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FINAL REPORT

Climate change risk
assessment for Southeast
Asian lakes (CCRASEAL)



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1. Summary

The Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) addresses threats posed by climate change to freshwater ecosystems vital for biodiversity and millions of livelihoods in mainland Southeast Asia (SEA). Rising temperatures, unpredictable rainfall, and intensified human activities emphasize the importance of assessing these ecosystems' vulnerabilities. CCRASEAL provides an assessment of climate-related risks to SEA lakes, supporting future conservation and management strategies.

Through an integrated approach, CCRASEAL combines global datasets, geospatial modeling, machine and deep learning, and stakeholder engagement to analyze lake ecosystems. These models assess climate impacts on lake basins, hydrology, land use, and water quality, incorporating various climate scenarios to project future conditions under different pathways. The project identified several lakes at high risk from climate change, with historical evidence of significant land use and climate changes potentially affecting water storage and runoff. Furthermore, quantitative analyses revealed critical trends, including rising lake surface water temperatures (LSWT), shifting lake water extents (LWE), and altered runoff patterns, all indicating heightened ecological stress. Critical insights emerged from the four primary research domains of CCRASEAL.

The first study evaluated historical and future land cover changes, analysing urban expansion, forest loss, and agricultural intensification across mainland SEA. From 2010 to 2020, significant shifts were observed, notably peaks in agricultural growth and reductions in forest cover. Future projections, influenced by factors like population growth and GDP, suggest potential shifts in urban, agricultural, and forest areas, highlighting the dynamic nature of regional land cover change.

The second study focused on historical and projected LSWT trends using predictive models trained on ERA5 and CHIRPS datasets, with MODIS-derived LSWT from 2000 to 2020 as the baseline. To estimate potential future changes in LSWT, the models used long-term downscaled and debiased projections from CORDEX-SEA, based on various Representative Concentration Pathways (RCP2.6, RCP4.5, and RCP8.5), and outputs from multiple General Circulation Models (GCMs) and Regional Climate Models (RCMs). The best-performing model projected LSWT from 1986 to 2100, highlighting historical and anticipated temperature dynamics. A risk assessment for exceeding critical LSWT led to the creation of a delineating LSWT change risk map. The data supporting the findings of this study have been made publicly available and can be accessed through a public data repository system for the academic and research community.

The third study investigated the grid-based NRCS-CN method for runoff estimation across the mainland SEA region. Runoff trends were analysed at both basin and pixel levels, with parameter adjustments improving accuracy across most basins. These findings emphasize the method's utility for high-resolution runoff estimation, suitable for local trend detection and integration into early warning systems. This flexibility makes it a valuable tool for researchers, practitioners, and policymakers requiring adaptable, high-resolution runoff data.

The fourth study developed the SEA-LWE dataset, covering 1984–2019, to monitor water extent changes in over several hundreds lakes. This dataset, available in vector and tabular formats for continuous analysis, facilitated seasonal and long-term water extent pattern assessments. Results indicated that northern SEA basins, particularly in the Mekong and Chao Phraya regions, are heavily impacted by anthropogenic activities and precipitation shifts. These findings underscore the region’s ecological vulnerabilities and the need for adaptive management strategies.

Finally, CCRASEAL fostered collaboration between scientists and communities, enhancing participation in local governance and resource management. The project improved technical capacities for managing climate and geospatial data, supporting more resilient local responses to climate impacts.

2. Objectives

Overall objective of the project was to set up a methodological and analytical framework that leverages on existing data, methods and knowledge to assesses the current and projected climate change impacts and related risk on the mainland SEA region freshwater lakes.

There are 3 key objectives and related sub-objectives:

1. To detect and measure spatial and temporal patterns of present and future climate in SEA lakes. In particular:
 - i. to detect and measure air temperature changes and trends;
 - ii. to detect and measure precipitation trends;
 - iii. to detect extreme events and changes in timing of seasons.
2. To assess spatial and temporal patterns of changes of freshwater lakes and link observed alteration to threats. In particular:
 - i. To generate an updated and standardized compendium of climatic and hydro-environmental variables;
 - ii. To generate future land use scenarios;
 - iii. To find spatial and temporal patterns and linkages between climate, land use and hydro-environmental variables
3. To assess the climate change risk over investigated lakes and adjacent areas in future climates. In particular:
 - i. To estimate the risk of water quantity and quality decrease in future climates;
 - ii. To estimate the risk of the encroachment of lakes on rural, urban and agricultural areas adjacent to the lake
4. To elicit a better consideration of multi-threats approach in CC impact assessment on mainland SEA lakes region into decision making processes.

3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
<p>C-GeoDB dataset</p> <p>Climatic geodatabase</p> <p><i>Historical climatic datasets (1986–2020):</i></p> <p>ECMWF ERA5: ATmean (°C), ATmax (°C), ATmin (°C) , RH (%), R (mm), EW (m s⁻¹), NW (m s⁻¹), SWR (w m⁻²), CF (%); CHIRPS v0.2: Precipitation</p> <p><i>Future climatic dataset (2000 - 2100):</i></p> <p>Same as historical variables downscaled and debiased extracted from the CORDEX-SEA’s Simulations (MOHC-HadGEM2-ES_RCA4, MPI-M-MPI-ESM-MR_RegCM4-7, CNRM-CERFACS-CNRM-CM5_RCA4, MOHC-HadGEM2-ES_RegCM4-7, NCC-NorESM1-M_RegCM4-7, LULC-GeoD.</p>	<p>i) Climatological statistics were estimated at the lake level across 80 major lakes in SEA;</p> <p>ii) Downscaled historical and future time series for air temperature, relative humidity, wind direction and speed, shortwave radiation, cloud cover, and precipitation were generated at both lake and basin levels;</p> <p>iii) The historical estimations incorporated multiple CORDEX-SEA simulations, encompassing various potential climate scenario and climatic drivers of change</p>	<p>Enhancement of Environmental Management: The analysis supports improved strategies for managing major lake ecosystems in the mainland SEA region.</p> <p>Improved Climate Predictions: generation of downscaled historical and future time series for key climate variables increases the accuracy of local climate forecasts for SEA lakes.</p> <p>Robust Water Resource Management Strategies: stakeholders can develop effective strategies for managing water resources and adapting to changing climatic conditions in critical ecosystems.</p> <p>Comprehensive Scenario Planning: Integration of multiple CORDEX-SEA simulations allows for thorough planning under various climate scenarios.</p> <p>Collaboration Among SEA Stakeholders: The use of CORDEX-SEA, recognized for its accuracy and widespread utilization, fosters collaboration and data sharing among various stakeholders involved in climate adaptation and environmental management efforts.</p>
<p>LSWT-SEA dataset</p>	<p>It is an original and publicly available CCRASEAL original dataset which includes historical and future (under different</p>	<p>Enhanced Research Opportunities: The dataset allows researchers to conduct in-depth studies on the effects of climate</p>

Historical and future Lake Surface Water Temperature for 80 major lakes in SEA dataset

predicted scenarios) Lake Surface Water Temperature for 80 major lakes in SEA

change on lake ecosystems, facilitating a better understanding of thermal dynamics and their ecological implications.

Informed Management

Decisions: By providing both historical data and future projections under various climate scenarios, the dataset empowers stakeholders, including governmental and non-governmental organizations, to make informed decisions regarding water resource management, conservation efforts, and climate adaptation strategies.

Climate Change Mitigation: The insights gained from analyzing LSWT trends can inform strategies aimed at mitigating the effects of climate change on freshwater ecosystems, contributing to the preservation of biodiversity and ecosystem services.

Public Accessibility and

Community Engagement: As a publicly available resource, the dataset fosters transparency and encourages community engagement in environmental monitoring and management, promoting awareness of climate issues among local populations.

Collaboration and Data Sharing:

The existence of a comprehensive and accessible dataset encourages collaboration among academic institutions, governmental bodies, and local communities, facilitating

data sharing and joint efforts in climate research and action.

LULC-GeoDB

Land use and land cover geodatabase

Historical LULC datasets:

- i. Global Land Cover 2000 (GLC2000) for the year 2000
- ii. MODIS Land Cover (MCD12) from 2001 to 2020
- iii. Global Land Cover (GLOBCOVER) for the years 2005 and 2009
- iv. Climate Change Initiative Land Cover (CCI LC), from 1999 to 2020
- v. Land Cover Global Version (GLCNMO) for the years 2003, 2008, 2013

Future dataset: project CCI LC using the Markov Chain model and considering input dataset: population density, cropland, GDP, precipitation trends, land surface temperature, forest restoration plans, slope, proximity to cities, and accessibility to road networks.

