Assessing the Impacts of Dams on the Dynamic Interactions A mong Distant Wetlands, Land Use, Rural Communities in the Lower Mekong River Basin

PI: Jiaguo Qi

US Co investigators:

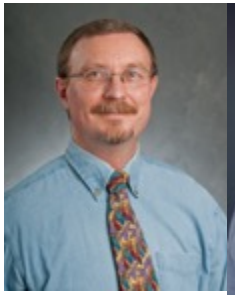
@MSU: Dan Kramer, David Hyndman, Jinhua Zhao, Joseph Messina, Peilei Fan, William McConnell and Yadu Pokhrel; @AGS: Nathan Torbick and William Salas; @VT: Venkataramana Sridhar

Int'l Partners:

Sura Pattanakiat, Mahidol University, Thailand. Apisom Intralawan, Mae Fah Laung University, Thailand. Charlie Navanugraha,Nakhon Phanom University, Thailand. Le Duc Trung, Vietnam National Mekong Committee, Vietnam, Pham Tuan Phan,Mekong River Commission, Laos. Vu Ngoc Ut,Can Tho University, Vietnam. Siam Lawawirojwong,GeoInformatics and Space Technology Development Agency, Thailand. Tep Makathy,Cambodian Institute for Urban Studies, Cambodia. Zaw Naing, Mandalay Technologies, Myanmar. Aiko Endo, Research Institute for Humanity and Nature, Japan. Anik Bhaduri, Sustainable Water Future Programme, Australia. Thongchai Suwonsichon, Kasetsart University, Thailand.

