Annual Field campaign Report

Mekong Delta Living Lab – An Open-air Laboratory for coastal protection and nature-based solutions

Vietnam, 2024

Credit

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Part I. Introduction

I.1. Project Overview

With inspiration from the project "Restoration and Sustainable Management of Coastal Forests in the Mekong Delta to Enhance Environmental Change Adaptation Capacity" in December 2023 and the sustainable innovation platform for stakeholders and researchers – the Green Village (Delft University of Technology), the project Mekong Delta Living Lab – An open-air laboratory for coastal protection and nature-based solutions was found early 2024. A remarkable conclusion has been made from the 2023 project showing that the five provinces in the Mekong Delta are very different from each other in their physical, sociocultural, and socio-economic conditions and policies. As a result, finding a location similar to the Green Village is the most challenging task for the Living Lab project.

The envisaged living lab in the Mekong Delta will serve as a 1) platform and collection of relevant knowledge and lessons learned based on a variety of in-field scientific measurement campaigns in the Mekong Delta and 2) demonstrating a variety of solutions to relevant stakeholders on a permanent physical site. Indoor flumes focus on scientific pursuits, whereas field measurement campaigns emphasize real-life solutions. Therefore, the aim of this living lab is to bridge the gap between theory and practice, from the indoor lab of ThuyLoi and the other institutes to the complex outdoor reality in the Mekong Delta. Especially since, in the past years, many project efforts have been implemented to improve the coastal system but had limited success. A living lab allows for showcasing the various mangrove restoration methods and, as such, supports improved and more evidence-based decision-making with a more long-term commitment.

For the last 9 months, the team has done several fieldwork campaigns for the first-year goals, including finding the permanent location for the living laboratory, mastering measuring equipment, and understanding other provinces.

I.1.1. Overview of Fieldwork Locations

I.1.1.1. Bac Lieu Province

Bac Lieu province is located in a part of Ca Mau Penisula in southern Vietnam. It includes nearly 2700 km^2 and ranked 7th among other Mekong deltaic provinces. Its natural topography is relatively flat, consisting mostly of plains. Bac Lieu's coastline is quite straight with an extremely gentle slope, with water depth reaching 30 m at 100 km from the shore. Bac Lieu has a seasonal climate, which is dominated by southwest monsoon in the summer and northeast monsoon in the winter. Furthermore, Bac Lieu's population reached nearly 1 million in 2021 and is quite scattered between the city (27.67%) and the countryside (72.23%).

Figure 1. Bac Lieu boundary

Total mangroves in Bac Lieu reached 2800 ha in 2018, in which Hoa Binh district has the largest area with 1300 ha (48.1%), Dong Hai district ranks second with 1100 ha (40.9%), and Bac Lieu city stays at the bottom with only 311 ha (11%). Mangroves in Bac Lieu have been stated to have an increase of 1070 ha after 30 years (1988). It was recognized that an increase in shrimp ponds due to their benefits to farmers resulted in a large number of mangroves needing to be destroyed in order to build ponds. Consequently, the impact of low quality of water treatment and high water pollution made the survival rate of the mangroves lower. However, with the increase of quantity and competition in shrimp markets, Vietnam and Mekong deltaic provinces in general and Bac Lieu in particular no longer the most aquaculture farming. With both environmental and economic impacts, farmers have slowly stopped using intensive aquaculture shrimp ponds and started using the shrimp-mangrove method. This act leads to a restoration of mangroves in Bac Lieu.

In the past decade, with the significant increase in sand exploitation and decrease of sedimentation/sediment due to hydraulic dams, mangroves at several locations have now disapeared, for example, mangroves in Nha Mat. The

number of coastal infrastructures has increased due to a false assessment of the local authorities.

I.1.1.2. Phu Long Commune, Cat Ba, Hai Phong

Located on the Northwest of Cat Ba island, Phu Long commune is as large as about 4300 ha with more than 2300 people. Interestingly, the commune includes 488.5 ha of the core zone and considerable parts of the other two zones defined above. The first group of 15 families was believed to have arrived and established Hau Village in this area 500 years ago. At the beginning of the 20th century, Phu Long village was officially documented to exist with 500 residents. Mudflats, mangroves, and waters dominate the landscape of the commune, making them a notable characteristic. Nowadays, of the 800 hectares of mangrove forests in Cat Ba, a significant portion, amounting to 600 hectares, is located within the commune. Inhabiting the area adjacent to the mangroves, the people of the old village, and now the commune, have amassed knowledge and experience about these ecosystems from generation to generation.

The mangrove ecosystem in this area remains one of the few relatively intact and healthy regions left. Notably, many families still have leased land and water surfaces from the authorities for aquaculture and livestock farming, alongside initiatives for mangrove afforestation and land reclamation. Consequently, healthy mangrove trees often line the banks or grow within aquaculture ponds. However, as the arrival hall of Cat Ba island, Phu Long has changed rapidly with ferry ports, cable lines and stations, asphalt roads, concrete bridges, and many new modern houses. A large part of the mangrove forests have been transformed into aquaculture ponds and, more recently, intensive aquaculture facilities. Additionally, it has been discovered that younger generations are pursuing a variety of occupations for their livelihood. Nevertheless, these professions are often hardly relevant to mangrove ecosystems.

A quick survey and observation revealed that no more than five local community members frequent the mangrove forest for daily harvests. Some aquaculture ponds are still operated and remain, but only by the older generation, continuing a long-standing practice (20 - 30 years). Conversely, their children display a lack of interest in both the mangroves and related endeavors. This suggests that although the mangrove forests on Cat Ba Island's northwest remain robust and healthy, signs of deterioration are emerging, possibly driven by the community's diminishing involvement in conserving and enhancing these vital ecosystems.

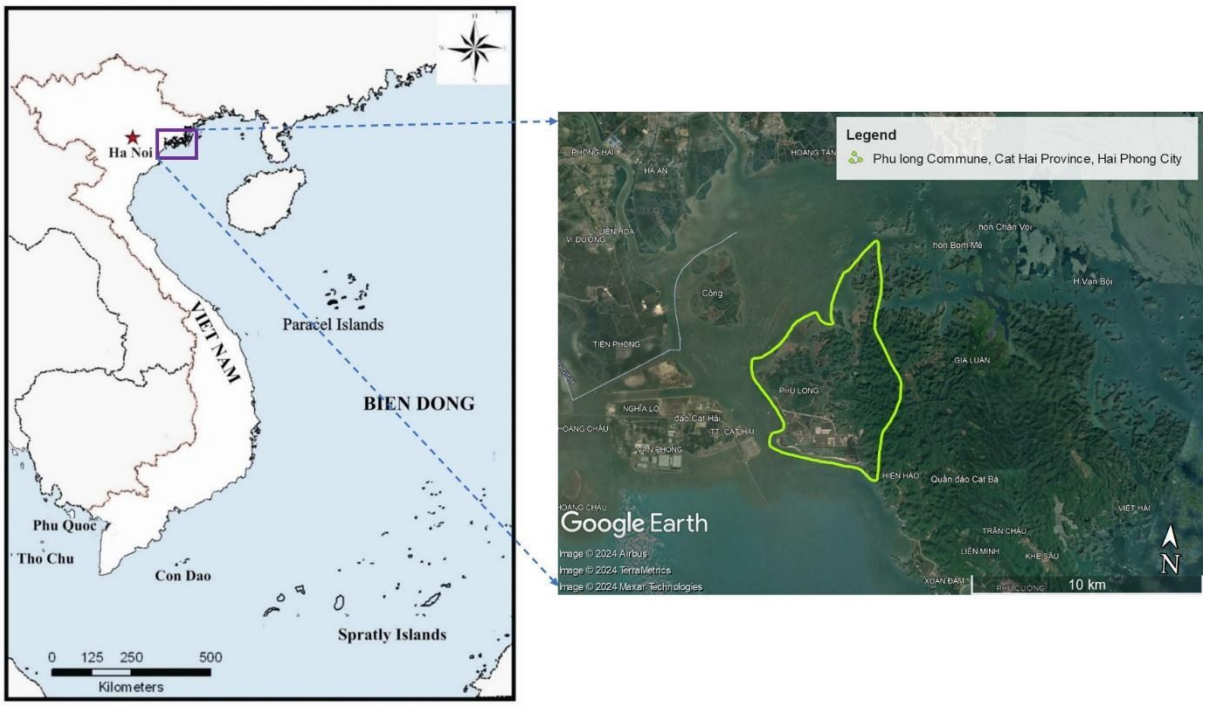

Figure 2. Phu Long Commune (green line) east of Cat Hai, Hai Phong.

I.1.2. Objectives

-/ Conducting site investigations and analysis in the different provinces and understanding the differences between the provinces, their difficulties and their coastlines.

-/ Involving the local communities in the search for a location for the living lab by organizing focus group sessions and creative sessions.

-/ Plan and design the interior layout of the lab, considering factors like equipment placement/storage, workstations, and safety measures to create a functional and efficient workspace.

-/ Conduct the first few experiments in the living lab together with students and staff of our partner universities/institutes.

Part II. Equipment and methods

II.1. Equipment

The list of equipment is listed below:

Table 1. List of measurement devices from Obscape

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

Note that all equipment is low-maintenance with self-recharged by solar cells.

These equipment are developed by Obscape company, Delft University of Technology. Measured data will be streamed to the Obscape servers with a high internet connection installed inside the device. Every station is equipped with solar power cells that can recharge under the sunlight. As a result, the installed devices can measure for up to a year without changing batteries.

(a) Wave bouy: OBS-Buoy 400

(b) Weather station

(c) Time-lapse camera

(d) Pressure-based wave gauge

(e) Level gauge Radar

Figure 3. Obscape devices.

II.1.1. Wave bouy

OBS-Bouy 400 can be installed at an offshore location so data can be obtained for model validation and calibration. Wave bouy uses 8 Lithium D-cells (3000mAh, 3.7 V), resulting in data recording up to 10-12 months. Data specifications are presented in Table 2.

Table 2. 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)

No.	Data specifications	Note
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)

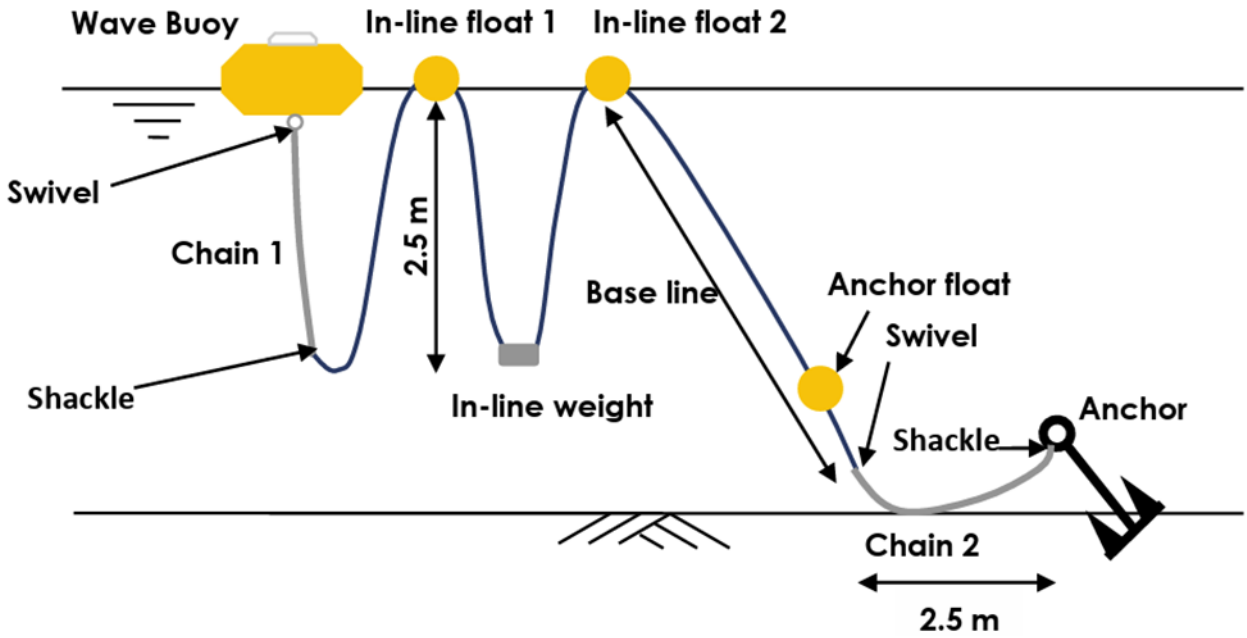

Figure 4. Measurement scheme of Wave bouy.

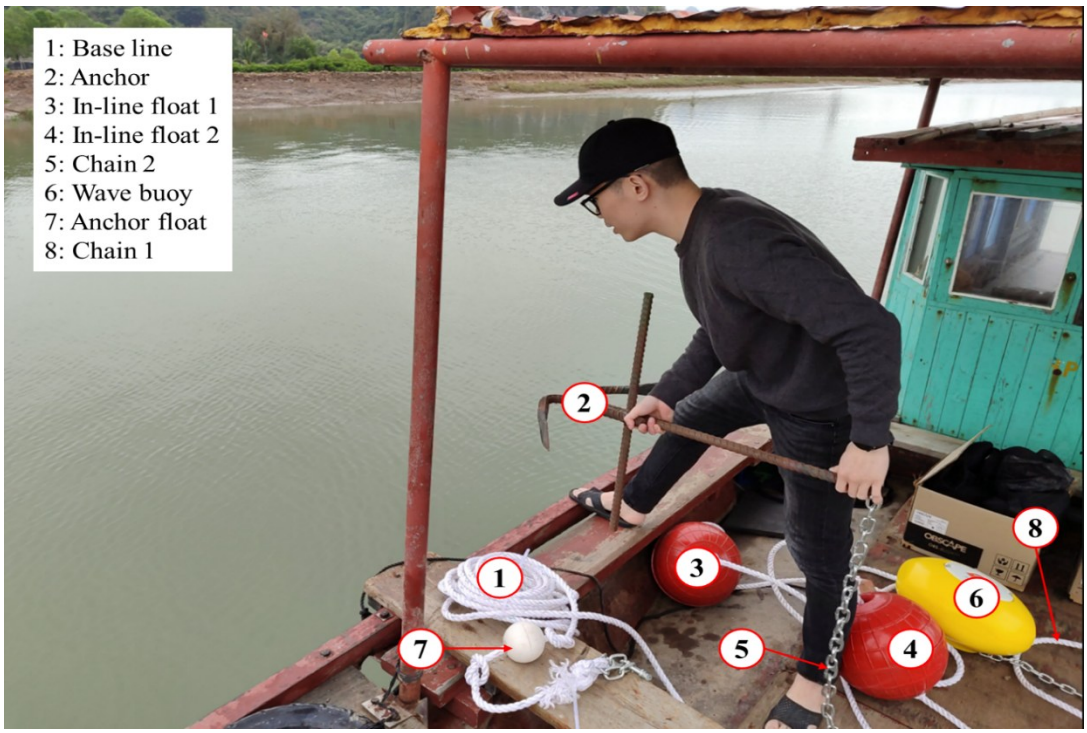

Figure 5. Wave buoy installation processes.

