Utilizing Satellite Based Observations and Physical Hydrological Modeling for Freshwater Ecosystem Health in The Lower Mekong River Basin

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Abstract

This presentation will show an ongoing freshwater health assessment stemming from a partnership between the National Aeronautical and Space Agency (NASA) and Conservation International (CI) that is dedicated to improving natural resources assessment for conservation and sustainable management. The goal of this work is to develop a calibrated satellite- and hydrologic modeling-based tool to support the assessment of hydrologic environmental health and value natural capital in the Lower Mekong River Basin. Vollmer et al., (2018) have presented the social-ecological framework named the Freshwater Health Index (FHI), which takes account of the interplay between governance, stakeholders, freshwater ecosystems and the ecosystem services they provide. The FHI framework and its accompanying indicators are oriented toward management and stakeholder engagement, and they make a significant contribution by providing a systematic, evidence-based quantitative tool that supports the integration between social and ecological nature of fresh waters at the basin level. Since the FHI is intended to be used iteratively, we leverage multiple data products and hydrological modelling capabilities specifically created to improve decision support in the Lower Mekong basin (Mohammed et al., 2018). Mohammed et al. modelling capabilities enable the integration of satellite-based daily gridded precipitation, air temperature, digital elevation model, soil characteristics, and land cover and land use information to drive watershed model water simulations over the Lower Mekong River Basin. Multiple dam reservoirs scenarios have been envisioned and tested based on stakeholder engagement to enhance the results of the integrative social and ecological nature of fresh waters at the Srepok, Sesan, and Sekong (3S) River Basins of the Lower Mekong. This assessment provides a comprehensive picture of freshwater ecosystem health, the services it provides and the status of its governance at the Lower Mekong.

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INTRODUCTION

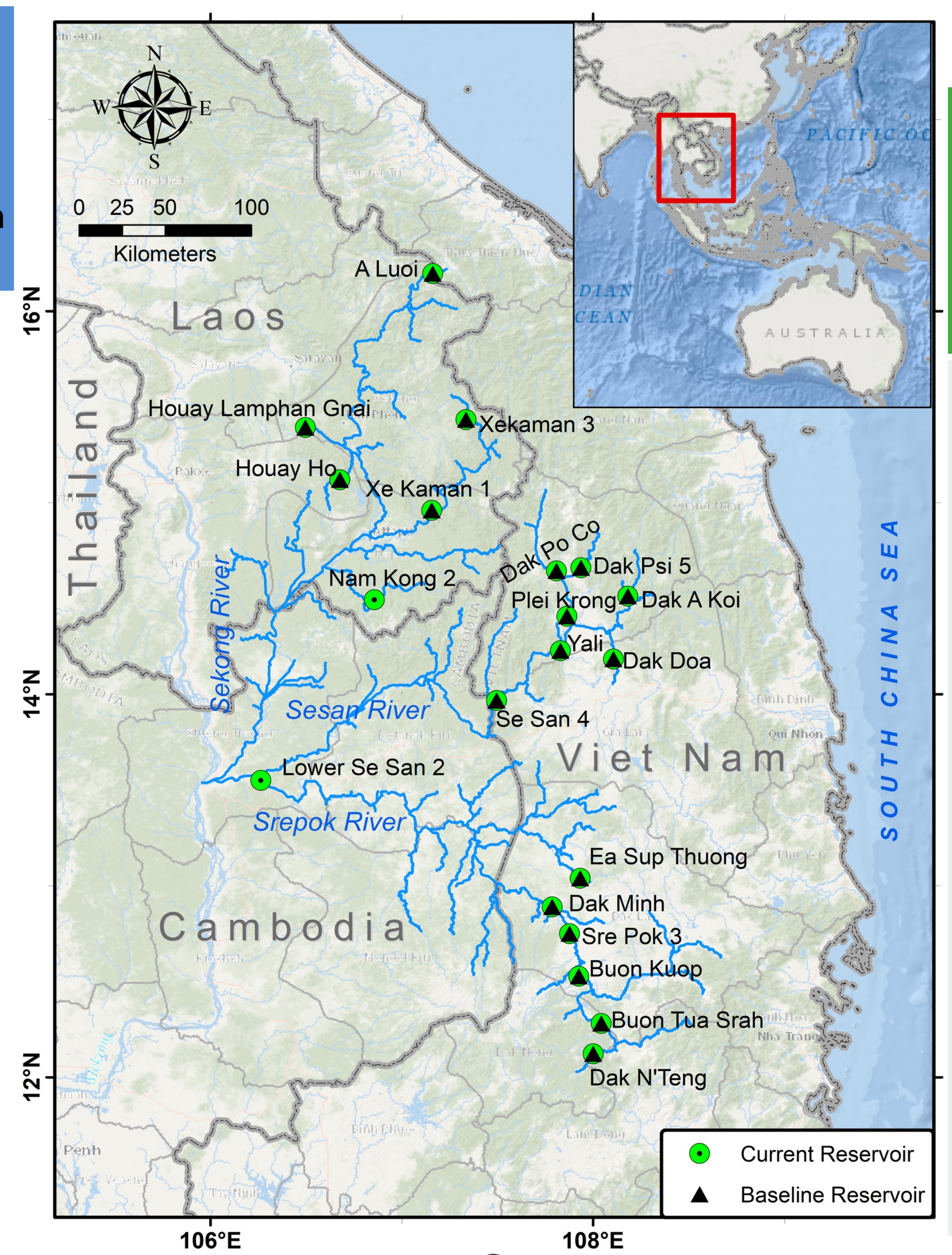
- Freshwater availability is necessary to promote economic growth through agriculture, fisheries, transport, environmental health, and social equity.
- The National Aeronautics and Space Administration (NASA) and the Conservation International (CI) are partnering to use remote sensing Earth observations to improve regional efforts that assess natural resources for conservation and sustainable management.
- Vollmer et al., (2018) have presented the social-ecological framework named the Freshwater Health Index (FHI), which takes account of the interplay between governance, stakeholders, freshwater ecosystems and the ecosystem services they provide.
- In this work, we develop decision support and making tools for natural resources conservation in the Lower Mekong by leveraging the FHI framework, multiple data products, and hydrological modeling capabilities (Mohammed et al., 2018).
- Mohammed et al., (2018) modeling capabilities enable the integration of satellite-based daily gridded precipitation, air temperature, digital elevation model, soil characteristics, and land cover and land use information to simulate water flux framework.

