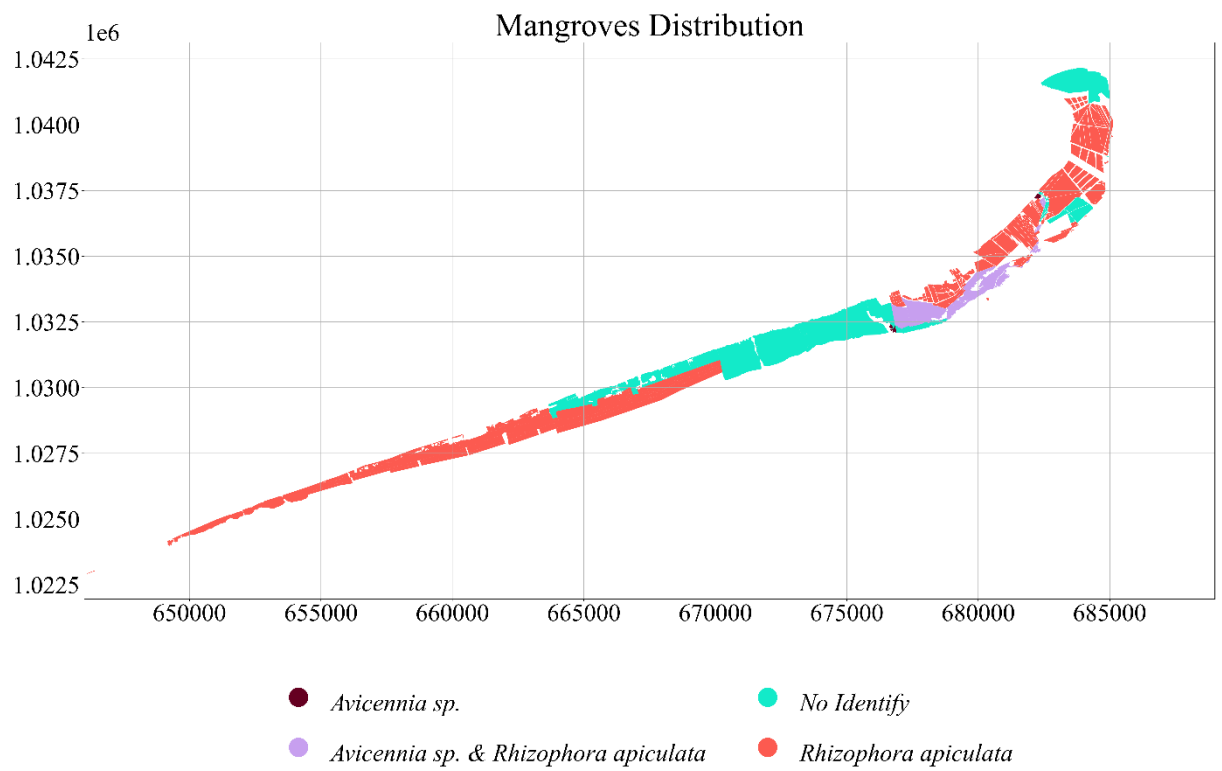


Figure 3.23. Mangrove distribution over Vinh Chau.

4 Digital Living Lab Platform

4.1 Mangrove Living Lab's digital space

As part of the project, the team is developing a digital space, referred to as the Mangrove Living Lab's digital space. The primary purpose of this digital space is to support sharing and connection between the project and its stakeholders. This includes:

- / Introducing the project's content, objectives, missions, approaches, expected outcomes, and collaboration opportunities to partners, stakeholders, donors, potential collaborators, interested individuals, and other research groups both domestically and internationally. (Living Lab Mission, Objectives, and Approach);

- / Sharing project activities that have been implemented, are ongoing, or planned for the short, medium, and long term. (Living Lab Actions);

- / Sharing knowledge, including concepts, terminologies, articles, publications, lessons learned, and experiences throughout project implementation, as well as the latest scientific hypotheses related to coastal mangrove restoration in the Mekong Delta and shoreline protection. (Living Lab Knowledge);

- / Sharing datasets collected and measured by the project with relevant stakeholders, and seeking collaboration opportunities to expand or implement additional activities that require supplementary funding. (Living Lab Database).