Figure 6. Wave bouy system after installing. 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 bouy. This system can work up to 12 months under normal conditions.

In the field, wave bouy is vulnerable under strong wave conditions, so it should be observed and have daily checking 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.

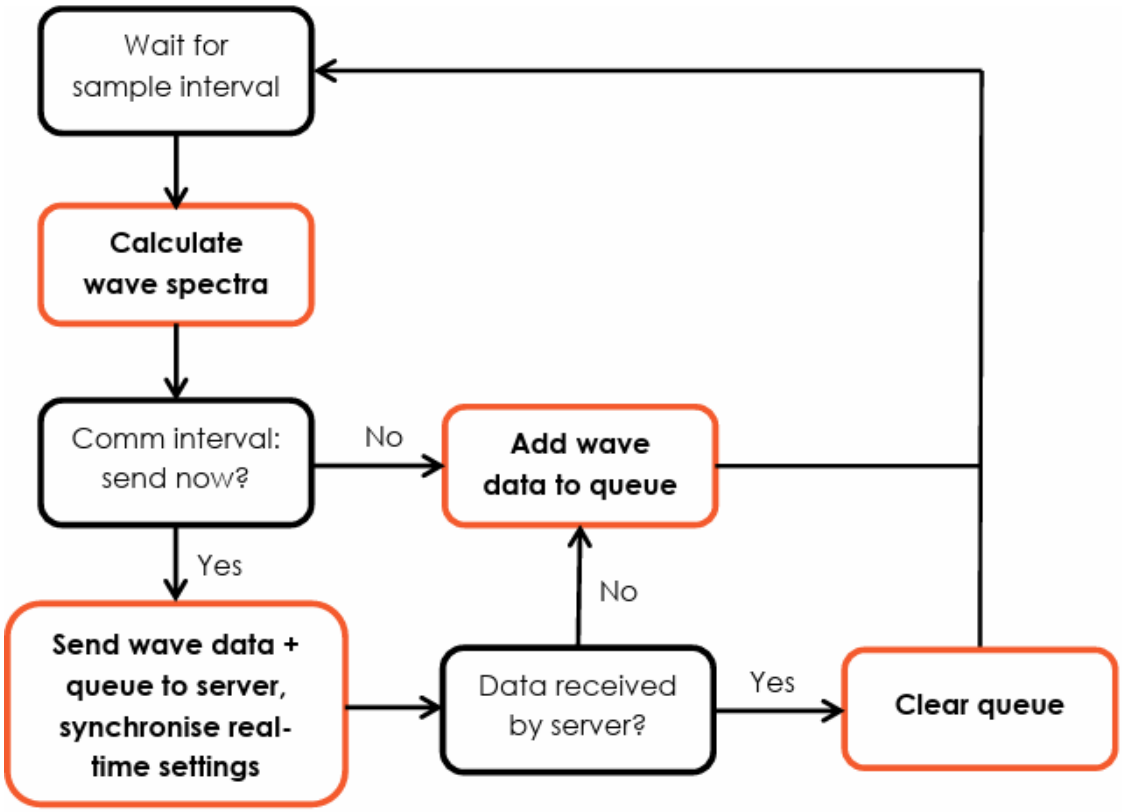

Figure 7. Measurement and telemetry cycle during the campaign.

II.1.2. Level Gauge

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

$$z_{water} = z_{housing} - d$$

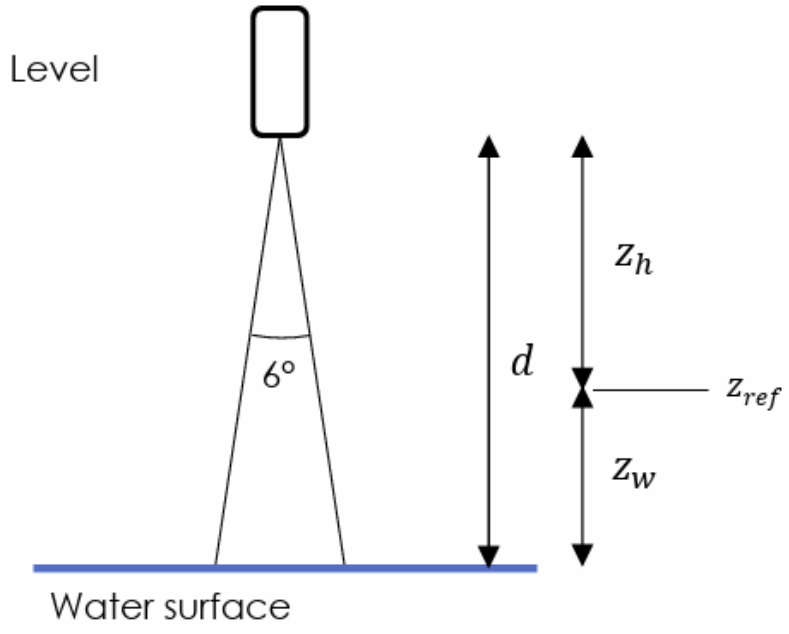

Figure 8. Level gauge radar principle.

II.2. Sedimentation

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

Sedimentation data is collected within the 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.

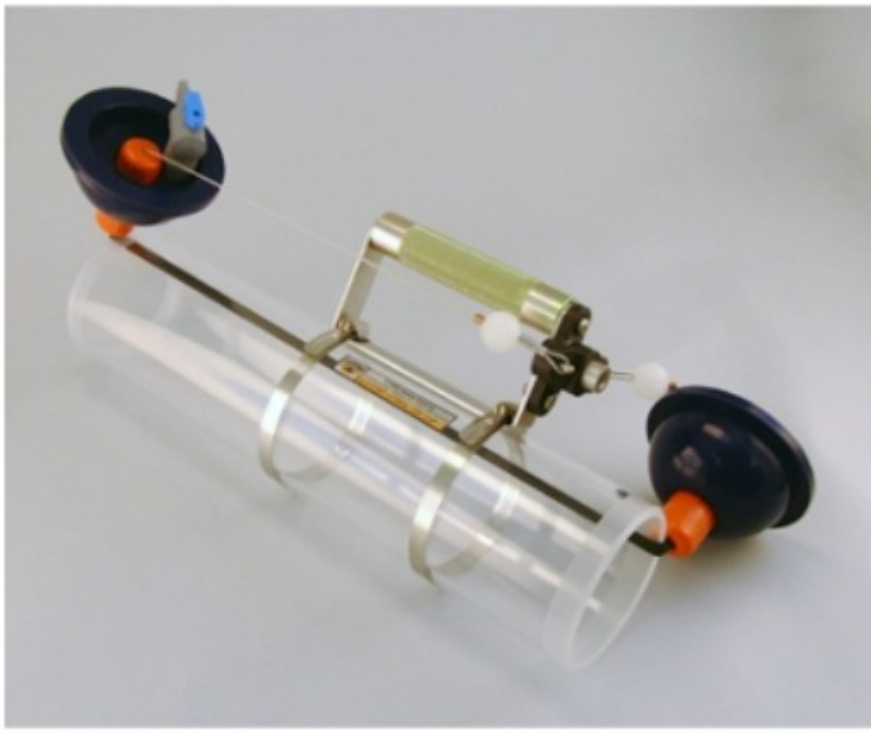

Figure 9. Sedimentation/Water quality collection toolkit

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.

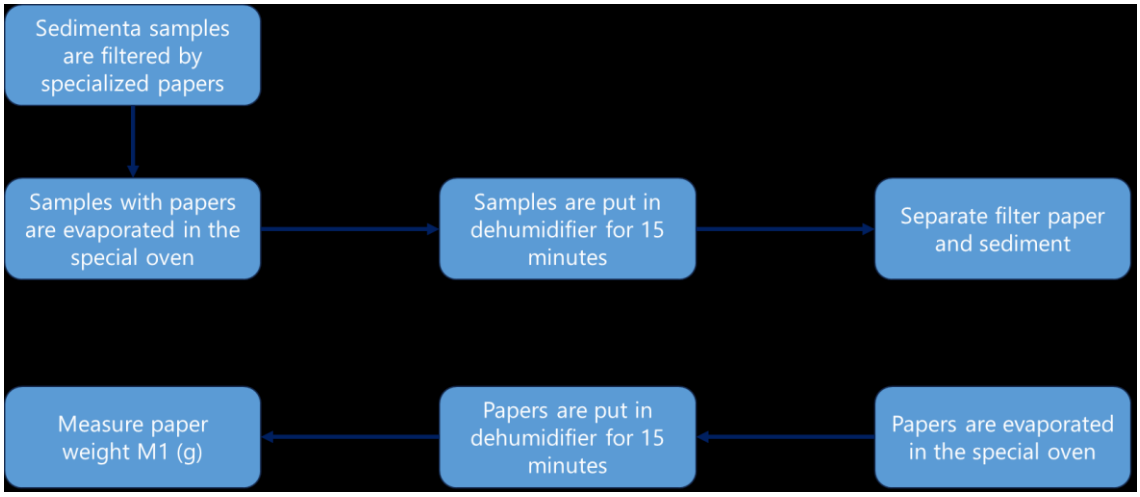

Figure 10. Analyzed processes for sedimentation

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

Figure 11. Examples of Sedimentation analyzed processes. Filter papers (Upper left and right panels), dried processes (Lower left panel), and weigh the filter paper with sediment (Lower right panel).

II.3. Biomass

Biomass is one of the important aspects recognized as the Above-Ground Biomass – AGB parameter. This parameter is analyzed from tree height (H), mean diameter in middle height (DBH), cover diameter (CD), and root diameter at 30 cm from the bed. All parameters are collected from an area of 10x10 m, and AGB will be estimated from one of existed empirical formulas in Table 3.

Table 3. Empirical formulas for AGB estimation

No.	Mangrove type	AGB estimation formulas	Measured parameters
1	Sonneratia caseolaris	AGB (kg)= $0.251\times\rho\times DBH^{2.46}$	DBH, H
		AGB_{root} (kg)= $0.199\times\rho\times0.899\times DBH^{2.22}$	
2	Bruguiera gymnorrhiza	AGB (kg)= $0.168\times DBH^{2.31}$	DBH, H

No.	Mangrove type	AGB estimation formulas	Measured parameters
3	Kandelia obovata	AGB (kg)= $2.594 \times CD^2 \times H$	CD, H (DBH<5cm)
		AGB (kg)= $0.251 \times \rho \times DBH^{2.46}$	DBH, H (DBH>5cm)
4	Avicennia marina	AGB (kg)= $1.8247 \times CD^2 \times H$	CD, H
5	Aegiceras corniculatum	AGB (kg)= $3.1253 \times CD^2 \times H$	CD, H
6	Rhizophora stylosa	AGB (kg)= $0.168 \times D^{2.42} \times H + Biomass_{stilt}(kg) = 0.0209 \times D^{2.55}$	D30, H

II.4. Surveys

Within the project, the team applies human-research surveys that are to collect individual information and perspectives associated with mangroves and coastal infrastructures. There are two types of individuals that the team has interviewed so far, (1) experts and (2) local residents.

-/ The number of experts is limited at the moment, including Economy, Psychology, Anthropology, and Civil and Coastal Engineering, who can create supportive and beneficial views for the project.

-/ Local residents will be interviewed at the field using questionares and face-to-face interviews.

Part III. Field Campaigns

The first visit to the Mekong Delta (MKD) occurred in December 2023 during the RVO project "Restoration and Sustainable Management of Coastal Forests in the Mekong Delta to Enhance Resilience to Environmental Change." This technical study offered the critical view that shows insightful support and advice to the Ministry of Agriculture and Rural Development (MARD) and provincal Departments of Agriculture and Rural Development (DARD) of the five MKD provinces. On the way of continuing to improve the principle knowledge of the MKD and mangrove restoration, the project Mangrove Living Lab started in early 2024, provides several field campaigns in order to fulfill the tasks that have been left questioning from the previous projects.

III.1.1. Field campaign in Bac Lieu

Fieldwork in Bac Lieu occurred in April and August 2024 in a 7-day duration. Our purpose for a bunch of activities in Bac Lieu will be:

+ Investigate and analyze the differences between laboratory sites.

+ Organising meetings and workshops in the way of developing a mangrove living lab.

+ Develop designs of fieldwork and start measurement campaigns.

A special task needed to fulfill the project is to understand the potential sites for the living lab.

III.1.1.1. Hoa Binh 1 – Wind Farm

1. Description

Hoa Binh 1 site, known as the wind farm resort locates south-east a distance of 12 km from Bac Lieu city center (Vĩnh Hậu A, Hòa Bình, Bạc Liêu, Figure 7).

Figure 12. Hoa Binh 1-Wind farm on the map, located at the south-east of Bac Lieu city center with a distance of 12 km.

Hoa Binh 1 – Wind farm, now so-called Hoa Binh 1, is a tourist place where tourists and local people can visit a set of wind turbines at an offshore location. The furthest point allowed for visitors is about 6 km from land, which is always submerged. Hoa Binh 1 has both pros and cons for the future campaign.

+ Advantage

Hoa Binh 1 is a resort place surrounded by homestays and restaurants. It is recognized to be a good place for logistics. Hoa Binh 1 has a combination of mangroves, coastal areas, and offshore sites, making it a good place for measuring water level, waves, flows, sediment/sedimentation, and bio-mass.