The *LULC-GeoDB* geodatabase provides a robust historical and future perspective on land use and land cover (LULC) in SEA, integrating multiple datasets spanning from 1999 to 2020. Historical datasets include GLC2000, MODIS, GLOBCOVER, CCI LC, and GLCNMO, offering insights into past land cover changes. For future projections, the dataset leverages the Markov Chain model, incorporating socio-economic and environmental factors like population density, cropland expansion, GDP, precipitation trends, temperature, and urban accessibility. This LULC-GeoDB enables a deeper understanding of land transformation drivers, assisting in planning and sustainable management across the region's landscapes.

Enhanced Understanding of Land

Use Dynamics: By providing a comprehensive historical and future perspective on land use and land cover, the LULC-GeoDB enables researchers and policymakers to better understand the drivers of land transformation in SEA.

Informed Land Management and

Planning: Insights derived from the integrated datasets facilitate informed decision-making for land use planning, helping stakeholders design sustainable land management practices that account for historical trends and future projections.

Adaptation to Climate Change:

By incorporating socio-economic and environmental factors, the LULC-GeoDB aids in identifying vulnerable areas, thereby supporting climate adaptation strategies that consider future land cover changes in the context of climate impacts.

Policy Formulation and

Evaluation: The availability of long-term land use data empowers policymakers to formulate, evaluate, and adjust land use policies based on historical changes and projected trends, ensuring they remain relevant and effective.

Support for Sustainable

Development Goals: The

geodatabase contributes to the achievement of sustainable development goals by promoting efficient resource management and minimizing negative impacts of land use changes on ecosystems and communities.

Risk-GeoDB dataset

This dataset contain the LSWT probability curves as well as the risk maps associated to each considered lake.

This dataset includes also LSWT, runoff and LWE trends maps

The *Risk-GeoDB* dataset offers probability curves and risk maps for LSWT across key SEA lakes, alongside trend maps for LSWT, runoff, and LWE. Together, these insights reveal critical climate risks and patterns, providing a strategic basis for climate-resilient lake management.

Informed Decision-Making for

Water Resource Management: By integrating trend maps for LSWT, runoff, and lake water extent (LWE), the Risk-GeoDB dataset equips decision-makers with comprehensive insights into changing hydrological patterns. This facilitates more informed decisions regarding water resource allocation and conservation efforts, helping to ensure sustainable management of freshwater resources in the face of climate variability and extremes.

Project website and social media content

The project website serves as a platform for sharing project news, reports, tools, and findings with the public and research communities. It provides directions and instructions downloadable datasets, research publications, and updates on ongoing activities.

The website aims to enhance transparency, foster collaboration, and support CCRASEAL knowledge dissemination by allowing users to explore and utilize the project's outcomes for further research,

Enhanced Transparency and

Collaboration: The project website significantly enhances transparency and accessibility by providing a centralized platform for sharing critical project information, reports, and datasets, thereby fostering collaboration among researchers, policymakers, and educators. This facilitates informed decision-making and promotes the integration of research findings into policy and practice.

Empowerment for Research and Education: By supporting

	policy-making, and educational purposes.	knowledge dissemination and offering directions to easily downloadable resources, the website empowers users to leverage project outcomes for further research and educational initiatives, ultimately contributing to improved climate resilience and sustainable management practices in SEA.
Scientific publications: 1 journal published 1 original dataset published 2 journal articles submitted 2 journal articles in preparation 9 abstracts and extended abstracts at international conference and symposiums	CCRASEAL generated a substantial body of scientific literature, including a published journal article, additional journal submissions, manuscripts in preparation, and multiple conference abstracts, which contribute to the broader scientific knowledge base on Southeast Asian lake ecosystems and climate impacts.	Improving consistency and reliability of scientific evidence for climate risk assessment Enhancing global awareness and informing policy on climate risks to Southeast Asian lake ecosystems.
2 regional workshop completed	Two regional workshops were successfully completed, fostering knowledge exchange and collaboration among institutional and academic. These workshops provided a platform for sharing insights, discussing regional climate challenges, and exploring actionable strategies to mitigate the impacts of climate change on SEA's freshwater ecosystems.	Strengthened Regional Collaboration: the workshops enhanced collaboration between institutions and academia, creating a network of stakeholders focused on addressing climate challenges in freshwater ecosystems.
2 regional training courses completed	The first training course engaged participants from five partner countries and their respective project institutions, focusing on remote sensing techniques for evaluating water quantity and quality.	Enhanced Technical Skills: Participants acquired advanced skills in remote sensing and climate data processing, enabling them to more effectively analyze and monitor environmental changes.

The second course, conducted in Los PDR, offered training in climate change downscaling and the automated processing of climatic data using Python coding.

Together, these courses equipped participants with essential skills and knowledge that enriched their professional backgrounds and have the potential to significantly impact their future work in climate data analysis and environmental monitoring.

Improved Capacity for Climate

Adaptation: The training empowers participants to implement better data-driven strategies for managing water resources and adapting to climate change, thereby positively influencing future environmental policies and practices in their respective regions.

4. Key facts/figures

- More than 600 lakes were studied across six countries in mainland Southeast Asia, covering a thirty-year time span with future projections of approximately sixty years as part of the CCRASEAL Project activities.
- One journal article in a high-quality journal has been published, two are submitted and under review, two are in preparation at the time of this report's publication, and nine abstracts have been presented at international conferences, symposiums, and workshops.
- One original dataset has been published in a publicly accessible data repository and further currently under review, at the time of this report's publication, for release in a publicly accessible data repository.
- One early career researcher, has been trained in his position of researcher and CCRASEAL Project Manager
- One PhD student and four Master students, conducted her research within the framework of the CCRASEAL Project, and one paper based on PhD is currently under review at the time of this report's submission.
- Two regional thematic workshops were organized on the integration of Earth observation, geospatial, and conventional technologies for water monitoring and risk assessment in Southeast Asia. The second workshop also served to disseminate project results to project partners, as well as to national public and private agencies and academic institutions.
- Sixty-six onsite participants (44 and 22, respectively) and over forty online attendees actively participated in the two thematic workshops, representing several academic institutions, six government agencies, one private sector company, and three research institutes from the project partner countries.
- Two capacity-building training events were organized for the project's partner officials and conducted in both hybrid and in-person formats.

- Thirty-six officials from government agencies and universities in partner countries were trained in climate science, remote sensing of water, Python programming, and geospatial modeling through both onsite and online sessions.
- One Project – Government Agencies knowledge exchange event was organized with Municipal Water Authority of Thailand and the Pollution Control Department of the Ministry of Natural Resources and Environment of Thailand during the first thematic workshop.
- One project results dissemination event was organized as a thematic parallel session on the CCRASEAL project within Vietnam International Water Week (VACI2022).
- A project website has been developed.

5. Publications

- Virdis, S. G. P., Kongwarakom, S., Juneng, L., Padedda, B. M., & Shrestha, S. (2024). Historical and projected response of Southeast Asian lakes surface water temperature to warming climate. *Environmental Research*, 247, 118412. <https://doi.org/10.1016/j.envres.2024.118412>
- Virdis, S. and S. Kongwarakom. 2023. Historical and future Lake Surface Water Temperature for 80 major lakes in Southeast Asia [LSWT-SEA] ver 1. Environmental Data Initiative. <https://doi.org/10.6073/pasta/28b913071646a8954b82e0b2eccc27e0>
- Virdis, S. G. P., Kongwarakom, S., Shrestha, S., Neng, L. J., Padedda, B. M., Phoesri, T., and Moe, A. C.: Are Southeast Asian lakes impacted by changes in climate and land-use? A historical and future scenario analysis., EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-17455. <https://doi.org/10.5194/egusphere-egu23-17455>
- Phoesri, T., Shrestha, S., Padedda, B.M., Tripathi, N.K., Das, P.K., Kongwarakom, S., Virdis, S.G.P., Long-Term Spatial and Temporal Patterns in Water Extent of Southeast Asian Lakes. Submitted and under review to *Environmental Research*.