Thus, the digital space serves as a primary connection point, acting as the central hub that links to the project's datasets and other relevant data repositories, facilitating the distribution and dissemination of project outputs.

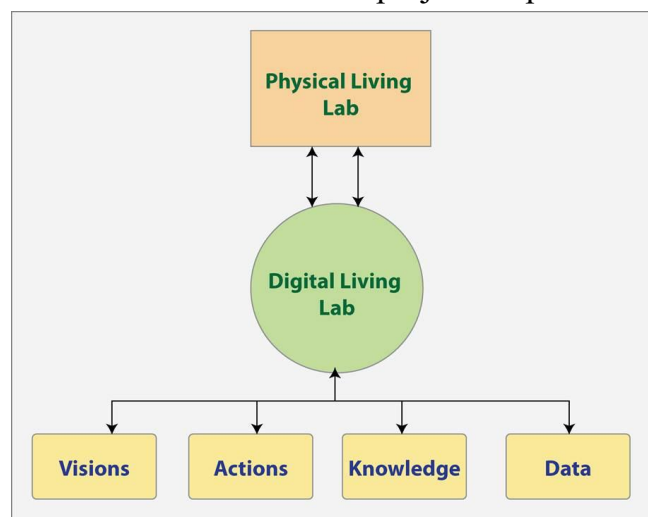


Figure 4.1. Conceptual idea of the Living Lab digital space

Initial Concept

Given that the Mangrove Living Lab project is highly scientific with in-depth technical terminology and content extending beyond knowledge sharing to include guidance, technical documentation, and datasets, the research team envisions the digital space as a wiki hub. This will act as a gateway to connect related digital components.

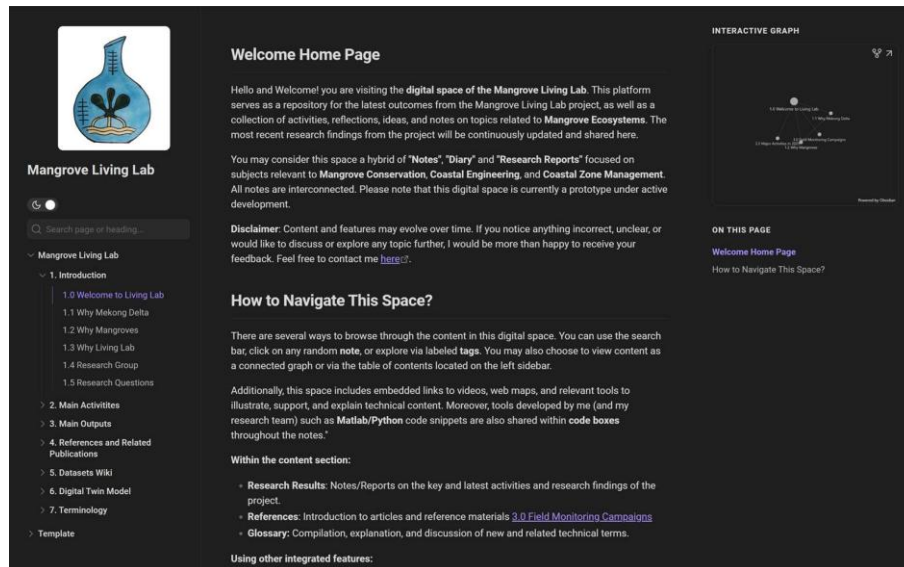


Figure 4.2. Welcome page of the Living Lab digital space

Technical Tools

The primary tool selected to establish the digital Living Lab space is Obsidian a note-taking application that allows users to publish content as a website. Its main advantages include simplicity, ease of use, updatability, and low cost. Moreover, Obsidian offers strong integration capabilities, allowing for the direct embedding of external websites, web applications, and web-GIS platforms, making the Living Lab digital space highly versatile and expandable. The digital space is currently under development. Its current version can be viewed at: <https://publish.obsidian.md/livinglab/Mangrove+Living+Lab/7.+Terminology/Mangroves>

In addition to Obsidian, other tools are being considered for web-GIS and web-app development, including ArcGIS, Python, and Streamlit, among others.

