Annex 1: *IHP training course*

I. Online Training Program – UNESCO-IHP at DPRI, Kyoto University

The 33rd IHP Training Course: Integrated Basin Management under Changing Climate (20th November to 30th November 2023)

1. Introduction and Course Objectives

The 33rd Online Training Course (*http://wrrc.dpri.kyoto-u.ac.jp/IHPkyototraining.html*) on Integrated Basin Management under Changing Climate was organized by the Water Resources Research Center (WRRC) of the Disaster Prevention Research Institute (DPRI), Kyoto University, in collaboration with the Institute for Space-Earth Environmental Research, Nagoya University. This program was conducted as part of Japan's contribution to the UNESCO International Hydrological Programme (IHP).

The core objective of the training was to study integrated basin management, focusing on hydrological extreme analysis, assessing climate change impacts, and Rainfall-Runoff-Inundation (RRI) modelling. The course sought to equip participants with technologies for prediction and vulnerability assessments essential for realizing a resilient society against extreme phenomena like floods and droughts exacerbated by recent climate change. Key outcomes included comprehending the basics of hydrology and water management, the challenges posed by climate change, and the application of advanced models, such as those related to the RRI model and land surface processes. Specific lectures covered the Fundamentals of RRI Modelling and Machine Learning Approaches for Flood Risk Assessment.

2. Applied exercises

As required by the self-paced exercises, the Sai Gon-Dong Nai (SGDN) basin in Vietnam was selected as the target river basin. The SGDN is Vietnam's largest internal river basin, covering Ho Chi Minh City. It encompasses an area of 29,667 km² and supports approximately 20 million people.

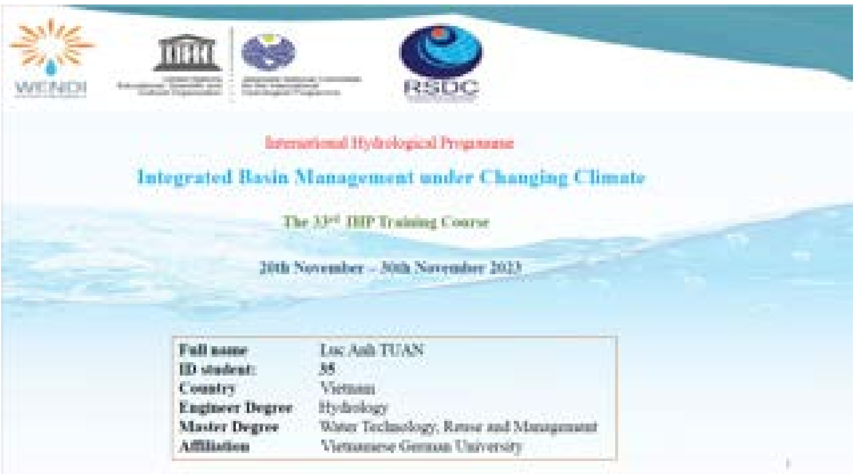


Figure 1. Final report presentation

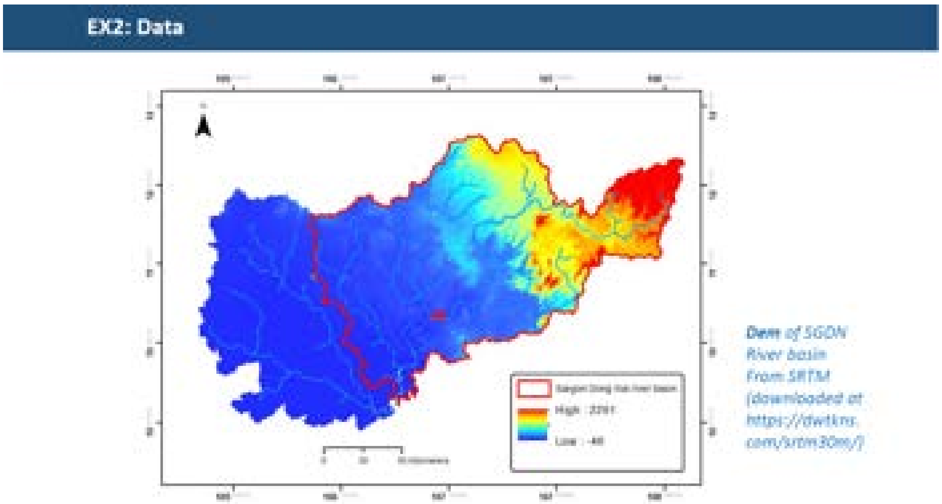
The basin faces severe challenges, including flooding, drought, salinity intrusion, bank erosion, and land subsidence. These issues are driven by factors such as climate change, land use, land cover change, urbanization, and a significant number of dams. The basin currently holds 75 dams, totaling approximately 10.6 km³ in capacity, which represents about 32.6% of the total annual discharge.

2.1. RRI Modelling Application

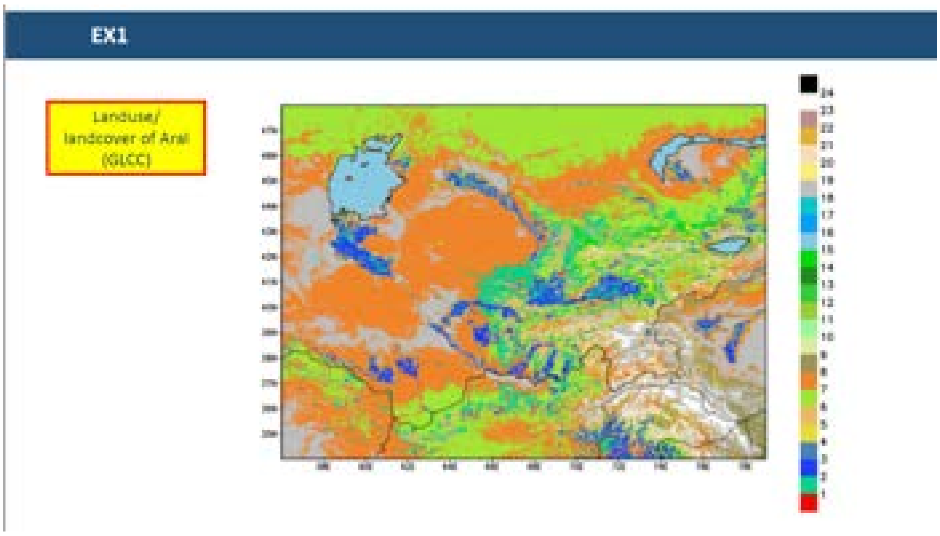
The Rainfall-Runoff-Inundation (RRI) Model was applied to the SGDN basin for Exercise.

2.1.2. Data utilized included:

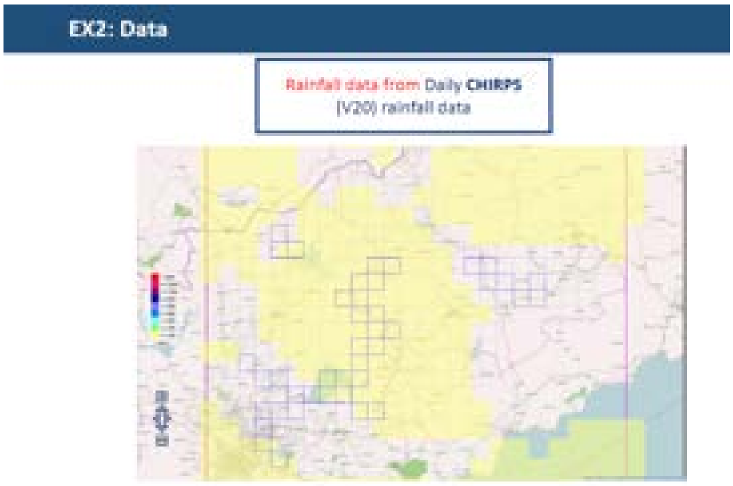
• Digital Elevation Model (DEM) of the SGDN basin from SRTM.



• Land Use/Land Cover (LULC) data for the 1990–2020 period.

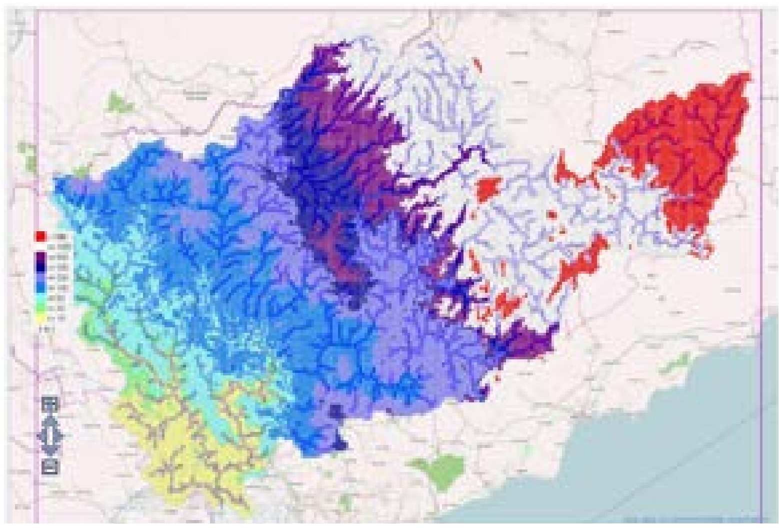


• Daily CHIRPS (V20) rainfall data.

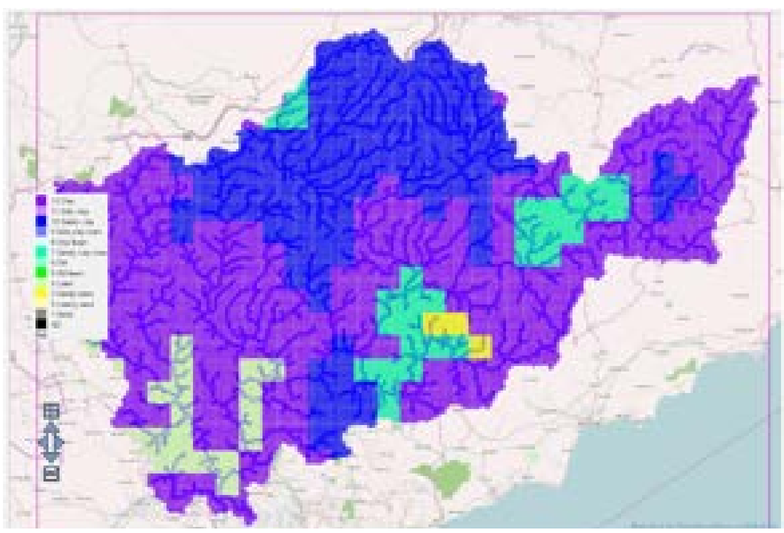


2.1.2. Setup and run Rainfall Runoff Inundation (RRI) Model:

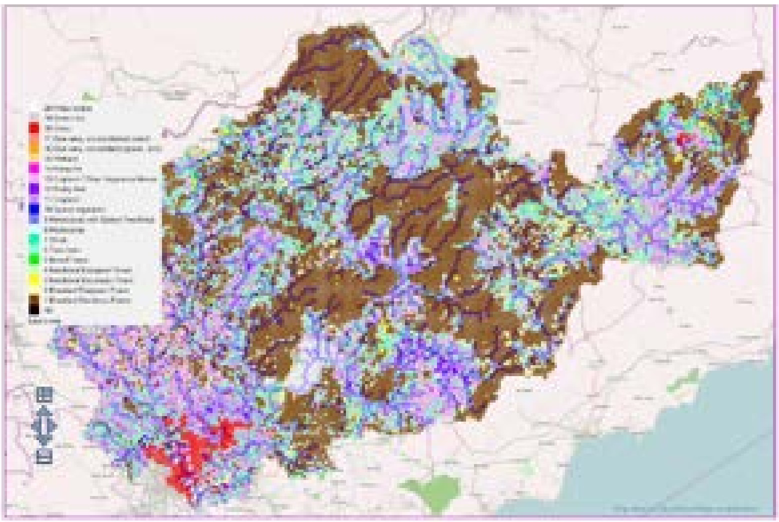
a. Create DEM for the model



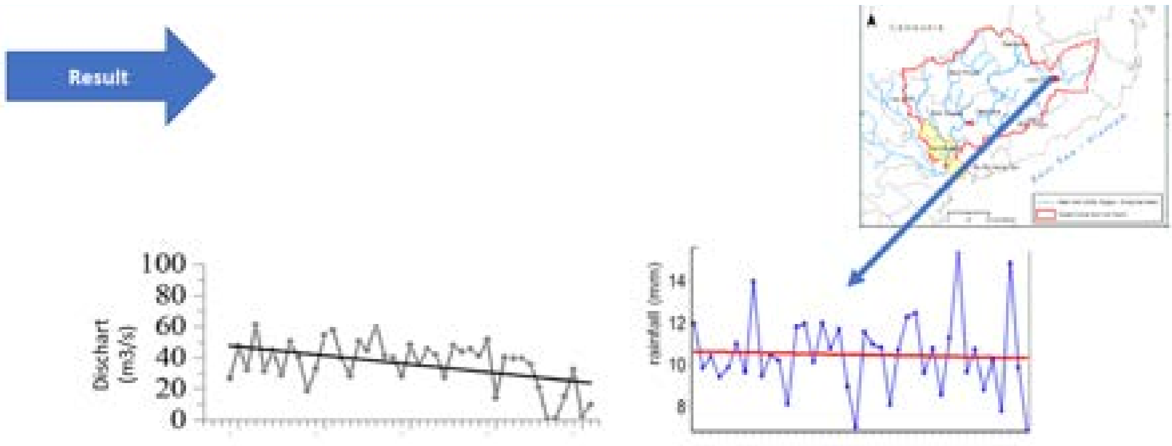
b. Create a soil map for the model



c. Create LULC map for the model



d. Simulation results



Flow and rain are in agreement

Findings and Limitations: The simulation results indicated that the calculated flow and the input rainfall data were in good agreement. However, a significant limitation arose due to the dense presence of reservoirs in the basin. Consequently, the simulation results were noted to be accurate primarily at upstream locations. As the necessary reservoir operating parameters were not included, the accuracy of the model at downstream locations remains.