MICHIGAN STATE UNIVERSITY

NASA


W. McConnell


D. Kramer


D. Hydnman


P. Fan


Y. Pokhrel


J. Zhao


J. Messina


J. Qi


W. Salas


V. Sridhar


N. Torbick


T. Makathy


P. Varnakovida


A. Intralawan


S. Pattanakiat


C. Navanugraha


Ho Long Phi


Pham Tuan Phan

Le Duc Trung


Vu Ngoc Ut


Lisa Robelo

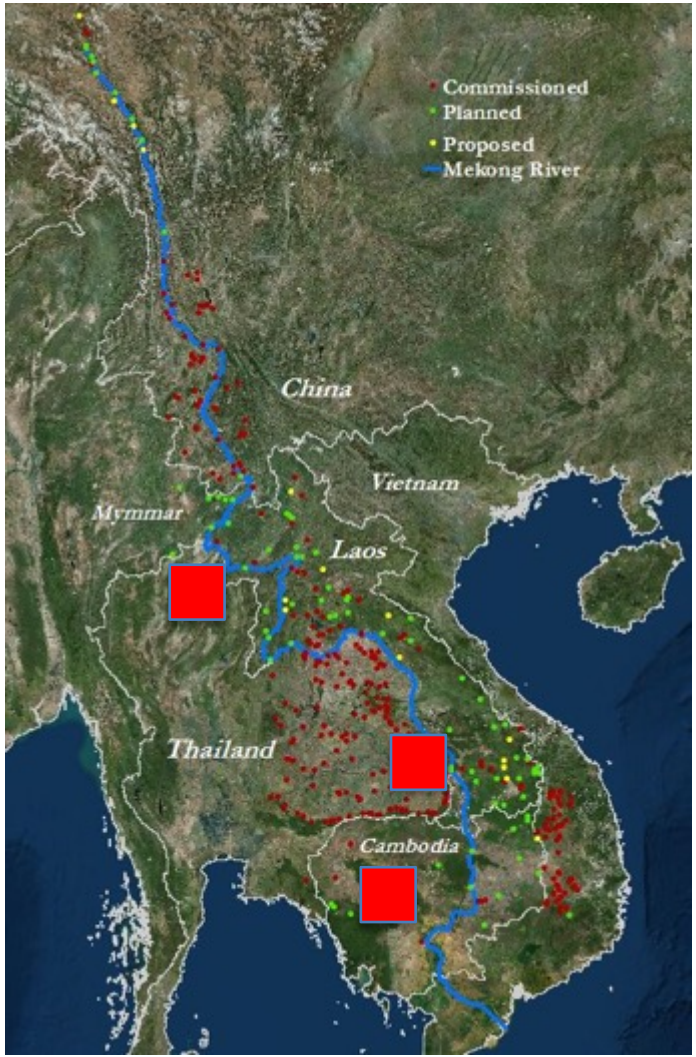

Aiko Endo


Claudia Pahl-Wostl


Anik Bhaduri

HYDRO DAMS

- A type of land use that is rarely mapped on LULC products;
- Huge impacts on water resources
- Significant implications to water-energy-food nexus;
- Important socioeconomic consequences;
- Very controversial in biological, hydrological and ecological impacts;
- Number of dams are increasing around the globe.



Mekong River Basin Facts:

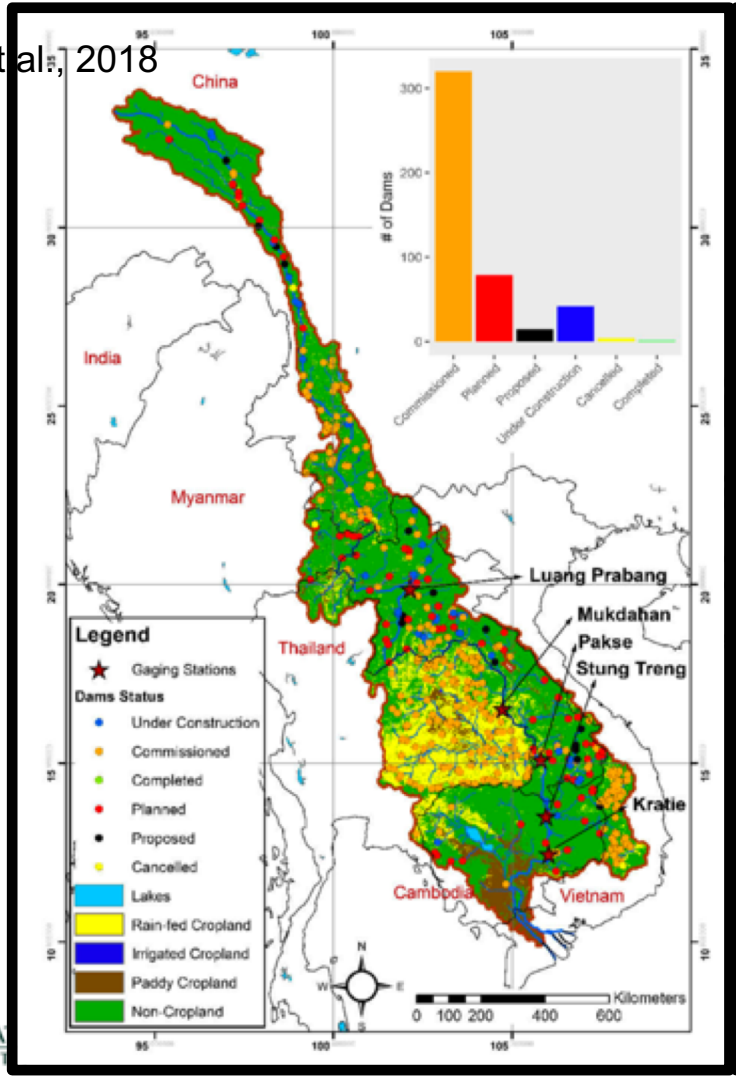
- **Length: 2,700 miles; longest river in Southeast Asia, the 7th longest in Asia, and the 12th longest in the world**
- **Hydropower dams:**