Examples of Integration

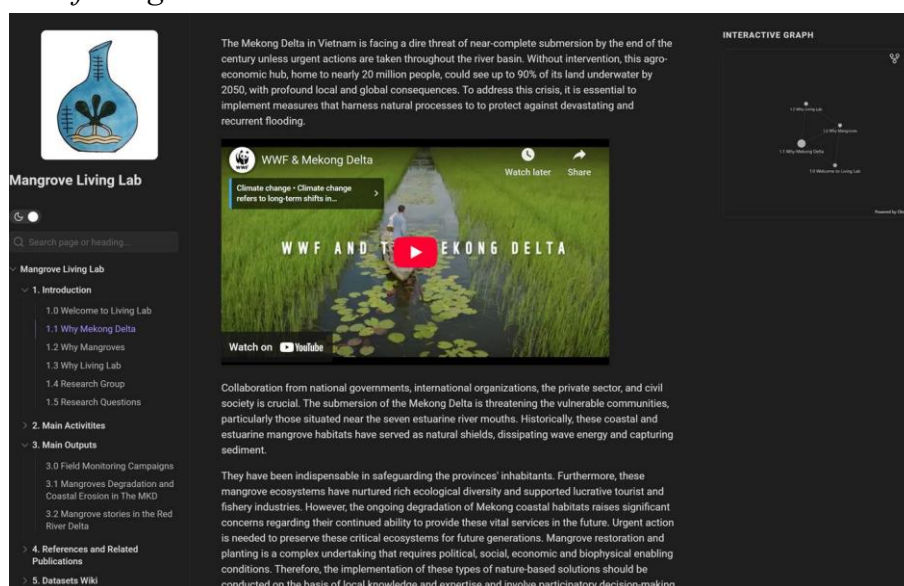


Figure 4.3. Direct integration with video platforms (e.g., YouTube), allowing users to watch promotional videos directly within the digital space.

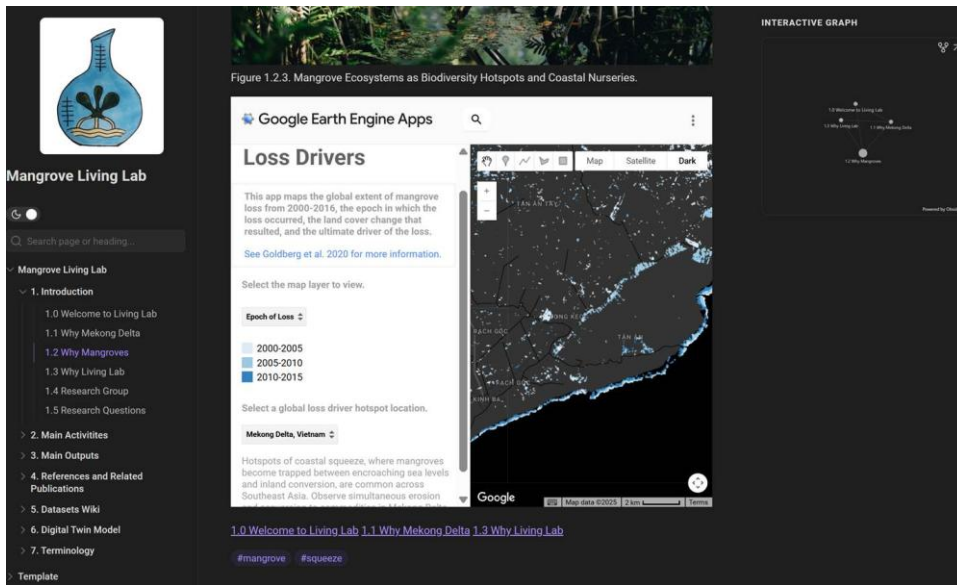


Figure 4.4. Direct integration with web-GIS platforms enables users to interact with integrated spatial datasets.