6. Media reports, videos and other digital content

- CCRASEAL Project website. <https://ccraseal.com/>
- CCRASEAL Project successfully hosted a parallel session titled “Climate Change Impacts on SEA Lakes Ecosystems” at the Vietnam International Water Week VACI2022. 21st Online event, September 2022. <https://ccraseal.com/special-ccraseal-session-at-vaci-2022/>
- Side Event organized with UNESCAP and the Government of Indonesia at the 10th Asia-Pacific Forum on Sustainable Development (APFSD). Bangkok, Thailand, 30th March 2023. <https://ait.ac.th/2023/04/ait-co-organizes-side-event-with-unescap-and-the-government-of-indonesia-at-the-10th-asia-pacific-forum-on-sustainable-development-apfsd/>
- “Remote Sensing of Water” training event https://www.ait.ac.th/2021/12/training-by-rsgis-and-partner-builds-capacity-for-remote-sensing-of-water-quality-for-the-region/?utm_source=rss&utm_medium=rss&utm_campaign=training-by-rsgis-and-partner-builds-capacity-for-remote-sensing-of-water-quality-for-the-region

Asian Institute of Technology Facebook post examples:

- Dissemination of project results <https://www.facebook.com/share/p/dTobzKE6Kh6HME3V/>

- 1st Thematic workshop <https://www.facebook.com/share/p/zGohLEBFrvBbxuhx/>
- Participation at EGU 2023 <https://meetingorganizer.copernicus.org/EGU23/EGU23-17455.html>
- 1st training workshop <https://www.facebook.com/share/p/S3ddrV31xNcJvWpg/>

7. Pull quotes

"The CCRASEAL Project demonstrated that coupled land use, land cover, and climate change have negatively impacted Southeast Asian lakes over the past 30 years. Even under optimistic projections, this negative trend is expected to persist, as future scenarios—both optimistic and pessimistic—continue to confirm these patterns."

Dr. Salvatore G.P. Viridis, AIT, Thailand

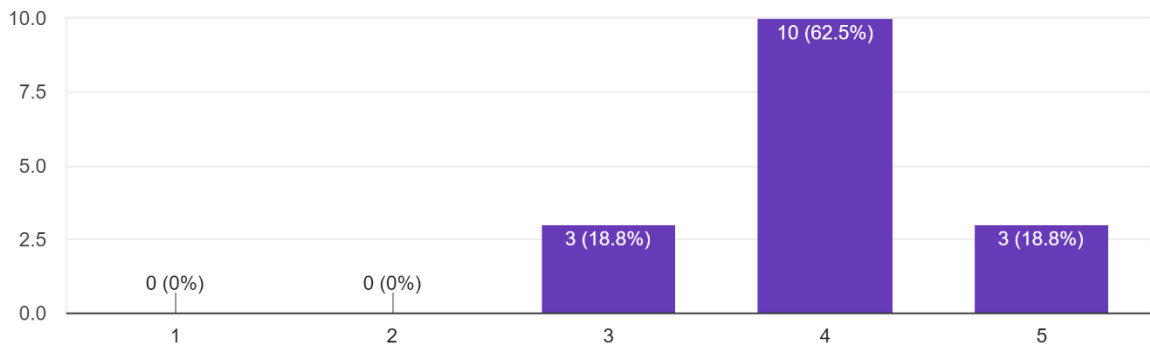
"It has been a true privilege to serve as both project manager and researcher on the CCRASEAL project. As an early-career researcher, this experience has been profoundly transformative. I have actively engaged in every stage of research, from developing research questions to presenting findings and moving toward publication, all with the invaluable support of experts from diverse fields. On the managerial side, the collaborative experience taught me how to work effectively with individuals from various backgrounds, allowing us to address regional-scale challenges and pursue the shared goal of resolving them. These experiences have paved the way for my PhD journey, where I am now conducting research under leading experts to investigate the complex issues facing socio-ecological systems, which pose serious risks to both nature and human well-being if left unaddressed. Toward the end of my work, I had the opportunity to share my insights with students, researchers, and practitioners, and I hope to inspire future generations of problem-solvers to adopt a collaborative approach that strengthens the science-policy-practice interface and fosters adaptive governance for long-term resilience and sustainability."

Siwat Kongwarakom, The University of Western Australia (UWA), Australia

Two training workshops were conducted as the primary tools for project dissemination and impact assessment, with feedback collected from participants through surveys. Each survey addressed various aspects, including participants' ratings of the venue, the workshop content, and the relevance of the training to their professional roles. Below is an excerpt from the Workshop 2 survey results. Out of ten satisfaction questions, two focused on overall satisfaction, with responses gathered from 17 government officials.

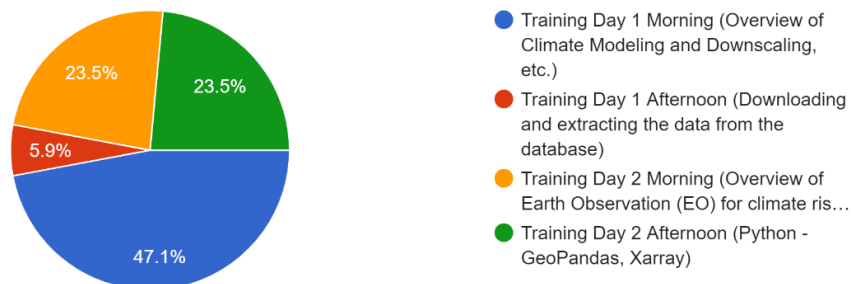
To what extent did this workshop meet your expectations? Please rate on a scale of 1 to 5. (1 being far below expectations, and 5 being exceeded expect...this question if you did not attend the workshop)

16 responses



Which training session will benefit your work the most? (You can skip this question if you did not attend the training)

17 responses



8. Acknowledgments

Dr Salvatore G.P. Virdis (CCRASEAL PI) and Prof Sangam Shrestha (Co-PI) would like to express their sincere gratitude to the Asia-Pacific Network for Global Change Research (APN) for funding this project.

Our heartfelt thanks go to Mr. Siwat Kongwarakom, Project Manager and Researcher, for his exemplary administration and for leading key scientific activities within the CCRASEAL initiative. We extend our appreciation to Dr. Liew Juneng (Universiti Kebangsaan Malaysia), Dr. Bachisio M. Padedda (University of Sassari, Italy), and Duong Du Bui (Ministry of Natural Resources and Environment, Vietnam) for their invaluable scientific support throughout the project.

We wish to recognize Raywadee Roachanakanan for her instrumental role in organizing the first CCRASEAL workshop and for facilitating connections between the project and national and

regional stakeholders. Our gratitude also goes to The Metropolitan Waterworks Authority (MWA) and the Pollution Control Department of the Ministry of Natural Resources and Environment of Thailand for graciously hosting the knowledge exchange event during the first CCRASEAL thematic workshop. Additionally, we thank Oulavanh Sinsamphanh (National University of Laos), along with Sengphasouk Xayavong and Vilakone Maniphousay (Ministry of Natural Resources and Environment, Lao PDR), for their significant scientific contributions and leadership to organizing the second CCRASEAL workshop in Luang Prabang, Laos.

We express our appreciation to all the students and administrative staff at the CCRASEAL partner institutions who assisted in organizing the two thematic workshops and the training sessions in Thailand and Laos.

Finally, we would like to extend special thanks to the researchers, government officials, and representatives from nongovernmental organizations who participated in this project, both directly and indirectly, by sharing their valuable time, expertise, datasets, and insights during the workshops and training conducted throughout the project.

