Coastal Erosion Monitoring Platform Based on Wireless Sensor Networks and 3D Point Clouds from Airborne LiDAR

- Concern of coastal erosion is growing due to habitat destruction, loss of biodiversity.
- Sustainable coastal management is necessary but lack of sufficient information.
- A data center platform that offers both raw and processed data is indispensable.
  - Sensors, video monitoring systems, 3D point clouds, and weather stations.
- In this project, we propose a platform for collecting, monitoring, and processing environmental data of coastal areas.
- This platform is designed to support decision-making by providing recommendations or predictions based on data analysis.

Objectives: 1) built a data center and data collection platform to provide information to policy maker and general people and 2) research data collection and processing techniques, models for prediction, classification, segmentation, etc. related to coastal erosion.

Speaker: Mr. Surasak Boonkla, PhD., National Electronics and Computer Technology Center (NECTEC), Thailand

Coastal Erosion Monitoring Platform Based on Wireless Sensor Networks and 3D Point Clouds from Airborne LiDAR

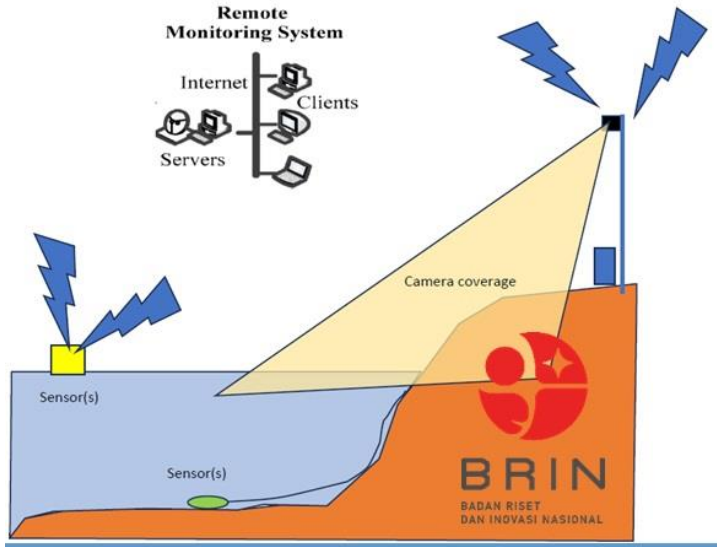
Institution	Name
National Electronics and Computer Technology Center, Thailand	Dr. Surasak Boonkla*, Dr. Jessada Karnjana, Dr. Kasorn Galajit, Dr. Sutat Saetang
School of Engineering, Thammasat University, Thailand	Dr. Akkharawoot Takhom, Mr. Pasut Insung, Mr. Pasut Insung
School of Information, Computer, and Communication Technology (ICT), Sirindhorn International Institute of Technology, Thammasat University, Thailand	Dr. Somrudee Deepaisarn
Faculty of Informatics, Burapha University, Thailand	Dr. Waranrach Viriyavit, Dr. Pichet Wayalun
Coastal Resources Conservation Division, Department of Marine and Coastal Resources, Thailand	Mr. Paramin Sansongsak , Mr. Parinya Tongkrathok
Universiti Teknologi Malaysia, Malaysia	Dr. Sharifah Hafizah Syed Ariffin, Dr. Shafishuhaza Sahlan
Institut Teknologi National Bandung, Indonesia	Dr. Soni Darmawan, Dr. Didin Permadi, Dr. Dian Noor Handiani, Dr. Yessi Nirwana Kurniad
Cambodia Academy of Digital Technology, Cambodia	Dr. Phut Phalla Kong, Dr. Hongly VA
Research Center for Oceanography - National Research and Innovation Agency, Indonesia	Dr. Johan Risandi, Dr. Yaya Ihya Ulumuddin, Mrs. Terry Louise Kepel

Project Budget: 40000 USD/year

Project Duration : 2 years, Apr. 2024 – Mar. 2026

Project Activities: Sensors and Data

Data for coastal dynamics analysis.