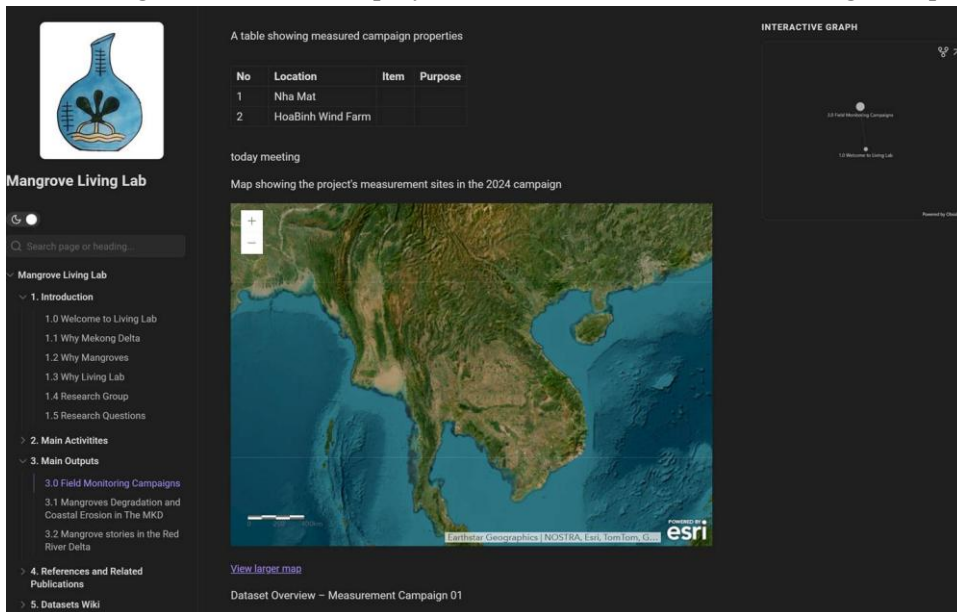


Figure 4.5. Mapping and measurement integration via web-GIS to display specific locations and recorded data.

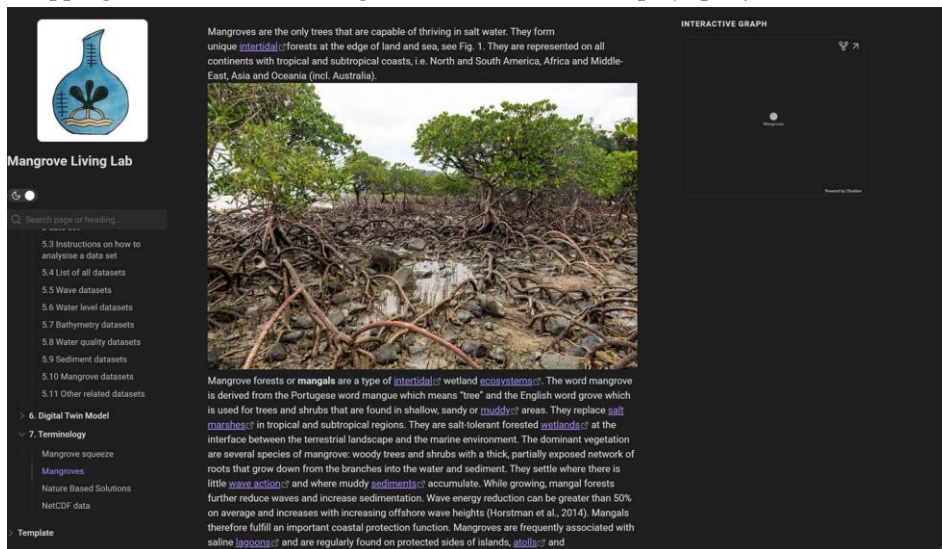


Figure 4.6. Interlinked scientific terms and concepts facilitate easier access and sharing of relevant scientific knowledge.

Implementation Plan

In addition to the core project members, the digital space will continue to be developed with support from members of the MDP student group from the Netherlands shortly.

4.2 DataWeb Platform

Data from previous fieldwork campaigns can be stored and presented via the WebGIS, which refers to the geographic information system. This allows the team and colleagues to access and download data. This WebGIS was developed in early 2024 by another team who strongly involved in collecting GIS data of mangroves and analyzing satellite images. This team also supports the data for Figure 3.23.

Figures 4.7 and 4.8 present the interface of the WebGIS of the project. Users can interact with a chosen station where data is available.