9. Appendices

Appendix 1 Journal abstract (published and submitted)

1. **Viridis, S. G. P.***, Kongwarakom, S., Juneng, L., Padedda, B. M., & Shrestha, S. (2024). Historical and projected response of Southeast Asian lakes surface water temperature to warming climate. *Environmental Research*, 247, 118412.
<https://doi.org/10.1016/j.envres.2024.118412>

Abstract

The temperature of surface and epilimnetic waters, closely related to regional air temperatures, responds quickly and directly to climatic changes. As a result, lake surface temperature (LSWT) can be considered an effective indicator of climate change. In this study, we reconstructed and investigated historical and future LSWT across different scenarios for over 80 major lakes in mainland Southeast Asia (SEA), an ecologically diverse region vulnerable to climate impacts. Five different predicting models, incorporating statistical, machine and deep learning approaches, were trained and validated using ERA5 and CHIRPS climatic feature datasets as predictors and 8-day MODIS-derived LSWT from 2000 to 2020 as reference dataset. Best performing model was then applied to predict both historical (1986–2020) and future (2020–2100) LSWT for SEA lakes, utilizing downscaled climatic CORDEX-SEA feature data and multiple Representative Concentration Pathway (RCP). The analysis uncovered historical and future thermal dynamics and long-term trends for both daytime and nighttime LSWT. Among 5 models, XGboost results the most performant (NSE 0.85, RMSE 1.14 °C, MAE 0.69 °C, MBE -0.08 °C) and it has been used for historical reconstruction and future LSWT prediction. The historical analysis revealed a warming trend in SEA lakes, with daytime LSWT increasing at a rate of +0.18 °C/decade and nighttime LSWT at +0.13 °C/decade over the past three decades. These trends appeared of smaller magnitude compared to global estimates of LSWT change rates and less pronounced than concurrent air temperature and LSWT increases in neighbouring regions. Projections under various RCP scenarios indicated continued LSWT warming. Daytime LSWT is projected to increase at varying rates per decade: +0.03 °C under RCP2.6, +0.14 °C under RCP4.5, and +0.29 °C under RCP8.5. Similarly, nighttime LSWT projections under these scenarios are: +0.03 °C, +0.10 °C, and +0.16 °C per decade, respectively. The most optimistic scenario predicted marginal increases of +0.38 °C on average, while the most pessimistic scenario indicated an average LSWT increase of +2.29 °C by end of the century. This study highlights the relevance of LSWT as a climate change indicator in major SEA's freshwater ecosystems. The integration of satellite-derived LSWT, historical and projected climate data into data-driven modelling has enabled new and a more nuanced understanding of LSWT dynamics in relation to climate throughout the entire SEA region.

Keywords: Machine and deep learning, MODIS, LSWT, Climate change impact, Essential climate variable.

2. Phoesri, T., Shrestha, S., Padedda, B.M., Tripathi, N.K., Das, P.K., Kongwarakom, S., **Virdis, S.G.P.***. Long-Term Spatial and Temporal Patterns in Water Extent of Southeast Asian Lakes. Submitted.

Abstract

Lakes are closely linked to climatic conditions, responding rapidly to environmental changes and serving as effective indicators of climate change impacts. This study mapped and analyzed changes in lake surface water extent (LWE) across 651 lakes in mainland Southeast Asia, a region vital for its ecosystems and highly susceptible to climate change. Utilizing a 36-year monthly time series (1984–2019) of LWE derived from Landsat-based Global Surface Water (GSW) products, we employed a semi-automated approach to detect, delineate, and map these changes, resulting in three datasets: a discontinuous monthly LWE dataset (SEA-LWEun), a gap-filled continuous monthly LWE dataset (SEA-LWEgf), and a gap-filled and smoothed continuous monthly LWE dataset (SEA-LWEsm). The continuous datasets (SEA-LWEgf and SEA-LWEsm) enabled detailed analyses of LWE on both monthly and annual scales, including seasonal variations (JFM, AMJ, JAS, OND). We assessed the SEA-LWE dataset's accuracy by comparing long-term average LWE with similar global datasets using RMSE, MAE, Bias, and NSE indicators, noting discrepancies likely due to differences in dataset design. By addressing the discontinuities in earlier datasets, this study enhances the accuracy of regional LWE change assessments, revealing a net positive change in LWE across Southeast Asia. Specifically, 192 lakes showed a significant average increase of 0.004 km²/year (total gain of 24.9 km²), while 127 lakes experienced an average decrease of -0.002 km²/year (total loss of 10.8 km²). The Mekong, Chao Phraya, and Irrawaddy basins were the most affected, influenced by anthropogenic interventions and changing precipitation patterns. The SEA-LWE dataset offers a GIS-ready vector format for LWE trend analysis, addressing critical gaps in long-term hydrological data and enhancing our understanding of climate variability's effects on LWE over the past 30 years.

Keywords: LWE delineation; Long-term trends, Time Series Analysis, Remote Sensing.

Appendix 2: Conference presentations list

Topic	Authors	Conference/Symposium/Seminar Name	Year
Long-Term Spatiotemporal Analysis of Lake Surface Water Area Changes in Southeast Asia	Phoesri, T., Virdis, S.G.P., Tripathi, N.K., Shrestha, S., Padedda, B.M., Kongwarakom, S., Das, P.K.	OHOW: The 1st International Symposium on One Health, One World presentation December 2022	2022
Long-Term Spatiotemporal Analysis of Lake Surface Water area changes in Southeast Asia	Phoesri, T., Virdis, S.G.P., Tripathi, N.K., Shrestha, S., Padedda, B.M., Kongwarakom, S., Das, P.K.	Vietnam International Water Conference, special Session on CCRASEAL Project, 12-21 September 2023, online and on-site, Hanoi, Vietnam	2022
Assessment of surface runoff historical changes in main South East Asia river basins	Sukarasuta, N., Kongwarakom, S., Tun Ye Lin, Shrestha, S., Virdis, S.G.P.	Vietnam International Water Conference, special Session on CCRASEAL Project, 12-21 September 2023, online and on-site, Hanoi, Vietnam	2022
Modeling Lake Surface Water Temperature (LSWT) in Southeast Asia	Virdis, S.G.P., Kongwarakom, S., Juneng, L., Padedda, B.M., Shrestha, S.,	Vietnam International Water Conference, special Session on CCRASEAL Project, 12-21 September 2023, online and on-site, Hanoi, Vietnam	2022
Analysis of Lake Surface Water Temperature Spatial Trend in Tonlé Sap using MODIS	Kongwarakom, S., Juneng, L., Padedda, B.M., Shrestha, S., Virdis, S.G.P.	Vietnam International Water Conference, special Session on CCRASEAL Project, 12-21 September 2023, online and on-site, Hanoi, Vietnam	2022
Assessment of land use and land cover changes in main Southeast Asia river basins	Aung Chit Moe, Kongwarakom, S., Shrestha, S., Virdis, S.G.P.	Vietnam International Water Conference, special Session on CCRASEAL Project, 12-21 September 2023, online and on-site, Hanoi, Vietnam	2022
Critical role of RS and Geo-spatial sciences in achieving the SDGs: experiences from the Asian Institute of Technology (AIT), Thailand	Virdis, S.G.P.	Networking Event: Multi-Stakeholder Roles for Strengthening Space Applications and Sustainable Development, UNESCAP, Bangkok, 29 March 2023	2023
Are Southeast Asian lakes impacted by changes in climate and land-use? A historical and future scenario analysis	Virdis, S.G.P., Kongwarakom, S., Shrestha, S., Juneng, L., Padedda, B.M., Phoesri, T., Aung Chit Moe	EGU General Assembly 2023, Vienna, Austria, 23-28 April 2023	2023
Long-Term Spatiotemporal Analysis of Lake Surface Water Area for Southeast Asia based on Global Surface Water Dataset	Phoesri, T., Virdis, S.G.P., Tripathi, N.K., Shrestha, S., Padedda, B.M., Kongwarakom, S., Das, P.K.	Society for Freshwater Science Annual Meeting 2024, NexGen Mekong Scientists Program, June 2–6 Philadelphia, PA, USA 2024	2024

Appendix 3 Abstracts and extended abstracts at conferences and symposiums

3. **Virdis, S. G. P.***, Kongwarakom, S., Juneng, L., Padedda, B. M., & Shrestha, S. (2024). Historical and projected response of Southeast Asian lakes surface water temperature to warming climate. *Environmental Research*, 247, 118412.
<https://doi.org/10.1016/j.envres.2024.118412>