3. Conclusion and Acknowledgment

The 33rd IHP Training Course was highly valuable. The course emphasized the importance of conducting robust data analysis when presenting results. Although the course duration was short (10 days), it provided the participant with fundamental knowledge and helped him recognize the need to continue practicing to become more proficient in this field.

CERTIFICATE

The undersigned hereby certify that

LUC ANH TUAN

completed the 33rd IHP Training Course in Asia and Pacific Region on "Integrated Basin Management under Changing Climate", which was held from 20th November to 30th November 2023 by Water Resources Research Center, Disaster Prevention Research Institute, Kyoto University, under the auspices of UNESCO Office, Jakarta.

Ms. Maki Katsuno-Hayashikawa
Director and Representative
UNESCO Office, Jakarta

Dr. Kenji Tanaka
IHP Training Course Convener
Director of Water Resources Research Center
Disaster Prevention Research Institute,
Kyoto University

WENDI

CERTIFICATE

The undersigned hereby certify that

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Ms. Maki Katsuno-Hayashikawa
Director and Representative
UNESCO Office, Jakarta

Dr. Kenji Tanaka
IHP Training Course Convener
Director of Water Resources Research Center
Disaster Prevention Research Institute,
Kyoto University

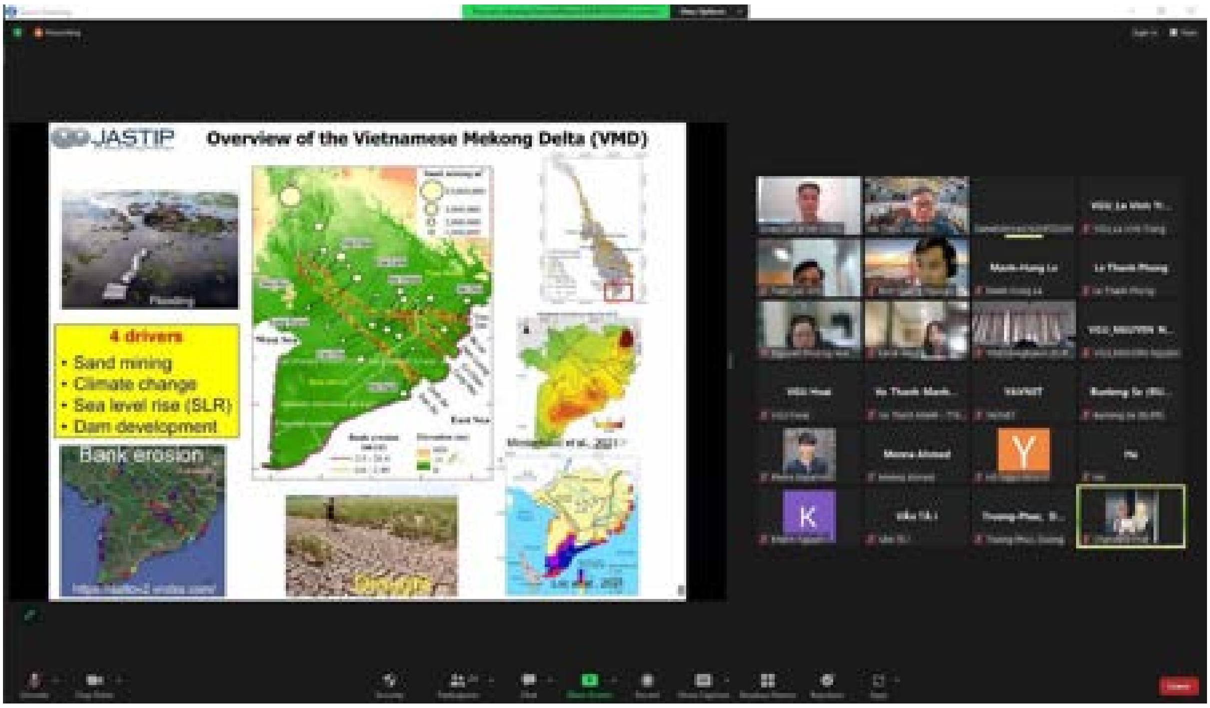
WENDI

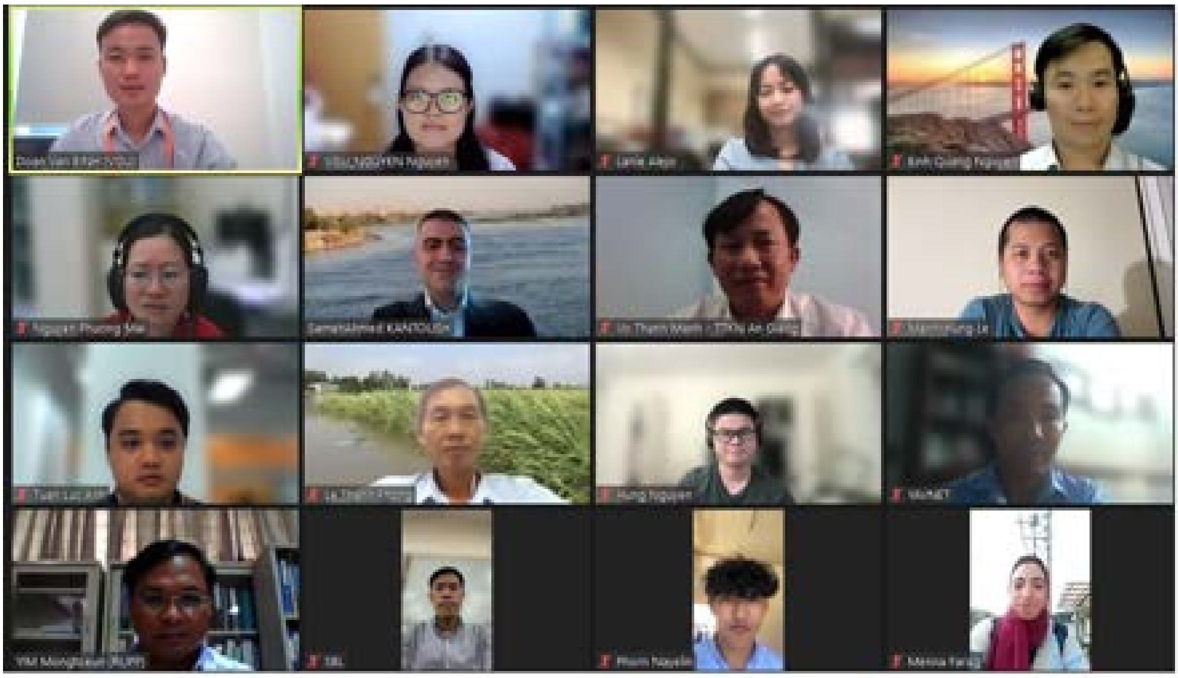
Annex 2: *Kickoff meetings*

1. Online kickoff meeting

We organized the online kickoff meeting in 10/2023 to introduce all project members. Dr. Ha Thuc Vien, Vice President of VGU, presented a welcome speech. Dr. Doan Van Binh, Project Proponent, introduced the overview of the projects, including the project general methodology and detailed methodologies to achieve each project objective. Prof. Sameh Ahmed Kantoush, Kyoto University, introduced practices in river basin management and lessons learnt from Japan and other countries. Ms. Le Thanh Phong (An Giang University) introduced flooding issues and floating rice and highly-yielded rice practices in the Mekong Delta. After the presentation, Dr. Doan Van Binh moderated the meeting to clarify the tasks of each project group and milestones to achieve key results.

Below are some photos taken during the meeting.






Introduction about
Climate Change Institute (CCI)
An Giang University – VNU-HCM
Msc. Le Thanh Phong
(Deputy Director of CCI)
24/10/2023

2. Onsite kickoff meeting

We organized the onsite kickoff meeting at VGU in 01/2024. Before the meeting, we visited the hydrology lab of VGU managed by Dr. Doan Van Binh. Prof. Sameh Ahmed Kantoush welcomed all delegates and shared research experiences from Japan and his previous APN project. Dr. Doan Van Binh introduced the overview of the projects, including the project general methodology and detailed methodologies to achieve each project objective. Following Dr. Binh's talk, other project members presented the methodology and plan for each working group. Mr. Le Thanh Phong presented the methodology and plan to conduct field survey to get information for the working group of An Giang University for the floating rice study and agricultural sustainability. Mr. Vo Thanh Manh, An Giang Department of Agriculture and Rural Development, presented problems in rice cultivation in An Giang Province and the need for addressing these issues. Dr. Nguyen Thi Thu Ha, Van Lang University, presented the methodology and plan to predict suspended sediment concentration in the Mekong River using machine learning models. Mr. Luc Anh Tuan, VGU, presented the methodology and plan to conduct field surveys and establish the MIKE model for sluice gate operations for sedimentation maximization in paddy fields in the Mekong Delta. Dr. Nguyen Quang Binh presented the methodology and plan the establish the SWAT model to simulate the effects of climate change and human activities on hydrology in the Mekong Basin. Kyuden Innovatech Vietnam shared a topic of decision support system for effective and safe operation of hydropower reservoirs in Vietnam. After each presentation, we underwent a Q&A session to clarify technical and logistical steps for each presentation. Finally, we jointly discuss all aspects of the project to have a clear view of achieving the project objectives.

Below are some photos taken during the meeting.


Sameh A. Kantoush
Kyoto University
Disaster Prevention Research Institute (DPRI)
Water Resources Research Center (WRRC)
Japan
Ten Years of Activities at
Vietnamese Mekong Delta
EXIT


Decision support system for effective and safe
operation of hydropower reservoirs in Vietnam
EXIT

Annex 3: *Training farmers and exhibitions*

The working group of An Giang University, led by Mr. Le Thanh Phong, conducted several meetings and training sessions with farmers in the Mekong Delta. The objective was to raise farmers' awareness of the potential of cultivating floating rice instead of highly-yielded rice to enhance livelihood sustainability. Farmers were trained how to optimize floating rice yield by changing and adapting the cultivation calendar.

The group also organized a workshop at An Giang University. Sediment samples collected in the floating rice field were exhibited at the workshop, where we also introduced floating rice varieties and disseminated cultivation processes of floating rice.


ĐẢNG CỘNG SẢN VIỆT NAM QUANG VINH MUÔN NĂM!
An Giang University
20 tháng 5, 2024 08:07 AM


TRƯỜNG ĐẠI HỌC AN GIANG


ĐẠI HỌC QUỐC GIA THÀNH PHỐ HỒ CHÍ MINH
TRƯỜNG ĐẠI HỌC AN GIANG

We also participated in an exhibition organized by the Department of Science and Technology of An Giang Province. We summarized the project results related to floating rice in a poster and exhibited the sediment samples collected in floating rice fields and floating rice varieties.


TRƯỜNG ĐẠI HỌC AN GIANG

AGU24
Washington, D.C. | 9–13 December 2024

University of Virginia

Hydrosense
University of Virginia

Climate Change and Dam Impacts on Climate Extremes in the Mekong River Basin

Thanh-Nhan-Duc Tran[1], Huy Dang[2], Amar Deep Tiwari[2], Bin Fang[1], Yadu Pokhrel[2], Binh Quang Nguyen[3,4], Sameh A. Kantoush[3], Doan Van Binh[5], Menna Farag Ahmed[3], Tetsuya Sumi[3], and Venkataraman Lakshmi[1]

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[2] Department of Civil and Environmental Engineering, Michigan State University, MI 48824, USA
[3] Water Resource Center, Disaster Prevention Research Institute (DPRI), Kyoto University, Kyoto 611-0011, Japan
[4] The University of Danang - University of Science and Technology, 54 Nguyen Luong Bang, Danang, Vietnam
[5] Faculty of Engineering, Vietnamese-German University, Ben Cat City, Binh Duong Province 820000, Vietnam

H11U-0959

Kyoto University · Bach Khoa Danang · Michigan State University · VGU Vietnamese-German University

Abstract

Man-made infrastructures with complex operational regulations and climate change can cause damage downstream and to the ecosystem. In this work, we address two pressing concerns in the Mekong River Basin (MRB):

(i) how currently operational and proposed dams in the near-future will impact natural water regimes and agricultural activities