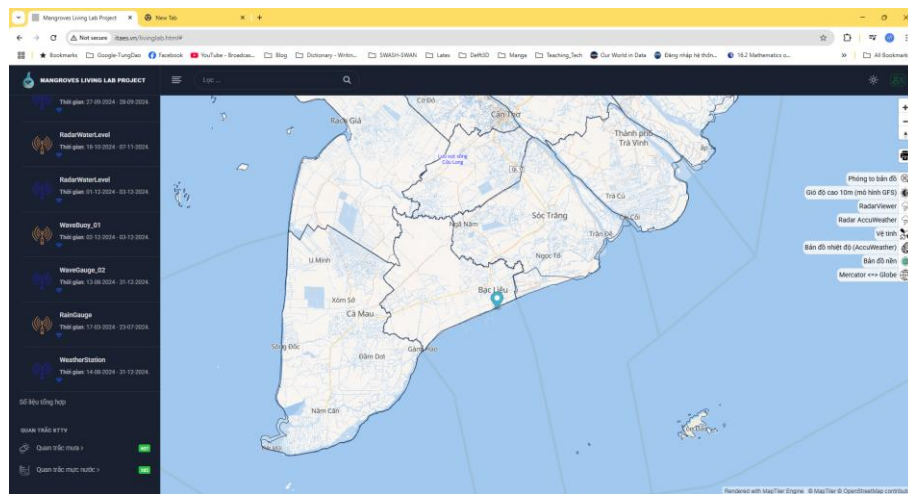


Figure 4.7. Data storage Website for the project. <http://itaes.vn/livinglab.html>

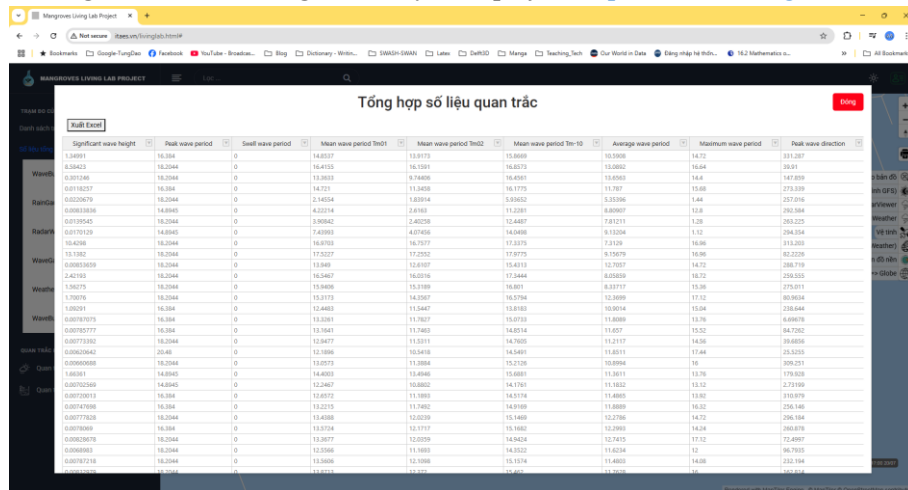


Figure 4.8. Data from one station can be extracted into Excel files and present again.

Even though this data web can be used for scientific and academic purposes, improvements for user updates should be added. The combination of Mangrove Living Lab's digital platform and DataWeb can be a good option.

5 Second term of 2025

The team will propose a list of activities for 2025 which is fit for the project goals. A number of activities can be listed below:

| No. | Activity | Time | Equipment/Method | Note |
|-----|---|---------------------------|---|--|
| 1 | Long-term monitoring of water levels at Hoa Binh Wind Farm | From July to October 2025 | Radar Water Level Gauge | Equipment should be installed in July |
| 2 | Cross-shore profile monitoring test in Vinh Chau | July 2025 | Bamboo/wooden poles | This is a test to see bathymetry changes. |
| 3 | Additional mangrove surveys in Vinh Chau | July 2025 | Additional sampling plots | Additional parameters |
| 4 | Joint measurement campaign in Kim Son, Ninh Binh | October 2025 | Wave buoy, Divers, Wave gauges, Flow and more | - |
| 5 | The second comprehensive measurement campaign at Vinh Chau in November (expected) during the spring tide period | November 2025 | Repeat equipment and measurement set-up as in June 2025 | Cooperative partners: ICE, ICOE, Cần Thơ Uni |