In the 6 km from land to offshore over a bridge, a mangrove width reaches about 150 m before approaching the coastal area. The gentle foreshore can be up to 1/1000, making the tidal area enormous. An advantage for setting up measurement devices on the bridge was recognized during the first attempt in the field, in which water level, wave gauges, and similar devices from Obscape can be set up without hiring a boat. The location is at a place where the water depth is 4 meters at low tide time. However, some devices from ICE which has water resistance can be installed at the brigde poles.

+ Disadvantage

The available devices for the project (see Table 1) have their own cons, which are not waterproof. As a result, it needs to be installed at a high place from the bridge to the water surface, even in the low tide. Hence, optimizing designs for measurement plans will be more challenging.

(a)

(b)

(c)

Figure 13. Measured location in Hoa Binh 1. (a) pier and (b) poles at the pier; (c) Location on map.

2. Activities and results

All measurements are installed and measured during the time mentioned above. There was a list of measurement activities in this period in which water level, wave measurement, and sedimentation were focused.

The team set the Level gauge and pressure-based wave gauges at the locations presented below.

Figure 14. Location of device installation in April and August 2024

-/ Water level and wave measurement. The devices are the Level gauge and Pressure-based wave gauge (see Table 1) and are shown below:

(a)

(b)

Figure 15. The level gauge for water level (a) and the Pressure-based wave gauge (b) were installed at the location presented in Figure 14.

The data captured from the two devices are presented with elevation raw level (Figure 16), significant wave heights (Figure 17), and mean wave period (Figure 18).

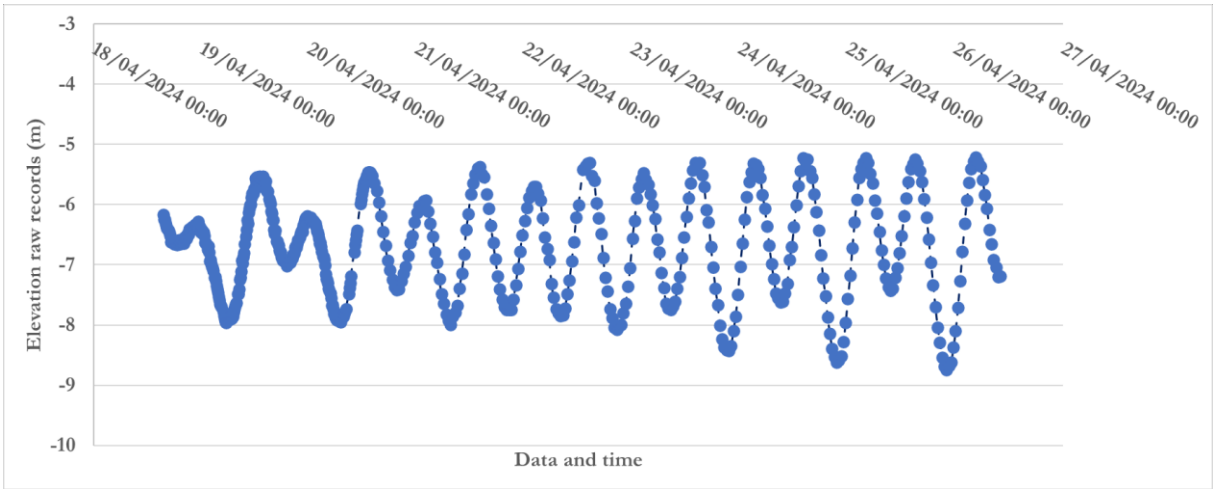

Figure 16. Elevation of raw records from the Level Gauge

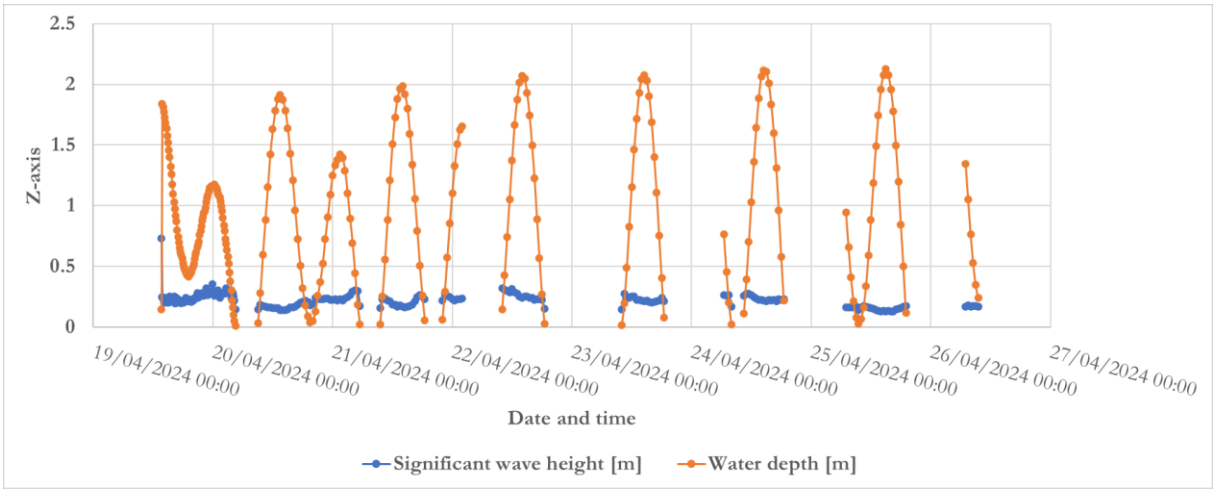

Figure 17. Significant wave height from pressure-based wave gauge.

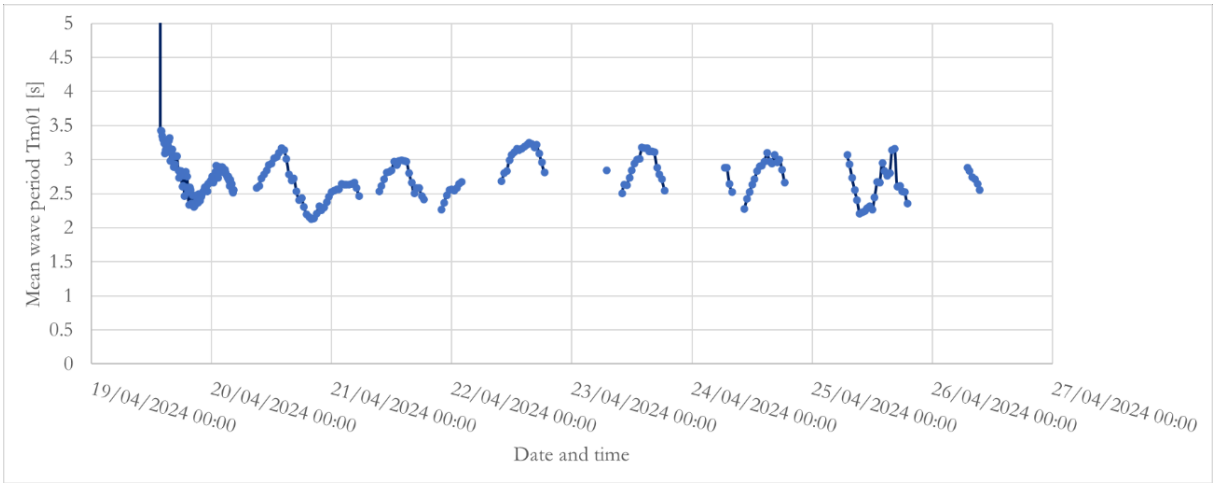

Figure 18. Mean wave period from pressure-based wave gauge.

-/ Time-lapse camera

The time-lapse camera was set in front of the mangrove belt so that the team could observe the change in tidal elevation and wave behaviors in/in front of mangroves. A few examples of captured images are shown below:

Date: 20 April 2024

Date: 21 April 2024

-/ Sedimentation

Sedimentation samples are collected twice a day, at 7 and 15 hours, and at two locations. Hence, there are four samples in a day from 24 to 26 April 2024. After all samples are collected in the field, they will be dried and measured again in the laboratory. The results are presented below:

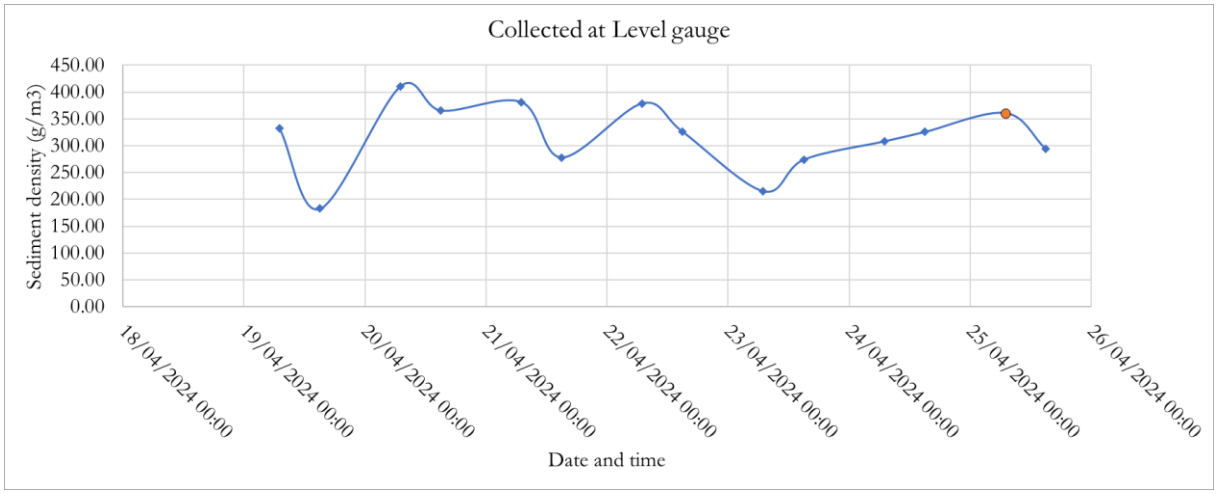

Figure 19. Sedimentation changes over time at the Level Gauge location

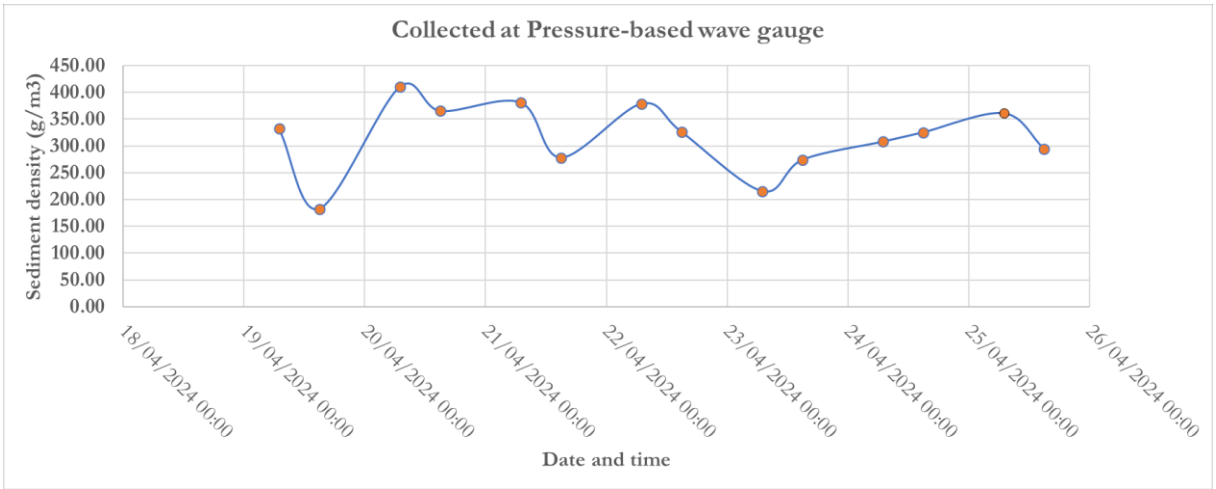

Figure 20. Sedimentation change over time at Pressure-based wave gauge location

-/ Other activities

Checking and observing measurement devices are done each time sedimentations are collected. These activities include observing water levels and checking the online portal which data are uploaded in real time.

On 26 April 2024, captured mangroves with drones in Vinh Chau ward, Soc Trang province, in 2 hours.

This fieldwork ended on 26 April 2024. Data on water level, waves, and time-lapse images is collected from the Obscape portal.

III.1.1.2. Nha Mat

Nha Mat is a ward belonging to Bac Lieu city, located about 10 km from the center. This area is a tourist place where the Nha Mat resort, shops and restaurants are available. Nha Mat restaurants are one of the tourism systems in Nha Mat ward which are built at 150 m from the land being submerged during the high tide.

Fieldwork at Nha Mat occurred two times in April and August 2024. The early visit is short and to assess the potential of this place for a permanent living lab location. Meanwhile, the second visit is a longer fieldwork in which the team installs measurement devices. On the second visit, the team eventually made the decision on this location, considering it would be the permanent lab.

1. Field trip in April 2024

On 18 April 2024, the team, Dr Le Hai Trung, pays the first visit to Nha Mat (Figure 21) and spends some time evaluating the potential location. This location is the land reclamation area formed for resorts, parks, and restaurants for tourism. In Figure 9b, the Nha Mat restaurant was built about 15 years ago, creating a good place for visitors, including 2 functional dining rooms, but only one now continues functioning. This area connects to the land via a small bridge (Figure 21b) and is only submerged due to the high tide.

The team wants to install measurement devices at the restaurants (see Figure 21b) because it is easy to observe and check every day. However, it is noticed that this area is surrounded by pourous structures, the hallow poles, making the situation complicated. For example, wave signals will be transmitted. The first assessment for device installation processes comes from the idea that all hydraulic conditions that should be measured will be blocked by the structures. Thus, it will be challenging to understand the insight mechanisms of hydrological problems. Another reason that makes this area more challenging to be a living laboratory is the tourists and visitors. The team is aware of the interruption from local people and visitors on signals as well as a high consideration for device security.

On the other hand, other processes, such as logistics, shops, and foods, are mostly available for longer fieldwork.

(a) **(b)**

Figure 21. Nha Mat area (a) and Nha Mat restaurants (b). Photo taken on 19 April 2024 when this building is abandoned.

2. Fieldword in August 2024

The second visit, as well as fieldwork, takes place from 12 to 22 August 2024. The aims of this field campaign include:

+/Assess the possibilities for all fieldwork processes, such as logistics, device installation, and more.