Abstract

The temperature of surface and epilimnetic waters, closely related to regional air temperatures, responds quickly and directly to climatic changes. As a result, lake surface temperature (LSWT) can be considered an effective indicator of climate change. In this study, we reconstructed and investigated historical and future LSWT across different scenarios for over 80 major lakes in mainland Southeast Asia (SEA), an ecologically diverse region vulnerable to climate impacts. Five different predicting models, incorporating statistical, machine and deep learning approaches, were trained and validated using ERA5 and CHIRPS climatic feature datasets as predictors and 8-day MODIS-derived LSWT from 2000 to 2020 as reference dataset. Best performing model was then applied to predict both historical (1986–2020) and future (2020–2100) LSWT for SEA lakes, utilizing downscaled climatic CORDEX-SEA feature data and multiple Representative Concentration Pathway (RCP). The analysis uncovered historical and future thermal dynamics and long-term trends for both daytime and nighttime LSWT. Among 5 models, XGboost results the most performant (NSE 0.85, RMSE 1.14 °C, MAE 0.69 °C, MBE -0.08 °C) and it has been used for historical reconstruction and future LSWT prediction. The historical analysis revealed a warming trend in SEA lakes, with daytime LSWT increasing at a rate of +0.18 °C/decade and nighttime LSWT at +0.13 °C/decade over the past three decades. These trends appeared of smaller magnitude compared to global estimates of LSWT change rates and less pronounced than concurrent air temperature and LSWT increases in neighbouring regions. Projections under various RCP scenarios indicated continued LSWT warming. Daytime LSWT is projected to increase at varying rates per decade: +0.03 °C under RCP2.6, +0.14 °C under RCP4.5, and +0.29 °C under RCP8.5. Similarly, nighttime LSWT projections under these scenarios are: +0.03 °C, +0.10 °C, and +0.16 °C per decade, respectively. The most optimistic scenario predicted marginal increases of +0.38 °C on average, while the most pessimistic scenario indicated an average LSWT increase of +2.29 °C by end of the century. This study highlights the relevance of LSWT as a climate change indicator in major SEA's freshwater ecosystems. The integration of satellite-derived LSWT, historical and projected climate data into data-driven modelling has enabled new and a more nuanced understanding of LSWT dynamics in relation to climate throughout the entire SEA region.

Keywords: Machine and deep learning, MODIS, LSWT, Climate change impact, Essential climate variable.

4. **Phoesri, T.;** Virdis, S.G. Long-term spatiotemporal analysis of lake surface water area changes in Southeast Asia, in Proceedings of the OHOW 2022 – The 1st International Symposium on One Health, One World, Amari Pattaya Hotel, 8–10 December 2022, MDPI: Basel, Switzerland, doi:10.3390/ohow2022-13594

Abstract

Southeast Asia (SEA) contains the largest number of lakes that are crucial for providing essential ecosystem services for human society, such as water supply, agriculture, tourism, and recreation. SEA region has a strong climate with frequent and severe natural disasters. Both direct and indirect factors, such as anthropogenic activities and climate variability and change, have had an impact on lake surface water. Mapping surface water over time provides the explicit data essential for understanding the relative impacts of climate variability and changes and human activities. This research aims to monitor a change in surface water areas of lakes in SEA by delineating and analyzing high spatial resolution of satellite images in time series. The primary tools used in the methodology for tracking and delineating the surface water areas over the timescale are Geographic Information Systems (GIS) and remote sensing technology. The map generalization methods were applied to ensure the consistency of the data. The results demonstrate high-resolution data with an estimation of the surface water area for each lake. The map reveals the surface water dynamic changes over the region, which is essential for understanding the relative impacts on the surface water of lakes in SEA.

Keywords: Surface water, freshwater lakes, monitoring, remote sensing, temporal pattern.

5. **Phoesri, T.,** Virdis, S.G.P., Tripathi, N.K., Shrestha, S., Padedda, B.M., Kongwarakom, S., Das, P.K.. Long-Term Spatiotemporal Analysis of Lake Surface Water area changes in Southeast Asia

Abstract

Southeast Asia (SEA) hosts a large number of lakes that are crucial for providing essential ecosystem services such as water supply, agriculture, tourism, and recreation. Both direct and indirect factors, such as anthropogenic activities and climate variability and change, have had severe impacts on lakes' surface water and their extent. This research aims to monitor change in lake surface water areas across the whole SEA by delineating and analysing multi-resolution long-term satellite imagery. A methodology has been set up to track and delineate surface water areas over more than 20 years using Landsat-derived datasets. Map generalization methods were applied to ensure spatial and temporal consistency of data. Preliminary results reveal spatial and temporal patterns of surface water extent dynamics, essential for understanding the relative impacts of changing climate and land uses.

Keywords: Monitoring, freshwater lake, surface water, remote sensing, temporal pattern.

6. **Sukarasuta, N.**, Kongwarakom, S., Tun Ye Lin, Shrestha, S., Virdis, S.G.P.. Long-Term Spatiotemporal Analysis of Lake Surface Water area changes in Southeast Asia.

Abstract

Predicting and estimating surface runoff in Mainland Southeast Asia (MSEA) is essential for the assessment of water receiving potential of a watershed and for an appropriate planning of soil and water conservation measures. Due to MSEA rapid development, industrial, urban and population growth cause land degradation across the whole region. Even if several research have highlighted the need for long-term catchment studies to guide future proper runoff measures and management policies, runoff knowledge in the tropical region of Southeast Asia is still insufficient. In particular comprehensive studies having a regional focus at the multi-basins scale have not been addressed before in MSEA. This work aims at setting up an empirical model for the surface runoff estimation at the multi basins scale in the Mainland Southeast Asia. We present preliminary results of annual and monthly estimations of surface runoff distribution using the SCS-CN model approach from 2000 to 2020

Keywords: rainfall, runoff, Mainland Southeast Asia, remote sensing, SCS-CN method, curve number.

7. **Virdis, S.G.P.**, Kongwarakom, S., Juneng, L., Padedda, B.M., Shrestha, S.. Modeling Lake Surface Water Temperature (LSWT) in Southeast Asia

Abstract

The impact of climate variability/change in Southeast Asian lakes is expected to exacerbate as business-as-usual anthropogenic emissions continue. This posed multiple threats to hundreds of millions of people relying on their ecosystem services. Therefore, it is important to quantify the severity of such impact on these lakes in order to develop a suitable mitigation and adaptation strategy. Lake surface water temperature (LSWT) among many is an important parameter for the physical and biochemical processes occurring within water as well as in air-water interactions because temperature regulates physical, chemical, and biological processes in water. Therefore LSWT is an important indicator to be measured in impact studies, however, this information is often lacking in Southeast Asia region. This study presents preliminary results of LSWT predictive modelling exercise built from ERA5 reanalysis climate data and LSWT from MODIS products using various machine learning and deep learning algorithms. Predictive models have been applied on historical and projected climate data from different GCM-RCMs to predict LSWT time series for the past and future scenarios. Lake-wise trends have been detected and measured. Additionally, evaluation on model performances and accuracy of calculated trends are also provided.

Keywords: Lake surface water temperature, modeling, machine learning, risk map, climate change.

8. **Kongwarakom, S., Juneng, L., Padedda, B.M., Shrestha, S., Viridis, S.G.P..** Analysis of Lake Surface Water Temperature Spatial Trend in Tonlé Sap using MODIS

Abstract

Tonlé Sap lake is the largest and the most productive freshwater lake in Southeast Asia, providing food for millions of people residing in and around the lake. Thus, monitoring the lake is a crucial task, as the impact of climate change in the future could disrupt its ecosystem services. Lake surface water temperature (LSWT) is considered as an essential climate variable and an important indicator for lake management. In contrast, the number of available monitoring stations, especially for LSWT, is limited and poorly distributed in proportion to the size and shape of the lake. For this reason, analysis solely based on the observations from the stations is not sufficient to capture spatial and temporal trends exhibited locally. In recent decades, remote sensing data has become a cost-effective input for researchers and decision makers to detect changes due to its spatiotemporal coverage and accessibility. By leveraging the satellite observation data, this study provides a spatial and temporal trend analysis of LSWT and land surface temperature (LST) in Tonlé Sap floodplain and surrounding area using MODIS product. In addition, other climate variables such as air temperature and wind were also examined to quantify their influences on LSWT.

Keywords: Tonlé Sap lake, water temperature, spatial trend, remote sensing, management

9. **Aung Chit Moe, Kongwarakom, S., Shrestha, S., Viridis, S.G.P..** Assessment of land use and land cover changes in main Southeast Asia river basins

Abstract

Lakes in Southeast Asia provide wide range of ecosystem services and are a vital natural resource for a variety of uses, including water supply, manufacturing, farming, transportation, aquaculture, and recreational activities. It has been shown that they are extremely susceptible to the risk posed by environmental and climate change. The Southeast Asian region has already been severely affected by the impact of climate change, and those effects will only increase and worsen as the rate of climate change accelerates. Studies conducted within the Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL) project, are attempting to measure current and future climatic patterns, evaluate spatial and temporal lake changes and link that to threats, estimate climate change risk in lakes and other areas in the future, and improve multi-threat approach in climate change impact assessment on mainland Southeast Asian lakes into decision making processes. With relation to these perspectives, land use and land cover change detection analysis becomes crucial in establishing a quantitative and analytical framework for the anthropogenic impact assessment coupled with current and projected climate on mainland Southeast Asian lakes. In this study we present preliminary analysis on major LULC changes occurred in main lake river basin across whole Southeast Asia. The assessment is conducted by using and comparing different LULC time series dataset.