GISDA:THEOS-2

DJI

Orthogonal image and 3D point cloud

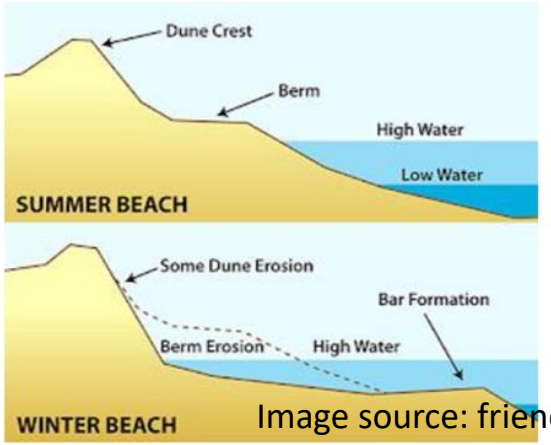
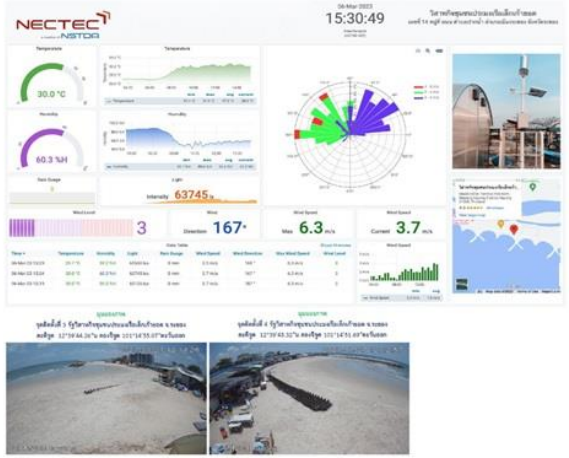
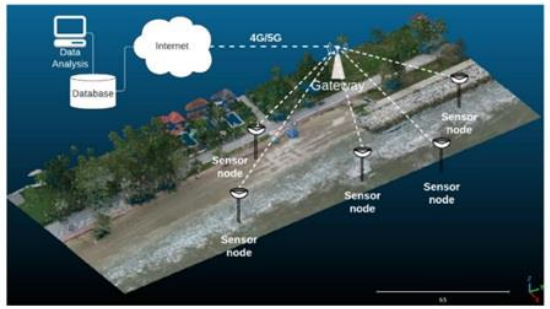
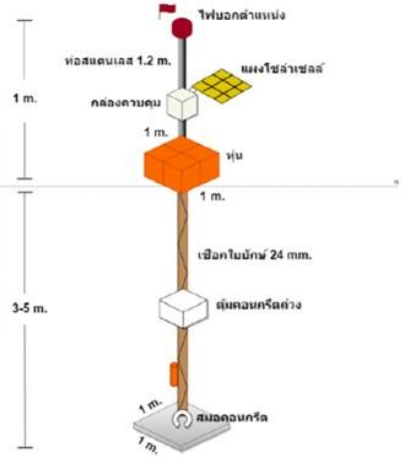


Image source: friendsofibsp.org

Weather station + CCTV

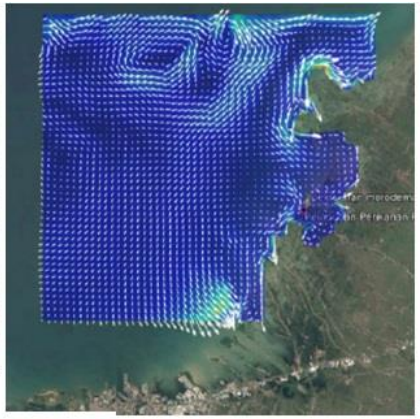


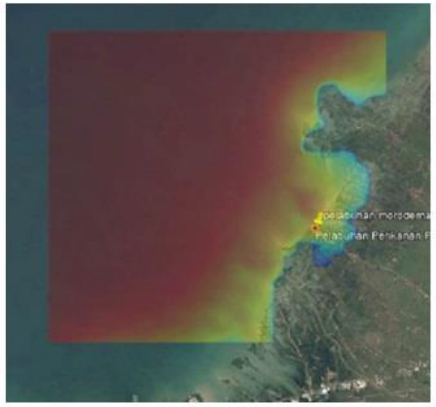




Project Activities: Analysis

Nearshore dynamics, erosion and sediment transportation, beach profile, coastal vulnerability, shoreline detection





Beach profile

Rip current detection and analysis

Effectiveness of wave breaker

Effectiveness of sand fence

Project Activities: (Prior Work) Dominant Wave Height Estimation Based on Spectral Analysis for Coastal Erosion Monitoring System in Real Time

Parin Jatesiktat , **Kasorn Galajit** , Thanaphat Khemniwat , PatthranitKaewcharuay , Pannathorn Sathirasattayanon , **Jessada Karnjana,** iSAI-NLP-AIoT, November, 2023