OBJECTIVE

The overarching goal of this work is to develop decision-making tools and practices based on satellite observations of Earth that can be applicable globally.

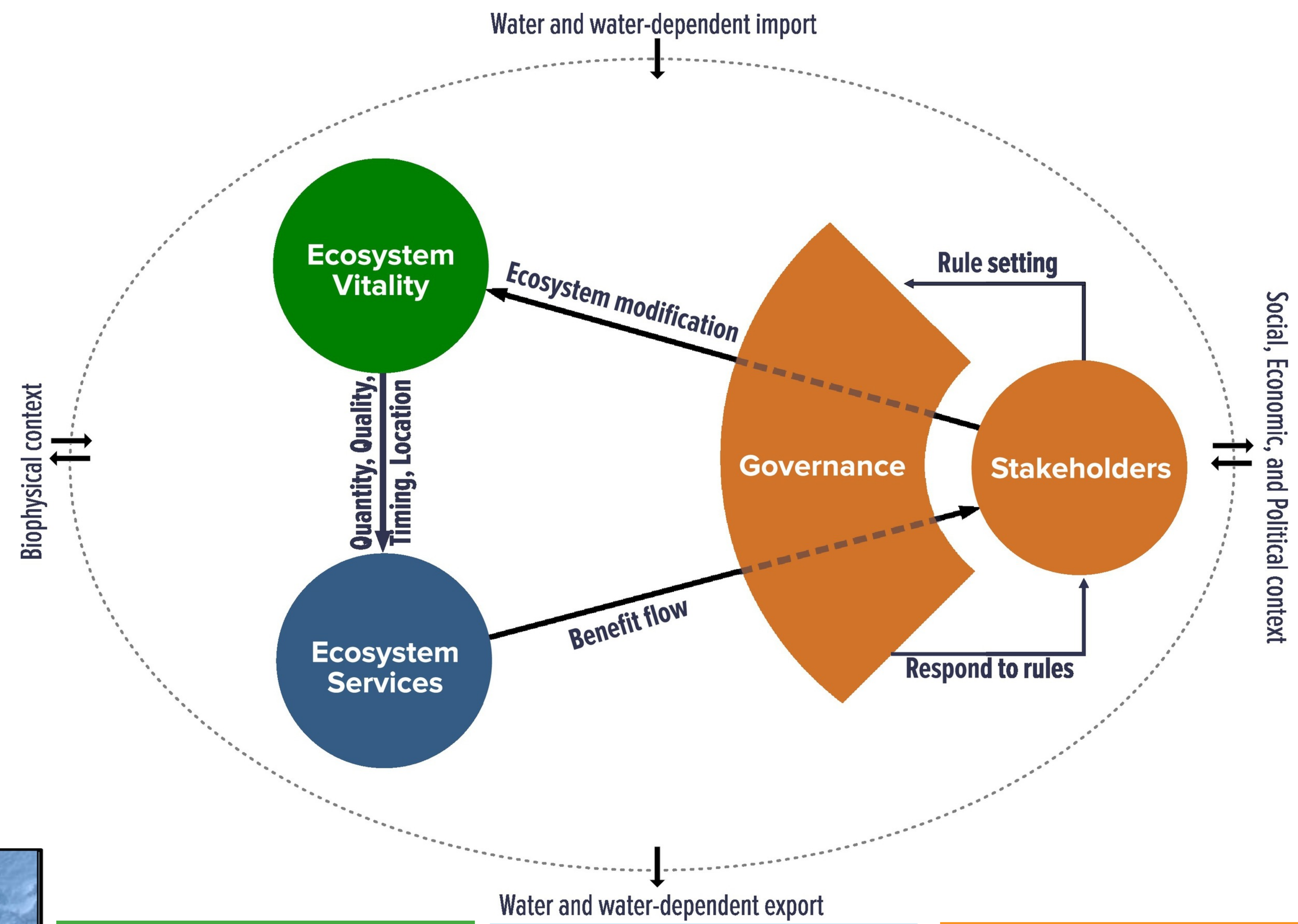
STUDY AREA

- Water resources planning efforts in the Lower Mekong River region (Laos, Vietnam, Cambodia, Thailand, and Myanmar) are complicated by uncertainty stemming from patterns of economic growth, changes in water use patterns, land use change, and climate change.
- While these processes directly increase demands, or decrease supply, research has demonstrated that there are complex processes and dynamic feedbacks among physical processes, biological, biochemical and human-mediated processes that determine change in the water system.



METHODS

The Fresh Health Index (FHI) is a conceptual framework for freshwater Social-Ecological Systems (SESs) comprised of Governance and Stakeholders, Ecosystem Vitality and Ecosystem Services.



ECOSYSTEM VITALITY

Water Quantity
- Deviation from natural flow
- Groundwater storage depletion

Water Quality
- Suspended solids
- Total nitrogen
- Total phosphorus
- Other quality parameters of concern

Basin Condition
- Bank modification
- Flow connectivity