Keywords: climate change effects, Southeast Asia, lake basins, remote sensing, land use land cover, change detection, zonal statistics, global datasets

10. **Virdis, S. G. P.**, Kongwarakom, S., Shrestha, S., Neng, L. J., Padedda, B. M., Phoesri, T., and Moe, A. C.: Are Southeast Asian lakes impacted by changes in climate and land-use? A historical and future scenario analysis., EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-17455, <https://doi.org/10.5194/egusphere-egu23-17455>, 2023.

Abstract

Southeast Asian lakes provide several ecosystem services and are an important natural resource for water supplies, industry, agriculture, shipping, fishing, and recreation. It has been demonstrated that they are highly vulnerable to anthropogenic and climate threats. Recent scientific findings clearly demonstrated that climate change has already significantly affected the SEA region and that these impacts will continue and expand as the pace of climate change accelerates. However, a deep understanding of "if" and "how" climate change as well as intensification of land uses may exacerbate those impacts on such vulnerable ecosystems across the whole region is lacking. To contribute towards filling some of the existing knowledge gaps, in a renowned data scarce region, we present the results of a 3-year-long interdisciplinary research project entitled Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL), led by the Asian Institute of Technology and funded by the Asia Pacific Network for Global Research (APN). We present new insights on: i) historical, remote sensing derived, yearly land use changes from 1992 to 2021 estimated at basin scale across whole mainland SEA; ii) historical and future changes in climate respectively for the periods 1970-2006 and 2007-2100 using different downscaled CORDEX-SEA climate data at lake level; iii) detected and assessed climate and land use long-term trends and their coupled impacts on both monthly runoff at multi-basin scale level and lake surface areas of more than 700 water bodies. Finally, we detected and assessed the satellite-derived Lake Surface Water Temperature (LSWT) trends, an essential climate variable (ECV), within defined historical and future scenarios and across whole mainland SEA. To achieve our results, we used and integrated multi-source and multi-resolution datasets made of satellite derived water and land products along with available climatic CORDEX-SEA climate datasets. Furthermore, we used a combination of conventional remote sensing, GIS, machine- and deep learning based processing approaches. In our studies we analysis possible spatial and temporal linkages between observed alterations to multiple-threats, to understand "if", "when", "how" and "where" climate and land use changes had affected and will affect SEA lakes.

Results have been validated using, when available, ground-based observation collected at national and regional scales.

11. **Phoesri, T.**, Viridis, S.G.P., Tripathi, N.K., Shrestha, S., Padedda, B.M., Kongwarakom, S., Das, P.K.. Long-Term Spatiotemporal Analysis of Lake Surface Water Area for Southeast Asia based on Global Surface Water Dataset. Society for Freshwater Science Annual Meeting 2024, NexGen Mekong Scientists Program, June 2–6 Philadelphia, PA, USA 2024

Abstract

Southeast Asia (SEA) contains the largest number of lakes that are crucial for providing essential ecosystem services for human society, such as water supply, agriculture, tourism, and recreation. SEA region has a strong climate with frequent and severe natural disasters. Both direct and indirect factors, such as anthropogenic activities and climate variability and change, have had an impact on lake surface water. Mapping surface water over time provides the explicit data essential for understanding the relative impacts of climate variability and changes and human activities. This research aims to monitor a change in surface water areas of lakes in SEA by delineating and analyzing high spatial resolution of satellite images in time series. The primary tools used in the methodology for tracking and delineating the surface water areas over the timescale are Geographic Information Systems (GIS) and remote sensing technology. The map generalization methods were applied to ensure the consistency of the data. The results demonstrate high-resolution data with an estimation of the surface water area (SWA) for each lake. The map reveals the surface water dynamic changes over the region, which is essential for understanding the relative impacts on the surface water of lakes in SEA. For the result, we generated the Southeast Asia (SEA) monthly lake water area (LWA) dataset including three sub-LWE datasets over a 36-year from January 1984 to December 2019. These three sub-datasets included: 1) the SEA-LWEoriginal are stored in tabular format, comprising 655 lakes in SEA whose extents were calculated automatically delineated and filtered to avoid spurious and anomalous LWE values, 2) the SEA-LWEgap-filled is also in tabular format, which includes 655 lakes with polished extent values, removed outliers and temporal gaps filled, and 3) SEA-LWEsmoothed in tabular format as well, containing gap-filled and smoothed lake water extent values for 655 lakes and 432 epochs.

Appendix 4: Program of the 1st CCRASEAL thematic workshop: Towards the Integration of Earth Observation, Geospatial and Conventional Technologies for Water Quality and Quantity Monitoring and Assessment in Southeast Asia

CCRASEAL is a Project led by



Funded by



Project Collaborators



National Center for Water Resources Planning and Investigation (NAWAPI)



National University of Laos, Lao PDR



Ministry of Natural Resources and Environment, Thailand



Ministry of Natural Resources and Environment, Lao PDR



Universiti Kebangsaan Malaysia, Malaysia



Ministry of Environment, Cambodia



University of Sassari, Italy

Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL)

1st Thematic Workshop

Towards the Integration of Earth Observation, Geospatial and Conventional Technologies for Water Quality and Quantity Monitoring and Assessment in Southeast Asia

10th January 2023

On site event at:
Novotel Bangkok Future Park Rangsit,
Thanyaburi District, Pathum Thani 12130

and on line:
Zoom Meeting ID: 910 3855 6609
<https://ait-ac-th.zoom.us/j/91038556609>

Registration

Please scan the following QR code



or visit the CCRASEAL website
<https://ccraseal.com/>

Event organized by:

AIT Asian Institute of Technology
P.O. Box 4; 58 Moo 9, Km. 42,
Paholyothin Highway, Klong Luang
Pathum Thani, 12120, Thailand

Towards the Integration of Earth Observation, Geospatial and Conventional Technologies for Water Quality and Quantity Monitoring and Assessment in Southeast Asia

10th January 2023, Bangkok Thailand

On site event at:

Novotel Bangkok Future Park Rangsit, Thanyaburi District, Pathum Thani 12130

and on line via Zoom:

Zoom Meeting ID: 910 3855 6609

Password: No password

<https://ait-ac-th.zoom.us/j/91038556609>

CCRASEAL Project background

The *Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL)* is a research project funded by the Asia-Pacific Network for Global Change Research (APN) and lead by the Asian Institute of Technology AIT, Thailand.

Overall objective of the project is to set up a methodological and analytical framework that leverages on existing data, methods and knowledge to assesses the current and projected climate change impacts and related risk on the mainland SEA region freshwater lakes.

The Asian Institute of Technology AIT is implementing the project in collaboration with 6 partners from 5 different countries in Southeast Asia and Europe, namely:

- Ministry of Natural Resources and Environment, Thailand;
- National Center for Water Resources Planning and Investigation, Ministry of Natural Resources and Environment, Vietnam;
- Universiti Kebangsaan Malaysia (UKM), Malaysia;
- Ministry of Natural Resources and Environment, Lao PDR;
- National University of Laos, Laos PDR;
- Ministry of Environment, Cambodia;
- University of Sassari, Italy (associate partner).

CCRASEAL Project outputs have the potential to allow government agencies, industry, practitioners and decision makers to track changes across Southeast Asia basins with unprecedented, homogeneous and consolidated spatial and temporal detail. CCRASEAL has indeed produced valuable insights across many areas, including coupled climate and land use and land cover changes, water availability and quality.

Workshop scientific rationale

Monitoring and assessment of physical, chemical and biological characteristics of water are crucial to support decision-making on health and environmental issues. Monitoring water quality and quantity should therefore receive adequate attention particularly in developing and transitioning countries where existing water monitoring networks and expertise on water resources assessment and management are all lacking.

Over recent years, Earth Observation (EO) and geospatial technologies have consolidated their capability and confidence of assessing water variables through radiometric measurements of water's optical properties. Furthermore, they showed to be essential tools to assess the ecological state of inland and coastal waters and to identify changes or trends over a continuous and broad range of spatial and temporal scales. However, even though important parameters (i.e. surface areas and levels, suspended sediments, dissolved organic matter, phytoplankton pigments and biomass, submerged aquatic vegetation, temperature etc.) have been quantified with adequate accuracies, water -related information retrieved through EO and geo-technologies is still complementary to traditionally retrieved information.