+/ Capture measurement data at the shallow zone.

+/ Address the differences between Hoa Binh I and Nha Mat in other aspects, which become the criteria for living laboratory, for example, logistics (shops, restaurants), livelihood accesses for surveys, craft shop for external items for installing devices, and more.

On 12 August, the teams arrived at Nha Mat, Bac Lieu (see Figure 21), and started to install measured devices. However, it was recognized that this location is surrounded by visitors and tourists during the daytime. This brings challenges for installing devices along the bridge without thinking of device security. The team then found a small tent about 500 m from the shore belonging to a local farmer (Figure 22a and 22c). It is not an easy choice to reject the opportunity to set the devices up, including waves and water quality, while the weather station was set up at the hotel (see Figure 22b).

(a)

(b)

(c)

Figure 22. Wave and water quality devices (a) and weather station (b) and a tent belonging to a local farmer further offshore (c) where wave and water quality stations are installed.

In the meantime, the team visited several infrastructures, such as the Hallow Pie Dike (Figure 23), the Hallow Pile Rocks Dike (Figure 24), the left and the right side of the bridge to Nha Mat restaurants (Figure 25), and finally discussed on the standards of the living lab location (Figure 26b). The team also paid respects to the farmer, who was willing to help the team install the devices in his tent (Figure 26a).

(a)

(b)

Figure 23. (a) the Hallow pile rocks dike is on the right side of the Hallow pie dike, and (b) the circle porous dike.

(a)

(b)

Figure 24. The hallow pile rocks dike at the seaside (a) and at the land side (b). Natural mangroves can survive behind the dike due to an increase of sedimentation and high bed elevation enough for mangrove surviving.

(a)

(b)

Figure 25. (a) The left side of the bridge to Nha Mat restaurants. Senior and young mangroves behind the piers. This area has been left out due to several failed projects. (b) The right side of the bridge to Nha Mat restaurants. This area is close to the river mouth and protected by Hallow Pile Rocks Dikes, and the Tetrapod at the dike slope.

(a)

(b)

Figure 26. (a) The team thanked the farmer who let all devices be installed in his tent. (b) the team also visited Hoa Binh I – Wind farm to criticize the differences between Nha Mat and Hoa Binh I.

3. Data presentation

The presentation of data captured from the August fieldwork is shown below:

-/ Wind data is presented in Figure 27, showing that the main direction in 7-days duration is southwest with the highest velocity up to 4 m/s.

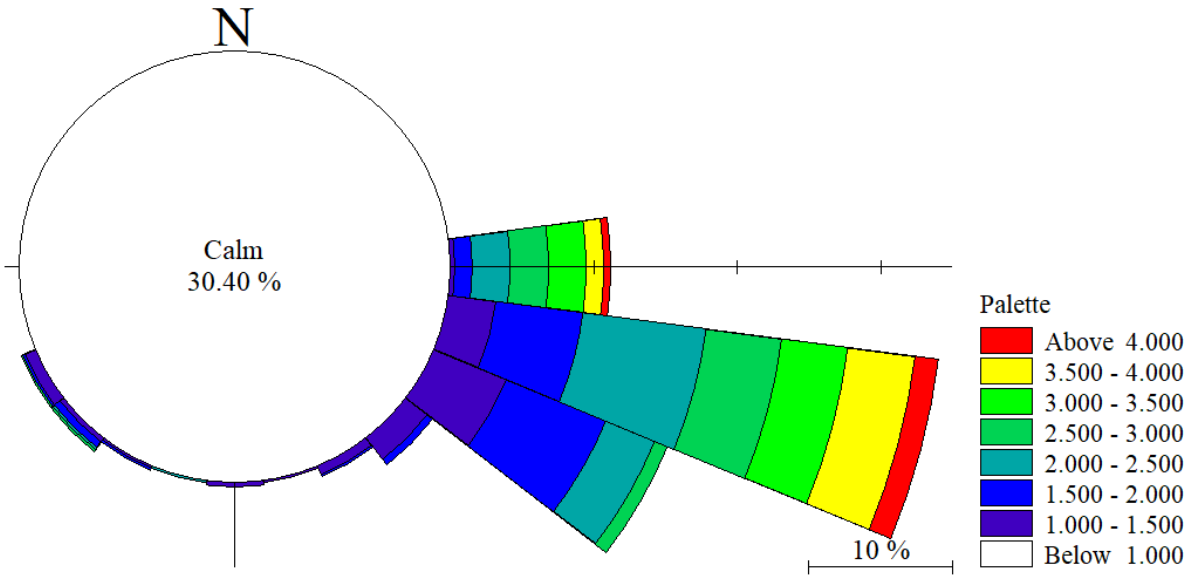

Figure 27. The wind rose in Nhat Mat from 13 to 22 August 2024

-/ Waves:

The significant wave heights and water depth from 12 to 22 August 2024 are shown in Figure 28. The average wave height is recorded around 0.35 m in nearly every water depth. The gentle foreshore is the cause of wave damping along the intertidal area.

The average wave period shown in Figure 29 is roughly 5 seconds. There are some enormous records in the wave period that can be explained by swell waves or long waves generated by very gentle foreshore.

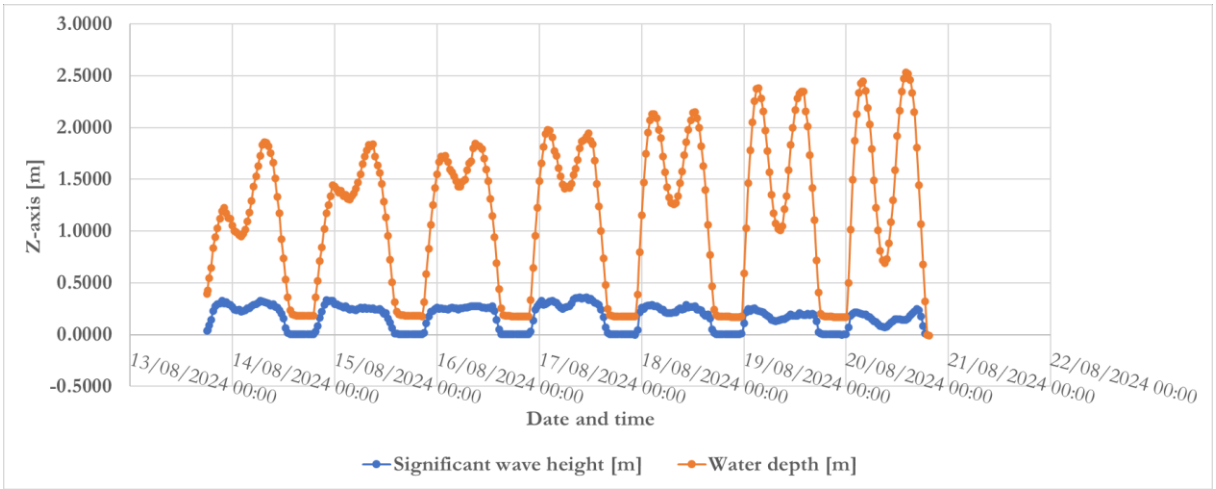

Figure 28. Significant wave heights from 12 to 22 August 2024

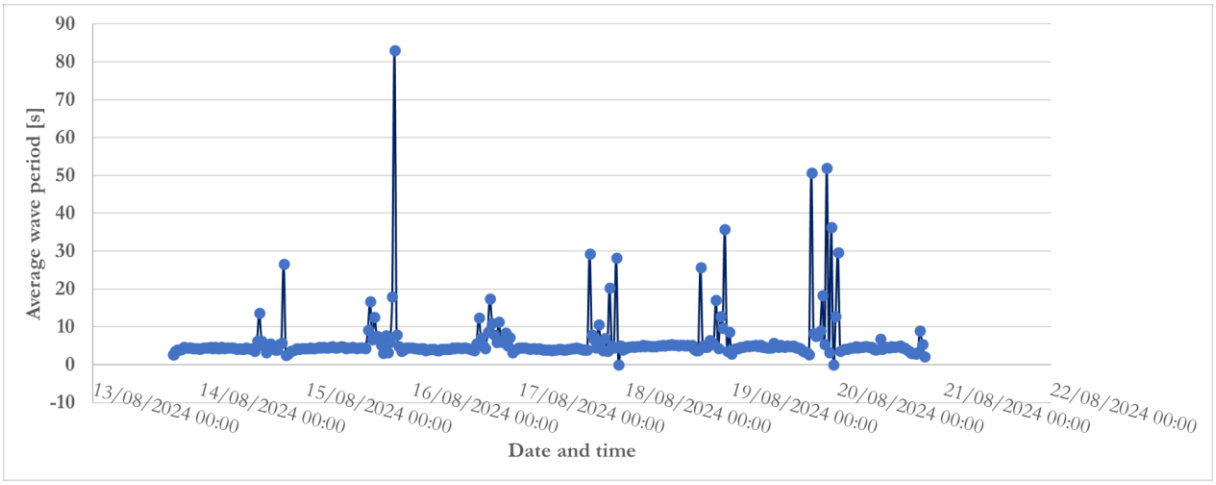

Figure 29. Averaged wave period from 12 to 22 August 2024

-/ Water Quality

Three parameters, e.g., water temperature, conductivity, and salinity, are presented in Figure 30. It appears that salinity is quite low (22 PSU) in comparison with a common value, 35 PSU, due to river influence from the channel close by. Meanwhile, water temperature is quite high because of the influence of summer time, with an average temperature along the day reaching 35°C.

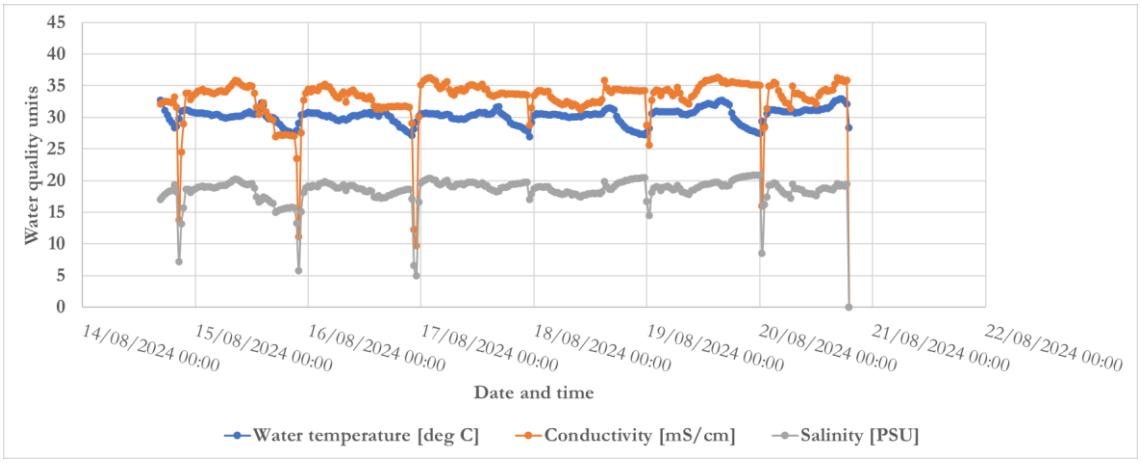

Figure 30. Water parameters from the Environmental station from 12 to 22 August 2024,

III.1.2. Field campaign in Phu Long, Cat Hai, Hai Phong

The measurement campaign in Phu Long in March is the first of many of the projects, occurring from 16 to 24 March 2024. The second visit was in April and occurred in one day, 12 April 2024. The final fieldwork took place in September 2024.

III.1.2.1. Fieldwork in March 2024

1. Description

In March, the team took into account several coastal aspects in the fieldwork, insisting on wave characteristics, water level, weather parameters, and water parameters.

Wave characteristics are obtained from only wave bouy. The location is set at 20.795600, 106.921000 (lat,lon) from 16 to 23 March 2024.

Figure 31. Designed location of Wave bouy.

Water level data is obtained from Level Gauge (see Table 1) and installed at the location shown in Figure 31. The schematic design for Leval gauges is shown in Figure 32.

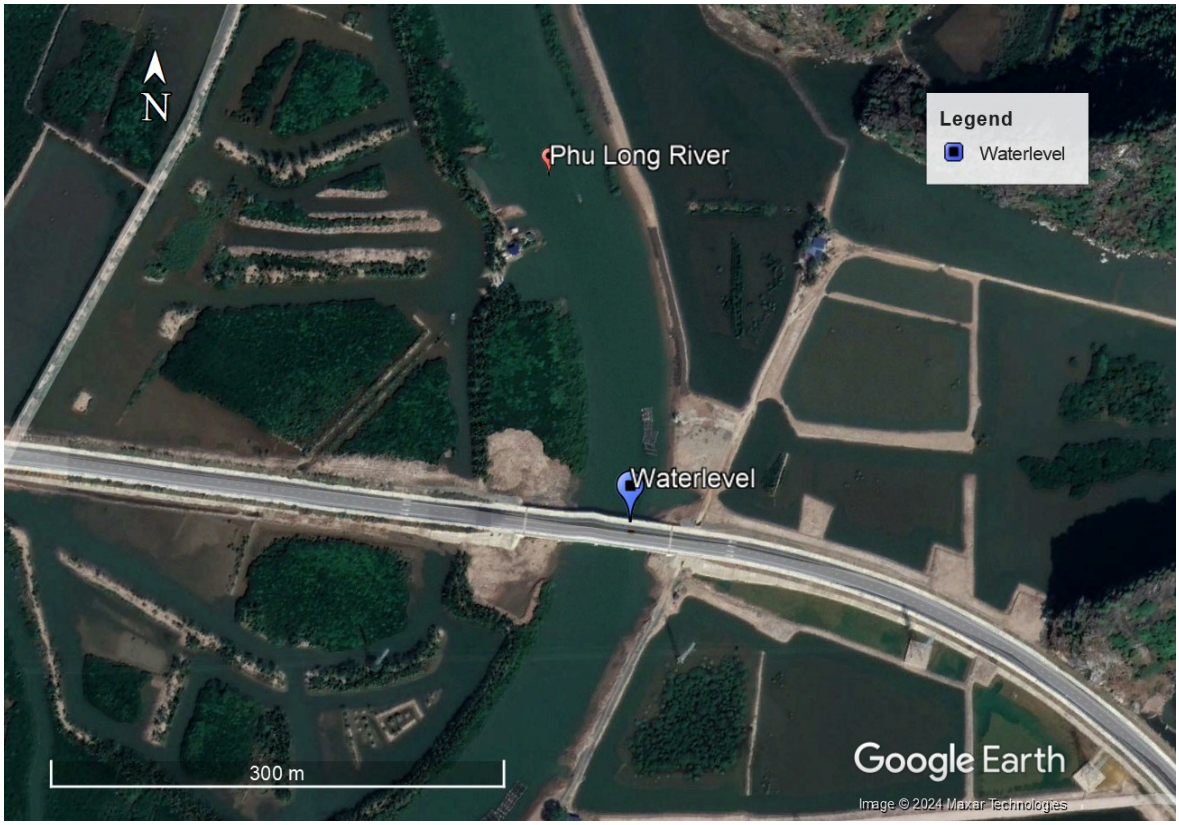

Figure 32. Level gauge location.