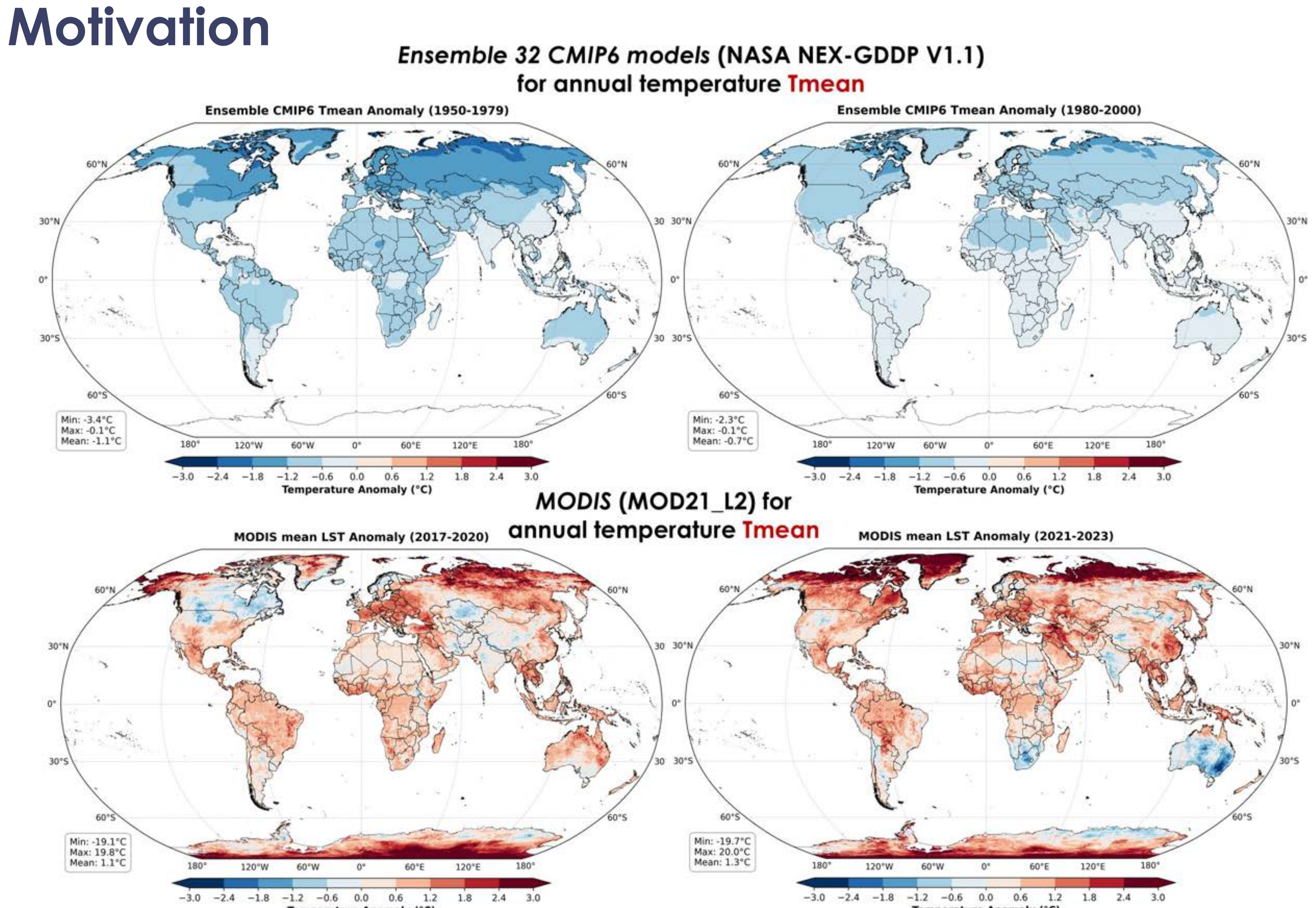
(ii) what are the projected impact of climate change on the intensity and frequency of extreme events by the end of this century

The Soil & Water Assessment Tool (SWAT) while incorporating ~400 major dams (capacity ≥ 1 million m^3) selected over 1,621 dams, including those under construction and planned for completion *before the 2030s*.

Additionally, an Ensemble-mean consists of 28 downscaled, bias-corrected forcing from NASA's General Circulation Models (GCMs), at a resolution of 0.25°, under four Shared Socioeconomic Pathways (SSPs 1-2.6, 2-4.5, 3-7.0, and 5-8.5) were used (2024-2100). Also, the 9-km global Soil Moisture (SM) dataset Soil Moisture Active Passive (SMAP) L3E will be used through the Ensemble Kalman Filter (EnKF) technique for Data Assimilation (DA) in this study.

Preliminary findings indicate that (1) newly constructed and near-future dams will significantly alter seasonal flow patterns, leading to a reduction in downstream sediment transport and subsequently impacting deltaic ecosystems and agricultural productivity, particularly during the dry season, and (2) mid- (2040s) and far-future (2070s) scenarios predict an increase in the frequency and intensity of extreme hydrological events. In general, our work provides insights into the interaction between reservoir operation, climate change, and the water cycle, aiding authorities and decision-makers in addressing conflicts and environmental issues caused by hydropower development across the transboundary MRB.

Motivation



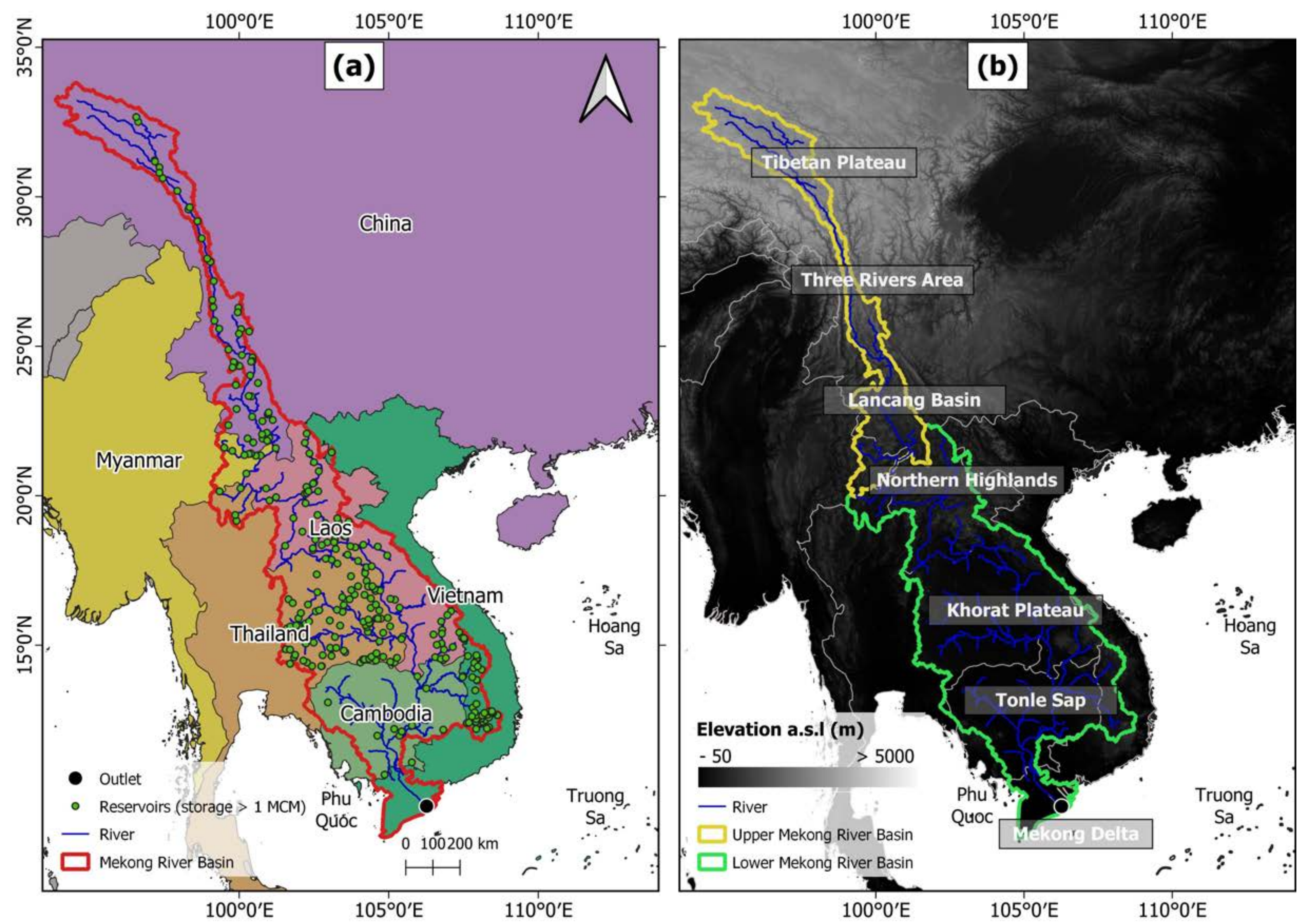
Changes in mean Temperature anomaly with *baseline (2004-2009)*

Data and Methods

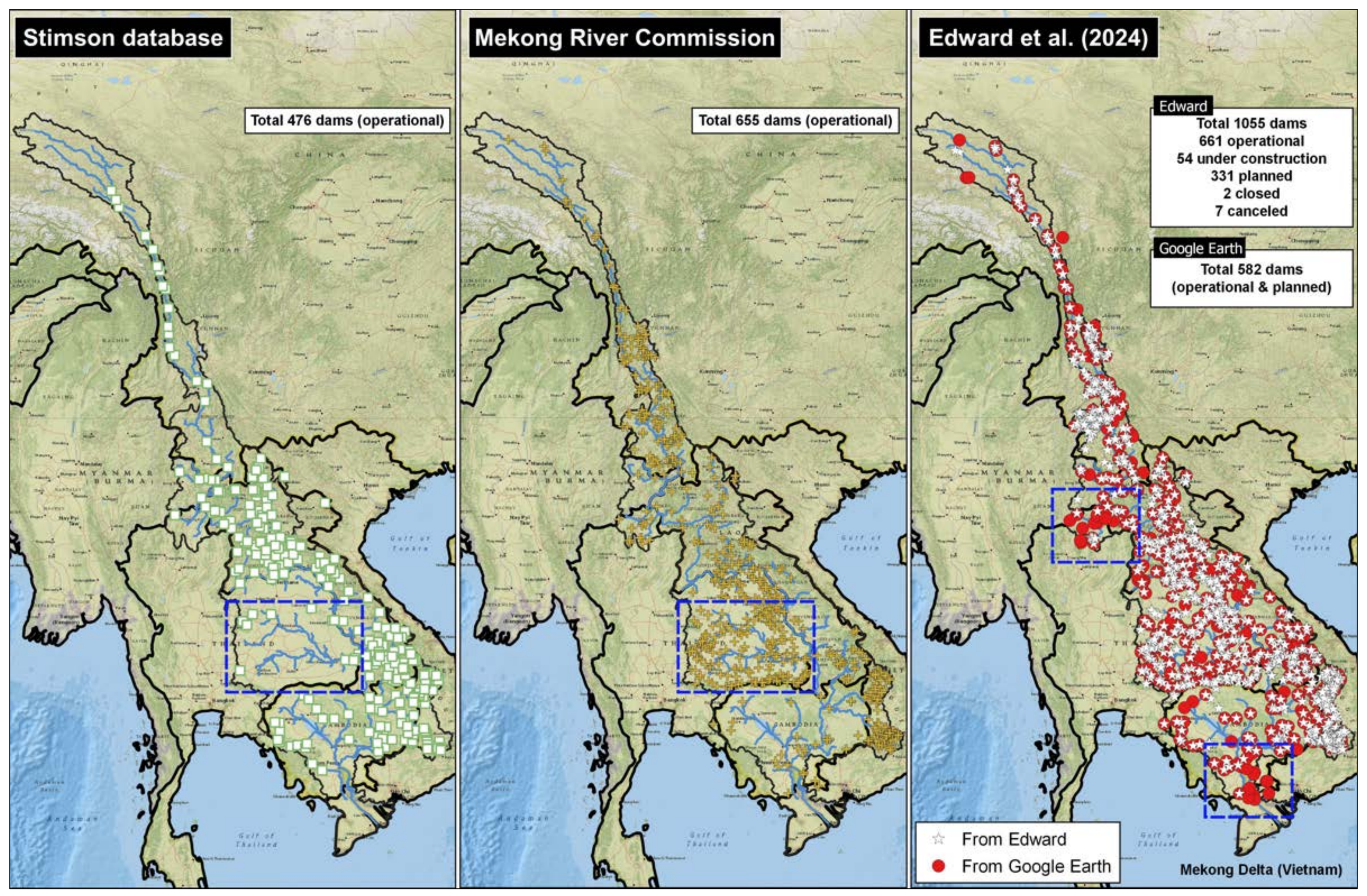
NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6), Soil Moisture Active Passive (SMAP) 9 km L3E, Moderate Resolution Imaging Spectroradiometer (MODIS), and Soil & Water Assessment Tool (SWAT) model.

Mekong River Basin (MRB) and *major* dams

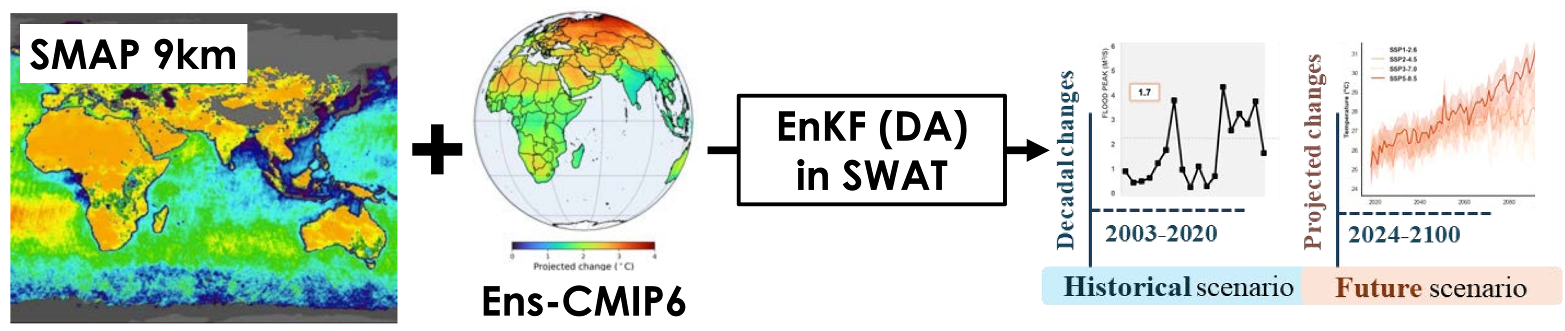
- ❑ The Mekong is one of the world's most prominent rivers
- ❑ Mean annual discharge of 14,500 m^3/s and length of 4,909 km
- ❑ Drainage area spans 795,000 km^2
- ❑ Importance lies in hydropower and agriculture
- ❑ Flows through Lao PDR (25% of the basin area), Thailand (23%), Cambodia (20%), Vietnam (8%), Myanmar (3%), and China (21%).



