APN
ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

FINAL REPORT

Investigating the impacts of human activities and climate change on mangrove systems in East and Southeast Asia

CRRP2020-06MY-LOH

2024

浙江大學 海洋学院
OCEAN COLLEGE
ZHEJIANG UNIVERSITY

Project Reference Number: CRRP2020-06MY-Loh

Project Duration: 3 years (October 2020 - October 2023), extended up to March 2024

Funding Awarded: USD 130,000

Project Leader and Contact Details:

Dr Pei Sun Loh, Ocean College, Zhejiang University, China, psloh@zju.edu.cn

Collaborators and Contact Details:

Professor Chantha Oeurng, Institute of Technology of Cambodia, Cambodia, chantha@itc.edu.kh

Dr Ty Sok, Institute of Technology of Cambodia, Cambodia, sokty_itc@yahoo.com

Dr Jianjun Wang, Yangzhou University, China, wangjianjun@yzu.edu.cn

Professor Selvaraj Kandasamy, Central University of Tamil Nadu, India, selvaraj@cutn.ac.in

Professor Gusti Z. Anshari, Tanjungpura University, Indonesia, gzanshari@live.untan.ac.id

Professor Che Abd Rahim Mohamed, Universiti Kebangsaan Malaysia, Malaysia, carmohd@ukm.edu.my

Dr Choon Weng Lee, Universiti Malaya, Malaysia, lee@um.edu.my

Dr Chui Wei Bong, Universiti Malaya, Malaysia, cwbong@um.edu.my

Professor Xixi Lu, National University of Singapore, Singapore, geoluxx@nus.edu.sg

Dr Siriporn Pradit, Prince of Songkla University, Thailand, spradit22@gmail.com

Dr Thi Phuong Quynh Le, Vietnam Academy of Science and Technology, Vietnam, quynhltp@gmail.com

Recommended Citation:

Asia-Pacific Network for Global Change Research (APN)

1. Summary

Mangrove forests support the global ecosystem and serve as blue carbon reservoirs. However, they are facing threats from climate change phenomena, such as sea level rise, and human activities, such as deforestation, erosion, pollution, reservoir construction, and coastal development. Few studies have examined the trends regarding carbon, nutrients, and pollutants in mangrove systems due to climate change and human activities over a timescale of 100–150 years. Thus, in this study, sediment cores were collected from the coastal fringes of mangrove forests across East and Southeast Asia to evaluate total organic carbon, total nitrogen, sediment phosphorus species, and microplastics. Our results showed that the differences in spatial and vertical distribution of sedimentary organic matter, carbon stock, phosphorus species, and microplastic were attributable to various factors such as tree age, geomorphic settings, sediment characteristics such as particle size, organic matter, and nutrient contents, and physical influence such as tidal effect and the intensity of human activities. The results of this study will provide important information for policymakers to use in maintaining the sustainability of these fragile ecosystems.

1.1. Study areas

Sediment cores were collected from Kuala Gula, Malaysia (on March 21, 2021); Sohgkhla and Pattani provinces, Thailand (March 30, 2021, and April 5, 2021); the Ximen Island and Guangxi mangrove forests, China (May 28–29, 2021, and June 30, 2021); Kampot Province, Cambodia (January 14 – 16, 2022); Mangrove Park at Sungai Pinyuh, Pontianak, West Kalimantan, Indonesia (July 2022); and Kuala Selangor mangrove, Malaysia (July 26, 2022; Appendix 1).

1.2. Sampling of sediment cores

Sediment cores of approximately 1 m in length were collected from each location using a gravity columnar sampler lined with a 60-mm-diameter polyvinyl chloride core tube (sampling photos in Appendix 2). The sediments were sliced at 2-cm depth intervals and transported back to the laboratory under cool storage. In the laboratory, each of the 2-cm sediment slices were freeze dried, ground with a mortar and pestle until homogenous, and determined for ^{210}Pb activity, particle size, bulk elemental composition, stable carbon isotope, lignin, microplastics, and P species.

1.3. Analytical methods

In brief, the ^{210}Pb dating was carried out using a high-purity germanium low-gamma spectrometer GWL series with a high-purity germanium coaxial-well photon detector system. Sedimentation rates were calculated based on ^{210}Pb activity. For particle size determination, sediment samples were subjected to H_2O_2 digestion and $(NaPO_3)_6$ dispersion, followed by the determination of particle size using a particle size analyzer. For bulk elemental analysis, 1 M HCl will be added to the dried sediments to remove inorganic carbon, dried, homogenized, weighed into tin foil, and analyzed for total OC (TOC) and total nitrogen (TN) using an elemental analyzer. The δ^{13}C compositions of the sediments

were determined using an isotope ratio mass spectrometer and reported in permille (‰) form relative to the Vienna Pee Dee Belemnite standard. Microplastics were extracted using the density-based floating separation technique. Dry sediment samples were subjected to lignin analysis using the cupric oxide oxidation method. Various sedimentary P forms were extracted using the sequential P extraction procedures

.