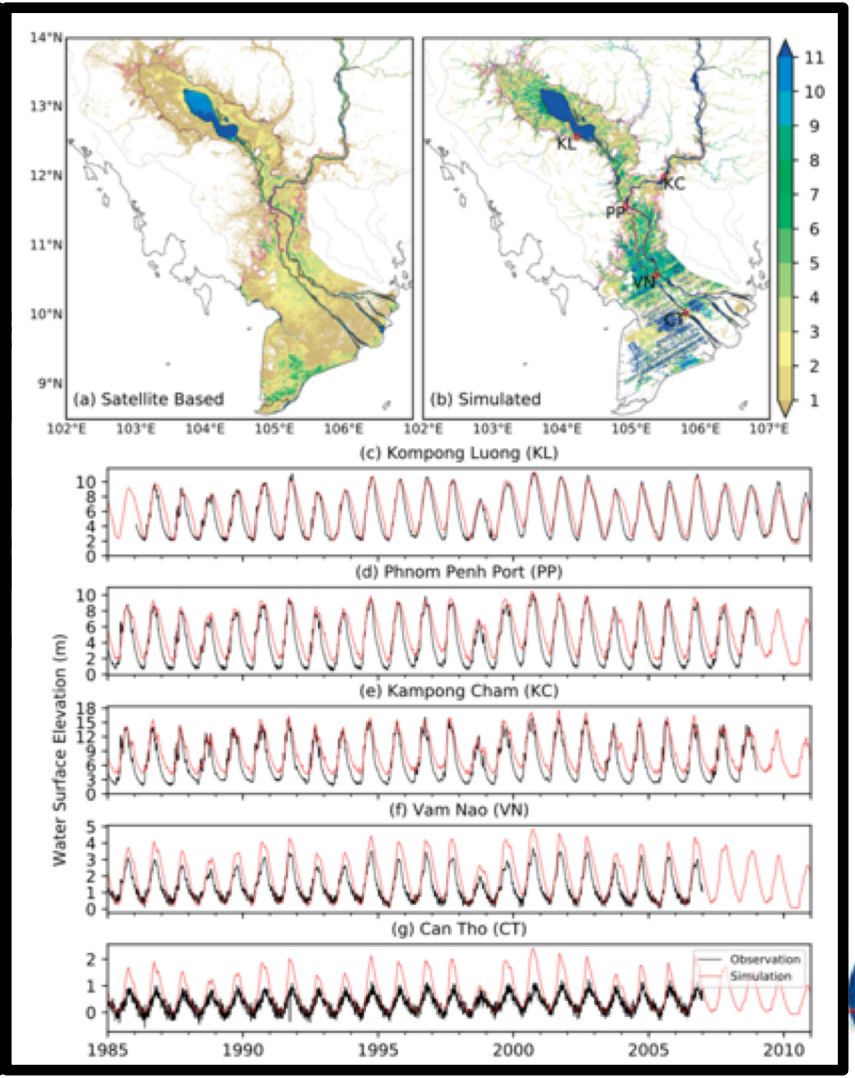
Country	No. Planned dams	No. Proposed dams
Cambodia	12	0
China	11	2
Laos	43	20
Myanmar	7	0
Thailand	7	0
Vietnam	1	1
Totals	74	23