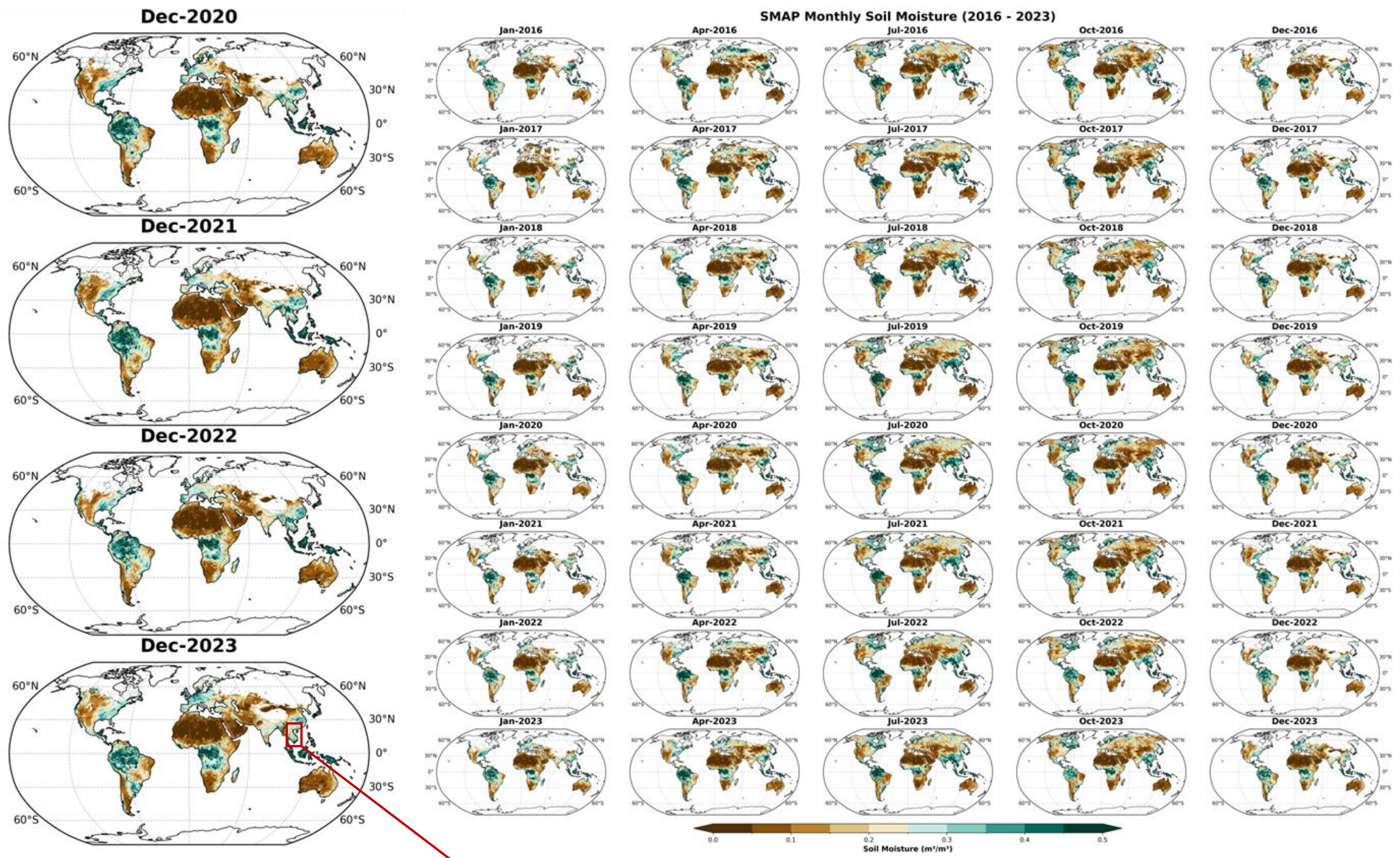
Analysis on current and planned dams

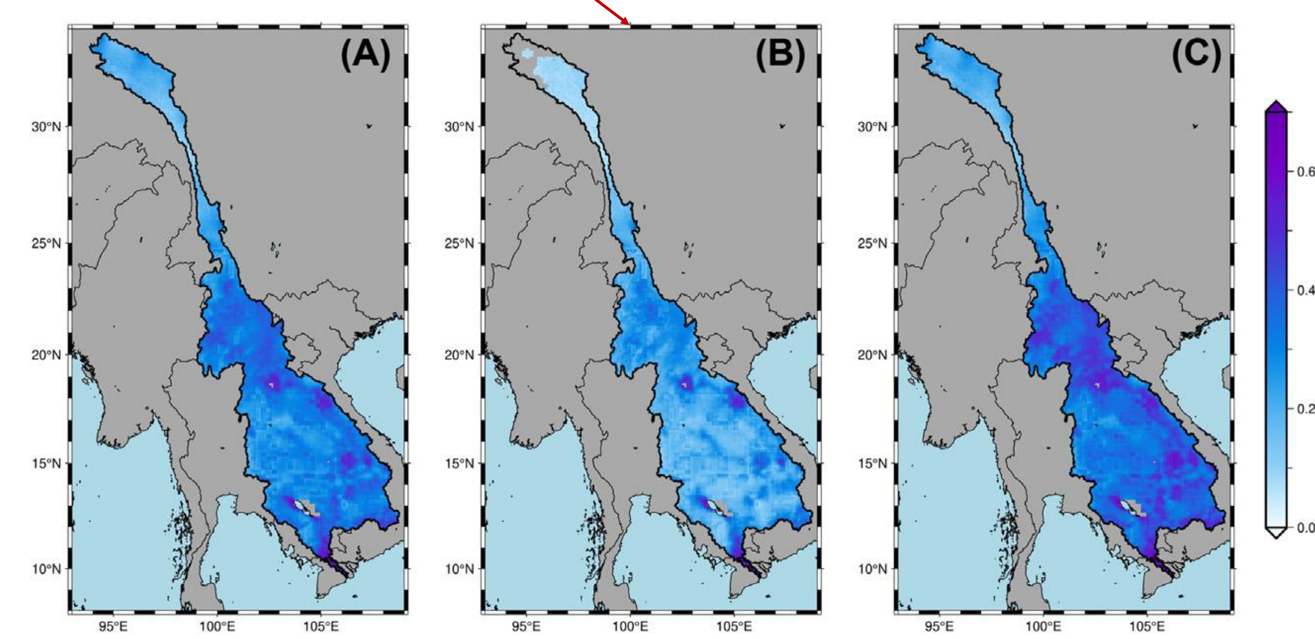


**Total of 1,621 dams and reservoirs have been mapped in combined dataset*



Global soil moisture using SMAP (2016-2023)

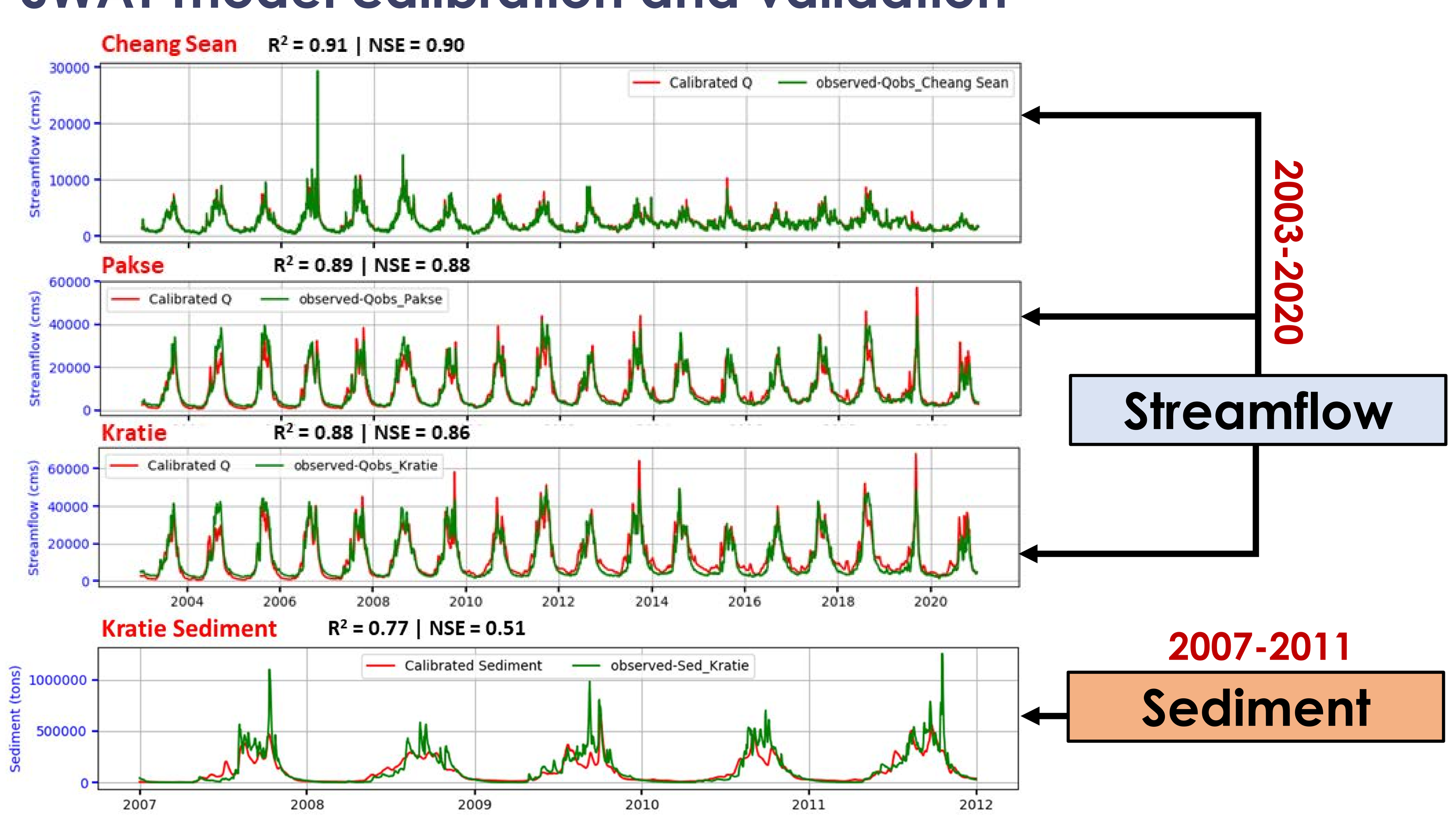




(A) Mean annual soil moisture (m^3/m^3) of the MRB from SMAP soil moisture in 2020.

(B-C) Seasonal variation of soil moisture divided for (B) dry season (December to March) and (C) wet season (April to November).

SWAT model calibration and validation



Acknowledgements

This research is funded by the Asia-Pacific Network for Global Change Research (APN) under project reference number CRRP2023-04MY-Doan Van (Funder ID: https://doi.org/10.13039/100005536), the Japan-ASEAN Science, Technology and Innovation Platform (JASTIP) under the JASTIP-Net 2023/24 Collaborative Research, and the collaborative research project (Grant number 2023IG-01) of the Disaster Prevention Research Institute of Kyoto University. Binh Quang Nguyen is supported by the JSPS Postdoctoral Fellowships Program (Fellowship ID: P24064).

UVA | SCHOOL *of* ENGINEERING & APPLIED SCIENCE

*Ang, W. J., **Edward. P**, et al. (2024). Dams in the Mekong: a comprehensive database, spatiotemporal distribution, and hydropower potentials. Earth System Science Data, 16(3), 1209–1228. https://doi.org/10.5194/essd-16-1209-2024*

Analysis flood dynamics alterations in the Vietnamese Mekong Delta from Earth observations

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2 Department of Geography, University of Allahabad, Prayagra, Uttar Pradesh, India.

3 Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA

4 Science Applications International Corporation, Greenbelt, MD, USA

5 Department of Civil and Environmental Engineering, University of Virginia, Charlottesville, VA, USA

1. Introduction

The Vietnamese Mekong Delta (VMD) is a key region for agriculture and aquaculture production in Vietnam, contributing 33.5% to the national GDP (IPSARD, 2019a). Specifically, it accounts for 70% of Vietnam's rice exports. Floods in the VMD play an important role in the region, providing sediment, creating favorable conditions for fish migration, and maintaining the unique ecosystem. Changes in flood dynamics have a significant impact on the VMD. Therefore, research to monitor flood changes in this region is essential. Remote sensing is an effective and widely applied method for observing natural phenomena such as floods and droughts. Satellites like Sentinel, Landsat, and MODIS are commonly used for Earth observation. Among them, MODIS is the most suitable for monitoring large study areas.

2. Objectives

- Assess long-term changes in flood extent and duration
- Analyze long-term changes in flood distribution and frequency

3. Methodology

Terra MODIS satellite suitable for monitor natural phenomena as floods by the large dataset (since February 18, 2000) and the large coverage.

