

Project title:  
Nature-based solutions  
for food security under  
climate change effects for  
sustainable development  
in the Mekong Delta



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## 1. Summary

The Mekong River Basin is heavily affected by climate change and anthropogenic activities such as river damming, land use change, and dyke construction, leading to extreme floods and drought occurring more frequently and unpredictably. Consequently, wetland compartments are disconnected from the main rivers, causing a lack of fresh water and nutrients for paddy fields in the Mekong Delta. The project aims to address these challenges by 1) assessing the impacts of climate change and human activities on hydrology, sediment, and agriculture, 2) proposing suitable agricultural cultivation calendars, 3) developing an effective nature-based solution using floating rice tolerant to floods, 4) exploiting flood water and sediment, and 5) proposing livelihood sustainability for farmers. The project results were communicated to stakeholders and policy-makers through workshops, direct meetings, and training courses. We also conducted technical training for young researchers and students.

We have conducted a series of field surveys and collected comprehensive datasets that not only serve this project but also lay the foundation for future projects in the Mekong Delta. Innovative technologies, such as AI and remote sensing, were employed to support large-scale assessment of flood and sediment dynamics in the delta. The results have been published in high-ranking journals and presented at various international conferences. Additionally, the project results were shared and discussed during the final workshop, organized in conjunction with the 3<sup>rd</sup> International Conference of Climate Change Adaptation and Disaster Risk Reduction Management, held at the Vietnamese-German University (27-31 August 2025). Researchers from various Asian countries participated in discussions on the potential of using nature-based solutions to adapt to the changing climate. Furthermore, two project members received training through the IHP training program, organized by UNESCO in collaboration with Kyoto University.

Our findings indicate that flooding in An Giang has declined by 10% per year between 2011 and 2023. Flood inundation decreased from 24% of the province's area in 2011 to 6.8% in 2023. Correspondingly, suspended sediment concentration has substantially decreased from 2000 to 2024. In the Mekong basin, both precipitation and temperature were forecasted to increase. Rising temperatures will intensify evapotranspiration, reducing soil moisture and baseflow, while intensified precipitation is likely to amplify peak flows and modify the timing of flood events. Peak flows are projected to decline under SSP scenarios, with reservoirs both reducing peak magnitudes and delaying the timing of annual floods by 1–1.5 months. Historical return periods for given peak discharges are generally higher than those projected under future scenarios, reflecting shifts in hydroclimatic conditions. In general, dams are expected to attenuate the effects of climate change by 2100 due to their large storage capacity. Riverbeds and riverbanks were severely eroded due to reservoir sediment trapping upstream. The lowered riverbed, combined with the diminishing flooding, isolates paddy fields from flood water and sediment, causing a decrease in natural fertilizer and an increase in applying artificial fertilizer and pesticides. Therefore, floating rice emerges as a promising solution to sustain the livelihoods of farmers, the environment, and ecosystems in the Mekong Delta.

## 2. Objectives

1. To assess the effects of climate change/climate variability and human activities (individual and compound effects) on streamflow, flood, drought, sediment, and agricultural productivity in the entire Mekong basin and the Mekong Delta.
2. To develop suitable and sustainable land use/land cover patterns and agricultural cultivation calendars in the two study areas in the Mekong Delta.
3. To propose, develop, and evaluate the effectiveness of a nature-based solution using floating rice tolerant to floods in the Mekong Delta.
4. To propose an integrated scheme to better exploit flood water and sediment under future climate change.
5. To develop livelihood sustainability in response to the compound effects of climate change and human activities.