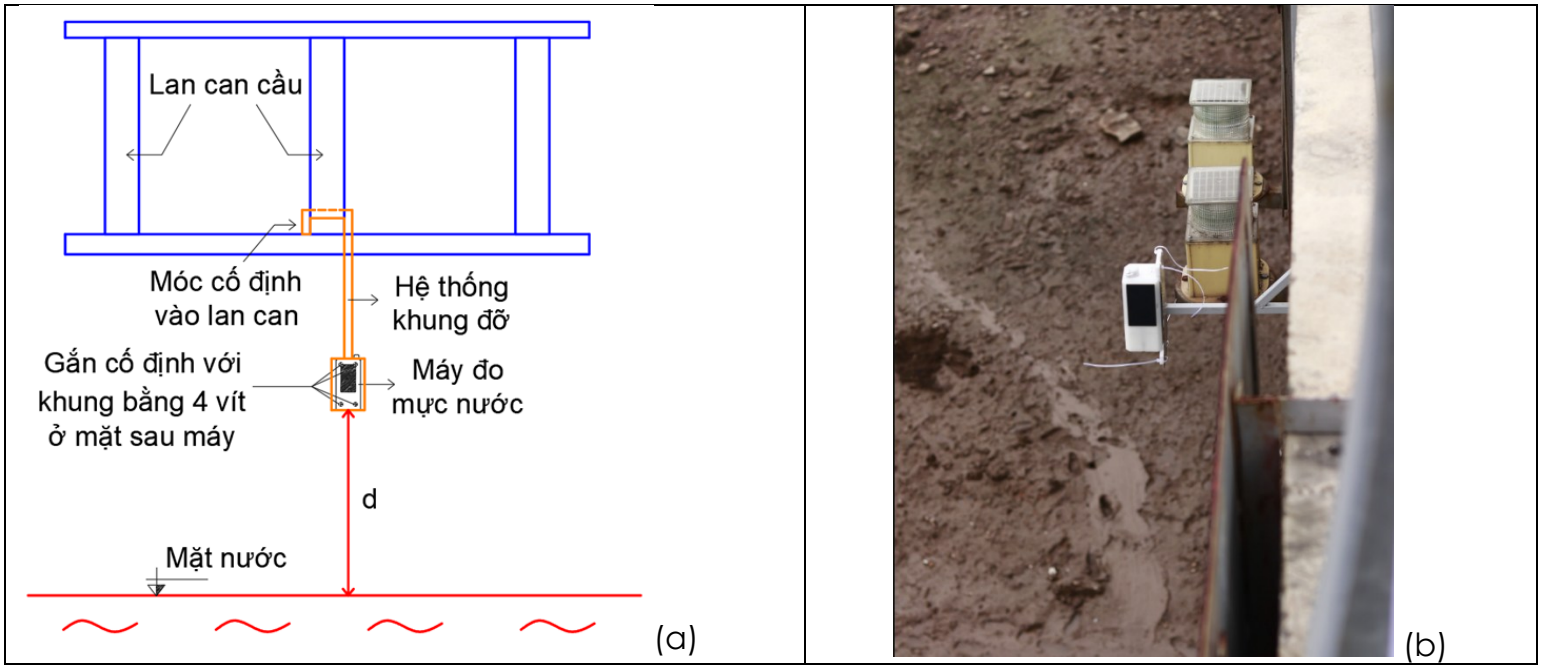

Figure 33. (a) Specifical design in setting up Level gauge and (b) Level gauges after installation.

A weather station is one of the important devices that can give a number of weather aspects to compare and match with hydraulic conditions. The station is set up at the location shown in Figure 34.

Figure 34. Weather station location

A water parameter station is set up on one of the piers inside the tidal channel. The location is set at 20.8046716, 106.9266376 (Lat, Lon) (see Figure 35)

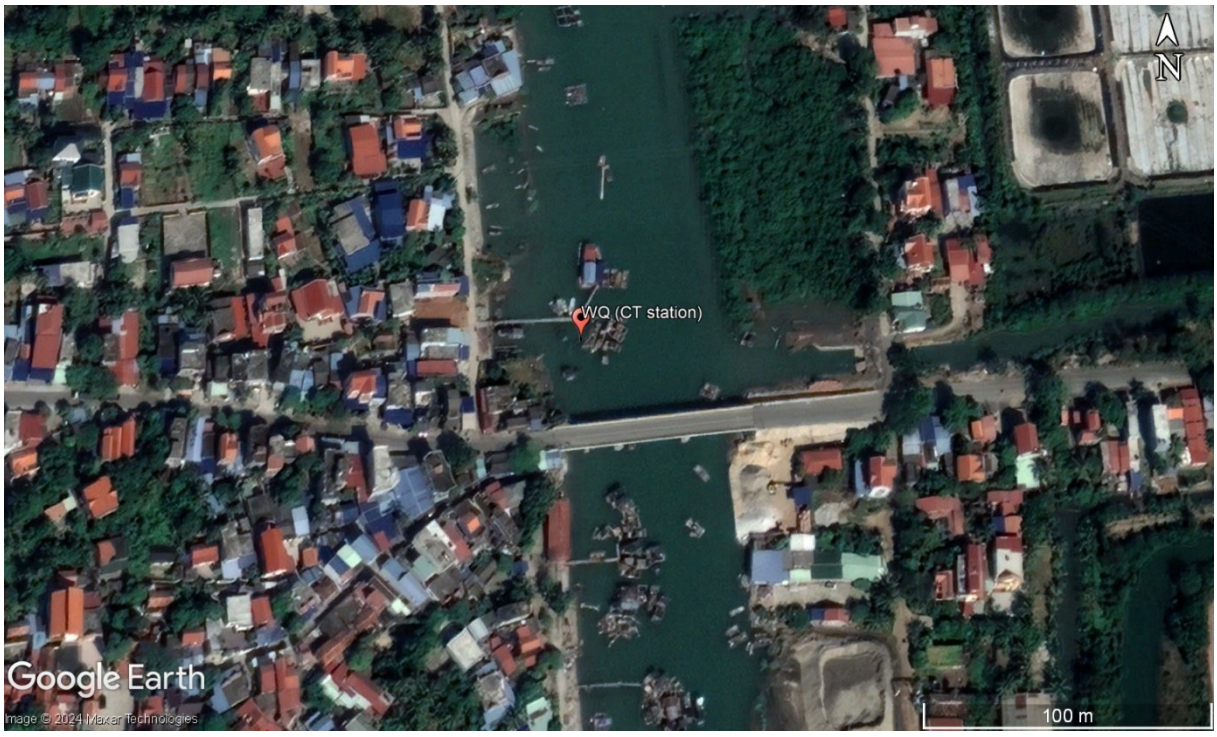

Figure 35. Water parameter station.

2. Activities and Results

Most of the plots of data recording in the first fieldwork in Phu Long are presented below.

-/ Wave data

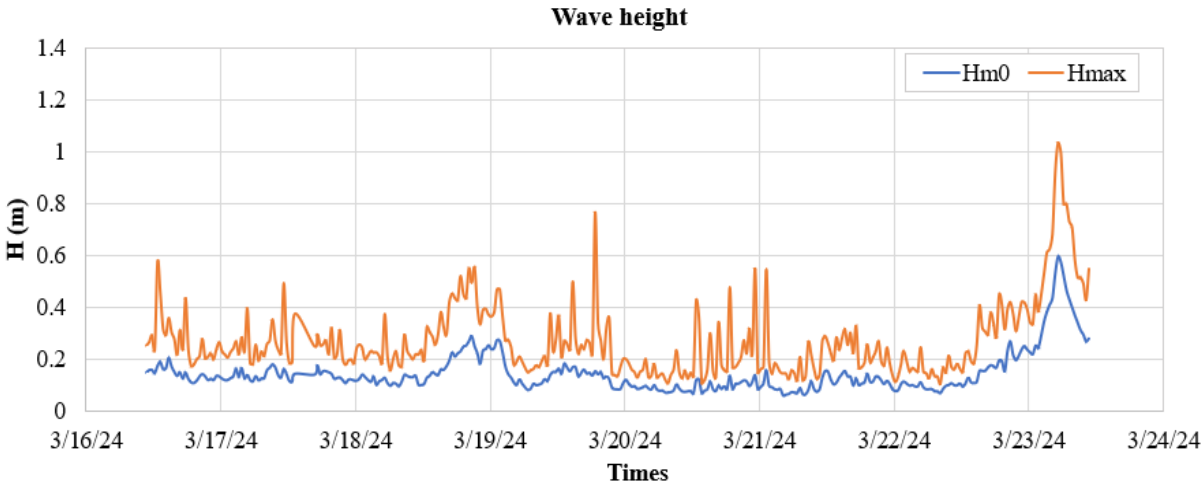

Figure 36. Significant wave height

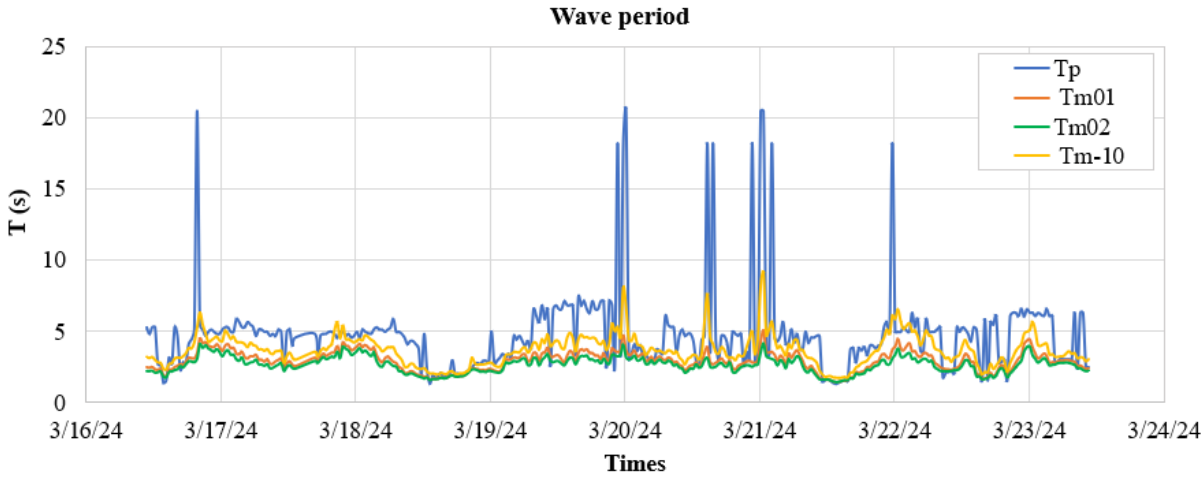

Figure 37. Wave period

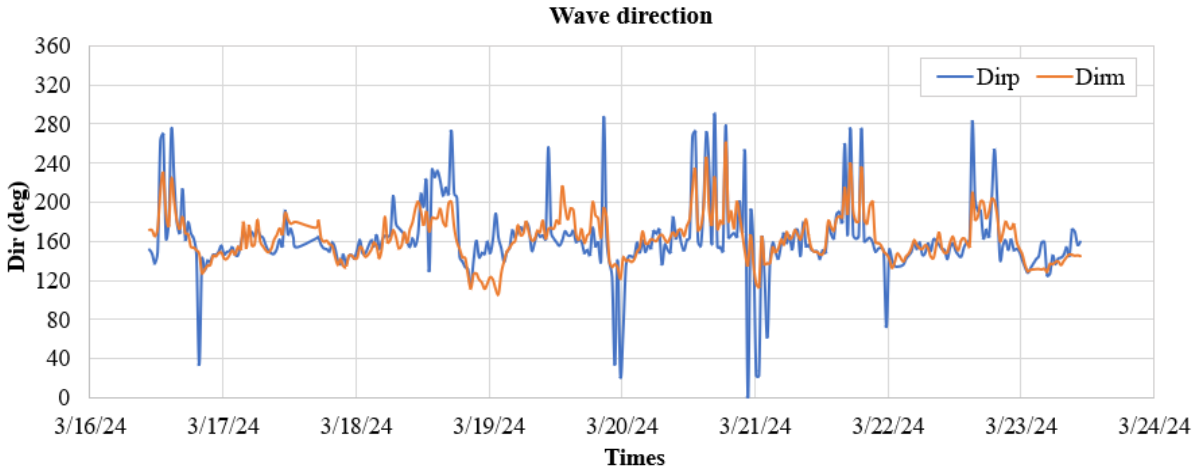

Figure 38. Wave direction

-/ Elevation raw records

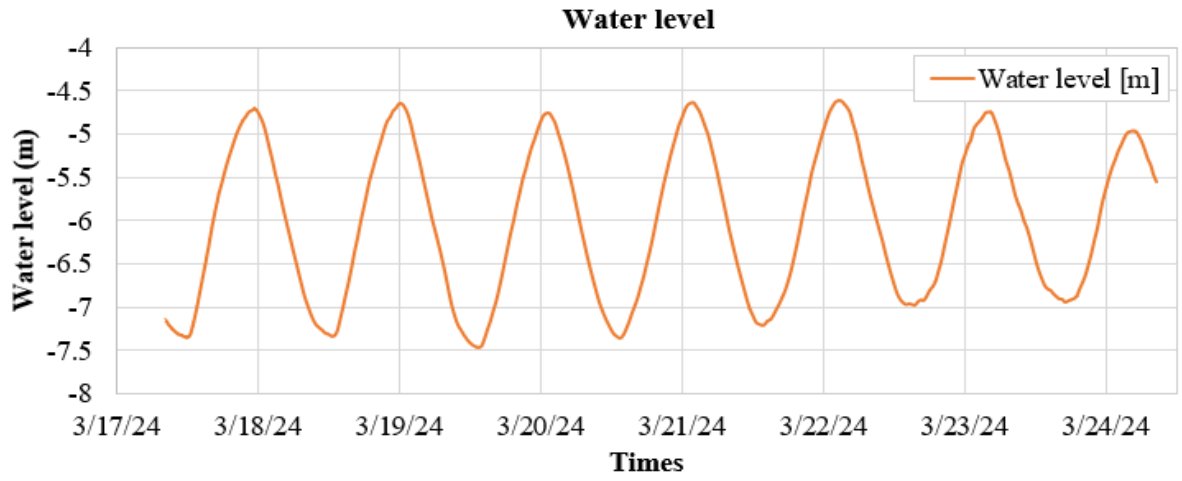

Figure 39. Water level. Note that it is needed to validate with national elevation