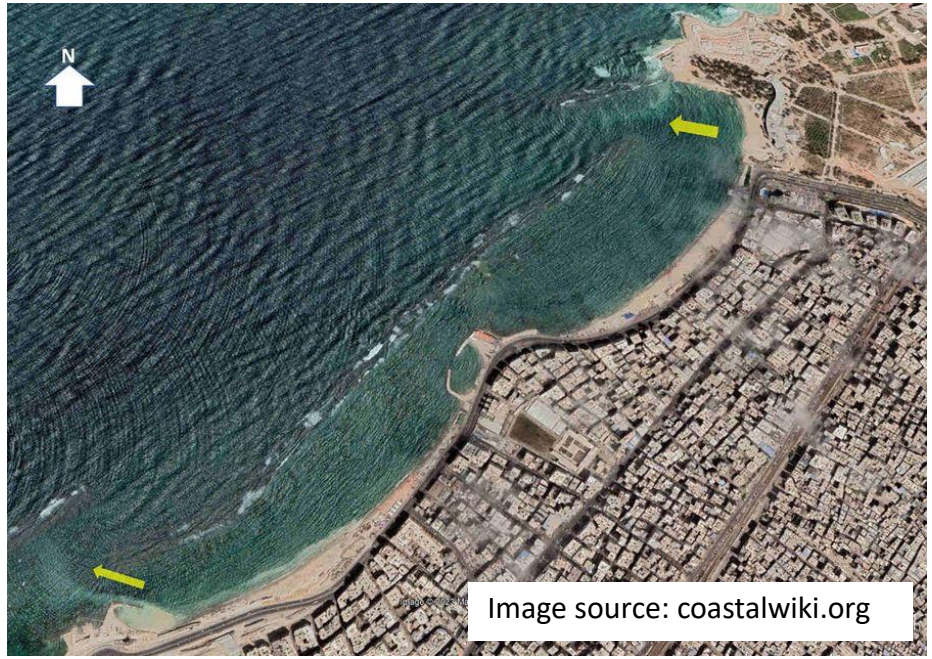
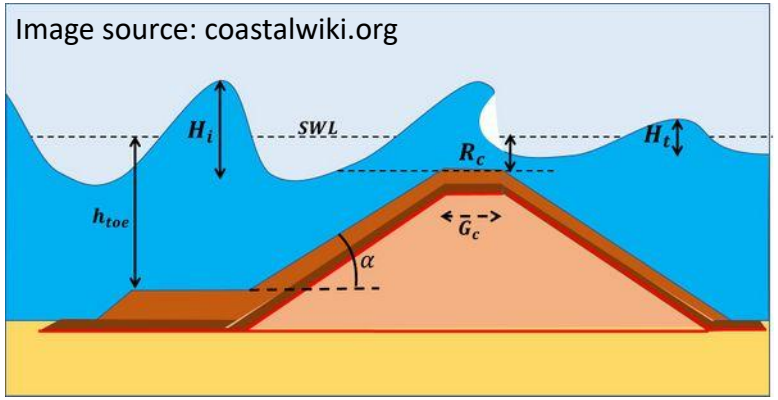


Image source: coastalwiki.org



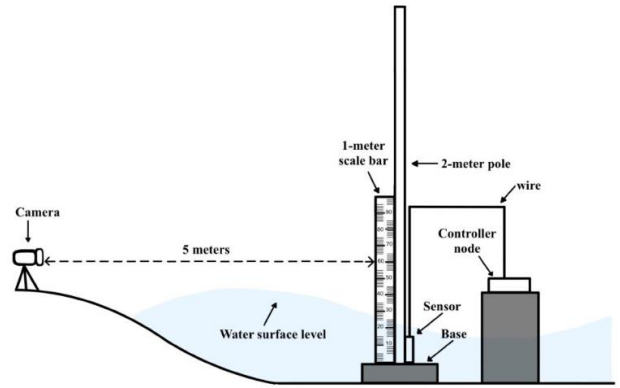
Wave transmission coefficient reflects breakwater efficiency.