1.4. Data obtained

Locations	Data						
	TOC, TN, TOC/TN	δ13C	210Pb	Particle size	Lignin	P species	Microplastic
Ximen Island & Guangxi, China	√	√	√	√	√	√	√
Songkhla & Pattani, Thailand	√	√	NR	√	√	√	√
Kuala Gula, Malaysia	√	√	NE	√	√	√	√
Kuala Selangor, Malaysia	√	√	√	√	√	√	NE
Sungai Pinyuh, Indondesia	√	√	√	√	√	√	NE

NR = not relevant as the cores are rather short

NE = not enough samples for microplastic analysis

1.5. Summary of Results and Implications

The sediments in older mangrove forest have higher capacity to preserve organic carbon and phosphorus compared to sediments in younger mangrove, salt marsh and bare mudflat, most probably due to the more developed root systems and trapping of finer particles in older mangrove system resulting in increased trapping and absorption of organic matter and nutrients. Our results showed that age, geomorphic setting, particle size, tidal effect and human activities affect the sources, abundance and distribution of sedimentary organic matter, carbon, phosphorus, and microplastic in the mangrove forests in this study (Appendix 3).

2. Objectives

The objectives of this study were (i) to determine the effects of human activities and climate change on the abilities of mangrove forests to serve as carbon and nutrient sinks, and (ii) to determine the potential of these mangrove forests facing deterioration over the past century.

3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
Published papers	Increased knowledge on mangrove dynamics in East and Southeast Asia	Reduced mangrove degradation
Completed meeting and conference	Increased awareness and collaboration	Mangrove conservation

4. Key facts/figures

- Held one internal/online meeting among collaborators (Appendix 4);
- Held one international conference event (Appendix 5);
- Published six peer-reviewed papers in scientific journals.

5. Publications

Hu J, Loh PS*, Pradit S, Le TPQ, Oeurng C, Mohamed CAR, Lee CW, Lu X, Anshari GZ, Kandasamy S, Wang J, Li Z, Qin H, Ji L, Guo J. (2022). Assessing the effect of age and geomorphic setting on organic carbon accumulation in high-latitude human-planted mangroves. Forests 13 (1), 105. doi:10.3390/f13010105.

Pradit S*, Noppradit P*, Loh PS, Nitiratsuwan T, Le TPQ, Oeurng C, Mohamed CAR, Lee CW, Lu X, Anshari GZ, Kandasamy S, Wang J. (2022). The occurrence of microplastics in sediment cores from two mangrove areas in southern Thailand. Journal of Marine Science and Engineering 10, 418. doi:10.3390/jmse10030418.

You S, Loh PS*, Li Z, Qin H, Pradit S, Le TPQ, Oeurng C, Mohamed CAR, Lee CW, Lu X, Anshari GZ, Kandasamy S, Wang J, Ji L, Guo J. (2022). Geochemical behavior of sedimentary phosphorus species in the northernmost artificial mangroves in Ximen Island, China. Forests 13, 610. doi:10.3390/f13040610.

Mohamed CAR, Shahruddin AN, Pradit S*, Loh PS, Nitiratsuwan T, Kobkeatthawin T, Noppradit P, Le TPQ, Oeurng C,Sok T, Lee CW, Bong CW,Lu X, Anshari GZ, Kandasamy S, Wang J. (2023). Depth profiles of microplastic in sediment cores in the mangrove area of Kuala Gula Mangrove, Malaysia. Journal of Marine Science and Engineering 11, 1223.

Hu J, Pradit S*, Loh PS*, Chen Z, Guo C, Le TPQ, Oeurng C, Sok T, Mohamed CAR, Lee CW, Bong CW, Lu X, Anshari GZ, Kandasamy S, Wang J. (2024). Storage and dynamics of soil organic carbon in allochthonous dominated and nitrogen-limited natural and planted mangrove forests in southern Thailand. Marine Pollution Bulletin 116064. doi:10.1016/j.marpolbul.2024.116064.

Guo C, Loh PS*, Hu J, Chen Z, Pradit S, Le TPQ, Oeurng C, Sok T, Mohamed CAR, Lee CW, Bong CW, Lu X, Anshari GZ, Kandasamy S, Wang J. Factors influencing mangrove carbon storage and its response to environmental stress. Frontiers in Marine Science 11, 1410183.

Pradit S*, Loh PS*,Jitkaew P, Nitiratsuwan T, Le TPQ, Oeurng C, Sok T, Mohamed CAR, Lee CW, Bong CW, Lu X, Anshari GZ, Kandasamy S, Wang J. Occurrence of microplastic in sediment cores of planted mangroves in XimenIsland and natural mangroves in Guangxi, China. Under review.

6. Media reports, videos and other digital content

"2023 Mangrove Conference" websites: "https://www.apn-gcr.org/event/2023-mangrove-conference-call-for-participation/" and
"http://oc.zju.edu.cn/2023/0905/c30428a2797670/page.htm".

7. Pull quotes

"The project and conference event have been successfully carried out, well done" - Professor Deqing MEI, Ocean College, Zhejiang University.

"This project has provided us a good opportunity to collaborate with scientists from other universities to conduct research to determine the dynamics of one of the most important blue carbon eecosystems in the world, mangrove forests" - Dr Pei Sun Loh, Ocean College, Zhejiang University.

"After listening to the research from experts around the world at the Mangrove Conference, I feel that the task of protecting mangroves is both important and challenging. Mangrove forests face threats not only from natural factors such as sea-level rise and extreme weather, but also from man-made influences like deforestation. Moreover, some countries introduce foreign species of mangrove plants for conservation purposes. While this might bring some short-term benefits, if inadequately managed, these foreign species could potentially become invasive, negatively affecting the local ecology in the long run. I believe that through the dedicated efforts of researchers worldwide, we would be able to fully understand the growth

and developmental trends of mangrove forests and the effects of external influences on them. This would in turn enable us to take targeted measures and adopt strategies to protect these coastal guards, thereby creating ecologically stable coastal environments.” - Chuanyi Guo, Ocean College, Zhejiang University.