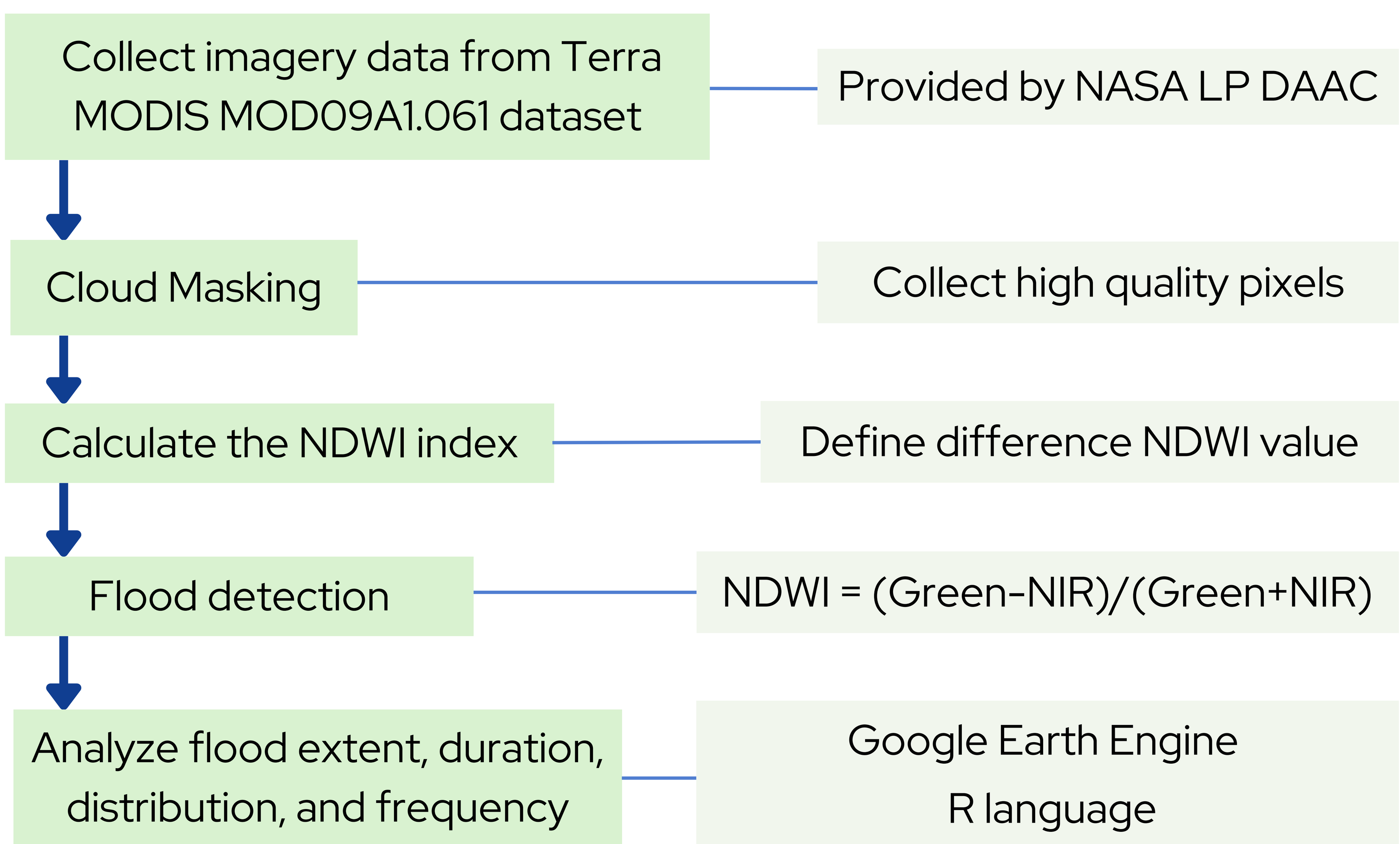
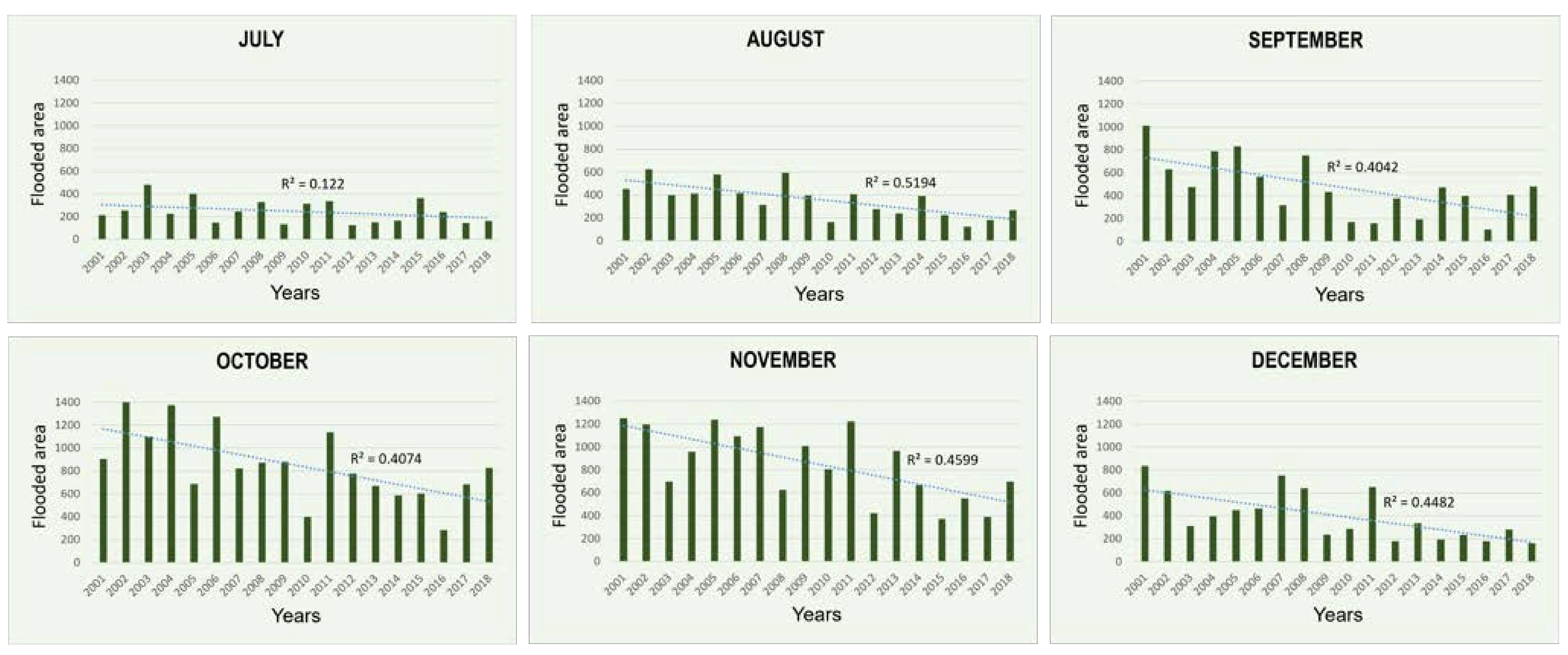


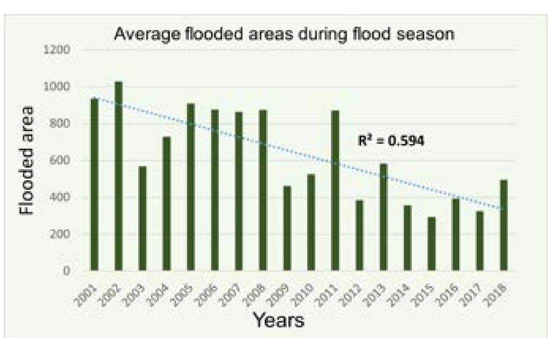
Fig 1. Schematic framework of the study methodology

We used Google Earth Engine platform and R language to detect and analyze the floods in VMD using MODIS imagery (Figure 1).

4. Results and Discussions

4.1. Alterations of inundation areas





- Flooded areas from 2001 to 2018 had the decreasing trends, with the slope value is 0.594.
- The decreasing trend of the flooded areas could be clearly seen in the flood peak duration (from September to November).
- The reasons for the reduction in the inundation area may come from river damming and the development of high dyke systems after the historic flood event in 2000.

4.2. Flood extent and frequency

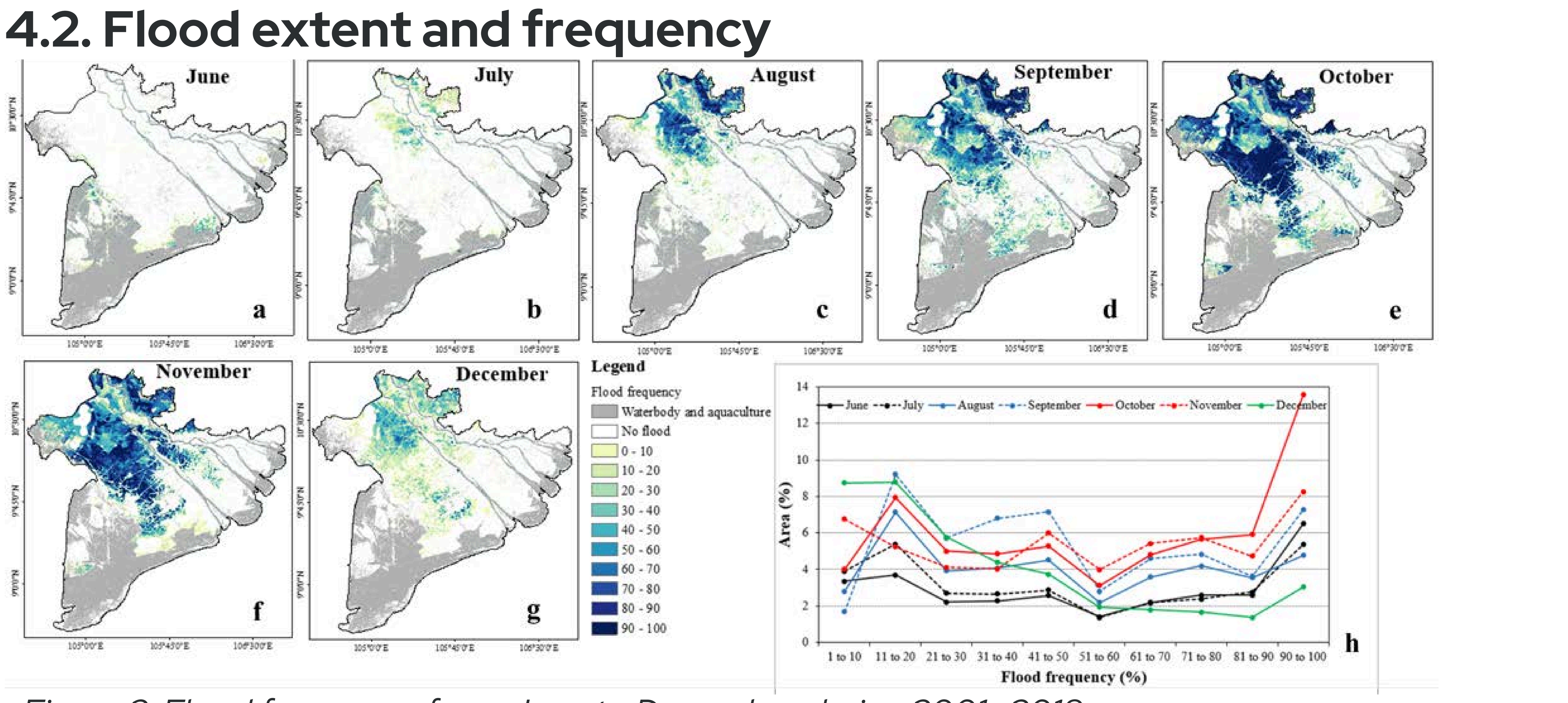


Figure 2. Flood frequency from June to December during 2001 -2018

- Flood occurs from July and end in December.
- October stand out with more than 13% inundation areas experienced 90-100% flood frequency.
- The highest flood frequency (over 80%) areas was observed in the upper and central part in VMD.
- Long Xuyen Quadrangle, Plant of Reeds and Can Tho City were the regions having the highest flood frequency due to its low-lying terrain, except for the An Giang and Dong Thap provinces because 65% cultivation area in An Giang and 40% in Dong Thap were protected by high dyke systems (Thanh et al., 2019)