Selected field study sites: Mae Chan; Pak Munn and Tonle Sap

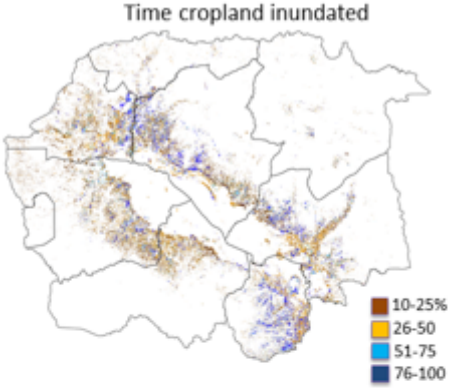
Pak Mun Dam

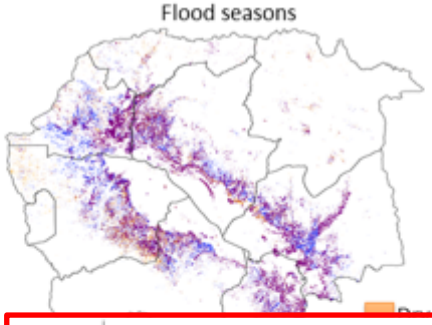
Pokhrel et al., 2018

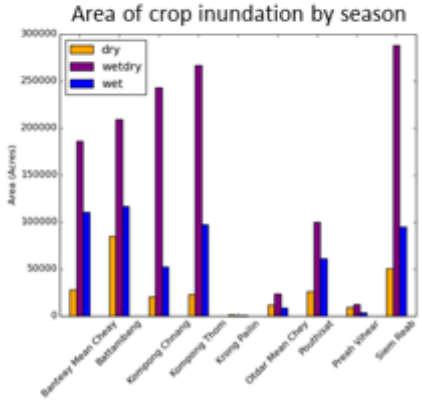


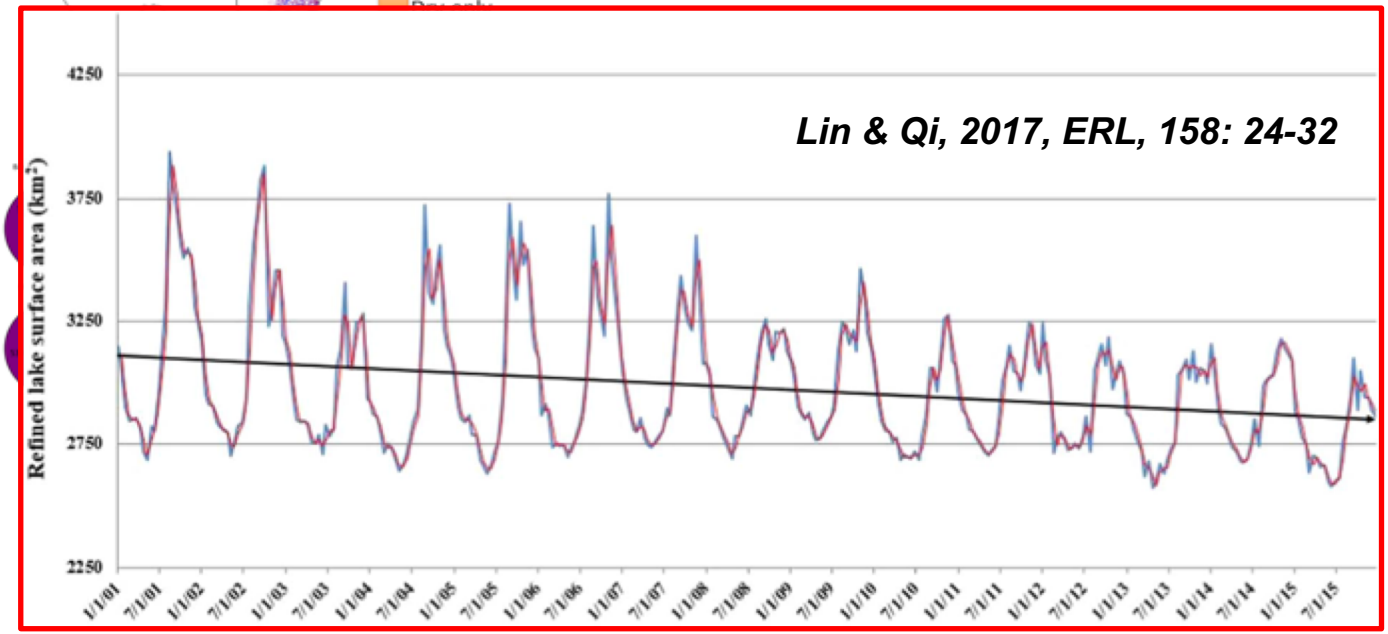


Tonle Sap Lake









In a sister IDS project

- We seek to improve our understanding of how large-scale human activities (dam infrastructure and associated irrigation) cumulatively affect ecological processes in wetland ecosystems, and to provide a scientific basis for the improved operation of such infrastructure to help mitigate the expected effects of climate change.