“The convening of this conference not only facilitates the preservation and sustainable development of global mangroves but also significantly contributes to fostering a community with a shared future for the ocean and achieving the global "double carbon" objective. Experts and scholars expressed their commitment to enhancing collaboration and jointly contributing their wisdom and efforts towards safeguarding our planet's homeland and advancing human civilization. The conference was jointly organized by the School of Oceanography of Zhejiang University, renowned universities, and research institutions in Southeast Asian countries, with support from the Asia-Pacific Global Change Research Network Fund. Wu Feng, Deputy Secretary of the Party Committee and Secretary of the Commission for Discipline Inspection of the College of Oceanography of Zhejiang University, congratulated the conference and highlighted the college's research and noteworthy progress in exploring mangrove ecological functions and species diversity. He expressed his hope that participating experts and scholars would enhance learning and exchanges, foster academic innovation, further strengthen international cooperation, and realize the inspirational vision of "Blue Bay" governance through the platform established by this conference.”- Zengxuan Chen, Ocean College, Zhejiang University.

8. Acknowledgments

The project leader and collaborators are extremely grateful to the Asia-Pacific Network for Global Change Research for supporting this project CRRP2020-06MY-Loh.

9. Appendices

APPENDIX 1 MAPS

APPENDIX 2 SAMPLING PHOTOS

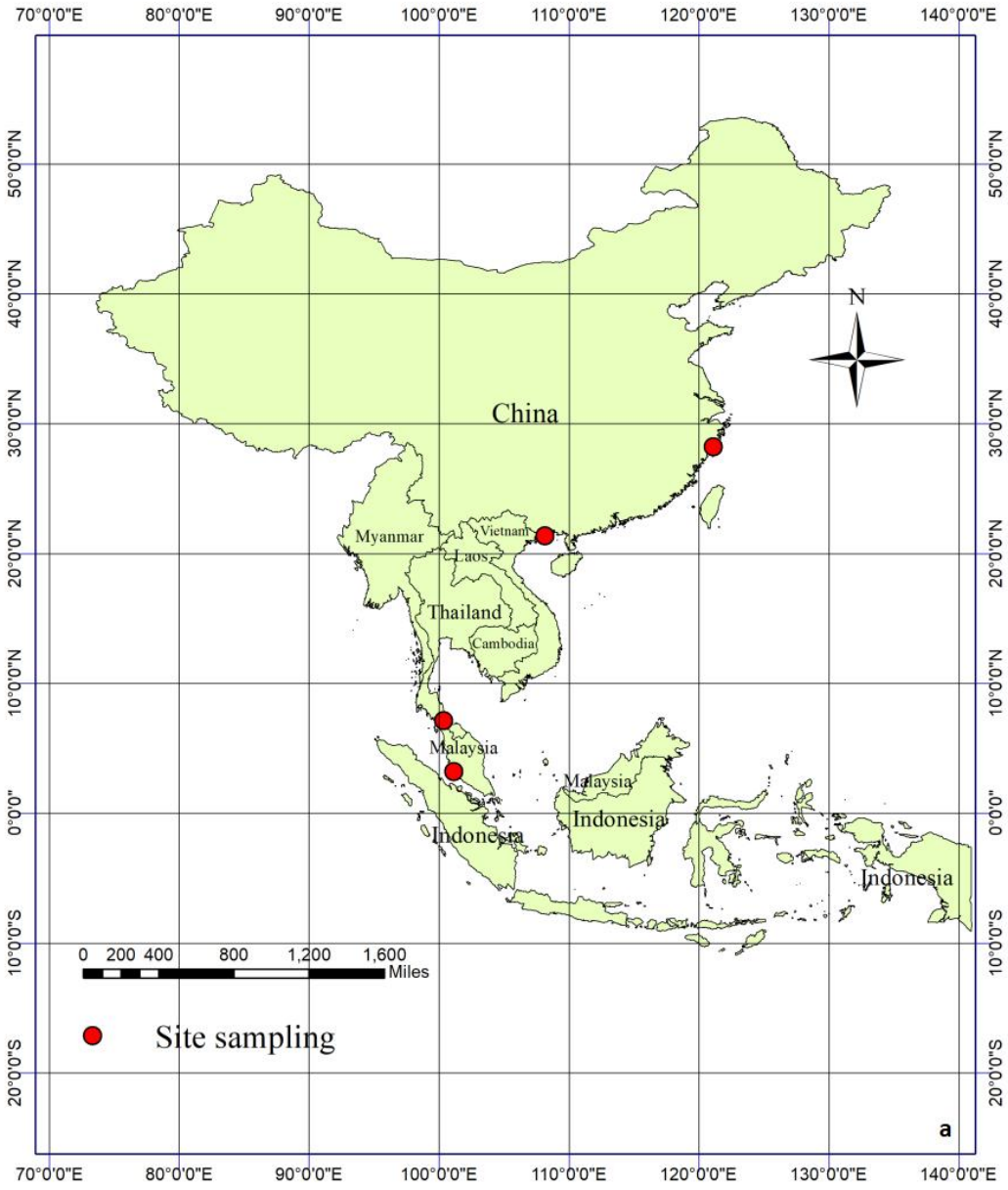
APPENDIX 3 RESULTS

APPENDIX 4 ONLINE GROUP MEETING

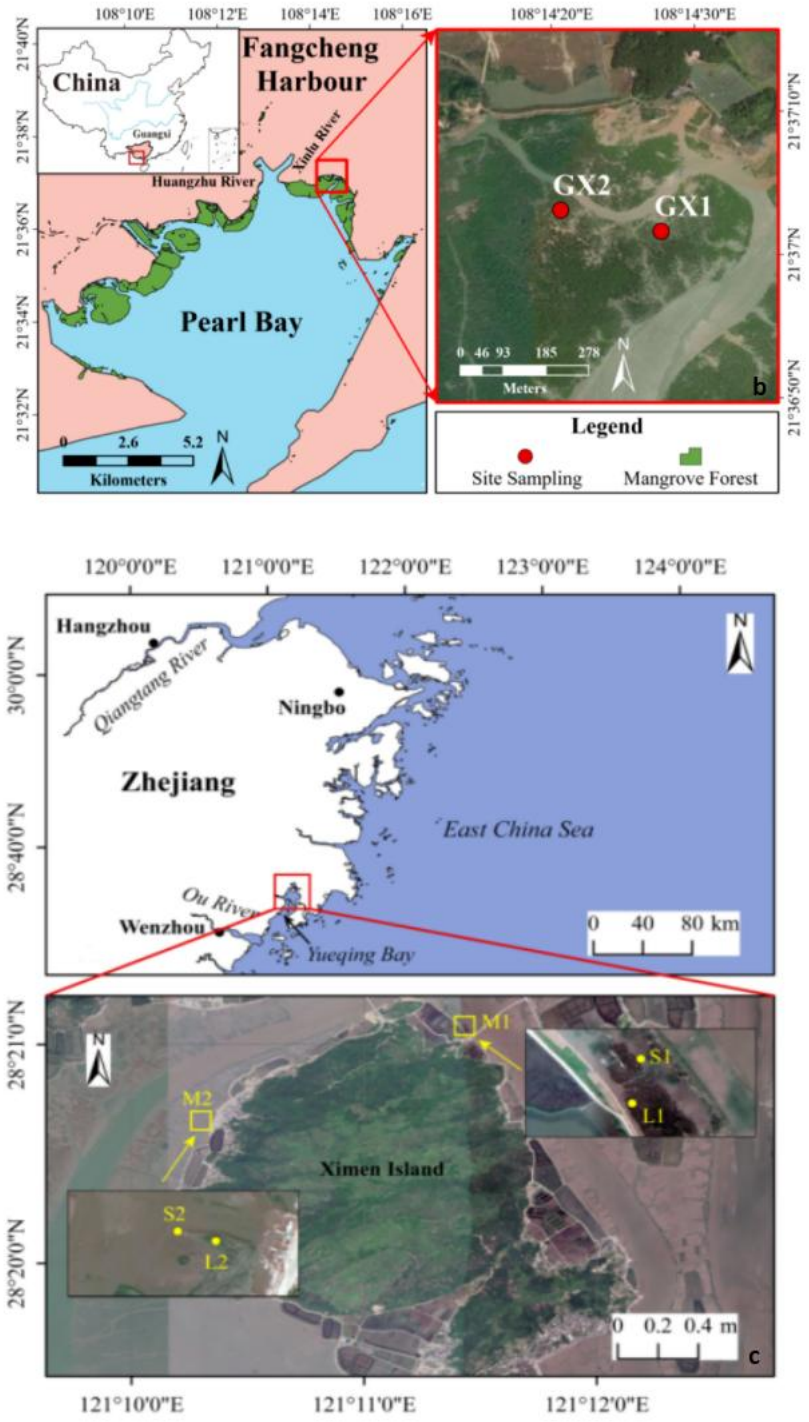
APPENDIX 5 2023 MANGROVE CONFERENCE

APPENDIX 1