4.3. Spatiotemporal distribution of flood duration

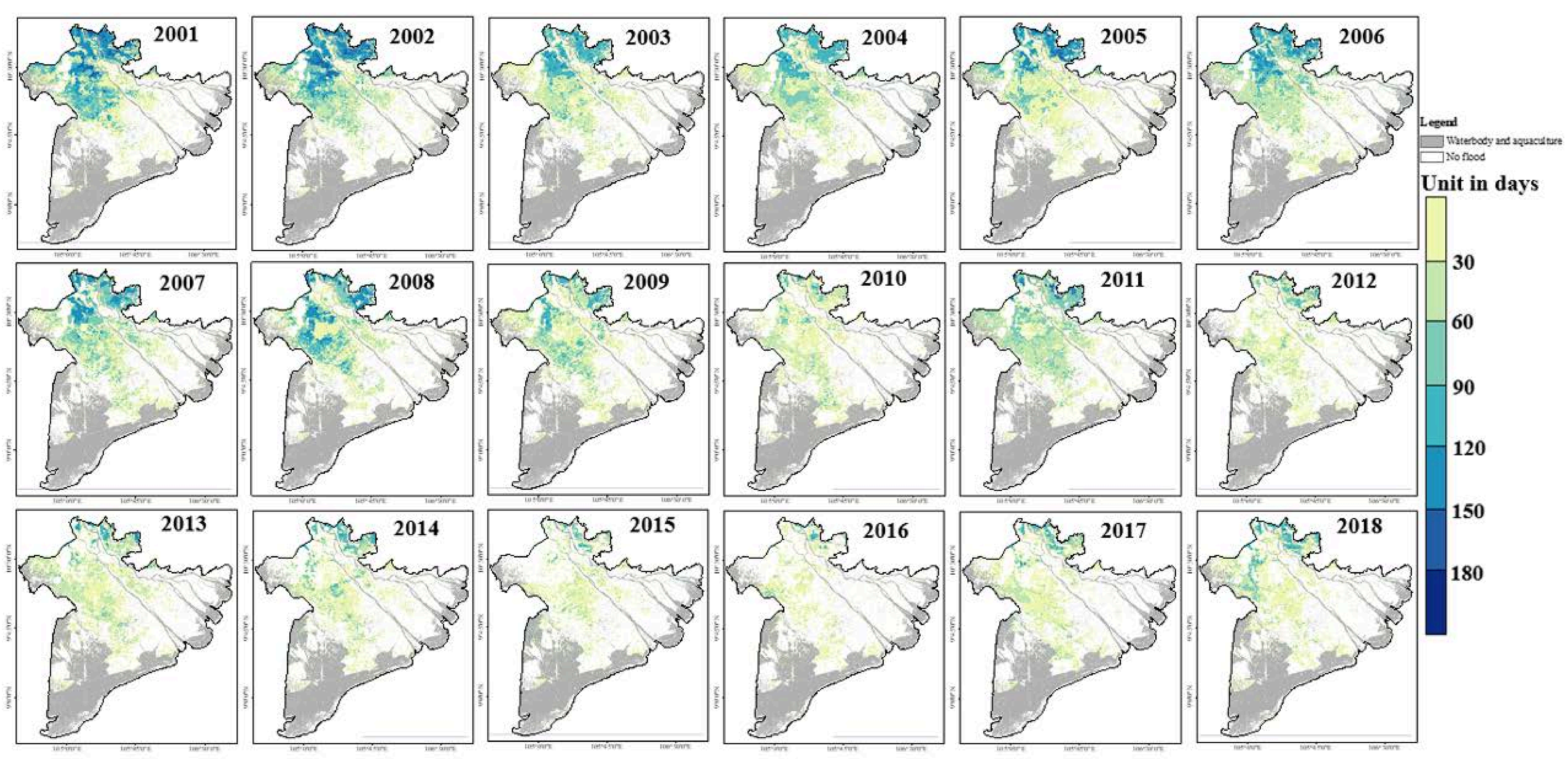
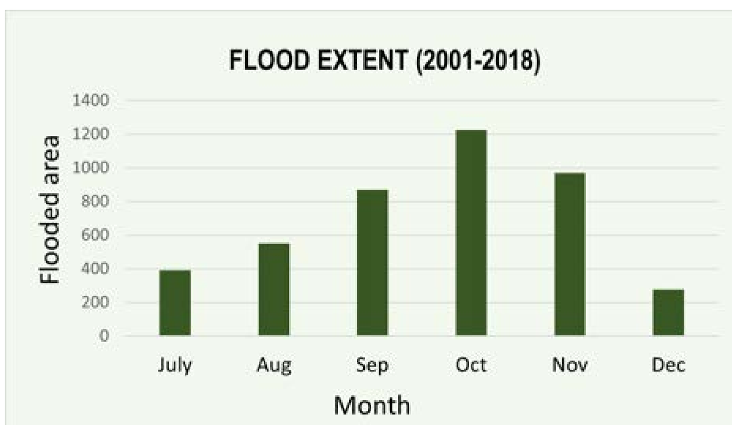


Figure 3. Spatial distribution of flood duration from 2001 to 2018 in VMD

- Flood duration varied spatially from 2001 to 2018 showing a decreasing trend in both space and time.
- From 2012 to 2018, flood duration in the VMD ranged from 60 to 90 days, decreasing significantly compared to the periods from 2001 to 2011 (120 to 150 days).
- The year 2016 had the shortest flood duration, also the most severe drought over the past 100 years (H.H. Loc et al., 2021)

5. Conclusions



- Floods start from July, reach its peak in October then gradually decreased to December.
- The high flood frequency (over 90%) was observed in the Can Tho City, LXQ and the PoR regions, particularly in downstream of An Giang and Dong Thap provinces.
- Flood frequency and flood inundation in the VMD was both gradually decreased, with the slope value in peak month is 0.4074
- The maximum flood duration also decreased, from more than 120 days in 2001 to jus over 60 days in 2018

Acknowledgments

This work was funded by the Asia-Pacific Network for Global Change Research (APN) under project reference number CRRP2023-04MY-Doan Van (Funder ID: https://doi.org/10.13039/100005536), the Japan-ASEAN Science, Technology and Innovation Platform (JASTIP) under the JASTIP-Net 2023/24 Collaborative Research, the collaborative research project (Grant number 2023IG-01), and the Research Unit for Realization of Sustainable Society of the Disaster Prevention Research Institute of Kyoto University and by World Bank project, entitled Mekong Delta Land, Climate & Water Data Analytics Services, contract number: 7189013.

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V. Q. Thanh, D. Roelvink, M. van der Wegen, J. Reyns, H. Kernkamp, G. V. Vinh, V. T. P. Linh, Flooding in the Mekong Delta: Impact of dyke systems on downstream hydrodynamics, Hydrol. Earth Syst. Sci. Discuss., 64 (2019), 10.5194,

OPERATION OF SLUICE GATES TO OPTIMIZE SEDIMENT DEPOSITION IN AGRICULTURAL LAND IN AN GIANG

Luc Anh Tuan[1], Doan Van Binh[1], Jens-Uwe Wiesemann[2]

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[2]. Department of Hydraulics Engineering and Hydraulics, Technical University of Darmstadt, Franziska-Braun-Straße 7, 64287 Darmstadt, Germany

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binh.dv@vgu.edu.vn

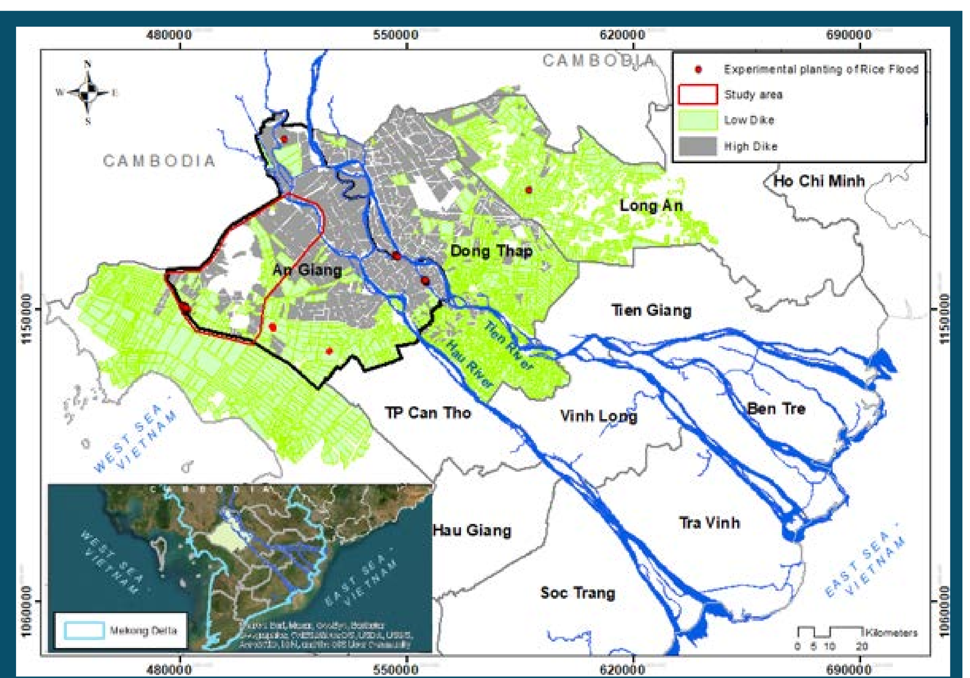
1. Introduction

MEKONG BASIN

Length: 4,881 km.
Flowing through 06 countries.
Area: 795,000 km^2.

THE VIETNAMESE MEKONG DELTA (VMD):

Plays an important role in economic development, especially Vietnam is a country with an export volume of rice in the **top 3 in the world**



Floodwaters overflow and **carry sediment** to fill fields, regenerate river ecosystems, and help push pests out of the field are very important to this region, making the crop more productive. This is the key factor that creates the region's traditional agriculture, which is rice.

2. Challenges & Objectives

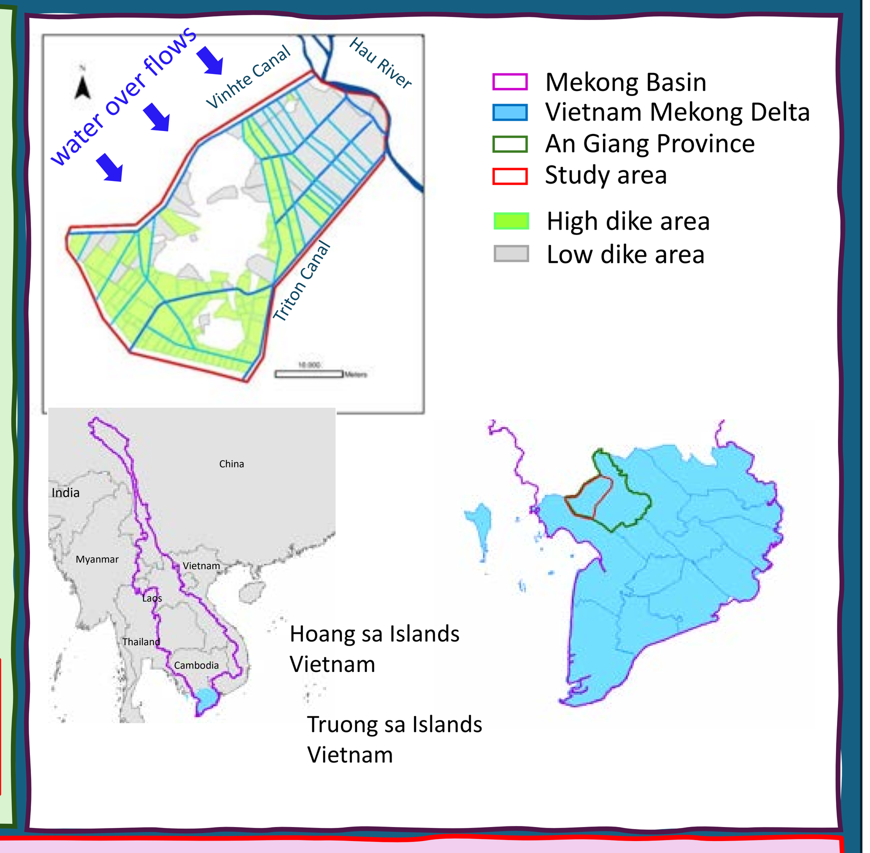
Challenges:

CLIMATE CHANGE DYKE SYSTEM
LAND USE AND & COVER CHANGE
HYDROPOWER PROJECTS

Reduced the sediment supply to the VMD

Prevented sediment from entering the floodplain agricultural areas

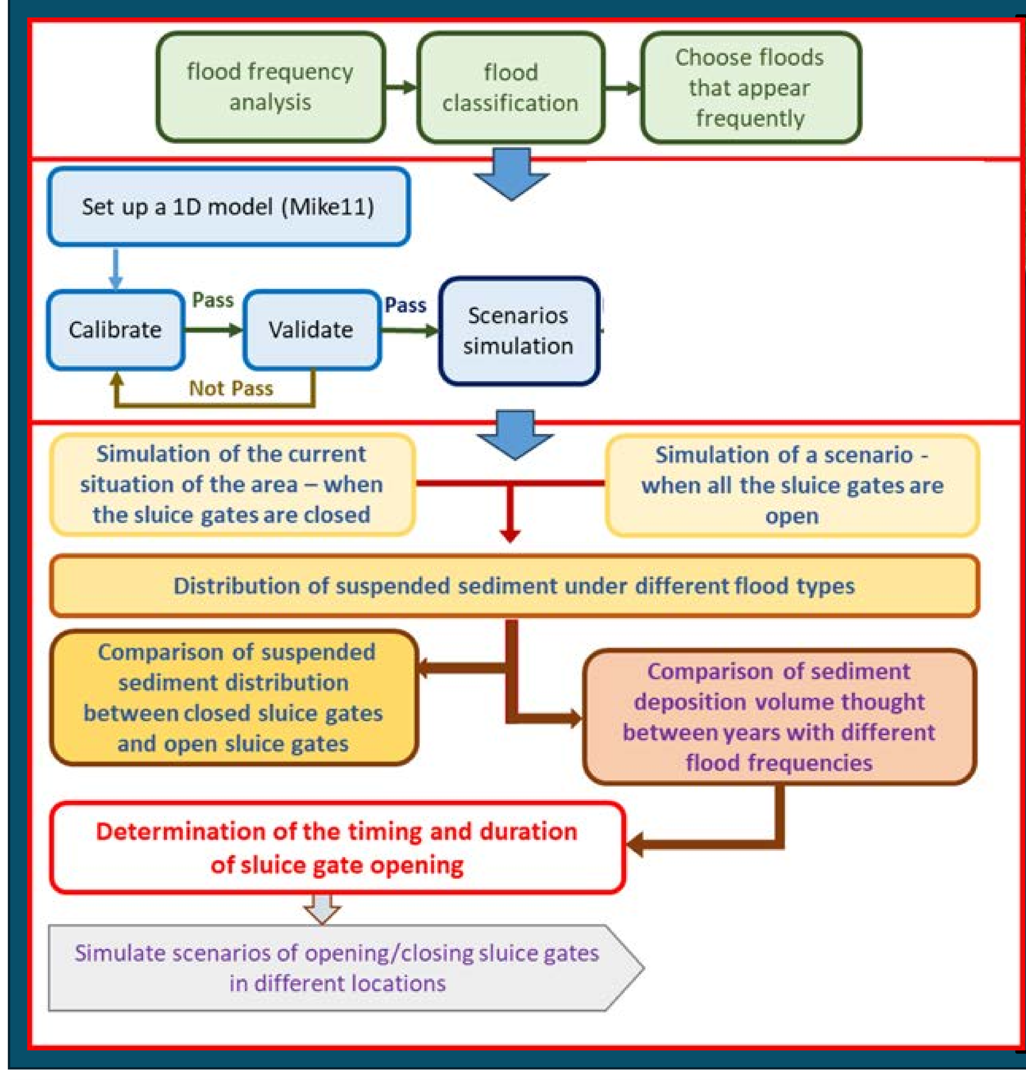
The amount of sediment in the floodplains is reduced by double