Relevant advances have been recently made in algorithms improvements, processing applications, sensor technology and satellite-derived products development and accessibility. This has certainly increased the potential applications of earth observation methods to water resources management.

However, to date, government and management agencies have been slow to adopt satellite-derived measurements because of lack of processing skills, expertise as well as of standard information retrieval protocols.

For this reason, there is still need discussions among scientists, stakeholders, policy makers and environmental managers on the effectiveness of integration of advanced EO and traditional technologies into national and international near-coastal and inland water quality monitoring efforts.

The aims of the workshop are

- To assess current earth observation advances technologies, methods and data integration for coastal and inland water quality/quantity monitoring and evaluation at regional and local level with a specific focus on SEA case studies.
- To identify best practices for the SEA region, new, improved and integrated data streams, products and strengthen communications between water quality managers and the research community.

Target audience

The event will bring together a range of stakeholders including CCRASEAL collaborators from the five focus countries (Thailand, Cambodia, Lao PDR, Malaysia and Vietnam), government officials, civil society, NGOs, working professionals on water quality/quantity assessment and management in private sectors and academia.

Structure of the Workshop

The workshop is a 2 (full) days event to be conducted in presence in Bangkok (Thailand) and online (via Zoom platform).

Day 1

- Morning session will be dedicated to scientific presentations to be provided by CCRASEAL Project Partners and invited speakers who are directly working on integration of earth observation, geospatial and conventional technologies for water quality and quantity monitoring and assessment in southeast asia or in other relevant regions globally.
- Afternoon sessions will have a group and/or plenary discussion and/or round table form. Stakeholders will be invited in presence and online to participate to the discussion.

Day 2 (Only for Project partners and collaborators)

- Field trip to permanent monitoring stations at PCD and/or MWA (at rivers and/or lakes).

Registration

To register for the Day 1 of this event, please scan the following QR code or click the following link:

<https://forms.gle/jxh4ZFhTD6JNFNR69>



Please could you confirm your availability to join the workshop to Siwat Kongwarakom, siwatk@ait.asia, specifying whether you will be joining in person or online (Zoom link to follow).

This event is published on the CCRASEAL website: <https://ccraseal.com>. You are invited to visit it regularly for updates.

Day 1: 10th January 2023

8:00 – 8:30	Registration
Welcome and Opening addresses	
	Welcome addresses by Prof. Shobhakar Dhakal , Vice President for Academic Affairs (VPAA), Asian Institute of Technology (AIT)
8:30 – 8:45	Welcome addresses by Dr. Monthip Sriratana , Senior Adviser at National Research Council of Thailand (NRCT) and APN National Focal Point
	Opening address by Dr. Salvatore G.P. Virdis , CCRASEAL PI
Opening Session & Invited Talks	
08:45 – 9:10	<i>“CCRASEAL Project overview, workshop format, objectives and expected results”</i> (Dr. Salvatore G.P. Virdis, CCRASEAL PI)

09:10 – 09:30	Invited Talk 1: <i>"The power and promise of remotely sensed water quantity and quality - From lake area to lake trophic state"</i> Dr. Michael Frederick Meyer (USGS, USA)
09:30 – 09:50	Invited Talk 2: <i>"Studying Eutrophication processes: a conventional monitoring approach from the watershed to water-body"</i> Dr. Bachisio M. Padedda (UNISI, Italy)
09:50 – 10:00	Q&A Session

**10:00 –
10:20** **Coffee break & Photo session**

Technical Session 1: EO and conventional techniques to assess coastal, estuarine and inland waters

Chair: Prof. Sangam Shrestha (AIT, Thailand)

10:20 – 10:40	<i>"High Resolution Future Climate Scenarios for Southeast Asia"</i> Dr Liew Juneng (UKM, Malaysia)
10:40 – 11:00	<i>"Land use and land cover changes in Southeast Asia from 1992 to 2020"</i> Mr. Aung Chit Moe (AIT, Thailand)
11:00 – 11:20	<i>"Integrated Water Management and Climate Change Resilience: experiences and best practices in Lao"</i> Ms. Sengphasouk Xayavong, Mr. Vilakone Maniphousay & Ms Oulavanh Sinsamphanh (MONRE and NUoL, Laos PDR)
11:20 – 11:40	<i>"Long-Term Spatiotemporal Analysis of Lake Surface Water area changes in Southeast Asia"</i> Ms. Tatsaneewan Phoesri (AIT, Thailand)
11:40 – 12:00	Q&A Session

**12:00 –
13:00** **Lunch Break**

Technical Session 2: Integration of multi-source and multi-resolution EO systems for coastal, estuarine and inland waters: changes/trends/shifts detection

Chair: Dr. Sarawut Ninsawat

13:00 – 13:20	<i>"Integrating remote sensing derived water quality parameters into national monitoring networks: case studies in high productive inland and coastal waters"</i> Dr. Salvatore G.P. Viridis (AIT, Thailand)
13:20 – 13:40	Invited Talk 3: <i>"Current Situation and Water Quality Management in Thailand"</i> , Dr. Chaiyo Juisiri (PCD, Thailand)
13:40 – 14:00	<i>"Rainfall-runoff modelling using SCS-CN Method at the Multi-Basin scale in Mainland Southeast Asia"</i> Mr Siwat Kongwarakom (AIT, Thailand)
14:00 – 14:20	<i>"Development of multi-basin models, water data services and sciences hub for Vietnam and the Mekong region"</i> Dr Duong Du Bui (NAWAPI, Vietnam)
14:20 – 14:40	Q&A Session

14:40 – 15:10	Invited Talk 4: <i>“Improving regional groundwater storage by data assimilation techniques with satellite gravimetry data”</i> Dr. Natthachet Tangdamrongsub (AIT, Thailand)
15:10 – 15:20	Coffee break
Panel discussion: Integration of Earth Observation, Geospatial and Conventional technologies for Water Quality and Quantity Monitoring and Assessment: integration potential in South East Asian public and private institutions.	
	Moderators: Dr Salvatore G.P. Viridis and Prof. Sangam Shrestha
15:20 – 16:20	Prof. Nitin K. Tripathi (AIT, Thailand) (TBD) Dr. Sarawut Ninsawat (AIT, Thailand) (TBD) Dr. Thi Phuoc Lai Nguyen (AIT, Thailand) Dr Noppadon Khiripet (NSTDA/NECTEC, Thailand) Mr. Federico Puggioni (UDDI Thammasat University)
16:20 – 16:30	Closing Remarks by Prof. Dieter Trau , Dean of the School of Engineering and Technology (SET), Asian Institute of Technology (AIT)

Day 2: 11th January 2023 (Only for CCRASEAL Project Partners)

Project partners and collaborators will be visiting 2 permanent monitoring stations located at Chao Phraya river and other lake/reservoir belonging to the Metropolitan Water Authority (MWA) of Thailand and Pollution Control Department (PCD) of the Ministry of Natural Resource and Environment of Thailand.

PCD Sam Khok (Wat Chankapo) Station

- Located in Wat Chankapo, CCRASEAL project partners will meet experts from PCD.

MWA Sam Lae Station

- Located near Wat Sam Lae, CCRASEAL project partners will meet experts from MWA and join the meeting at Sam Lae Station.

Some glimpse of the workshop

Day 1: Workshop opening remarks, group photo, panel discussion





Day 2: visit at MWA and PCD





Appendix 5: Second Thematic CCRASEAL: “Southeast Asian Lakes in the Face of Climate Change: Results from CCRASEAL Project”

CCRASEAL is a Project led by



Funded by



Project Collaborators



National Center for Water Resources
Planning and Investigation (NAWAPI)



National University of Laos, Lao PDR



Ministry of Natural Resources and
Environment, Thailand



Ministry of Natural Resources and
Environment, Lao PDR



Universiti Kebangsaan Malaysia,
Malaysia



Ministry of Environment,
Cambodia



University of Sassari,
Italy

Climate Change
Risk Assessment
for
Southeast Asian Lakes
(CCRASEAL)

2nd Thematic Workshop

Southeast Asian Lakes in the
Face of Climate Change:
Results from CCRASEAL Project

23rd - 25th August 2023

On site event at:
Souphattra Hotel, Souphanouvong Rd, Ban Navienkham
Luang Prabang, Lao PDR

and on line:
Zoom Meeting ID: 955 2045 1657
Password: no password is needed
<https://ait-ac-th.zoom.us/j/95520451657>

Registration

Please scan the following QR code



or visit the CCRASEAL website
<https://ccraseal.com/>

Event Co-organized by:

Asian Institute of Technology
58 Moo 9, Km. 42,
Paholyothin Highway, Klong Luang
Pathum Thani, 12120, Thailand

and

Faculty of Environmental Sciences
National University of Laos
Dongdok Village, Xaythany District,
Vientiane, Lao PDR

Date and Venue: The Workshop-Training took place on 23rd - 25th August 2023 at the Souphattra Hotel, Souphanouvong Rd, Ban Navienkham, Luang Prabang, Lao PDR.