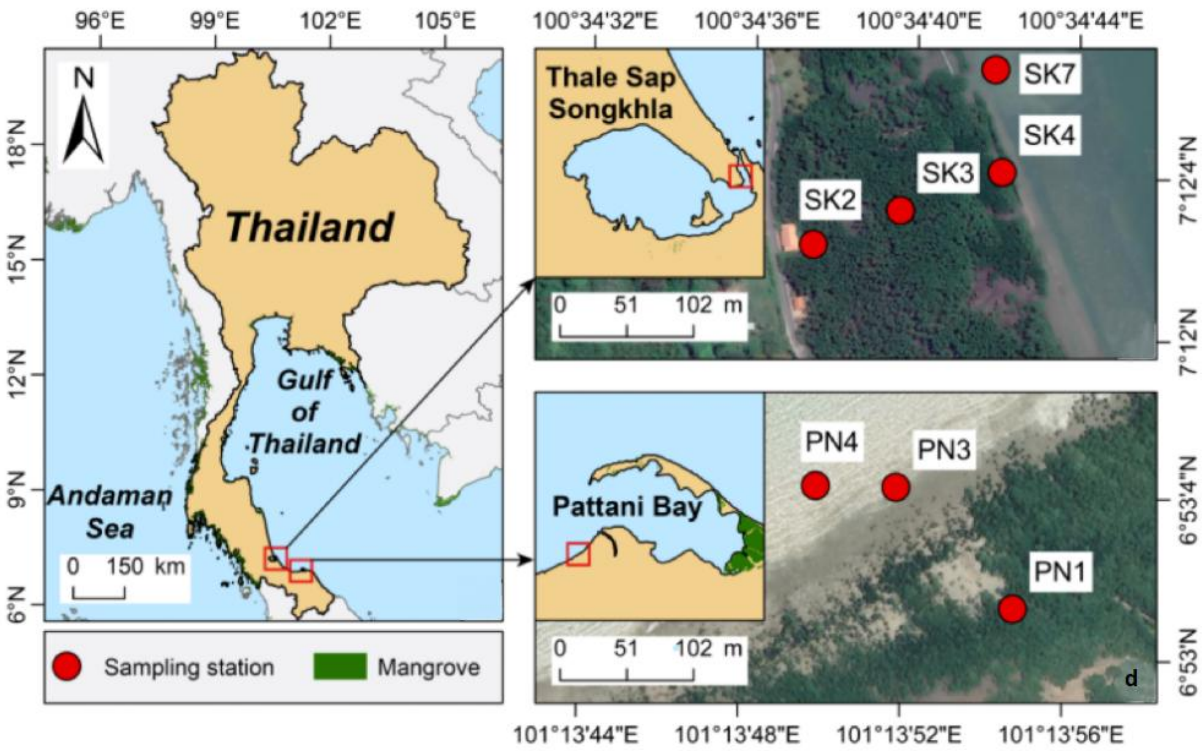
MAPS



Map showing sampling points in China, Thailand and Malaysia



The locations of Fangcheng Harbor (pink), Pearl Bay (blue), and mangrove forests (green) surrounding Pearl Bay, southern China; (c) the Ximen Island mangrove area in the northern part of Yueqing Bay, Zhejiang Province, China



The study area in southern Thailand along the coast off the Gulf of Thailand

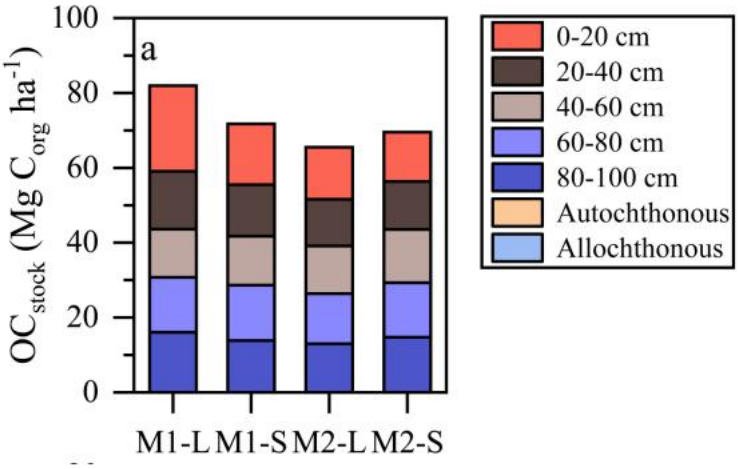
APPENDIX 2

SAMPLING PHOTOS

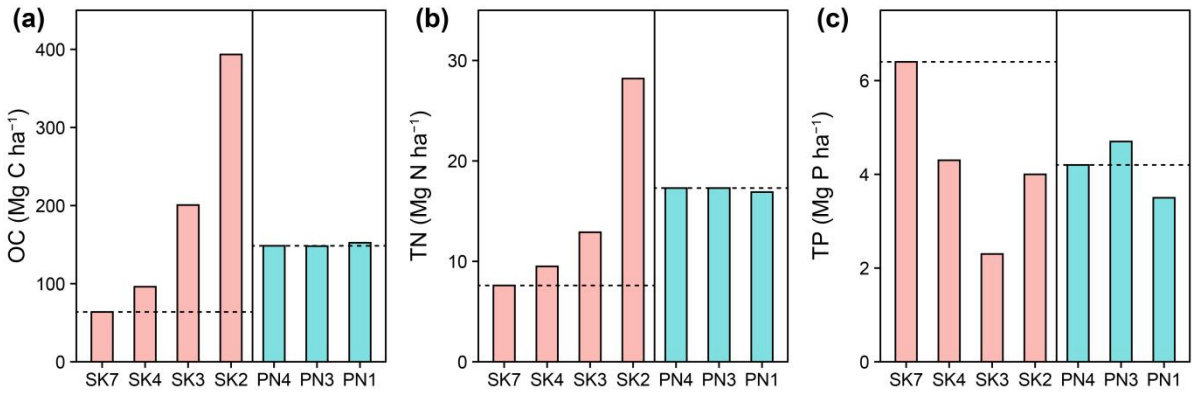

S3-1-(10-12cm)

APPENDIX 3

RESULTS



Results showed highest OC stock in M1-L (old mangrove), followed by M1-S (salt marsh stand), M2-S (bare mudflat), and M2-L (young mangrove) (from Hu et a., 2022).



Spatial distributions of (a) SOC, (b) TN, and (c) TP stocks in the top 1 m of the soils in the sampling locations along Songkhla (SK) and Pattani (PN) mangrove forests (from Hu et al., 2024).