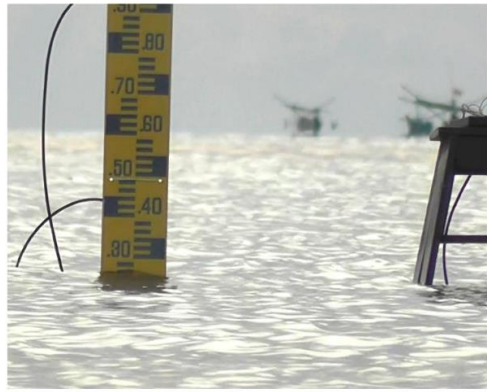
Transmitted wave

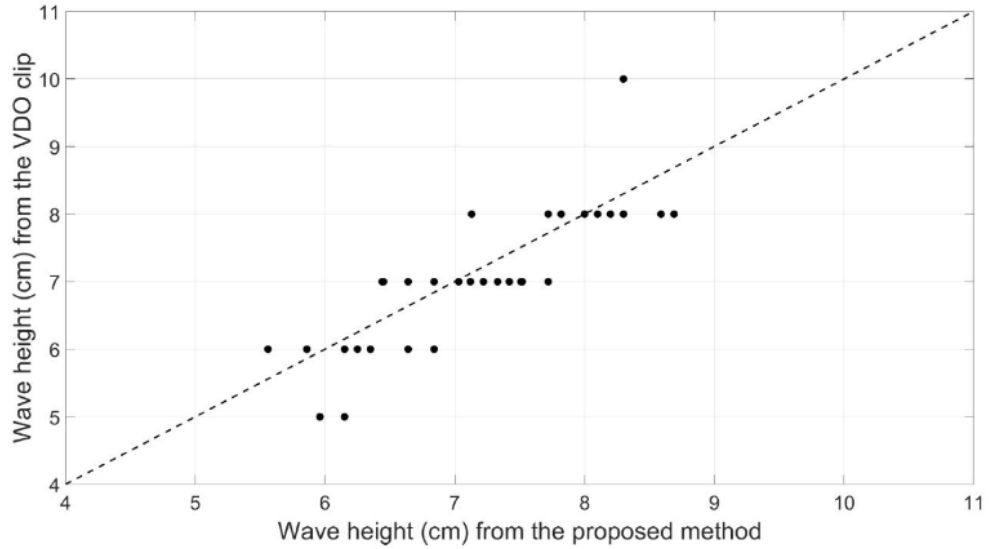
$$K_t = \frac{H_t}{H_i}$$

Incoming wave

Real time dominant wave height estimation is important for monitoring wave breaker efficiency.



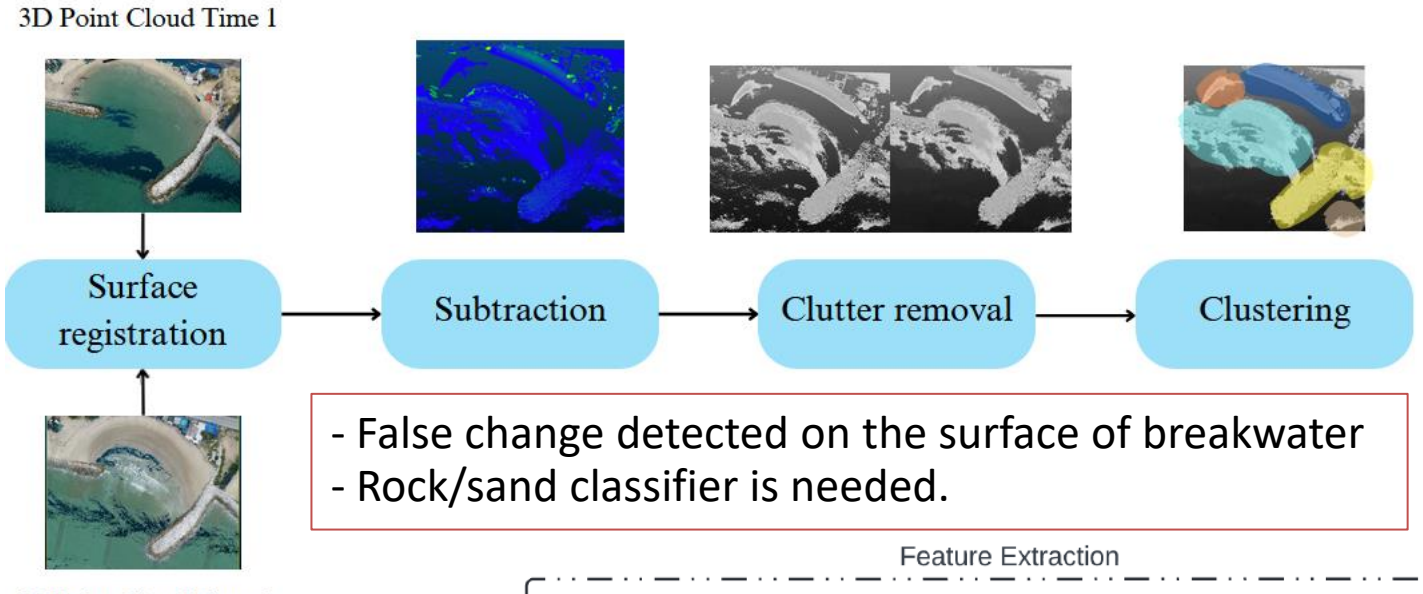




Project Activities: Utilizing a Classification Tree for Rocky Terrain Detection in 3D Point Clouds for Coastal Erosion Studies

Pasut Insung, **Peerapat Supasri**, Phattarakorn Limsuwat, Setthanan Thitathanapat**, Akkharawoot Takhom**, **Kasorn Galajit**, **Surasak Boonkla**, **Jessada Karnjana,** SICE, Aug. 2024