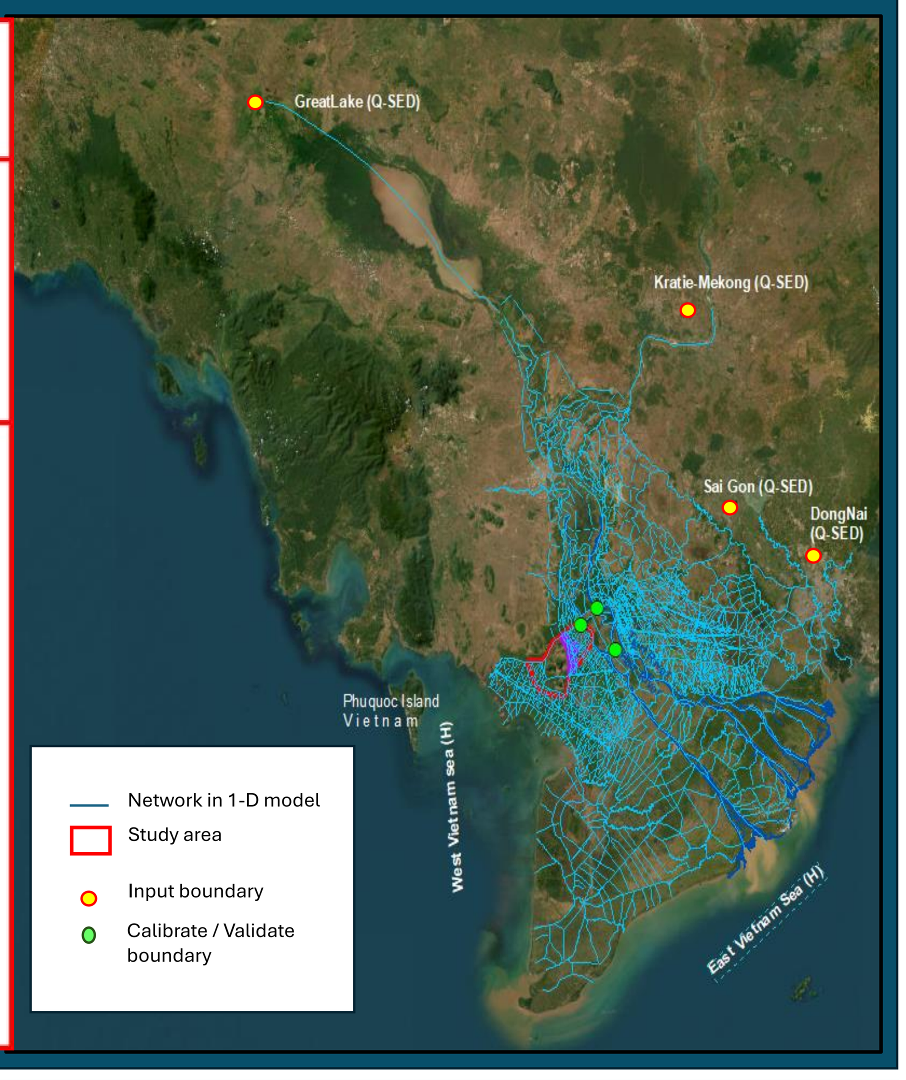


Objectives:

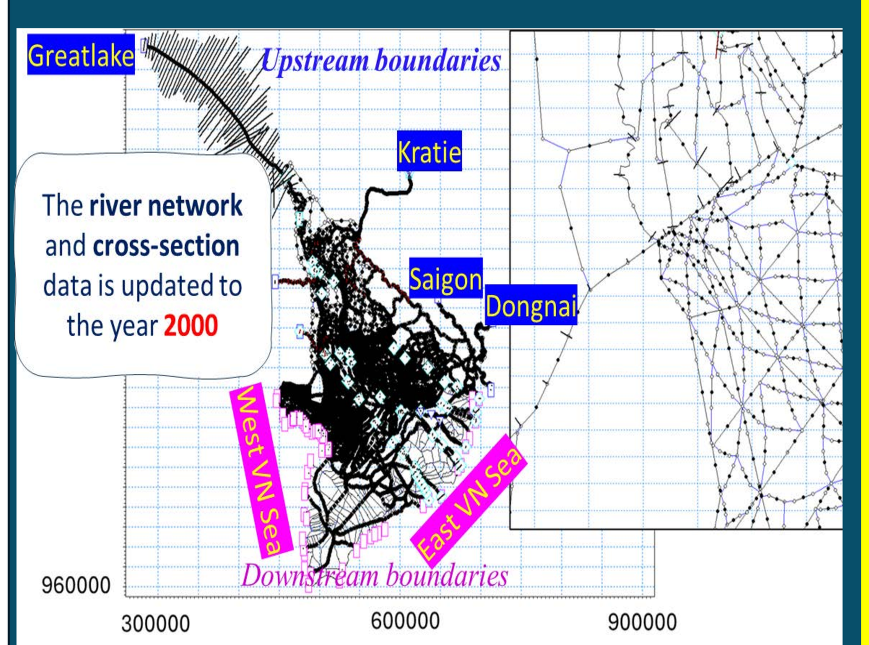
- Understand **sediment pattern/distribution** in the **agricultural land** under flood levels.
- Assess the effect of **sluice gates openings** on **the re-distribution of sediment** in the agricultural area under flood levels.
- Determine **the timing** of **sluice gate openings** to **maximize** sediment deposition in the study area.

3. Methods & Simulation boundary



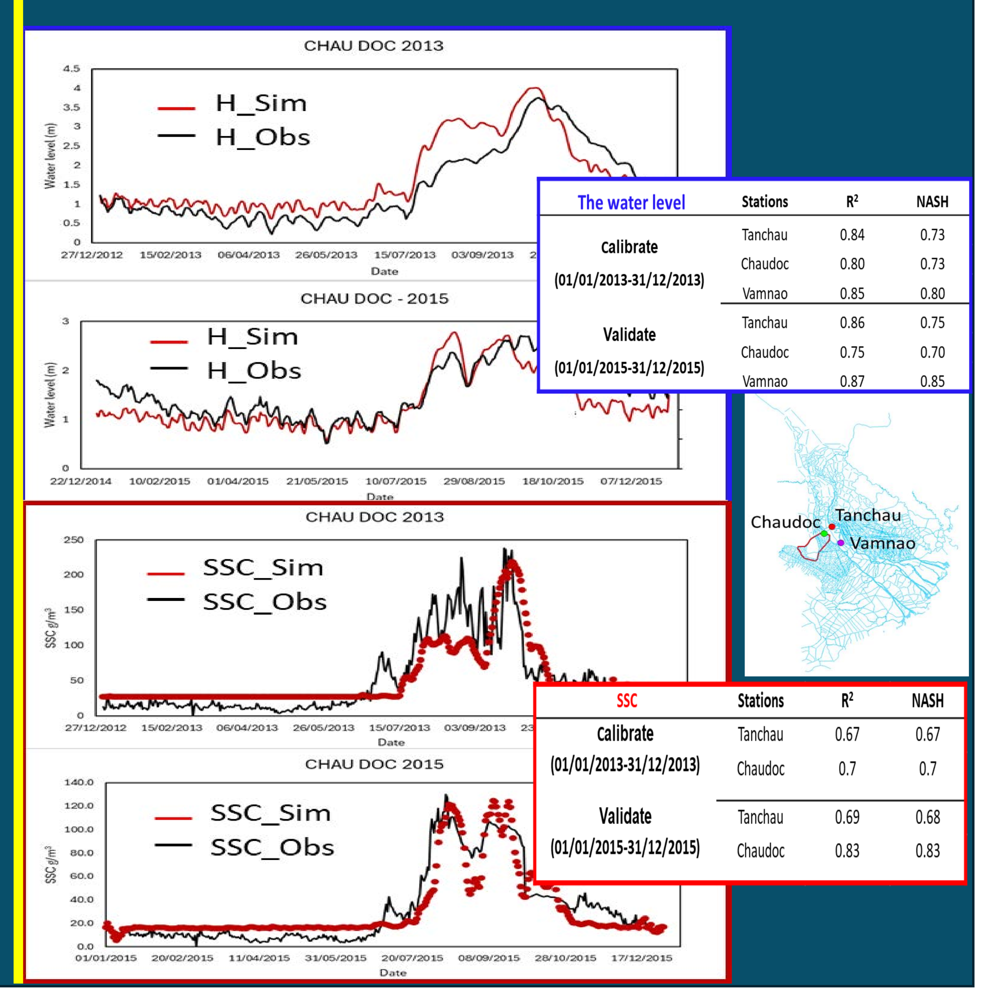


4. Data and Model setup – 1-D Model



	Data type	Time step	Time series
Upstream boundaries	Q SSC	1 Hour	from January 1, 2013 to December 31, 2013 (12 months) and from January 1, 2015 to December 31, 2015 (12 months).
Downstream boundaries	H	1 Hour	

Calibration and Validation

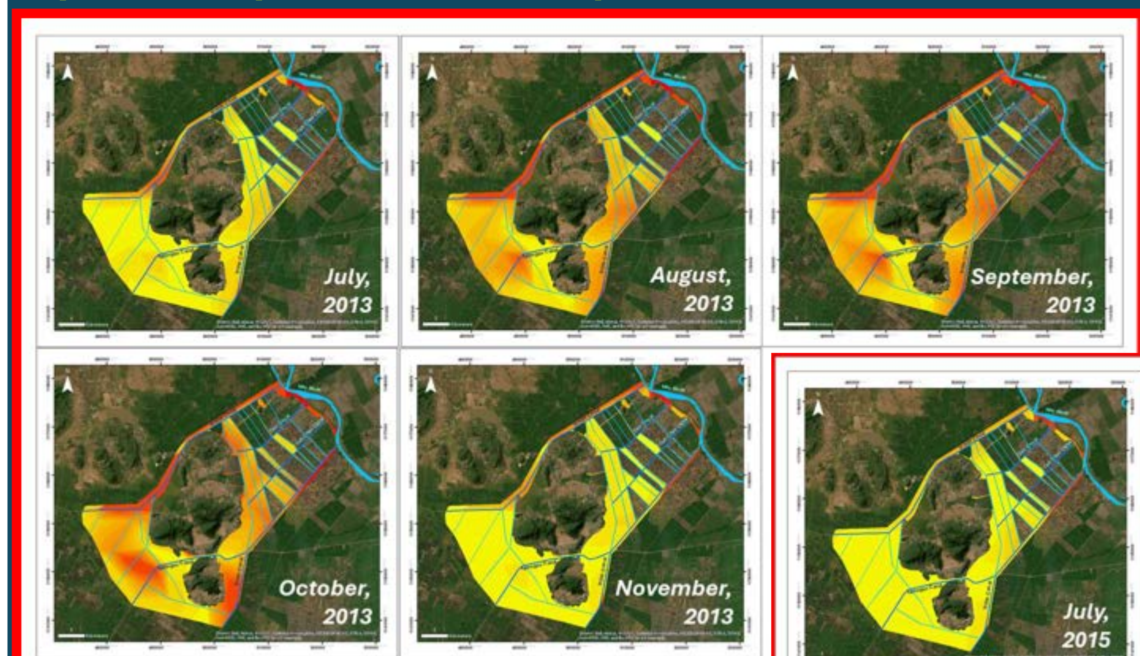


The water level	Stations	R^2	NASH
Calibrate (01/01/2013-31/12/2013)	Tanchau	0.84	0.73
	Chaudoc	0.80	0.73
	Vamnao	0.85	0.80
Validate (01/01/2015-31/12/2015)	Tanchau	0.86	0.75
	Chaudoc	0.75	0.70
	Vamnao	0.87	0.85

SSC	Stations	R^2	NASH
Calibrate (01/01/2013-31/12/2013)	Tanchau	0.67	0.67
	Chaudoc	0.7	0.7
Validate (01/01/2015-31/12/2015)	Tanchau	0.69	0.68
	Chaudoc	0.83	0.83