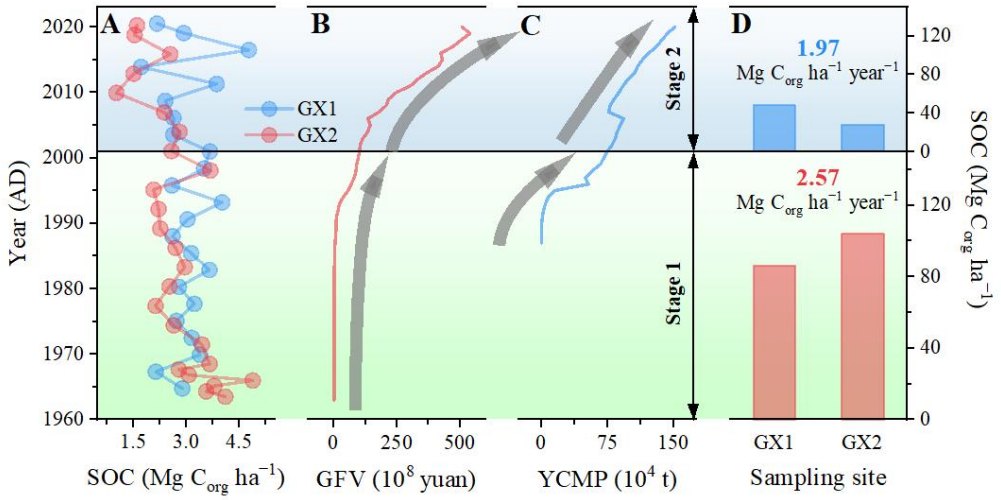
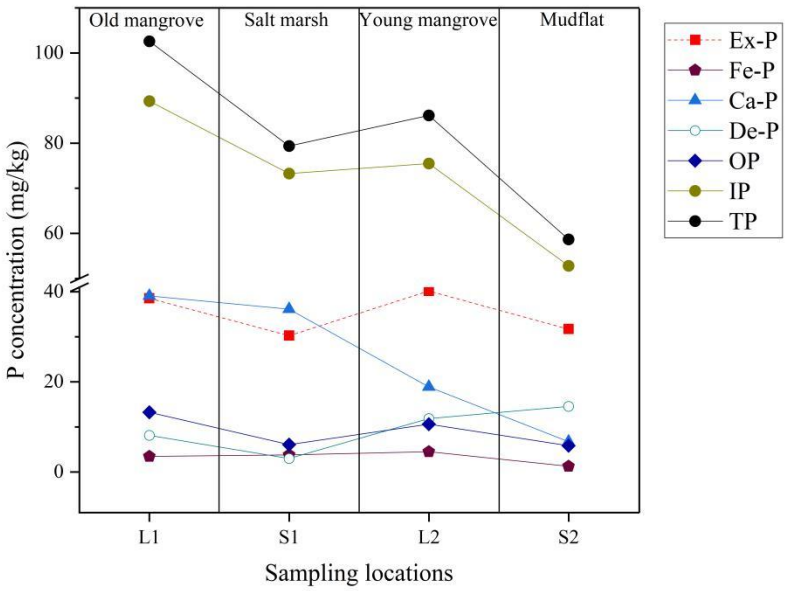


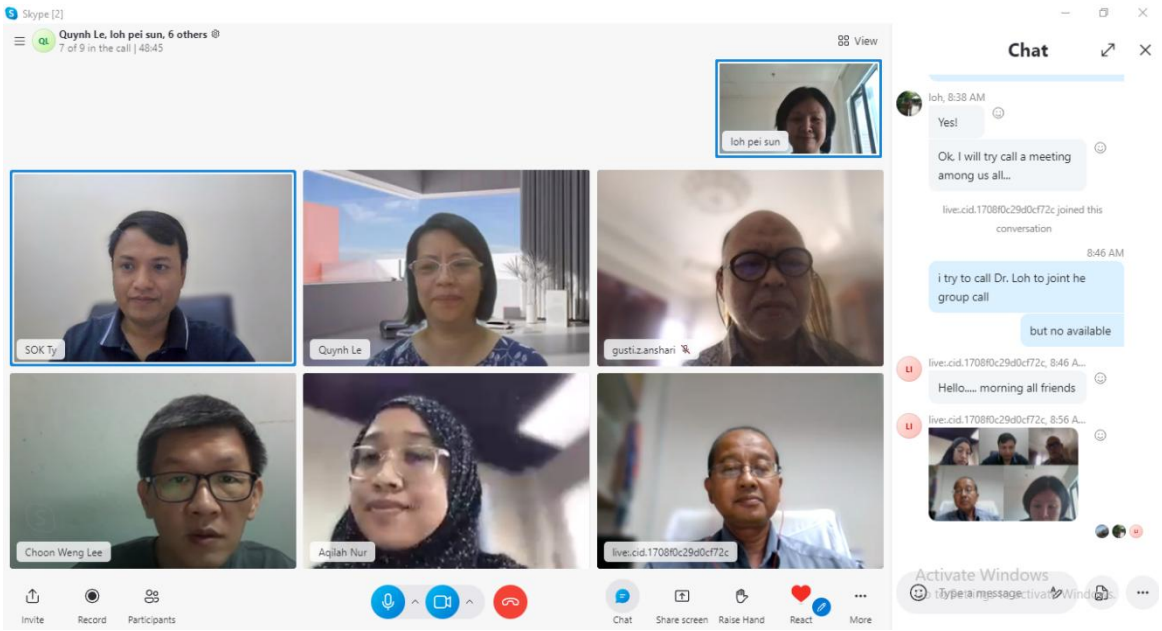
Figure showing decreasing trend of SOC from bottom toward surface along the GX1 and GX2 cores and overall higher carbon stock at the bottom portion compared to surface portion of sediments (from Guo et al., submitted), in accordance with increasing gross fishery value (GFV)andyield of cultured marine products (YCMP) in Guangxi (cited from 2022 Guangxi Statistical
Yearbook,ttp://tjj.gxzf.gov.cn//tjsj/tjnj/material/tjnj20200415/2022/zk/indexch.htm).