## 3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
<ul style="list-style-type: none"> <li>- Organized training courses at the Vietnamese-German University, Vietnam, and at the National University of Battambang, Cambodia.</li> <li>- Conducted flood survey in the Vietnamese Mekong Delta (VMD). (Objective 1)</li> </ul>	<ul style="list-style-type: none"> <li>- Trainees learnt remote sensing techniques in studying flood and sediment dynamics in the Mekong basin.</li> <li>- Flood maps were generated using MODIS and Sentinel satellites.</li> <li>- Spatiotemporal distribution of the suspended sediment concentration (SSC) in the VMD was generated using the Landsat satellite. (Objective 1)</li> </ul>	<ul style="list-style-type: none"> <li>- Learners can apply remote sensing in their research.</li> <li>- A master student, who was trained at the Vietnamese-German University (VGU), has applied remote sensing to study flood and sediment dynamics in the Vietnamese Mekong Delta.</li> <li>- A bachelor student, who was trained at VGU, has applied remote sensing to study salinity intrusion in the VMD. Thanks to this training course, he became a master student in the Master program in Water Technology, Reuse and Management of VGU.</li> <li>- Published papers in journals and international conferences.</li> </ul>
<p>Established and validated a SWAT model for the whole Mekong basin.</p>	<ul style="list-style-type: none"> <li>- Quantified the combined effects of dams and climate change on flow regimes of the</li> </ul>	<p>The outputs of the SWAT model were the input for a hydrodynamic model to assess</p>

(Objective 1)	Mekong basin from 2020 to 2100. - Conducted data analysis (Objective 1)	the effects of dams and climate change on flood and sediment dynamics in An Giang Province.
Developed machine learning models to predict SSC in the Mekong basin. (Objective 1)	- Developed semi-supervised-based deep neural network models to enhance the prediction accuracy. - Reconstructed missing SSCs at stations along the Mekong River. (Objective 1)	- Reconstructed SSC time series for long-term spatiotemporal trend analyses, from which the drivers of changes can be identified. - The method can be used for other types, such as salinity concentrations. - The method can be applied to tributaries of the Mekong basin and other river systems.
Conducted four field surveys to measure riverbed elevation using the multibeam echosounder in the Tien River (Objectives 1, 2, 3, 4)	- Measured riverbed elevations by scanning the riverbed using the multibeam echosounder, helping in quantifying riverbed evolution. - Quantified riverbed incision in the entire VMD. - Delineated susceptibility zones, categorized into seven classes for incised and accreted sediment volumes, considering the influence of sand mining activities. - Quantified effects of sand mining on riverbed incision in the VMD. (Objectives 1, 2, 3, 4)	- Highlighted the influence of sand mining on exacerbating the vulnerability of different areas within the VMD. - Provided valuable insights for effective sediment management strategies. - Served as a vital reminder of the ever-evolving morphology of the VMD, shaped by anthropogenic forces, with implications for delta stability in the future. - Underscored the need for a holistic approach to manage and mitigate the impacts of these surging activities on the environment of the Mekong Delta and its inhabitants.
Developed deep learning for boat detection and numerical modelling to assess sand	- Quantified sand mining using the Sentinel-1 Satellite. - Estimated sand mining impact	- There is an urgent need for improved sediment management strategies and

<p>mining impacts on river morphology in the VMD (Objectives 1, 5)</p>	<p>on morphology using the Delft3D-Flow model. (Objectives 1, 5)</p>	<p>regulatory frameworks to mitigate the environmental impacts of excessive sand extraction.</p> <ul style="list-style-type: none"> <li>- Supported the development of sustainable river management strategies in the region.</li> <li>- Future research should prioritize the development of sustainable sand mining policies to ensure the long-term stability of the Bassac River and the resilience of its associated ecosystems.</li> </ul>
<p>Conducted field surveys in the Vietnamese and Cambodian Mekong Deltas (Objectives 1, 2, 3, 4, 5)</p>	<ul style="list-style-type: none"> <li>- Collected water and sediment samples.</li> <li>- Measured SSC, bathymetric data, and hydrological parameters.</li> <li>- Installed sediment traps</li> <li>- Analyzed physical-chemical parameters of the collected sediment in the floating rice field.</li> <li>- Identified floating rice variety and cultivation technique</li> <li>- Measured floating rice</li> <li>- Supported farmers for rice sowing.</li> <li>- Interviewed local farmers</li> <li>- Conducted data analysis (Objectives 1, 2, 3, 4, 5)</li> </ul>	<ul style="list-style-type: none"> <li>- Input data for the MKE model.</li> <li>- Assessed the effects of sediment on floating rice yield</li> <li>- Assessed perceptions of farmers on floods and sediment.</li> <li>- Compared farmers' income between two farming systems: floating rice-cassava rotation and intensive high-yield rice cultivation.</li> <li>- Proposed suitable land use/land cover patterns and rice calendars.</li> <li>- Recommended dyke operations, maximization to get sediment benefits, and paddy field design.</li> <li>- Proposed effective nature-based solutions using floating rice.</li> <li>- Farmers in the study area recognize the significant value of sediment in agricultural</li> </ul>