6 Conclusion

6.1 Remarks on Project Goals

The team has reviewed all working packages (WP) in the proposal and listed out below:

Table 6.1. WP 1 Scoping & selection

| No. | Activities | Status | Plan |
|-----|---|--|--|
| 1.1 | Site investigations | Plenty has been done. | Continue in 2025, early 2026 |
| 1.2 | Researching current solutions for coastal protection | Currently working | Continue in 2025, 2026 |
| 1.3 | Organizing meetings and workshops on the idea of a living lab | Red River and Mekong Delta | Continue in 2025, 2026 |
| 1.4 | Involving big donors like ADB and the World Bank | Currently working | Continue in 2026 |
| 1.5 | Make the selection of a suitable site in one of the provinces in the Mekong Delta | 2 Options: -/ Vĩnh Châu, Sóc Trăng -/ Hoa Binh Wind farm, Bac Lieu | Wait for the November 2025 field campaign for a decision. |
| 1.6 | Permission needs to be granted for the chosen location of the living lab | Currently working | September and October 2025 (ICOE) |
| 1.7 | Involving the local communities in the search for a location for the living lab | Currently working | Continue working (ICOE) |
| 1.8 | Make a decision on the location of the living lab | 2 Options: -/ Vĩnh Châu, Sóc Trăng -/ Hoa Binh Wind farm, Bac Lieu | Wait for the November 2025 field campaign for a decision. First choice: Vĩnh Châu, Sóc Trăng |

Table 6.2. WP 2 Design and construction

| No. | Activities | Status | Plan |
|-----|---|---|------------------------|
| 2.1 | Make the design of the living lab | Currently working | Continue in 2025, 2026 |
| 2.2 | Plan and design the interior layout of the lab | Currently working | Continue in 2025, 2026 |
| 2.2 | Conduct the first few experiments in the living lab together with students and staff of our partner universities/institutes | Has done many MDP groups from TU Delft | Continue in 2025, 2026 |
| 2.3 | Develop a (joint) research agenda to advance knowledge on nature-based solutions in the Mekong Delta | Has done in MKD, the Red River Delta (Kim Son, Ninh | Continue in 2025, 2026 |

| No. | Activities | Status | Plan |
|-----|---|---|---|
| | | Binh) | |
| 2.4 | Embedding the field lab in the various relevant institutions and programs through educational activities | Has connected with: -/ Institue Technology of Bandun / IInstitut Teknologi Bandung, Indonesia in August 2024 -/ Kumamoto University, Japan in June 2025 | Continue in 2025, 2026 |
| 2.5 | Developing a digital platform in which we will share our research findings, provide input on policies, and support decision-making processes and ongoing projects | 02 Platforms: -/ Mangrove Living Lab's digital space* -/ WebGIS Platform** | Continue working with contribution by Truong Hong Son, Phan Khanh Linh; and Nguyen Anh Hùng, Pham Quang Loi in 2025, 2026 |
| 2.6 | Engaging the local community by offering workshops, educational programs and public events | One activity so far in Phù Long, Cát Hải, Hai Phong | Continue in 2025, 2026 |

*<https://publish.obsidian.md/livinglab/Mangrove+Living+Lab/7.+Terminology/Mangroves>

**<http://itaes.vn/livinglab.html>

Table 6.3. WP 3 Experimentation and research

| No. | Activities | Status | Plan |
|-----|---|--|------------------------|
| 3.1 | Identify and implement appropriate research methods and monitoring protocols required for the actual design and construction of the living lab. | Discussion, inspiration by Prof Marcel Stive TU Delft Team visiting: -/ Bas & Thom visit September 2024 -/ Bas visit July 2025 | Continue in 2025, 2026 |
| 3.2 | Evaluate the suitability of existing instrumentation and make informed decisions on acquiring new equipment if needed. | Done | No further plan |
| 3.3 | Purchasing the necessary equipment and materials for monitoring and evaluation | Done | No further plan |
| 3.4 | Carry out the experiments and the tests in the living lab | 07 campaigns in the Red River & | Continue in 2025, 2026 |

| No. | Activities | Status | Plan |
|-----|--|---|-----------------|
| | | Mekong Delta | |
| 3.5 | Create and develop a specialized data platform for the physical permanent living lab location and the mobile measurement campaigns | -/ Showcase in Hòa Bình wind farm, Bạc Liêu (new Cà Mau) -/ Measurement location in Vĩnh Châu, Sóc Trăng (new Cần Thơ) | No further plan |