Sedimentary P species in the surface sediments (0-2 cm) of the Ximen Island mangrove ecosystems showing highest P in old mangrove, followed by young mangrove, salt marsh stand, and mudflat (from You et al., 2022).

APPENDIX 4

ONLINE GROUP MEETING (28 JUNE 2022)



APPENDIX 5

2023 MANGROVE CONFERENCE - *MONITORING, CONSERVATION, AND SUSTAINABLE DEVELOPMENT*


Welcoming specialists and

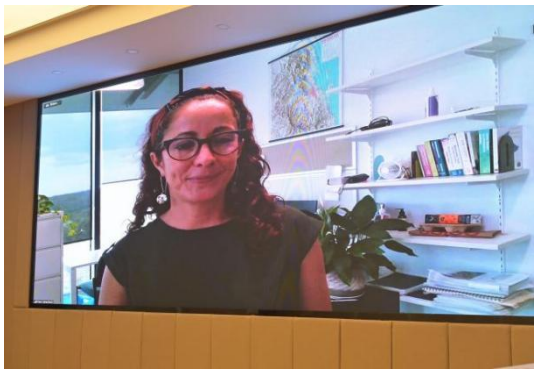

护 与 可 持 续 发 展 学 术

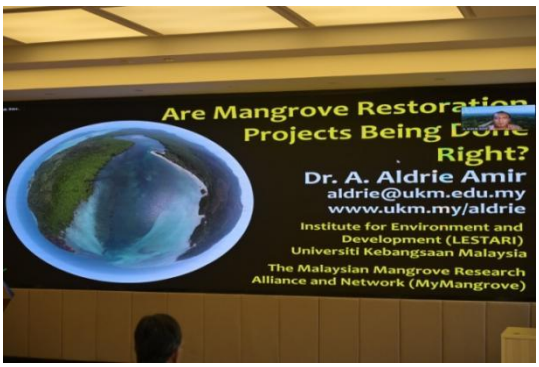

IPCC (2023)


Kelp
Exported carbon

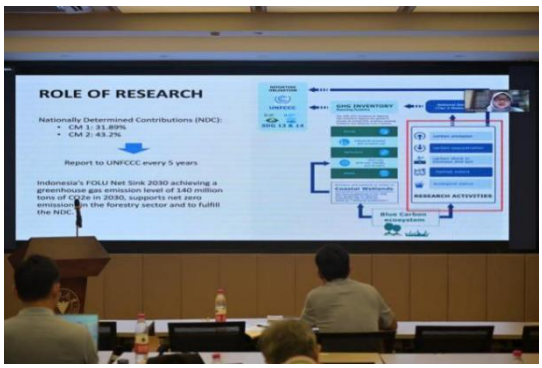

Syarafina Zul Qist
Fery Kurniawan
Aliati Iswantari

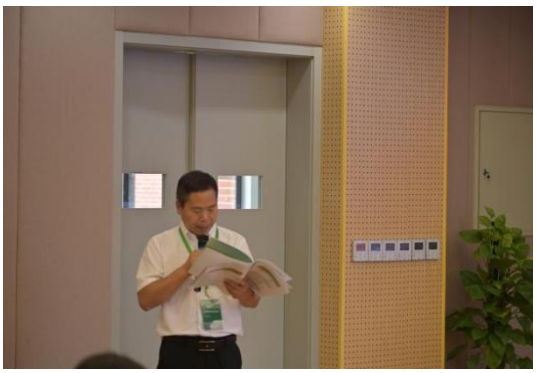

ne Management), Vrije
elgium (Grade of Distinction)
, Chulalongkorn University,
f Environmental
of Songkla University
ast Asian Fisheries
Training Department




Are Mangrove Restoration
Projects Being Done
Right?
Dr. A. Aldrie Amir
aldrie@ukm.edu.my
www.ukm.my/aldrie
Institute for Environment and
Development (LESTARI)
Universiti Kebangsaan Malaysia
The Malaysian Mangrove Research
Alliance and Network (MyMangrove)