- Land cover naturalness

Biodiversity
- Species of concern
- Invasive & nuisance species

ECOSYSTEM SERVICES

Provisioning
- Water supply reliability
- Biomass for consumption

Regulation & Support
- Sediment regulation
- Water quality regulation
- Flood regulation
- Disease regulation

Cultural
- Conservation areas
- Recreation

GOVERNANCE & STAKEHOLDERS

Enabling Environment
- Water resources management
- Right to resource use
- Incentives & regulations
- Financial capacity
- Technical capacity

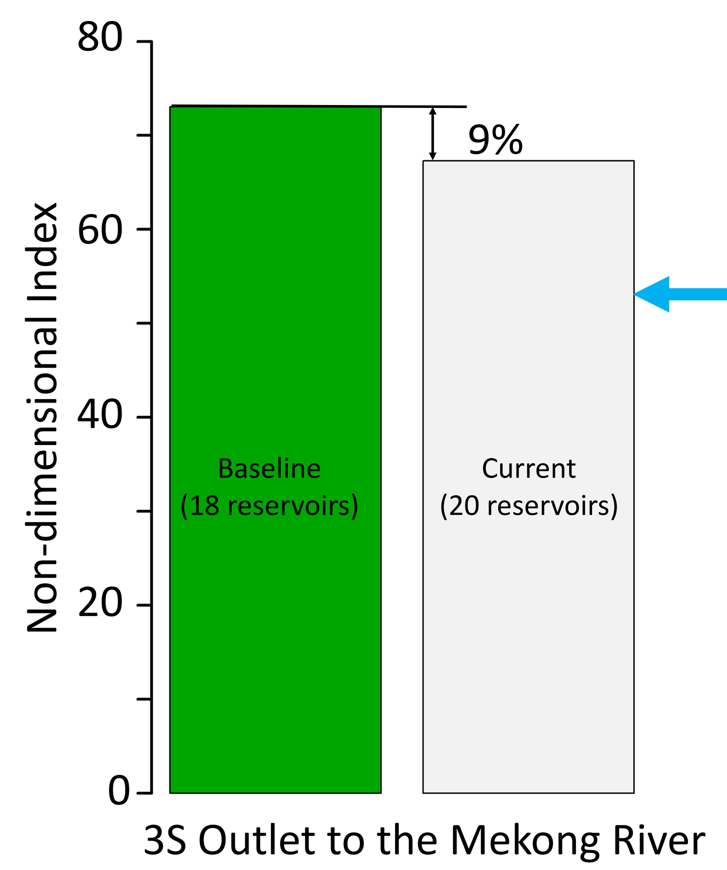
Stakeholder Engagement
- Information access
- Engagement in decision-making processes

Vision & Adaptive Governance
- Strategic planning & adaptive management
- Monitoring & learning mechanisms

Effectiveness
- Enforcement & compliance
- Distribution of benefits
- Water-related conflict

PRELIMINARY RESULTS

Ecosystem Vitality Indicator – Water quantity – Deviation from natural flow regime



Ecosystem Vitality indictor (sub indicator for FHI) – is represented by Deviation from Natural Flow (DvNF) regime at the Sekong, Sesan, and Srepok river basins. The DvNF indicator depicts changes in the stock and flow of water through the drainage basin and water storage capacity.