Organizers: Asian Institute of Technology (AIT) and Faculty of Environmental Sciences of National University of Laos (NUOL-FES) under the research project “Climate Change Risk Assessment for Southeast Asian Lakes (CCRASEAL)”, funded by the Asia-Pacific Network for Global Change Research (APN)

Event Coordinator: Assist. Prof. Oulavanh Sinsamphanh (NUOL-FES)

Opening Remarks By: Assoc. Prof. Dr. Chanda Vongsombath (Dean, NUOL-FES); Prof. Kazuo Yamamoto (President, AIT); by Dr. Linda Anne Stevenson (Head of Knowledge Management and Scientific Affairs and Deputy Head of Development and Institutional Affairs, APN)

Speakers: Dr. Salvatore G.P. Viridis (CCRASEAL PI); Mr. Pinthong Salermxay (Department of Water Resources Management, MONRE, Lao PDR); Dr. Outhai Soukkhy (Acting Principal of Northern Agriculture and Forestry College); Mr. Vilakone Maniphousay (Department of Climate Change, MONRE, Laos PDR); Dr. Liew Juneng (UKM, Malaysia); Ms. Tatsaneewan Phoesri (AIT, Thailand); Ms. Dung Do (NAWAPI, Vietnam); Mr. Siwat Kongwarakom (AIT, Thailand)

Training Team: Dr. Salvatore G.P. Viridis (CCRASEAL PI); Dr Liew Juneng (UKM, Malaysia); Mr. Siwat Kongwarakom (AIT, Thailand); Mr. Abdul Azim bin Amirudin (UKM, Malaysia);

Agenda: The workshop and training aimed to promote interdisciplinary collaboration and knowledge-sharing among concerned stakeholders. Ultimately, the goal was to develop strategies and approaches that can help Southeast Asia mitigate the negative impacts of climate change and land use change, and build resilience to these challenges. The event brought together a range of stakeholders including CCRASEAL collaborators from the five focus countries (Thailand, Cambodia, Lao PDR, Malaysia and Vietnam), government officials, civil society, NGOs, working professionals on water quality/quantity assessment and management in private sectors and academia.

Day 1 (Workshop): Opening and Introduction; Technical Session 1: Bridging the Gap: Integrating Climate Change and Water Resources Management in Southeast Asian Freshwater Systems; Technical Session 2: Bridging the Gap: Integrating Climate Change and Water Resources Management in Southeast Asian Freshwater Systems; Group discussion: Unlocking Solutions for Southeast Asian Freshwater Resources

Day 2 (Training): Climate Modeling and Downscaling; CORDEX-Southeast Asia; Climate Model Biases and Bias-correction; CORDEX Downscaling Simulations Database - SARCCIS and ESGF;

Day 3 (Training): Earth Observation (EO) for Climate Risk Assessment; Introduction to EO Data Archive; Python for Geospatial Data Analysis

Participants: The workshop on day 1 was attended by 22 people, while the training on days 2 and 3 had 26 attendees (list of in-person participants can be found in the supplementary document titled “List of Participants”). Participants came from various government and non-government agencies in Lao PDR, including the National University of Laos, Souphanouvong University, and the Ministry of Natural Resources and Environment. Additionally, collaborators from CCRASEAL in Thailand, Lao PDR, Malaysia, and Vietnam also participated.

The Workshop: On the first day, local participants listened to presentations provided by CCRASEAL project collaborators detailing research results and other activities conducted under the project's umbrella. In addition, they had the opportunity to present their own work related to the workshop's theme. The workshop emphasized topics as follows: i) Climate change and land use change impacts on freshwater resources; ii) Assessment methods and tools; iii) Policy and management implications. All participants also engaged in group discussions centered on the following three topics: i) Bringing academic knowledge into practice: list actionable/feasible ways to implement research findings into policy making at national / local level; ii) How to stimulate and enhance the interaction between all involved stakeholders from local and national sectoral agencies to academia?; iii) Water management challenges posed by climate change: what the threats and what the opportunities are? As concluded within the CCRASEAL project, the content of these discussions will be compiled into a short policy brief. This brief will integrate ideas provided by experts from both academic institutions and government and non-governmental organizations who participated in this session. The document will be a deliverable of the CCRASEAL project and will be published upon completion of the review process.

The Training: On the second day of the event, Dr. Liew Juneng, an Associate Professor and collaborator of the CCRASEAL project, along with Mr. Abdul Azim bin Amirudin, a Graduate Research Assistant from UKM, led the training. The focus was on providing participants with a fundamental understanding of climate modeling and downscaling, as well as its applications in climate change impact assessment. Participants were also introduced to the concept of model biases, bias correction, CORDEX-Southeast Asia simulations, and databases such as The Earth System Grid Federation (ESGF) through hands-on practices. On the third day of the event, Dr. Salvatore Viridis, CCRASEAL PI, and Mr. Siwat Kongwarakom, CCRASEAL Project Manager and Research Assistant, introduced participants to EO technology and its applications in climate change risk assessment. In the afternoon, the trainer delivered a lecture on Python for Geospatial Data Analysis. During this session, participants had the opportunity to utilize script-based processing tools to analyze a variety of large geospatial datasets at a regional scale.

Workshop-Training Assessment: The workshop-training was evaluated using a survey, with responses from 17 participants. This survey addressed various aspects, prompting participants to rate the venue, the content of the workshop-training, and its relevance to their professional roles. Additionally, we incorporated open-ended questions to solicit suggestions for future workshop topics and to collect general feedback. Overall, the workshop-training received positive feedback across all questions. To highlight a few points: the majority of participants felt that the workshop-training met their expectations (see Q9 in Appendix A) and expressed a

strong interest in attending similar events in the future (refer to Q10 in Appendix A). The general feedback echoed these sentiments. For example, participants mentioned that the duration for the training was limited, suggesting the addition of a basic Python course to complement the main training. Regarding potential topics for future workshops, we received a range of suggestions. These encompassed themes like climate change, climate and hydrological modelling, meteorology, as well as introductory Python courses and its application in modeling.\

Some glimpse of the workshop

Day 1: Workshop opening remarks and group photo





Day 2: training





Day 3: Training and certificate delivering





Appendix 6 List of young researchers

Name of Young Scientist	Institute	Country	Role in the project	Contact
Mr. Siwat Kongwarakom	AIT	Thailand	CCRASEAL Project Manage and Researcher	siwatkongwarakom@gmail.com
Ms. Naga Jyothsna Yalamanchili	AIT	Thailand	Research Assistant	yalamanchilinagajyothsna@gmail.com
Ms. Nazira Alimzhanova	AIT	Thailand	Research Assistant	nazalimzhanova@gmail.com
Ms. Thi Thu Tra Nguyen	MONR	Vietnam	Research Assistant	thutra1576@gmail.com
Mr. Abdul Azim bin Amirudin	UKM	Malaysia	Research Assistant	p115833@siswa.ukm.edu.my
Ms. Tatsaneewan Phoesri	AIT	Thailand	PhD Student	phoesri@gmail.com
Mr. Ye Lin Tun	AIT	Thailand	Master Student	yelinnhtun93@gmail.com
Mr. Aung Chit Moe	AIT	Thailand	Master Student	aungchitmoeiuss@gmail.com
Ms. Sukanya Phunsen	AIT	Thailand	Master Student	st121134@ait.asia
Mr. Kommanaboina Naga Venkata Sai Krishna	AIT	Thailand	Master Student	saikrishna.ongole@gmail.com
Mr. Bharath Kumar Singara	AIT	Thailand	Master Student	singarabharat@gmail.com
Mr. Nongrat Sukarasuta,	AIT	Thailand	Master Student	st121617@ait.asia