How to monitor coastal area from 3D point clouds



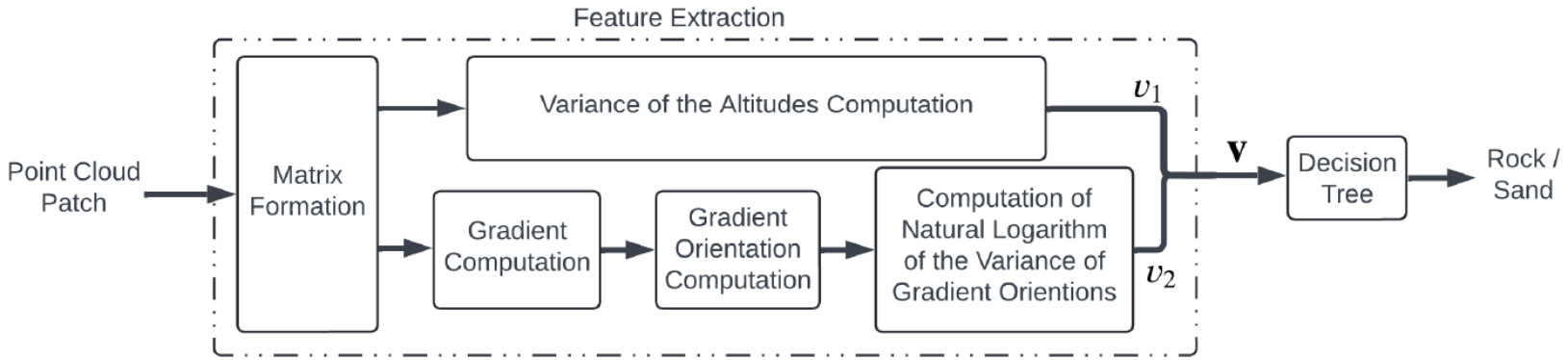
- False change detected on the surface of breakwater
- Rock/sand classifier is needed.

$$\mathbf{Q} = \begin{pmatrix} q_{1,1} & q_{1,2} & \cdots & q_{1,d} \\ q_{2,1} & q_{2,2} & \cdots & q_{2,d} \\ \vdots & \vdots & \ddots & \vdots \\ q_{d,1} & q_{d,2} & \cdots & q_{d,d} \end{pmatrix}, \qquad v_1 = \frac{1}{d^2-1} \sum_{j=1}^{d} \sum_{k=1}^{d} \left(q_{j,k} - \bar{q}\right)^2,$$

where

$$q_{j,k} = \frac{1}{|\Omega_{j,k}|} \sum_{i \in \Omega_{j,k}} z_i, \qquad v_2 = \ln\left(\frac{1}{d^2-1} \sum_{j=1}^{d} \sum_{k=1}^{d} \left(\theta_{j,k} - \bar{\theta}_{\mathbf{Q}}\right)^2 \right),$$

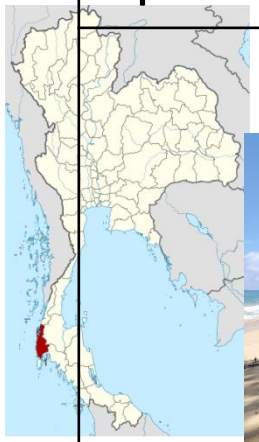
	Precision	Recall	F_1 score	Accuracy	Balanced Accuracy
Decision Tree	99.69	**99.70**	**99.69**	**99.69**	**99.69**
SVM	**100.00**	95.68	97.78	97.85	**99.69**
Logistic Regression	**100.00**	95.68	97.78	97.85	97.84



Project Activity Plan: Coastal Change Monitoring Using 3D point cloud by NECTEC, DMCR, and TU

2024 → 2025 → 2026 → End

Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar



- Data collection before and after rainy season using UAV LiDAR
- Develop sand volume change estimation method from 3D point cloud data within controlled conditions
- Apply the sand volume change estimation method to the data collected on the beaches.
- Develop low-cost UAV LiDAR, 3D point cloud dataset
- Develop low-cost UAV LiDAR, 3D point cloud dataset
- Apply the sand volume change estimation method to the data collected on the beaches.

Expected output: one 3D point cloud dataset of a beach, two publications, and a low-cost UAV with LiDAR.