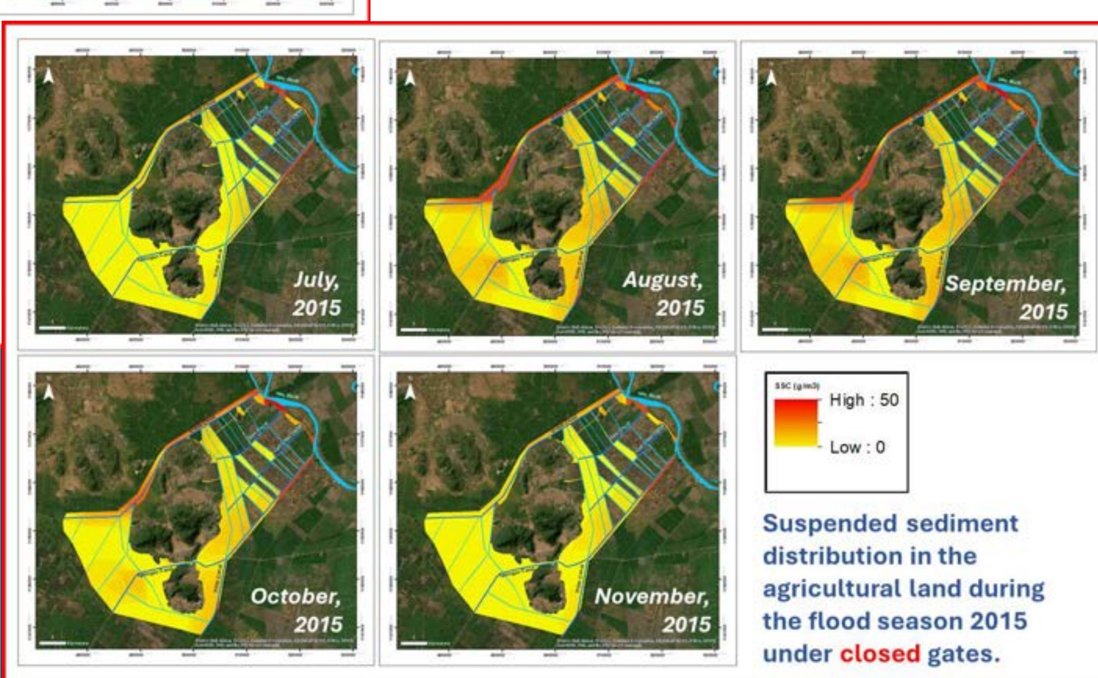
5. Results and Discussion

Spatiotemporal Sediment pattern



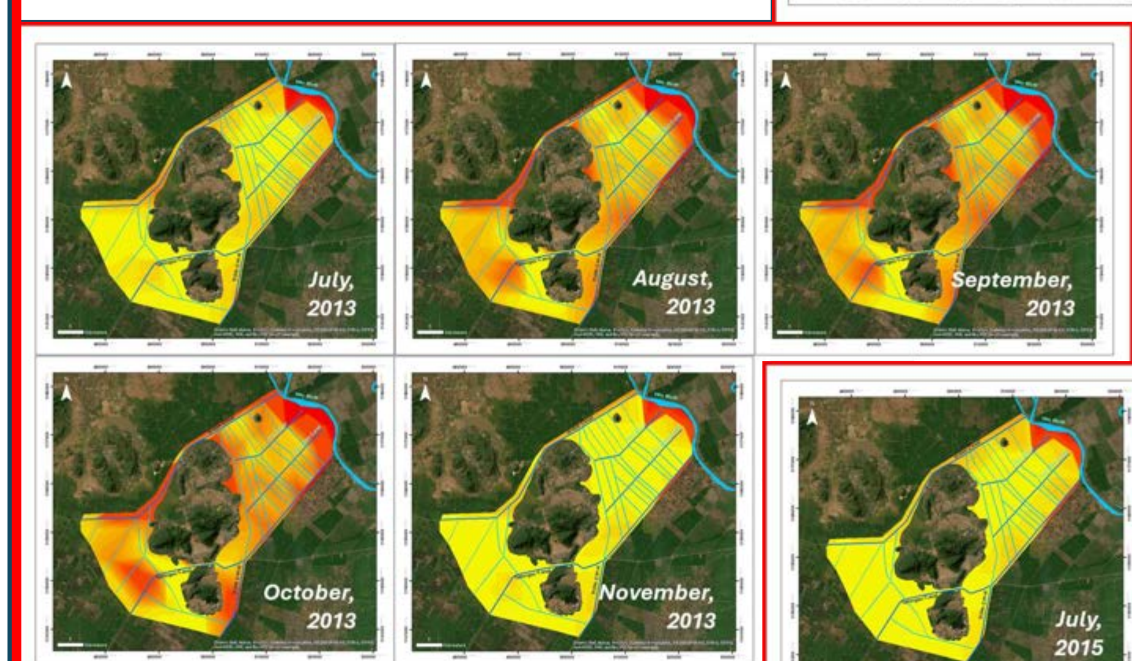
In the **2013**, the Suspended sand concentration peaked in **October**.

In the **2015** the Suspended sand concentration peaked in **September**.



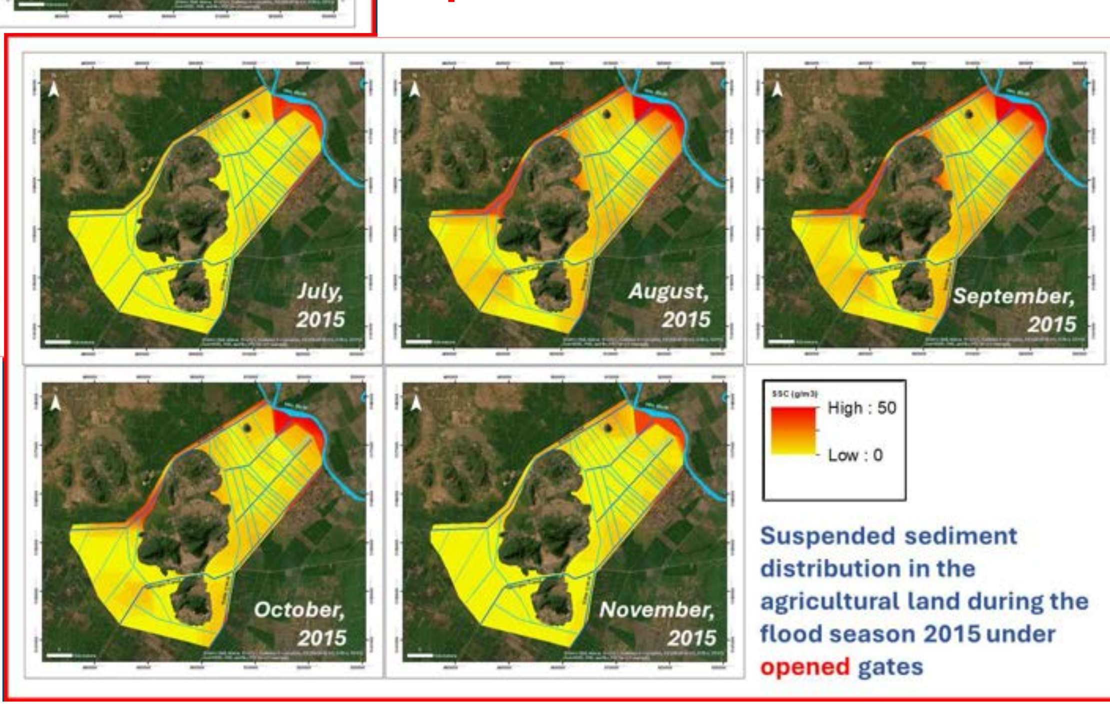
Suspended sediment distribution in the agricultural land during the flood season 2015 under **closed** gates.

The SSC is mostly distributed in areas near the main canal, gradually decreasing towards the secondary canals.



In the **2013**, the Suspended sand concentration peaked in **October**.

In the, the Suspended sand concentration peaked in **September**.

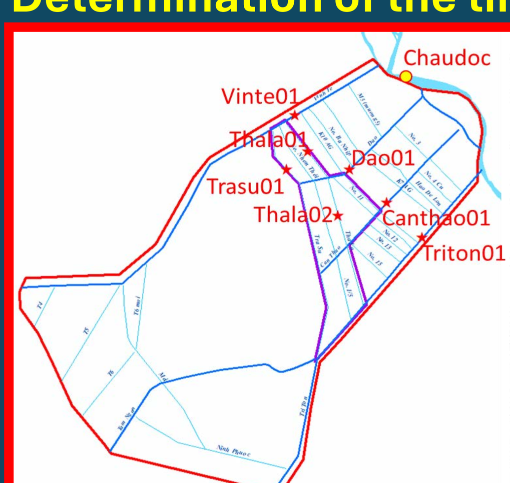


Suspended sediment distribution in the agricultural land during the flood season 2015 under **opened** gates

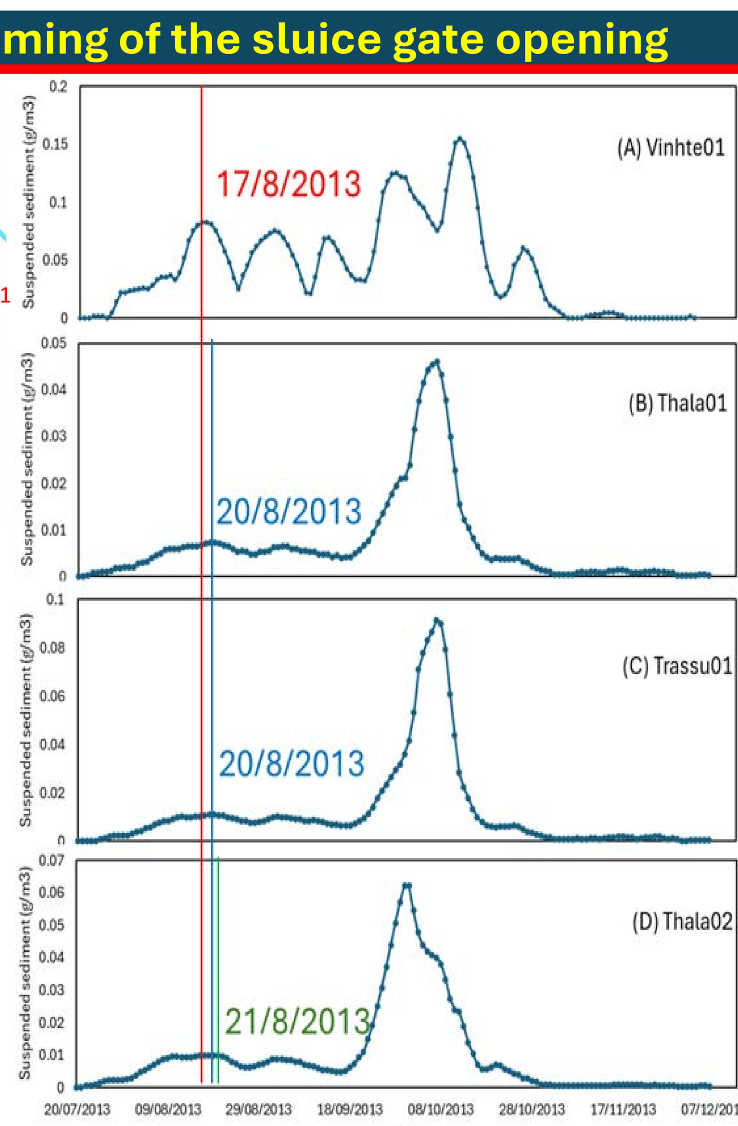
2013: The SSC in the high dyke area was distributed quite evenly with a ranging from **35 to 50 g/m3.**

2015: SSC distribution was less uniform than in 2013, SSC concentrated in the main canal area and significantly reduced in the secondary canal areas. The SSC is about **20 to 30 g/m3** in the main canal and about less than **15g/m3** in the secondary canal.

Determination of the timing of the sluice gate opening



*The time series from **September 26** to **October 19, 2013** to simulate sluice gates operating scenarios* to analyze the sediment distribution in the high dyke area in different operating scenarios and choose the scenario that takes the most sediment distribution



The travelling time from **Vinhte01** to **Thala01 and Trasu01** is **three days** (*between the red line and the blue line*). The travelling time from **Thala01** to location **Thala02** is **one day** (between the blue line and the green line). Thus, the travelling time from the main Vinh Te canal to the infield is about **four days**.

In addition, the SSC peak of the infield area is between **October 1st and 8**. Therefore, the appropriate time to open the sluice gates to take the peak of the SSC into the infield can range from ***September 27*** to ***October 18*** for the ***2013*** medium flood-type year.

6. Conclusion

The flow in VMD varies between the flood season and the dry season. In the flood season, the flow tends to decrease and in the dry season, the flow tends to increase. In agricultural land areas, sediment flows into the infield around September and October. When the sluice gates of the high dike system are not operating, the suspended sediment is mainly transported from the Vinh Te canal into the Tha La and Tra Su canal areas; Here, additional suspended sediment from the Tri Ton canal is added. Then, through the Tam Ngan and Tri Ton canals, the suspended sediment is transported to the low dike area. The sediment flow from the Dao and Canthao canals is very small and insignificant.

The opening and closing of sluice gates in the high dike area affect the sediment flow in the low dike area. The type of flood can govern the influence of sluice operation on the change in total sediment in low-dike areas. In addition, further downstream (the main direction of movement of sediment), the impact of closing/opening the sluice on the total suspended sand concentration is limited.

The flow time from the main Vinh Te canal to the infield is about 4 days. Therefore, every year, it is possible to determine the timing and duration of opening sluice gates to capture the sediment peak for the high dike area based on the monitored water level in the Vinh Te Canal. The most efficient scenario is to fully open the entire input sluice gates. All output gates should be closed until the flood peak timing (about 4 days lag compared to that in the Vinh Te canal), 1 day after the flood peak, gates all are opened with an aperture of 50%.

Within the framework of this study, due to time and computational resource constraints, the study only simulated one direction and was only carried out for two types of floods: medium and small floods (each type simulated for a flood lasting one year). Simulation should be carried out for all 3 types of floods, each flood type should be simulated for several typical years, so there will be a more general view of the sediment problem for the region.

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Productivity and Farmer Perception of Two Rice Systems Amid Changing Flood and Sediment Dynamics in Battambang, Cambodia

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Abstract

This study assesses the comparative productivity of floating rice (FR) and rainfed lowland rice (RLR) and investigates farmers' perceptions of floods, sediment, and climate change in Battambang, Cambodia. We interviewed 27 FR and 47 RLR farmers, collecting detailed data on farming practices and environmental perceptions. Results showed a fundamental trade-off: RLR generally achieved a higher grain yield but demanded significantly more fertilizer and incurred higher overall production costs. In contrast, FR offered lower yields but benefits from a longer growing season and lower seed/input requirements. Farmers reported a strong awareness of the crucial value of natural flood-borne sediment in enhancing soil fertility and reducing dependence on chemical inputs. Despite this, both cultivation systems are now challenged by declining water availability and unfavourable changes in natural sediment dynamics. Critically, the reduced frequency of flooding has enabled a widespread shift toward non-floating rice varieties in formerly deep-water areas. This transition signals a vulnerability of the traditional FR system and emphasizes the urgent need for integrated water and sediment management strategies to sustain both rice systems in a changing climate.

Keywords: agricultural trade-offs, climate change adaption, floating rice, rainfed lowland rice, sediment dynamics.