-/ Weather station

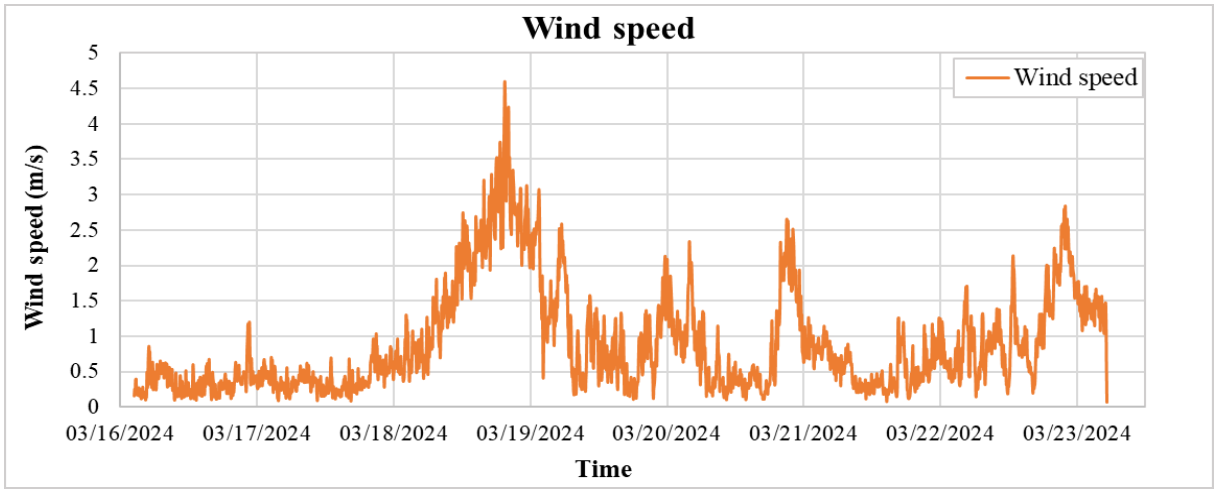

Figure 40. Wind speed

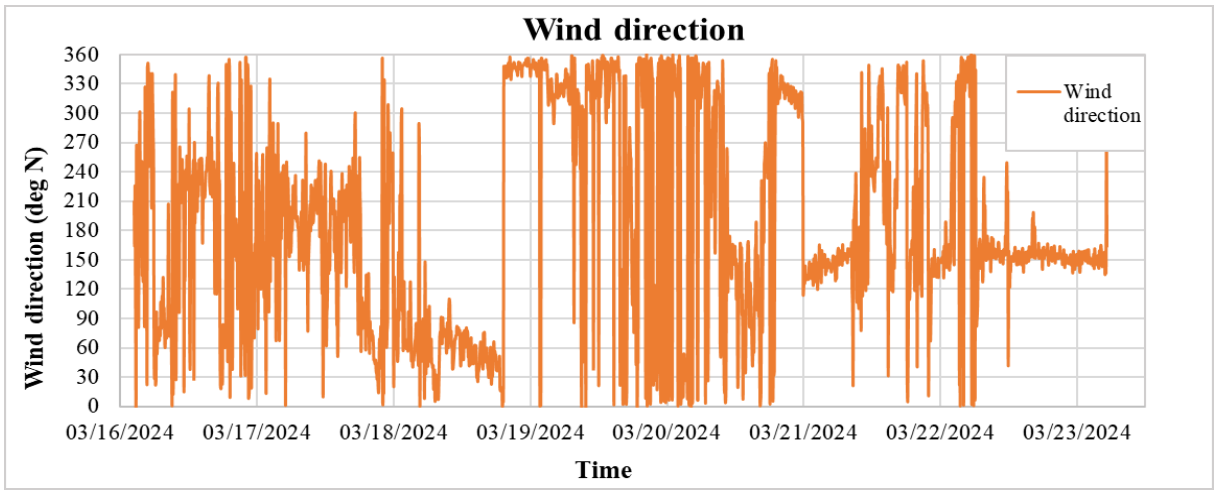

Figure 41. Wind direction

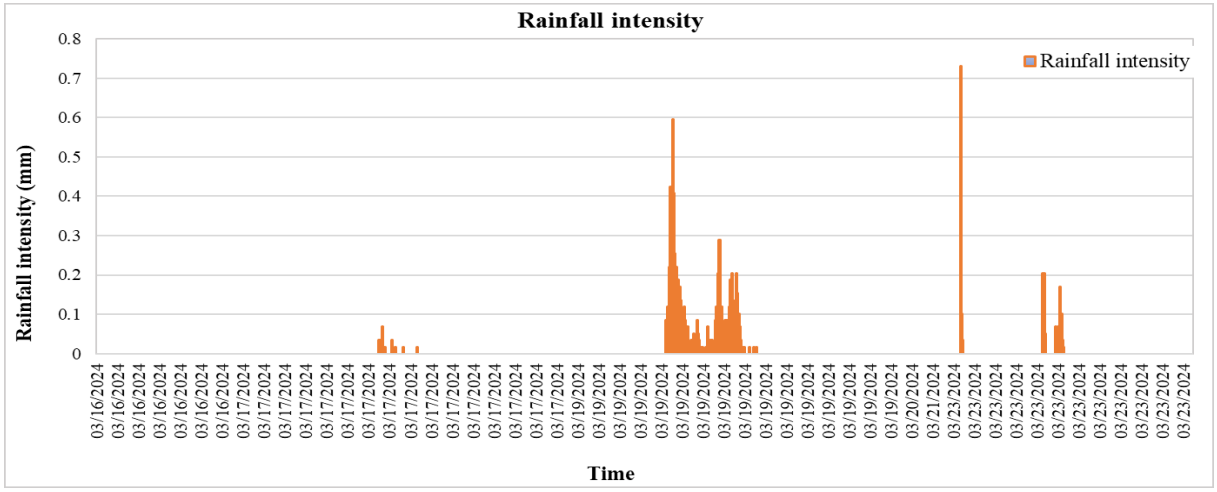

Figure 42. Rainfall intensity

-/ Water parameters

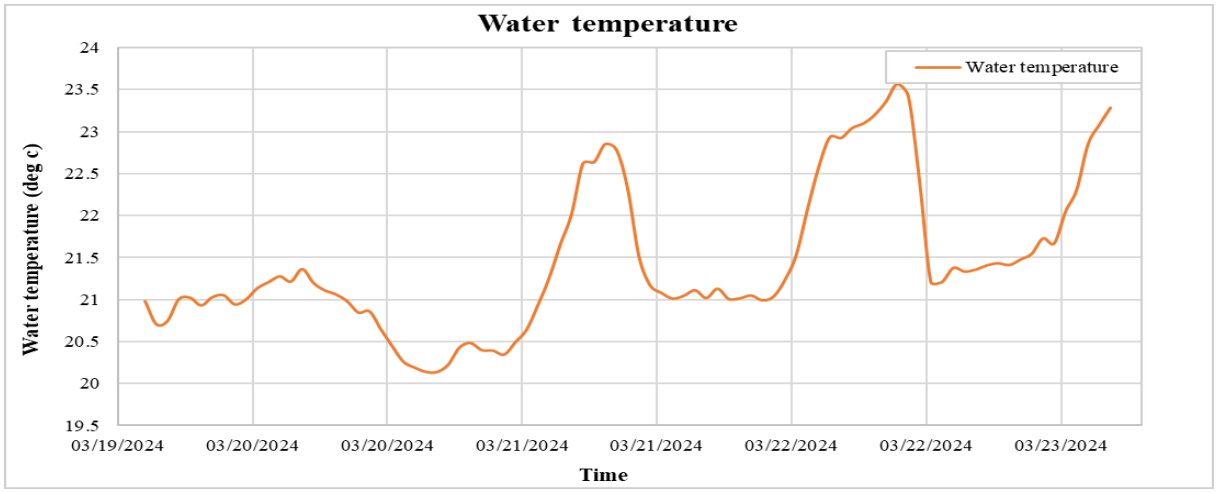

Figure 43. Water temperature

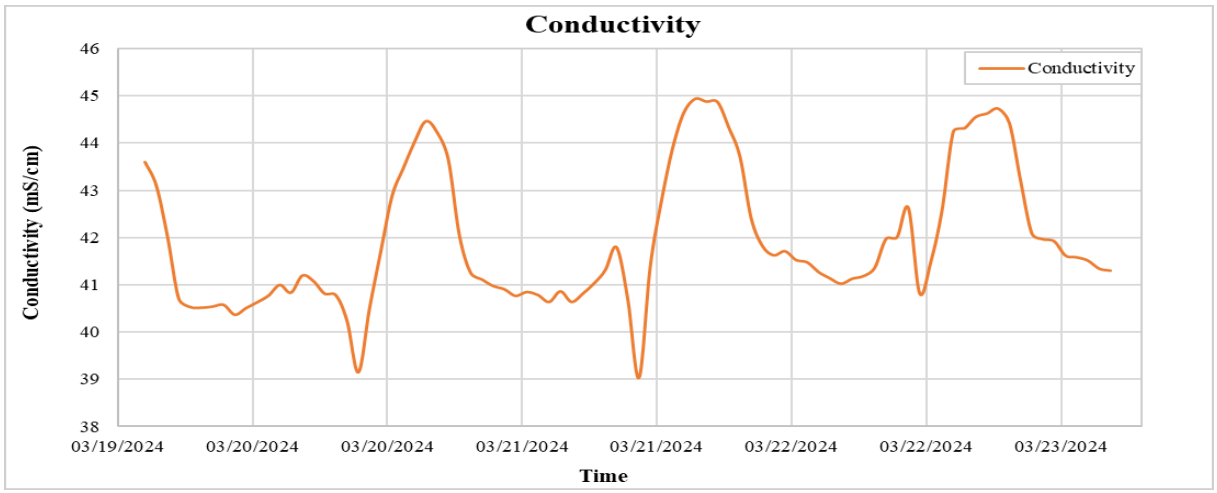

Figure 44. Conductivity

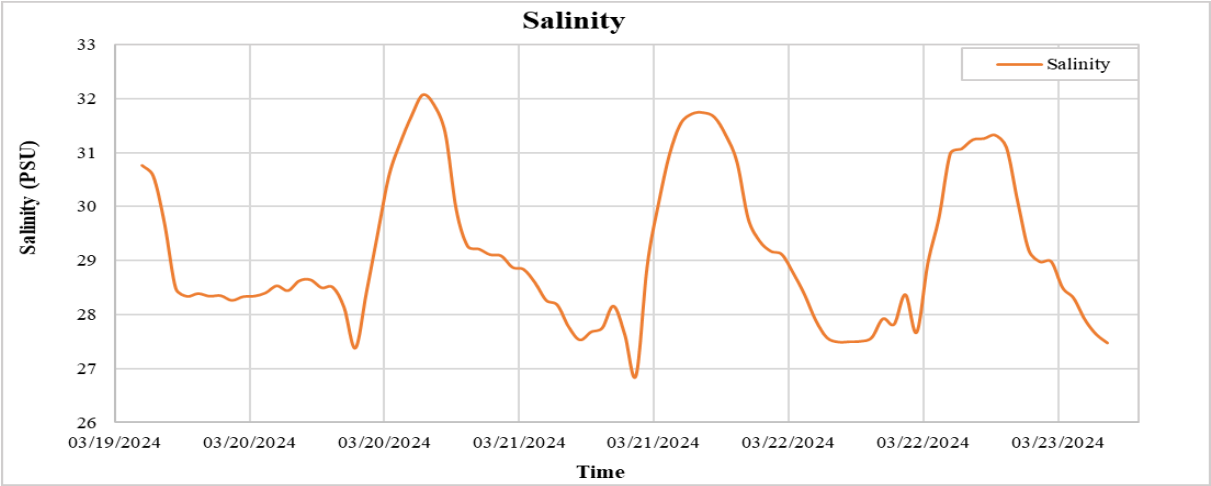

Figure 45. Salinity

-/ Biomass: Collected samples of mangroves are shown in Table 4 below

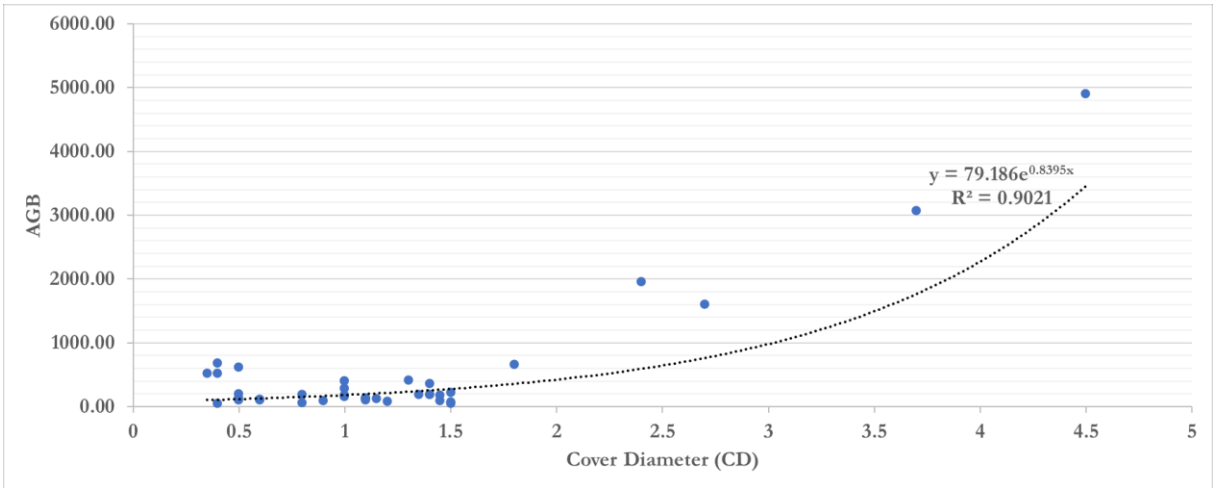

Figure 46. A relationship between Cover Diameter and AGB.