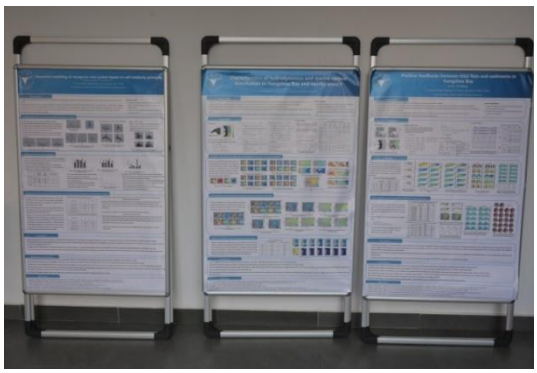

Background of the Study
climate resilience is the ability of a community to adapt with the effects of climate hazards
ADAPTIVE CAPACITIES
ECONOMIC DEVELOPMENT
SOCIAL CAPITAL
COMMUNITY COMPETENCE
INFORMATION & COMMUNICATION
ADAPTIVE CAPACITIES
COMMUNITY RESILIENCE
Figure 3. Community Resilience Framework (Kusumasari, 2015)


ROLE OF RESEARCH
Nationally Determined Contributions (NDC):
CM 1: 31.89%
CM 2: 43.2%
Report to UNFCCC every 5 years
Indonesia's FOLU Net Sink 2030 achieving a greenhouse gas emission level of 140 million tons of CO2e in 2030, supports net zero emission in the forestry sector and to fulfill the NDC
GHG INVENTORY
RESEARCH ACTIVITIES




2023 Mangrove Conference - Monitor
23 红树林湿地监测


2023 Mangrove Confer
Monitoring, Conservation and Sustainable Developme
Oct 17th-18th, 2023
Zhoushan, China




2023 Mangrove Conference - Monitoring, Conservation and Sustainable Development
2023 红 树 林 湿 地 监 测 保 护 与 可 持 续 发 展 学 术 会 议


2023 Mangrove Conference - Monitoring, Conservation and Sustainable Development
2023 红树林湿地监测保护与可持续发展学术会议

Conference talks:

17th October 2023 (afternoon session)	
Session 1	
Presenter	**Title**
Professor LIN Guanghui	Carbon cycle and blue carbon potentials of natural vs restored mangrove forests in China
Professor OUYANG Xiaoguang	Mangrove conservation and carbon sinks under global changes
Dr Ahmad Aldrie AMIR (online)	Are mangrove restoration projects being done right?
Session 2	
Professor Oleg SHIPIN (online)	Major unused C storage potential for mangroves in the deep inland areas, particularly, cities
Dr Kashif Ali SOLANGI (online)	Integrating electrophysiological data, remote sensing, and GIS techniques for the adaptive management of mangrove species
Dr Nicole KHAN	Thresholds of mangrove survival under rapid sea-level rise
Dr NGUYEN Tai Tue	Management of mangrove ecosystems for enhancing climate change response and sustainability in Vietnam
Professor WU Jiaping	Carbon sequestration and the changes of eco-environmental properties after mangrove transplantation in the northern most subtropical area of China

18th October 2023 (morning session)	
Session 3	
Presenter	**Title**
Professor Che Abd Rahim MOHAMED	Radionuclides is a tool to estimate the sedimentation rate at mangrove area
Dr Maria Fernanda ADAME (online)	Coastal wetlands that protect the Great Barrier Reef
Dr BONG Chui Wei	Prevalence of antibiotic resistant Escherichia coli and Klebsiella pneumoniae in tropical mangrove estuaries of Malaysia
Dr Bijeesh Kozhikkodan VEETTIL	Mangrove research in Vietnam: past, present and future
Session 4	
Professor CHEN Luzhen	Exploring on monitoring and trading mechanisms of coastal blue carbon
Mr Henricus Rotarius Octavianus TARIGAN	Determining rehabilitation strategy for mangrove ecosystems: Case of Sumenep Regency, Jawa Timur Province, Indonesia
Dr Virni Budi ARIFANTI (online)	Mangrove blue carbon research in Indonesia
Miss Alexa Samantha Tivera HERNANDEZ (online)	Mangroves enhancing local climate resilience: the case of Olo-Olo mangrove forest and ecopark, Lobo, Batangas

18th October 2023 (afternoon session)	
Session 5	
Presenter	**Title**
Professor Dixon GEVAÑA	Mangrove conservation: pressing challenges and future actions
Dr Siriporn PRADIT	Microplastic accumulation in sediment from two mangrove areas in Southern Thailand
Miss Sharafina Zul QISTHI	Anthropogenic impact assessing of mangrove ecosystem using biotic index in Sumenep, Jawa Timur Province, Indonesia
Dr LOH Pei Sun	Biogeochemistry of sedimentary organic matter and phosphorus in mangroves
Session 6	
Professor ZHANG Zhaohui	Carbon sources, trophic level and transfer of heavy metals through the aquatic food web in the largest mangrove reserve in China
Dr NGUYEN Hai -Hoa	Status of mangrove forests and enhancement of carbon storage & sequestration: solutions toward climate change mitigations in Vietnam
Dr Sigit SASMITO (online)	Identifying mangrove restoration opportunities in Indonesia
Mr Md Nurul ISLAM (online)	Understanding social resilience in Sundarbans Delta: stories from world's largest mangrove forest

Poster:

Dr KIM Jin-soo, CHEN Ran: Sharp NDVI declines in Hong Kong's mangroves related to weather extremes

Dr LI Li, WU Lihong: Positive feedbacks between tidal flats and sediments in Hangzhou Bay

Dr LI Li, ZHOU Yuanhang: Characterization of hydrodynamics and marine carbon distribution in Hangzhou Bay and nearby waters

Dr XIA Yuezhang, GAO Kai: Geometric modeling of mangrove root systems based on self-similarity principle