Table 6.4. WP 4 Demonstration of the living lab

| No. | Activities | Status | Plan |
|-----|---|---|---|
| 4.1 | Promotion material about the living lab, online as well as on-site, through visible signposts and markings | Currently working | Hoa Binh wild farm: poster, brochures, after getting nice results |
| 4.2 | Documentation and communication material in which we share the various experiments and research set-ups in the living lab | Currently working | The report is under construction |
| 4.3 | Set-up demos for validation and testing purposes | Done in Vĩnh Châu campaign in June 2025 | Continue in Vĩnh Châu campaign in November 2025 |

6.2 Lesson and learn

The project has done 05 measurement campaigns in its first year and 02 in the first 6 months of its second year in both the Red River and Mekong deltas. There are quite many activities have done so far, including site investigations, organizing meetings and workshops on the idea of a living lab, conduct the first few experiments in the living lab together with students and staff of our partner universities/institutes, evaluate the suitability of existing instrumentation and make informed decisions on acquiring new equipment if needed, and create and develop a specialized data platform for the physical permanent living lab location and the mobile measurement campaigns.

In the coming months, many more activities will be done, and the team will always come up front and ready to learn from the mistakes. Several data lost due to the lack of experience and necessary acts after having a proper plan. Practice in the field needs special skills and in some cases, experts need to "taste" first before taking acts. In the second campaign of 2025 in Vĩnh Châu, the team will carefully plan and calculate every matter that can negatively impact the whole campaign.

7 Events and workshops

For a past 6 months of 2025, the team continued to introduce and has already presented project's work to many potential partners. There are high school students that the team wants to focus on for future cooperation. In addition, there are potential partners who are already in partnership with TLU and ICE. Below messages are the events, workshop and meetings the team join.

1/ VinSTEM Fair

The VinSTEM Fair is the annual event that strongly encourages high school students in the VinSchool system to create their new researches. The team and TLU's students also attended on 11 January 2025 at VinSchool and introduced the Mangrove Living Lab. Additionally, the team brought measurement equipment and answer many questions from high school students.



Figure 7.1. TLU's students and the team at VinSTEM Fair (<https://vmat.vn/vi/tin-cong-ty/vmat-dong-hanh-cung-vinstem-fair-truyen-cam-hung-tu-khoa-hoc-den-xay-dung.html>)

2/ Delegation of CRISO, Chulalongkorn University, Griffith University

On the morning of January 21, 2025, Thuyloi University held a meeting and worked with delegations from CSIRO, Griffith University (Australia), and Chulalongkorn University (Thailand). The meeting aimed to discuss research and training issues and seek cooperation opportunities in common research areas. The team also had a chance to introduce the Mangrove Living Lab at the workshop and received many well feedback for coming cooperation.



Figure 7.2. Dr Le Hai Trung at the workshop and introduce the Mangrove Living Lab (<https://www.tlu.edu.vn/tin-tuc/truong-dai-hoc-thuy-loi-tiep-don-cac-27555>)

3/ Delegation of Lancang Mekong Water Resources Cooperation Center

On March 19, 2025, Thuy Loi University had a working session and exchange with the delegation of Lancang-Mekong Water Resources Cooperation Center to discuss water resources management issues and seek future cooperation opportunities. The meeting was chaired by Vice President Nguyen Canh Thai, with the participation of leaders of units in the university and experts from Lancang-Mekong Center and Yangtze River Basin Research Institute.

In addition, Associate Professor Dr. Le Hai Trung also introduced the Living Lab project in the Mekong Delta: Initial monitoring of waves and mangroves, emphasizing the role of mangroves in mitigating the impacts of climate change and protecting the coastline. The project aims to build a monitoring system, collect real-world data to serve research and propose sustainable solutions.



Figure 7.3. Dr Le Hai Trung at the workshop (<https://www.tlu.edu.vn/tin-tuc/truong-dai-hoc-thuy-loi-tiep-don-doan-28613>)