		production. - Proposed livelihood sustainability for farmers.
Developed a coupled MIKE 11 and MIKE 21 model for the Long Xuyen Quadrangle (Objectives 2, 3, 4)	- Simulated flood dynamics. - Simulated sediment dynamics. - Optimized sluice gate opening to maximize sedimentation in rice fields. (Objectives 2, 3, 4)	- Provided information for proposing suitable land use patterns. - Provided reference for proposing effective nature-based solutions using floating rice. - Proposed integrated scheme to better exploit flood water and sediment in rice fields.
- Participated in international conferences, met stakeholders, and discussed the project results. - Completed the project closing symposium. (Objectives 1, 3, 5)	Reported the final results of the project and closing summary. Organized an international conference. (Objectives 1, 3, 5)	Published and shared project results, networking, and well-formed a strong international research group for continuation of research, and future co-project funding applications
Completed a series of meetings and workshops	Conducted Kick-off workshops (both online and onsite) and project meetings	Helped time-to-time project monitoring, progress tracking, and successful project submission
Successfully submitted annual and bi-annual project reports	Email communication, and submitted project reports	

#### 4. Key facts/figures

- 02 project members attended and were issued certificates of completion by the Water Resources Research Center, Disaster Prevention Research Institute, Kyoto University, under the auspices of the UNESCO Office, Jakarta, upon completion of the 33<sup>rd</sup> IHP Training Course in Asia and Pacific Region on “Integrated Basin Management under Changing Climate” in November 2023.
- Trained 43 trainees at VGU and the National University of Battambang. Trainees learnt remote sensing techniques in studying flood and sediment dynamics in the Mekong basin.
- Signed MOA between the Vietnamese-German University, Vietnam, and the National University of Battambang, Cambodia, in 8/2024 to conduct the project on floating rice.

- Signed MOU between the Vietnamese-German University, Vietnam, and the Isabela State University (ISU), Philippines, in 6/2024. Colleagues from ISU support the project technically by providing advice and lessons from their 2020-2022 APN project in collaboration with Prof. Sameh Ahmed Kantoush of Kyoto University. The APN project, led by Dr. Doan Van Binh, also shared experience and research techniques with ISU.
- Signed MOU between the Vietnamese-German University, Vietnam, and Cagayan Valley Agriculture, Aquatic and Natural Resources Research and Development (CVAARRD) Consortium, Philippines, in 8/2025. VGU and CVAARRD exchanged experiences and research techniques related to research and adaptation to human impacts and climate change for agriculture.
- Expanded the International Association on Climate Change Adaptation and Disaster Risk Management (IO-CCA-DRRM) for global collaboration and formation of a larger network of agencies around the world.
- Over 150 participants to the final workshop in conjunction with the 3<sup>rd</sup> International Conference on Climate Change Adaptation and Disaster Risk Management in 8/2025. VGU collaborated with the IO-CCA-DRRM in organizing the joint final workshop for the project and the 3<sup>rd</sup> international conference at VGU.
- 20 founding members of the IO-CCA-DRRM organization and incorporators with top-notch executives gathered and discussed funding opportunities, future conferences, international organization's officers, financial accounts, strategic directions and expansion plans, and activities for the organization's global visibility in 8/2025 on the occasion of the project's final workshop and 3<sup>rd</sup> international conference.
- Supported young researchers in Vietnam and Cambodia.
- 04 times of bathymetric survey using multibeam echosounder.
- 01 time of bathymetric survey using a single-beam Acoustic Doppler current profiler.
- More than 10 times of field surveys in floating rice fields in the Vietnamese and Cambodian Mekong Deltas.
- Two training courses in Vietnam and Cambodia.
- Supported 02 PhD students and 01 master student in completing their theses.
- Published 04 journal articles, of which 3 are in Q1 journals.
- Presented a keynote speech at the Gordon Research Conference in New Hampshire, USA, in 6/2025.
- Presented 02 posters at domestic and internal conferences.
- Published 03 papers in international conference proceedings.
- Organized 04 field trips with international colleagues to the Vietnamese Mekong Delta (Japan, Italy, Cambodia).
- Presented 16 talks at domestic and international conferences.