III.1.2.2. Second visit in April 2024

The second visit to Phu Long occurred on 12 April 2024, attracting other experts in different fields, e.g., economy, psychology, and civil engineering, to do surveys with local authorities, primary and secondary schools, and local farmers.

1. Local authorities

The team had several questions on general economy, social, and livelihood information, including:

-/ There are four wards, e.g., Bac, Ngoai, Nam, and Ao Coi Ward, with a total area of up to 4230ha (2022) and a population of 2400 (~624 households). There are also 100 families working in aquaculture farming in a total of 1274ha, making the total number of people who work in this field up to 300, approximately 90% of local citizens.

-/ Economy structures consist of aquaculture shrimp farming, fishery, tourism, and freelancing. It is recognized that the unemployment rate is nearly 0%. The annual income is from 79 to 84 million VND per person. Agriculture farming is mostly intensive, whereas no information on career exchanges is recorded. However, the local specialization is quite poor when only two items are registered, e.g., Phu Long crab and Mangrove Honey.

-/ Mangroves in Phu Long consist of nearly 70% of the total mangroves in Cat Ba island, including about 632ha of mangroves and 100ha of tidal flats. The diversity of mangroves is quite poor since only four species presented, e.g., *Rhizophora sp., Bruguiera gymnorrhiza, Aegiceras sp., and Avicennia alba*. It recorded a reduction of mangroves before 2000 and recovery after a couple of years as a result of a new policy in improving local attitude and behavior on mangroves. Mangroves in Phu Long are also listed in UNESCO conservation standards as the natural habitat for maintaining natural landscapes.

(a) (b)

Figure 47. Living lab team work with local authorities (a) and farmers (b)

-/ Mangroves in Phu Long are under the management of a main force, the forest rangers of Cat Ba National Park, Phu Long ward, and Cat Hai province. As a result, a large number of projects in maintaining and restoring mangroves have been approved. However, a majority of projects are recorded unsuccessfully due to a lack of general knowledge and experience in mangroves. Other notices make unsuccessful projects are about applying different species that could not survive in the environment.

-/ A note from local authorities is that planting mangrove projects in Phu Long, in particular, and in Cat Hai province, in general, needed to have a confirmation to return an area of three times as given. However, there were no records for those successful mangroves given back to the local authorities.

2. Education activities

-/ On the same day, the team also worked with students in local primary and secondary schools. A workshop was created to seek out how local children understand mangroves. The team, with the support of a painting artist, created a very good atmosphere and environment for children and teachers in a fair and competitive drawing game.

Figure 48. Living Lab expert (left) and local teachers (right) in the workshop

Figure 49. Students and teachers in the workshop

-/ The outcome of this workshop showed a very positive sight in that most of the students acknowledged mangroves and livelihood from mangroves. It is due to that their parents are also farmers who work in aquaculture shrimp farms. The interesting point to the team is the diversity of student imagination on mangroves. In other words, the team should consider this a regular/annual activity for children in this area and bring up higher improvement for local people.

-/ After this activity, the team visited the kindergarten and acknowledged the percentage of parents who work in aquaculture shrimp farms is quite large. However, due to the time-consuming and less effective for children of this age to do activities, the team only had conversations with the directors of this school.

Figure 50. Workshop in the local primary and secondary school.

III.1.2.3. Fieldwork in September 2024

1. Description

The second fieldwork in Phu Long took place from 27 September to 04 October 2024 to obtain particular aspects of hydrology and meteorology, e.g., flow velocity, water level (elevation records), weather, and water parameters. The measurement stations were different from the previous time, which were close to each other. Figure 51 presents the locations of each station.

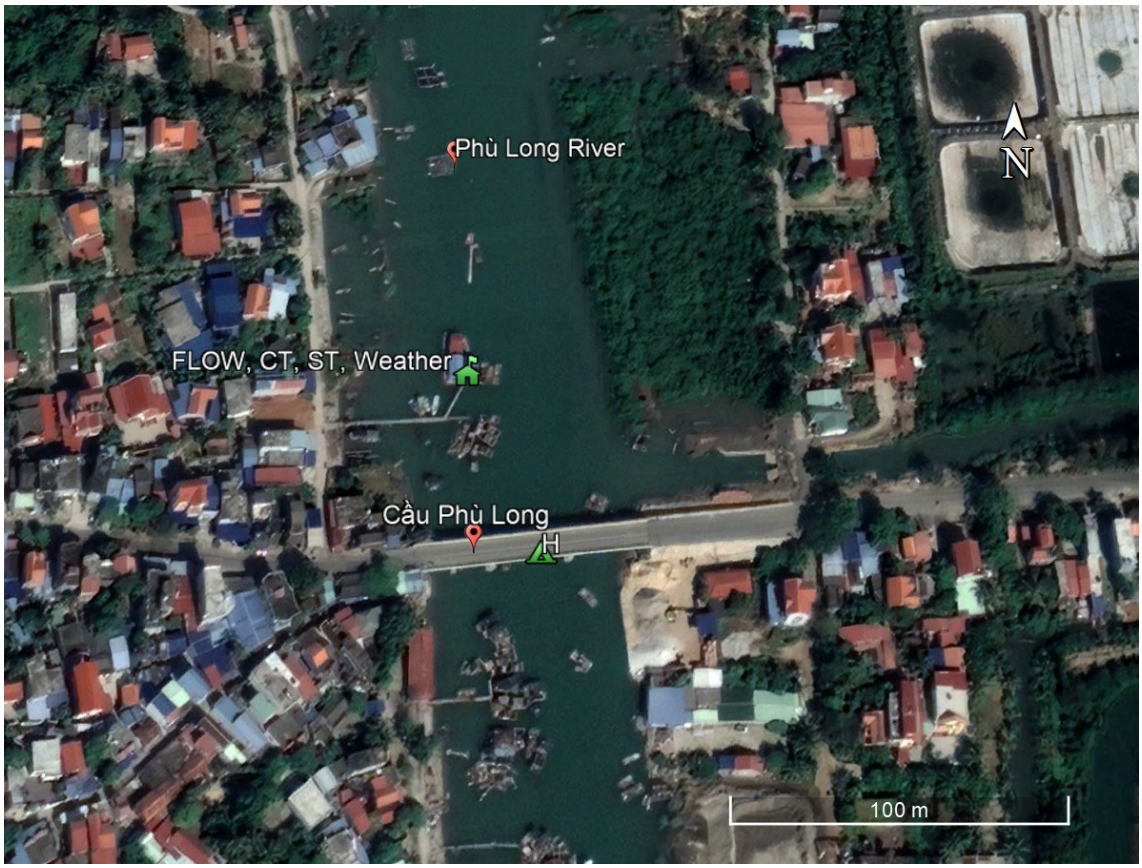

Figure 51. Locations of stations. A water Level station (elevation, H) is installed at Phu Long Bridge, while flow, water, weather, and sedimentation stations are located at a pier close by.

-/ Water level (elevation) station is installed at the sea side of the bridge (see Figure 52). Location is at 20.804063, 106.930708 (Lat, Lon). The national/global elevation is eventually obtained to validate.

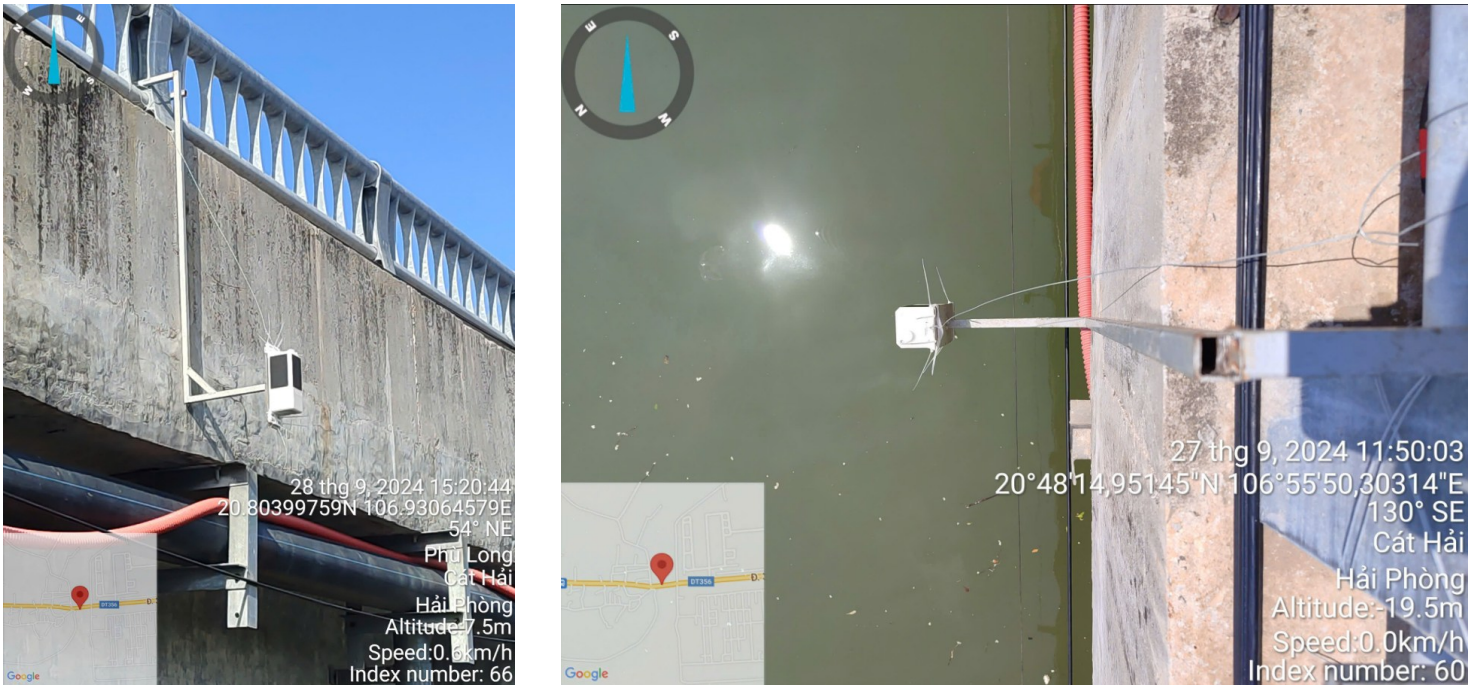

Figure 52. Level gauge devices after installation.

Figure 53. Obtaining national/global elevation.

-/ Flow velocity, weather, water parameter, and sedimentation stations are all located at 20.804617, 106.930490 (Lat, Lon) shown in Figures 54 and 55.

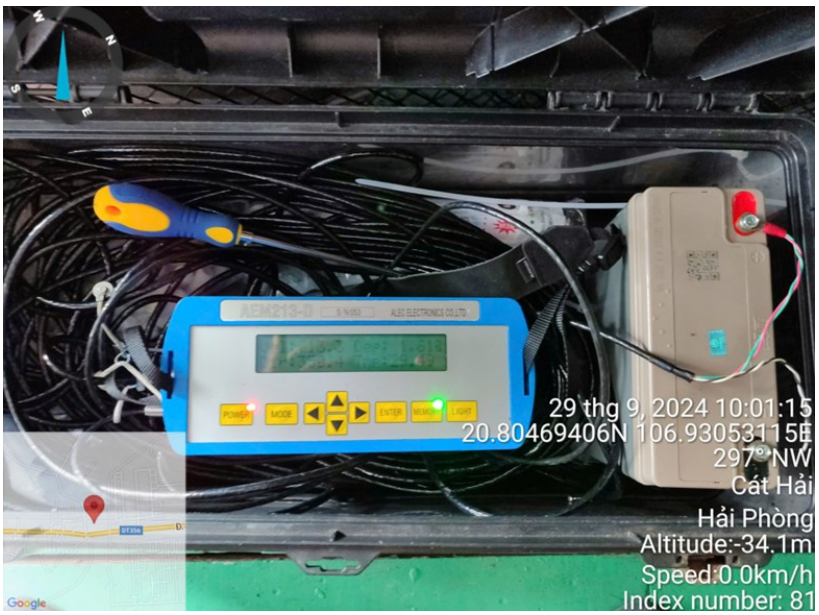

Figure 54. (a) The flow station includes a sensor put under the water surface and close to the bed (30 cm from the bed), and data records every 30 minutes with a frequency of 1/15. (b) Sedimentation collecting.

-/ Weather and Water parameter

Figure 55. (a) Collecting sedimentation samples. (b) Weather station. (c) Water parameter station.