NECTEC a member of NSTDA

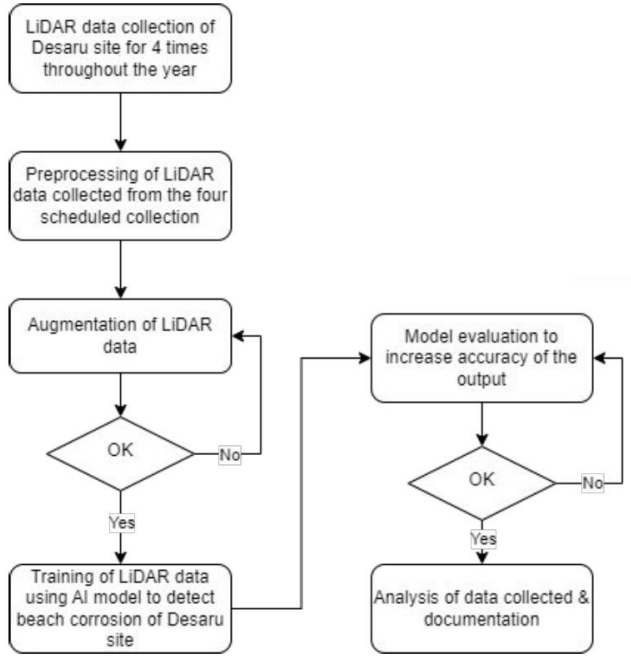
Project Activity Plan: Development of a Coastal Erosion Risk Prediction Using Machine Learning by UTM

		2024			2025				2026
	Month	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
No	Task								
1	Investigate suitable deep learning for 3d point cloud data	■							
2	Discussion with Geo Satellite Lab on usage of 3D point cloud Lidar		■						
3	Plan data collection & Tech acquisition			■					
4	Data Analysis & Paper writing				■				
5	Augmented data & Model training Paper presentation					■			
6	Model Evaluation						■		
7	Report Writing							■	■

Expected output: one 3D point cloud dataset of Desaru beach and one publication

Desaru Site and Data Collection Specifications

- Scanning area : 500m x 300m = 150000m2 = 15ha
- LiDAR sensor point density: 200 points/ meter squared
- LiDAR Measurement accuracy: +/- 5cm
- LiDAR Absolute accuracy: <15cm
- Establishing **base station** for data accuracy control.
- Establishing **check point** for data accuracy checking.
- Processing LiDAR data in terms of point cloud and trajectory file
- Performing **ortho rectification process** of aerial image
- Final data will be delivered in LAS format (Industry standard LiDAR data)

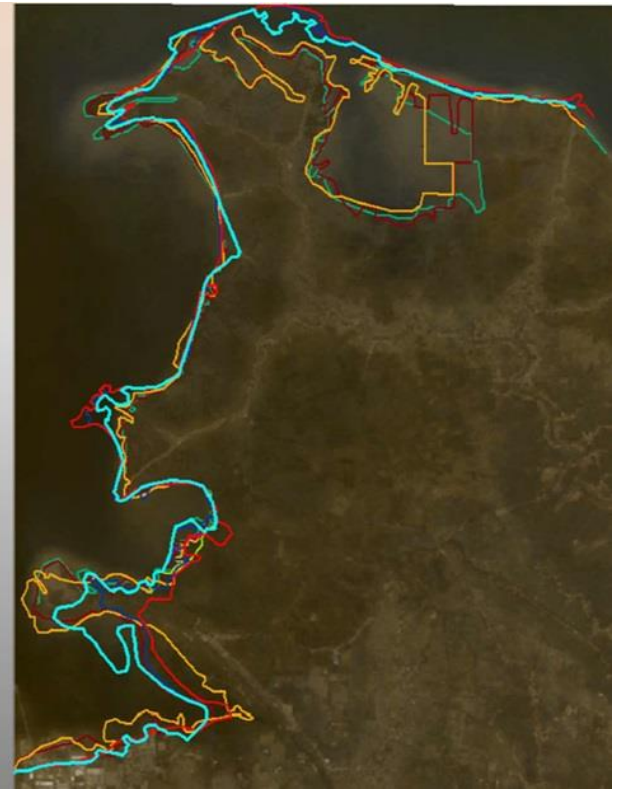


Project Activity Plan: Coastal Vulnerability Index Assessment, Coastal Line Changes Monitoring, and Rip Current Identification by ITENAS

- Coastal Vulnerability in North Coast of Bekasi Regency using Composite Vulnerability Index (CVI), PI: **Dr. rer. nat. Dian N Handiani +** Meteorological prediction (**Dr. Didin Agustian P**)
- Using remote sensing for monitoring of coastal line changes (Cirebon), PI: **Dr. Soni Darmawan**
- Rip current identification at the southern coastal areas in Java Island (Ciamis, Pangandaran), PI: **Yessi Nirwana, Ph.D**

itenas

- Erosion and accretion very fast in the study area.
- Need more investigation on the quantitative approach for estimating erosion and accretion, as well as its impact on the environment.



No	Activity	July	Augt	Sept	Oct	Nov	Dec
1.	Testing site-Field survey						
2.	International conference						
3.	Journal submission						
4.	Book chapter (draft)						

Expected output: 2 submitted articles to international journals, 2 Scopus indexed international proceeding, and 1 book chapter draft

Project Activity Plan: Develop a Visualization and Clustering Technique for Segmenting Temporal 3D Point Cloud Data by CADT

CADT IDRI
វិទ្យាស្ថានស្រាវជ្រាវ និង ទាន់ទ្រឹត្តន៍ឌីជីថល
Institute of Digital Research & Innovation

Data Acquisition
- Collect temporal 3D point cloud data
- Data covers various time intervals to capture changes in the coastal environment.