## 5. Publications

1. Thi Huong Vu, Lá Backhaus, Doan Van Binh & Sameh Ahmed Kantoush (2025): Applying deep learning for boat detection and numerical modelling to assess sand mining on river

- morphology: A case study in the Vietnamese Mekong Delta, *Geomorphology*, 490, 110010. <https://doi.org/10.1016/j.geomorph.2025.110010>
2. Menna Farag Ahmed, Doan Van Binh, Sameh Ahmed Kantoush, Edward Park, Nguyen Luyen Phuong Doan, Luc Anh Tuan, Vuong Nguyen Dinh, Thi Huong Vu, Binh Quang Nguyen, Trieu Anh Ngoc, Nguyen Xuan Tung & Tetsuya Sumi (2025): Intensified susceptibility to riverbank incision under sand mining impacts in the Vietnamese Mekong Delta: A long-term spatiotemporal analysis, *Geomorphology*, 470, 109535. <https://doi.org/10.1016/j.geomorph.2024.109535>
  3. Thi Thu Ha Nguyen, Duc Quang Vu, Ngoc Phu Doan, Huynh Thi Khanh Chi, Peixin Li, Doan Van Binh, Yimeng An, Pham Tuan Dung, Tuan A. Hoang & Mai Thai Son (2024): Reconstructing suspended sediment concentrations in the Mekong River Basin via semi-supervised-based deep neural networks, *Science of the Total Environment*, 955, 176756. <https://doi.org/10.1016/j.scitotenv.2024.176758>
  4. Ho Ngoc Nhu Y, Sameh A. Kantoush, Manh-Hung Le, Duong Cao Phan & Doan Van Binh (2025): Analysis of Riverine Flood Dynamics using Sentinel-1 Satellite Imagery in An Giang, Vietnam, *Hue University Journal of Science: Natural Science*. (Under review).
  5. Binh Quang Nguyen, Sameh A. Kantoush, Thanh-Nhan-Duc Tran, Menna Farag Ahmed, Doan Van Binh & Venkataraman Lakshmi (2025): Quantifying the combined effects of cascade dam operations and climate change on hydrological extremes in the Mekong River Basin using modeling and frequency analysis, *Communications Earth & Environment*. (Under review)
  6. Thanh-Nhan-Duc Tran, Huy Dang, Ama Deep Tiwari, Bin Fang, Yadu Pokhrel, Binh Quang Nguyen, Sameh A. Kantoush, Doan Van Binh, Menna Farag Ahmed, Tetsuya Sumi Venkataraman Lakshmi (2024): Climate Change and Dam Impacts on Climate Extremes in the Mekong River Basin, AGU2024.
  7. Menna F. Ahmed, Sameh A. Kantoush, Tetsuya Sumi, Doan V. Binh, Nguyen T.P. Mai, Binh Q. Nguyen, Nguyen P. Doan, Luc A. Tuan, Nguyen D. Vuong, Huong T. Vu, Le V. Quyen & Ha N. Thang (2025). Dynamics of estuarine circulation and morphological alterations: A case study of the Vietnamese Mekong Delta, *Proceedings of the 41<sup>st</sup> IAHR Congress-Innovative Water Eng. For Sustainable Development*, 22-27 June 2025, Singapore.
  8. Ho Ngoc Nhu Y, Arun Modal, Manh-Hung Le, Doan Van Binh & Venkataraman Lakshmi (2024): Analysis flood dynamics alterations in the Vietnamese Mekong Delta from Earth observations, *iVCEES 2024*, Quy Nhon, Vietnam.
  9. Luc Anh Tuan, Doan Van Binh & Jens-Uwe Wiesemann (2024): Operation of sluice gates to optimize sediment deposition in agricultural land in An Giang, *iVCEES 2024*, Quy Nhon, Vietnam.
  10. M.F. Ahmed, D.V. Binh, B.Q. Nguyen, S. Kantoush, T. Sumi, N.L.P. Doan, L.A. Tuan, N.T. Nguyen, N.D. Vuong, H.T. Vu, H.N. Thang & L.V. Quyen (2025): Assessing long-term morphological changes in the Vietnamese Mekong Delta, *River Flow 2024*, Liverpool, the UK.