2. Activities and results

-/ Water level (Elevation records)

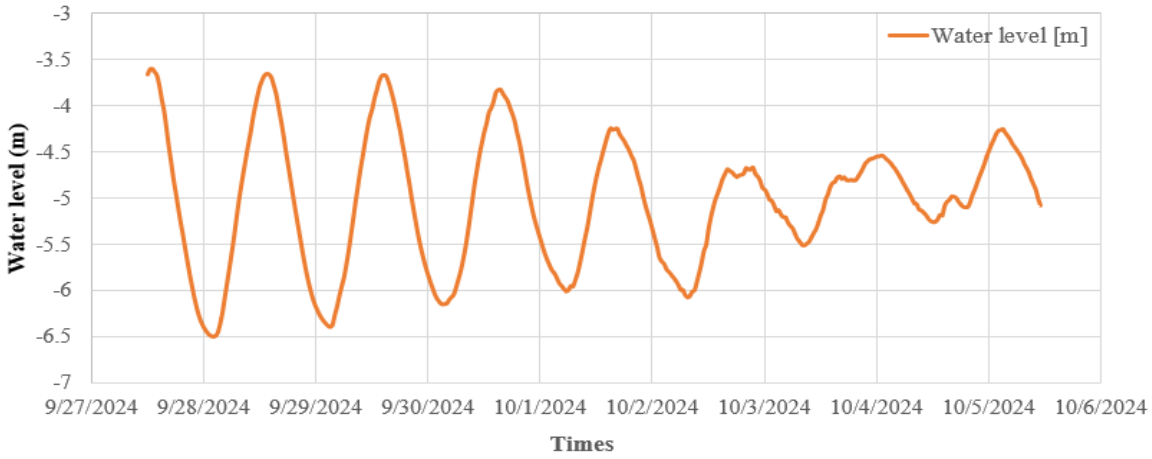

Figure 56. Elevation at the Level station

-/ Flow velocity

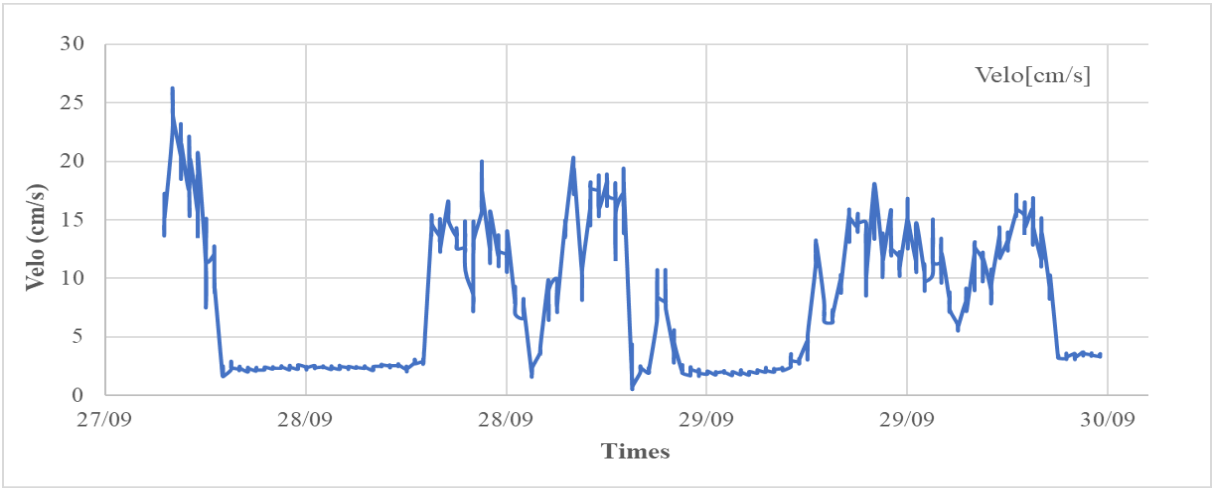

Figure 57. Flow velocity

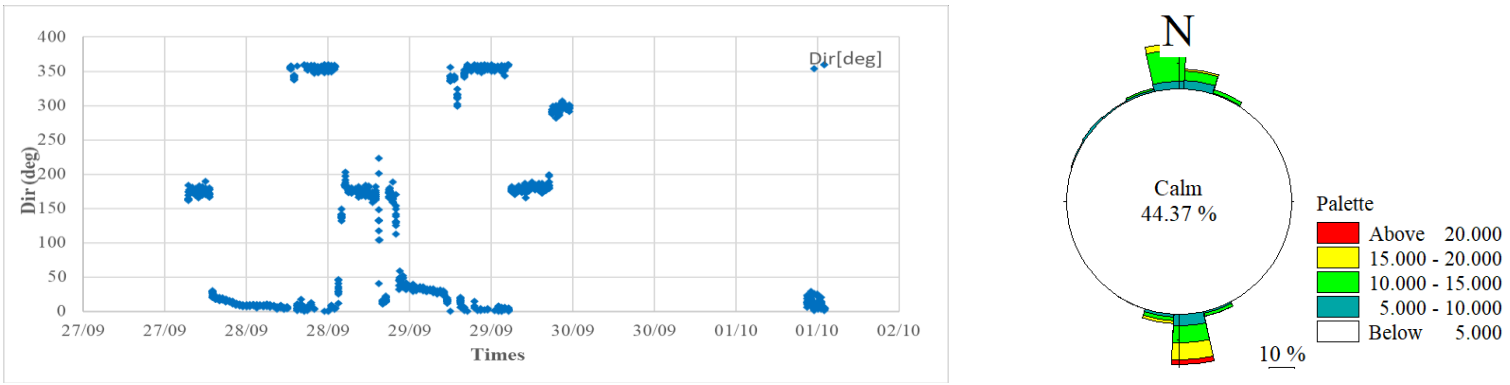

Figure 58. Flow direction

-/ Sedimentation

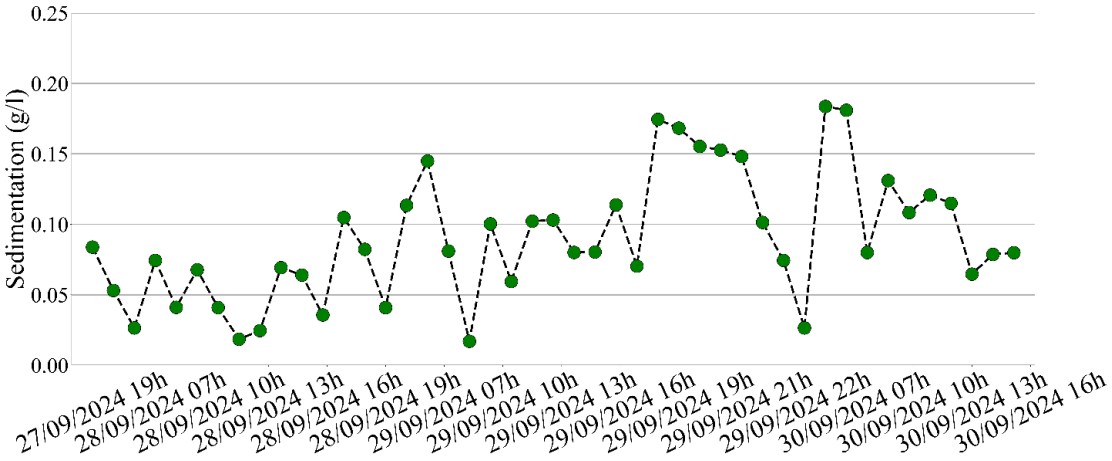

Figure 59. Final results of sedimentation during the fieldwork.

-/ Weather

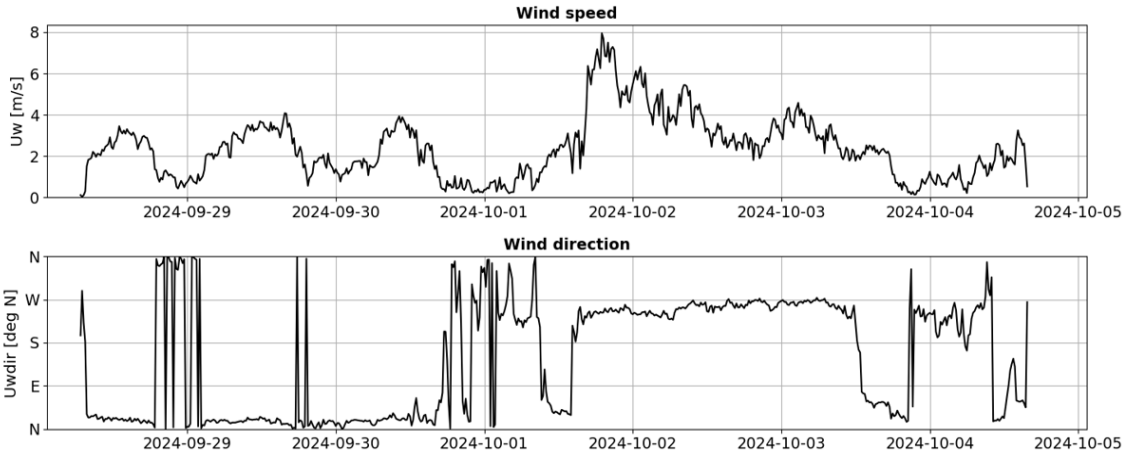

Figure 60. Wind speed and direction.

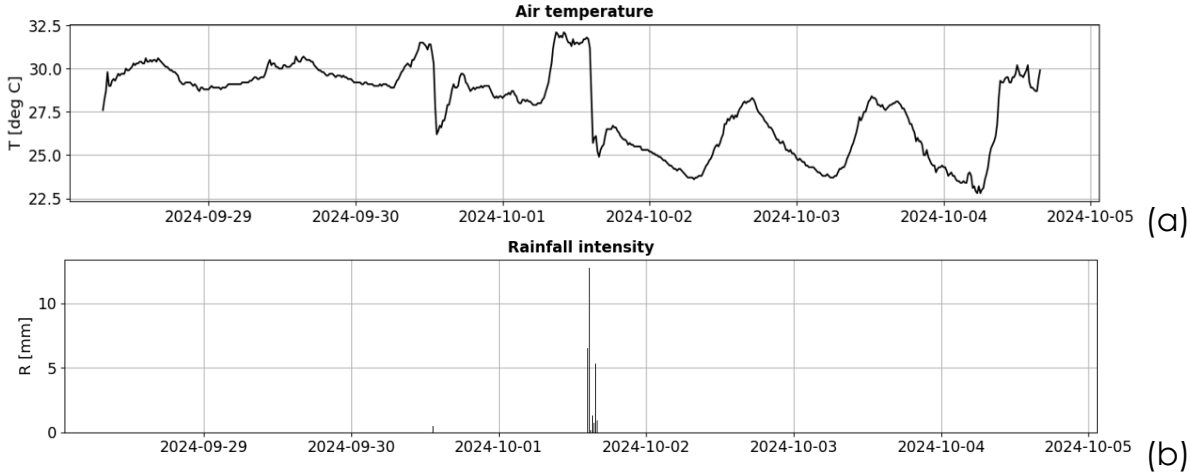

Figure 61. Air temperature (a) and rainfall intensity (b)

-/ Water parameter

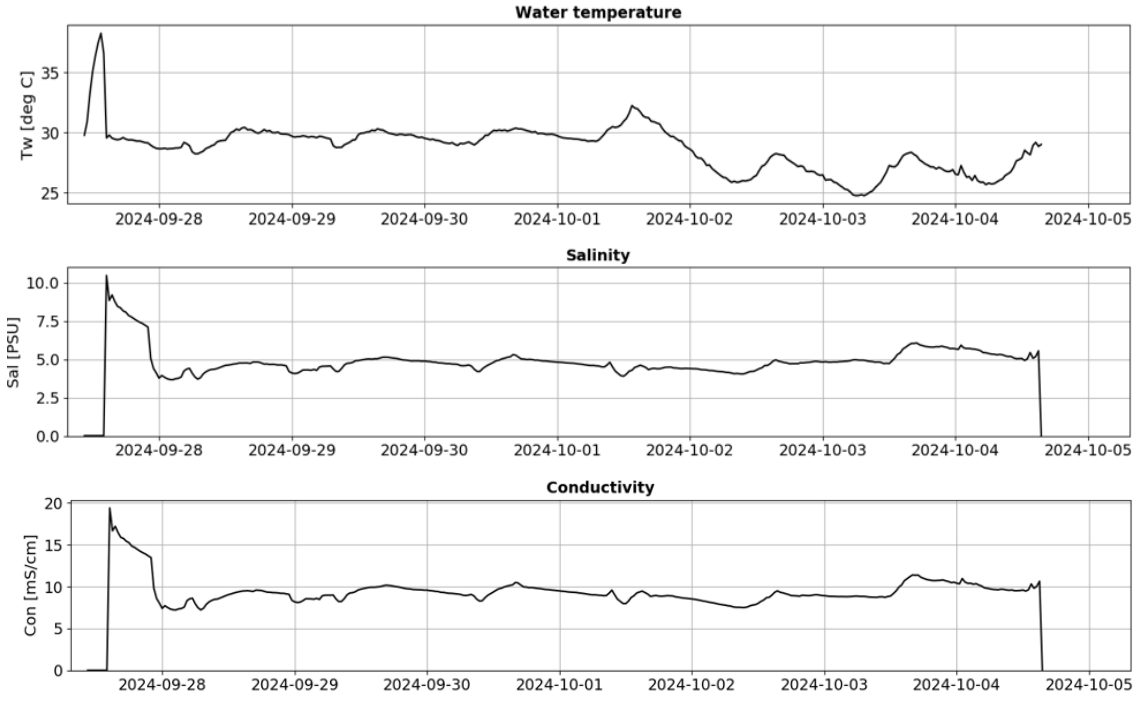

Figure 62. Water parameter from CT Station. (a) Water temperature; (b) Salinity; (c) Conductivity.

Part IV. Conclusion

- / New opportunities for mangrove research.

The particular characteristics of the north and south of Vietnam via the two campaigns in 2024 have established new windows for mangrove research in the future. Hydrogeological parameters, such as wave and water level, reflect the tide dominance found in Phu Long - Hai Phong, while the wave dominance is presented in Bac Lieu coasts.

Among the perspectives of coastal engineering, the biological ideas from experts also create new research questions relative to gaining economic benefits for local farmers and authorities. In Bac Lieu, the two sites, Nha Mat and Hoa Binh I, reflect two different conditions of mangroves. Nha Mat area has lost a significant amount of mangroves since 2016 due to natural and man-made activities following previous reports and studies. Meanwhile, mangrove retreating in Hoa Binh I is being occurred. This issue will leave a space for researchers to carry out the fundamental reasons for this mangrove difference.

More than that, the importance of bathymetry on mangrove growth is still questionable since the Bac Lieu coasts have been becoming over-protected. Various types of coastal protection infrastructures were built, including the hallow pile rock dike (a type of permeable structure) and circle porous dikes (See Figure 23), making Bac Lieu coasts an actual living lab for structures. This issue can be an interesting topic for researchers to carry out the scientific understanding of the real effects of structures on mangrove losses.

In Phu Long, mangroves are clearly influenced by the tide and human activities. Located in the south of Cat Ba island and directly under forces by ships and boats daily, mangroves

…

-/ Fieldwork should be carried out in a more optimism way.

…

-/ Pros and Cons

…

-/ Permenant site assessing