Data Pre-processing
- Clean and normalize
- Annotate and label
- Align and register the datasets from different time intervals

Clustering
- Choose an appropriate clustering algorithm
- Apply clustering to the preprocessed point cloud data
- Analyze the resulting clusters.

Segmentation
- Select a segmentation technique
- Apply segmentation

Post-Processing
- Down-sampling technique
- Change Detection and Analysis
- Validation
- Reporting and Visualization

Expected output: Clustered and segmented data, visualization, and a research manuscript

Main Activity	Activity in Detail	Indicative Timeline (month)
1. Project Initialization	1.1 Resource Allocation	
	1.2 Tool and Setup	
	1.3 initial literature review	
2. Data Acquisition	2.1 Data Source Identification	
	2.2Data Collection	
	2.3Point Cloud Visualization	
3. Data Pre-processing	3.1 Data Cleaning and Normalization	
	3.2 Data Annotation and Labeling	
4. Clustering and Segmentation	4.1 Clustering Algorithm Selection	
	4.2 Clustering Implementation	
	4.3 Segmentation Technique Selection	
	4.4 Segmentation Implementation	
5. Post-Processing	5.1 Down-sampling	
	5.2 Visualization Development	
6. Reporting and Documentation	6.1 Manuscript Preparation	
	6.2 Presentation Preparation	

Project Activity Plan: Coastal Change Prediction and Shoreline Detection from Images Recorded by Satellites and Drones by BUU

Coastal Change Prediction

- Sea level rise
- Storm intensity and frequency
- Wave action and currents
- Sediment supply and transport
- Geological factors (e.g., subsidence)
- Historical shoreline data
- Oceanographic data (waves, tides, currents)
- Climate models and projections
- Land use and coastal development information

Activities	2024									2025										2026		
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Literature review Survey available dataset	⟷			⟷				⟷																
Data Collection - Satellite images - Meteorology data and other							⟷				⟷						⟷							
Develop Shoreline detection model - Submit Conference								⟷			X													
Develop Coastal Change prediction model - Coastal Change from Historic Satellite images - Coastal Change from Meteorology data and other (expect image) - Submit Conference													⟷						X					
Conclusion and Report																				⟷				

Shoreline Detection

- Satellite Imagery: Covers multi-spectral analysis, SAR, and high-resolution sensors.
- Drone Imagery: high resolution capabilities, flexible deployment, and 3D mapping.

Expected output: one publication

Project Activity Plan: Processing of 3D Point Cloud Data and Orthogonal Images

RESEARCH PLAN

- Pre-processing of 3D point cloud data.
- Registration of the 3D point cloud on the image acquired from the same area.
- Determine differences in the coastal area over time.
- Applied object detection techniques to detect, e.g. green areas, houses intruding into the coastal area, etc.

PROPOSED BUDGET

- 2,000 USD Approx. to cover registration fees and travel cost for APSIPA 2025 conference between 22-24 OCT 2025 in Singapore.