11. Pao Srean, Ratha Rien, Sothea Rien & Doan Van Binh (2025): Productivity and farmer perceptions of two rice systems under changing flood and sediment dynamics in Battambang, Cambodia, *Journal of Sustainable Agriculture*. (Under review).
12. Leang E Heng, Pao Srean, Ratha Tien, Sothea Rien & Doan Van Binh (2025): Productivity and Farmer Perception of Two Rice Systems Amid Changing Flood and Sediment Dynamics in Battambang, Cambodia, The 9<sup>th</sup> SUT International Colloquium, 13-14<sup>th</sup> November 2025, Nakhonratchasima, Thailand.

## 6. Media reports, videos and other digital content

- Project's data storage  
(<https://drive.google.com/drive/u/1/folders/1fGmszmpT3rCAopQ8yNrAd7lgEBeeKTj3>)
- The project's final workshop and 3rd International Conference on Climate Change Adaptation and Disaster Risk Management (<https://io-ccadrrm.org/3rdIOCCADRRM/>).
- Social network for the project's final workshop and 3rd International Conference on Climate Change Adaptation and Disaster Risk Management  
(<https://www.facebook.com/APN.ISU.IFWARM>).
- Social network for the project activity by the Master Program of Water Technology, Reuse and Management of VGU  
(<https://www.facebook.com/profile.php?id=100063220029939>)

## 7. Pull quotes

The APN NbS-SUCCEED project (CRRP2023-04MY-Doan Van) provided an excellent opportunity to advance the understanding of how nature-based solutions can enhance food security and climate resilience in the Mekong Delta. Through hydrological modeling, field investigations, and socio-environmental analysis, the project identified effective strategies to utilize floodwater and sediment for sustainable agriculture. It also strengthened collaborations among researchers from Vietnam, Cambodia, the Philippines, Japan, and other Mekong countries, fostering a multidisciplinary approach to address climate–human interactions. Importantly, the project established a foundation for expanding and deepening future research to tackle complex water–sediment–agriculture–livelihood challenges in the Mekong Delta. The knowledge and experience gained have become a cornerstone of my ongoing research on flood–sediment dynamics and nature-based adaptation strategies.

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## **9. Appendices**

**Appendix 1:** IHP training course.

**Appendix 2:** Kickoff meetings.

**Appendix 3:** Training farmers and exhibitions.

**Appendix 4.1:** Journal article published in the Geomorphology journal: Ahmed et al., 2025.

**Appendix 4.2:** Journal article published in the Geomorphology journal: Vu et al., 2025.

**Appendix 4.3:** Journal article published in the Science of the Total Environment journal: Nguyen et al., 2024.

**Appendix 4.4:** Journal article submitted to the Hue University Journal of Science: Natural Science journal: Y et al., 2025.

**Appendix 4.5:** Journal article submitted to the Journal of Sustainable Agriculture: Srean et al., 2025.

**Appendix 4.6:** Journal article submitted to the Communications Earth & Environment journal: Nguyen et al., 2025.

**Appendix 4.7**\_Poster presented at the AGU2024 conference: Tran et al., 2024.

**Appendix 4.8**\_Conference paper published at the IAHR 2025 World Congress, Singapore: Ahmed et al., 2025.

**Appendix 4.9**\_Conference paper published at the River Flow 2024 conference, the UK: Ahmed et al., 2024.

**Appendix 4.10**\_Poster presented at the iVCEES 2024 conference: Y et al., 2024.

**Appendix 4.11**\_Poster presented at the iVCEES 2024 conference: Tuan et al., 2024.

**Appendix 12**\_Oral presentation at the 9<sup>th</sup> SUT International Colloquium: Heng et al., 2025.