MICHIGAN STATE UNIVERSITY

NASA

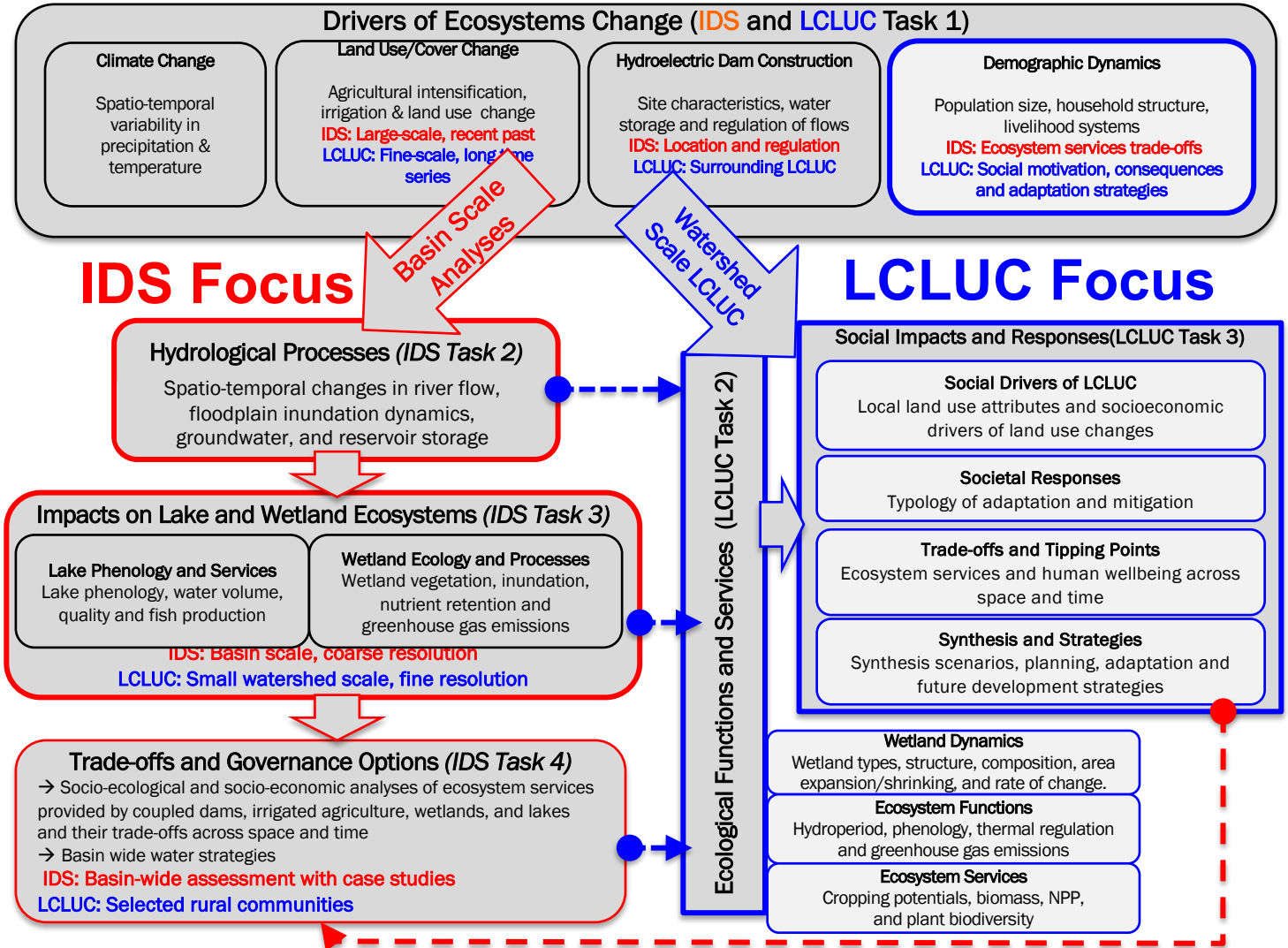
THIS LCLUC PROJECT GOAL

- To improve our understanding of the dynamic interactions among hydropower dams, distant ecosystem services, and livelihoods in rural communities with an emphasis on economic, ecological, and social tradeoffs under a range of dam operation scenarios.