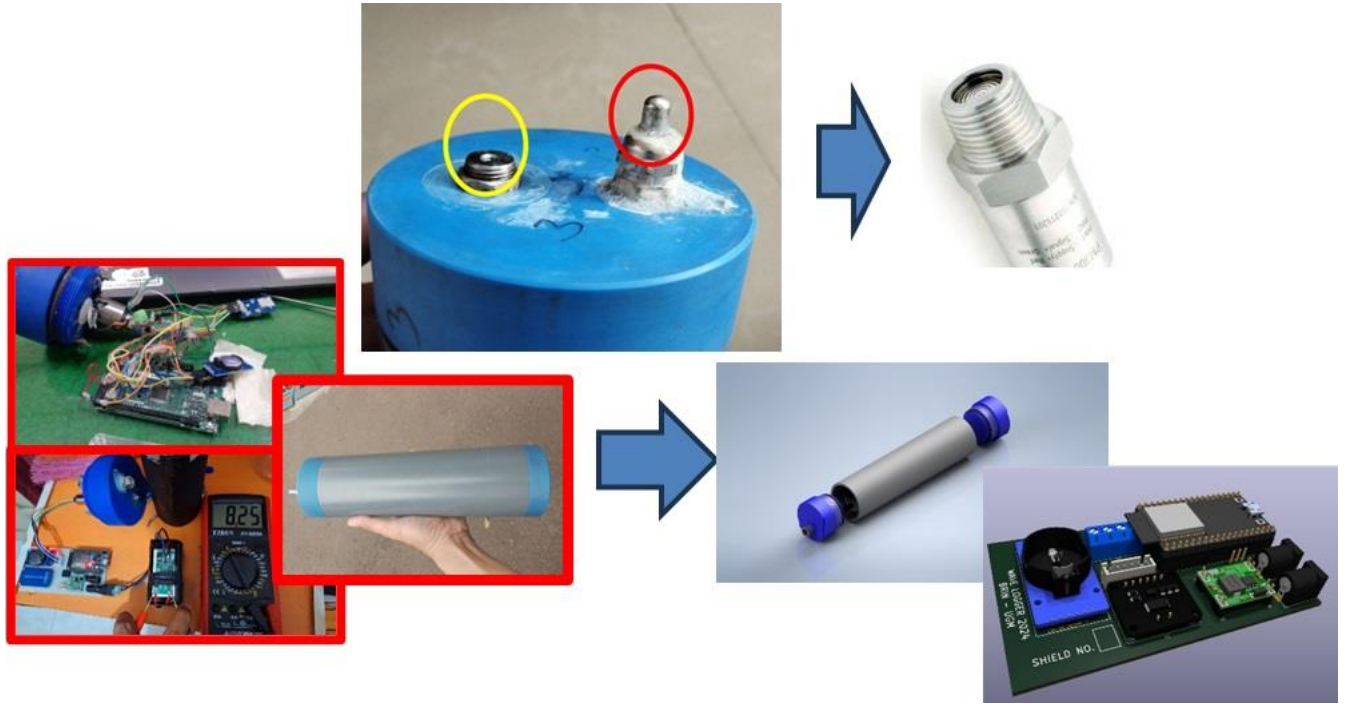
COLLABORATION

- Working closely with our NECTEC team and international partners.
- Acquiring a group of students.
- Co-supervise the student participating in this collaborative project.
- An expected international conference paper.

Project Activity Plan: OPTIMIZING WAVE LOGGER DESIGN FOR NEARSHORE APPLICATION by RCO-BRIN

Expected output: optimized prototype and publication

- Wave is the main driver of coastal erosion
- Wave observation is expensive, lack of in situ data
- A Low-cost wave logger is on going development



Current Problems on the prototype (ver.1)

- Power issues (quick drain, <7days) → larger batteries, microcomputer system replacement, wake-sleep management
- Barnacles inside the sensors → sensor replacement
- water resistant issue → better material
- Performance test → laboratory testing (2D Flume)
- Accuracy compared to commercial loggers → field testing in mangrove environment

	Month											
Activity	1	2	3	4	5	6	7	8	9	10	11	12
Preparation	✓	✓										
System development		✓	✓	✓	✓	✓						
Manufacturing					✓	✓	✓	✓	✓	✓		
Field testing								✓	✓	✓		
Paper writing		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Report											✓	✓

Budget Allocation Plan

Two-year plan 80000 USD

- Meeting + Forum: 30000 USD
  - Forum 2 times: 2000 USD
  - Onsite 4 times: Indonesia, Malaysia, Cambodia, Thailand: 28000 USD
- Conferences: 10 times (2-3 times for each country): 25,000 USD
  - Estimate cost: 2500 USD per a paper
- Equipment purchase: 12,000 USD
  - Low-cost drone + low-cost LiDAR sensor
- 3D point cloud data collection: 7000 USD
  - Testing site UTM: Desaru beach, Malaysia
- Remains: 6000 USD for spare for unplan activities
  - Testing site travel, Indonesia: North and South Java

First-year plan 40000 USD

- Meeting in Indonesia: 5,700 USD
- ASEAN IVO Forum in Cambodia: 1,000 USD
- Equipment purchase: 12,000 USD
  - Low-cost drone + low-cost LiDAR sensor
- 3D point cloud data collection: 7,000 USD
  - Testing site UTM: Desaru beach, Malaysia
- Publications:
  - ITENAS: 5,000 USD
  - Thailand: 5,000 USD
  - CADT: 2,500 USD
  - Test site travel: 1,800 USD

Scientific Contribution & Social Impact:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1	Utilizing a Classification Tree for Rocky Terrain Detection in 3D Point Clouds for Coastal Erosion Studies	**Pasut Insung**, **Peerapat Supasri**, Phattarakorn Limsuwat, Setthanan Thitathanapat**,** **Akkharawoot Takhom**, **Kasorn Galajit**, **Surasak Boonkla**, **Jessada Karnjana**	School of Engineering, Thammasat University, National Electronics and Computer Technology Center	Society of Instrument and Control Engineers (SICE)	30 Aug. 2024	Kochi, Japan

Academics society

- 3D point cloud datasets: Thailand and Malaysia sites
- Orthogonal images and 3D point cloud data processing techniques
- A rip current detection technique

Human society

- Knowledge for people
- Reducing losses