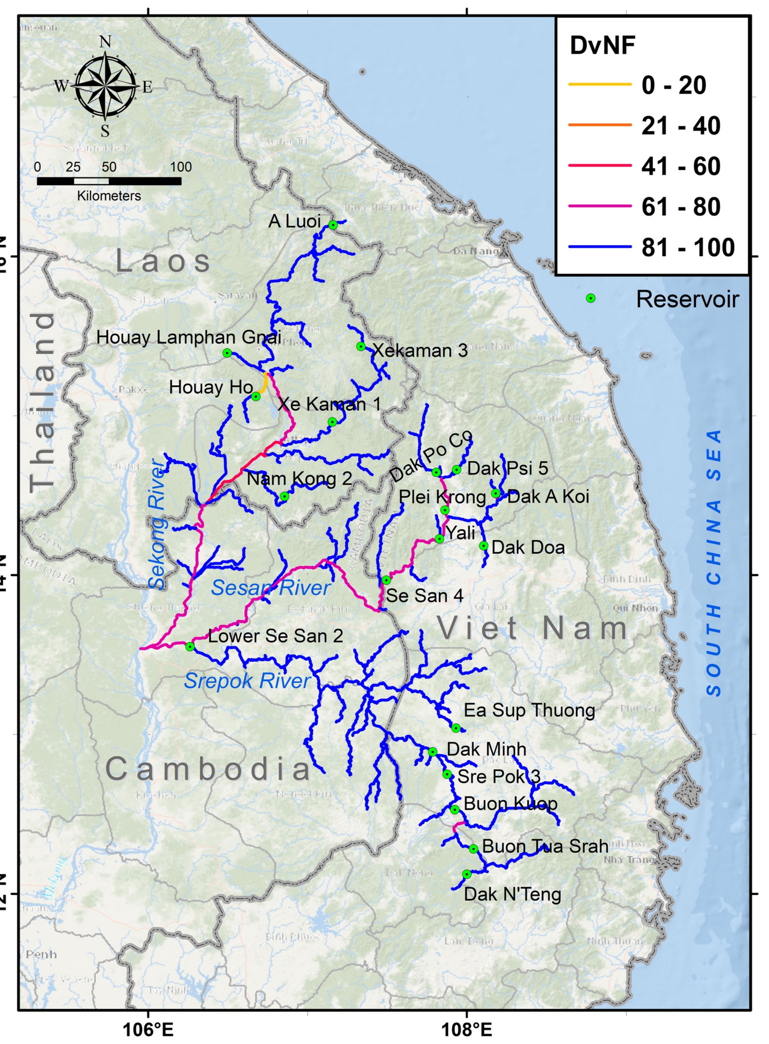


Figure gives the downstream propagation of variation for the Deviation from Natural Flow (DvNF) regime indicator under current reservoir storage. A non-dimensional scale of 0-100 where higher values denote a positive assessment regarding sustainable freshwater health is empolyed.

HIGHLIGHTS

- The utility of satellite earth observation data has enabled us to investigate the Lower Mekong ecosystem health and develop decision awareness tools that can be applied on a global scale.
- The Ecosystem Vitality indictor score results quantify the degradation seen in the Lower Mekong 3S basin ecology. Seasonal flow patterns change is correlated with increase in water storage capacity.
- Ecosystem services and Governance & Stakeholders preliminary score results are 80 and 43, respectively. Work is underway to refine these results.
- FHI builds on Ostrom's (2009) general social-ecological systems framework by characterizing freshwater systems as dynamic social-ecological networks, with linkages and feedbacks that highlight human water uses, the effects of these uses on freshwater ecosystems and, importantly, the role that governance plays in the sustainable and equitable delivery of water-based services through the maintenance of functioning ecosystems.

REFERENCES

Mohammed, I. N., Bolten, J., Srinivasan, R., & Lakshmi, V. (2018). Improved hydrological decision support system for the Lower Mekong River Basin using satellite-based earth observations. *Remote Sensing, 10*(6), 885. https://doi.org/10.3390/rs10060885.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, *325*(5939), 419-422. https://doi.org/10.1126/science.1172133.

Vollmer, D., Shaad, K., Souter, N. J., Farrell, T., Dudgeon, D., Sullivan, C. A., . . . Regan, H. M. (2018). Integrating the social, hydrological and ecological dimensions of freshwater health: The Freshwater Health Index. *Science of The Total Environment*, *627*, 304-313. https://doi.org/10.1016/j.scitotenv.2018.01.040.

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