MICHIGAN STATE UNIVERSITY

NASA

Approach


Drivers of Ecosystems Change (IDS and LCLUC Task 1)
Climate Change
Spatio-temporal variability in precipitation & temperature
Land Use/Cover Change
Agricultural intensification, irrigation & land use change
IDS: Large-scale, recent past
LCLUC: Fine-scale, long time series
Hydroelectric Dam Construction
Site characteristics, water storage and regulation of flows
IDS: Location and regulation
LCLUC: Surrounding LCLUC
Demographic Dynamics
Population size, household structure, livelihood systems
IDS: Ecosystem services trade-offs
LCLUC: Social motivation, consequences and adaptation strategies
Basin Scale Analyses
Watershed Scale LCLUC
IDS Focus
LCLUC Focus
Hydrological Processes (IDS Task 2)
Spatio-temporal changes in river flow, floodplain inundation dynamics, groundwater, and reservoir storage
Impacts on Lake and Wetland Ecosystems (IDS Task 3)
Lake Phenology and Services
Lake phenology, water volume, quality and fish production
Wetland Ecology and Processes
Wetland vegetation, inundation, nutrient retention and greenhouse gas emissions
IDS: Basin scale, coarse resolution
LCLUC: Small watershed scale, fine resolution
Trade-offs and Governance Options (IDS Task 4)
→ Socio-ecological and socio-economic analyses of ecosystem services provided by coupled dams, irrigated agriculture, wetlands, and lakes and their trade-offs across space and time
→ Basin wide water strategies
IDS: Basin-wide assessment with case studies
LCLUC: Selected rural communities
Ecological Functions and Services (LCLUC Task 2)
Social Impacts and Responses(LCLUC Task 3)
Social Drivers of LCLUC
Local land use attributes and socioeconomic drivers of land use changes
Societal Responses
Typology of adaptation and mitigation
Trade-offs and Tipping Points
Ecosystem services and human wellbeing across space and time
Synthesis and Strategies
Synthesis scenarios, planning, adaptation and future development strategies
Wetland Dynamics
Wetland types, structure, composition, area expansion/shrinking, and rate of change.
Ecosystem Functions
Hydroperiod, phenology, thermal regulation and greenhouse gas emissions
Ecosystem Services
Cropping potentials, biomass, NPP, and plant biodiversity

PRELIMINARY RESULTS (1)

- Impacts on hydrological and ecological processes;
  - Three models are being used:

    LEAF-Hydro-Flood (LHF); Pokhrel (CO-I)

    Variable Infiltration Capacity (VIC), Venkat Sridhar (CO-I)

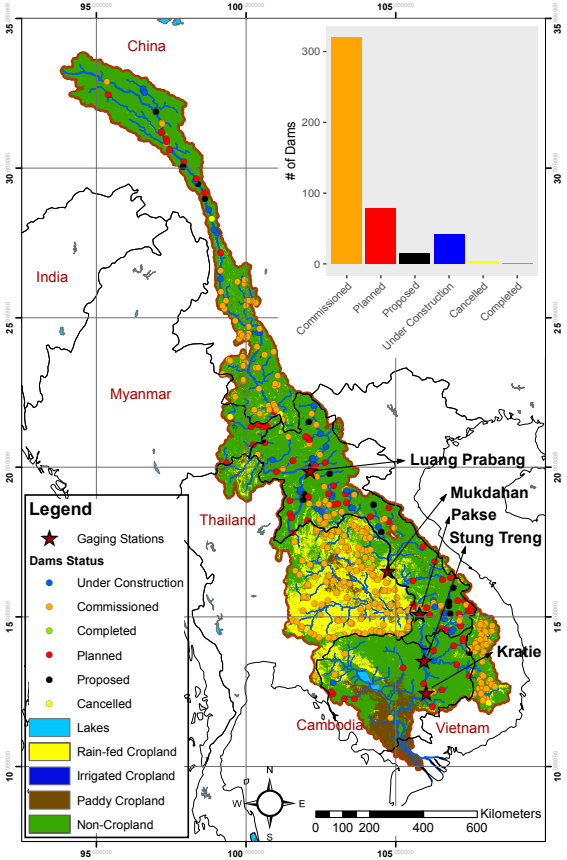
    The Landscape Hydrology Model (LHM), Hyndman (CO-I)

MICHIGAN STATE UNIVERSITY

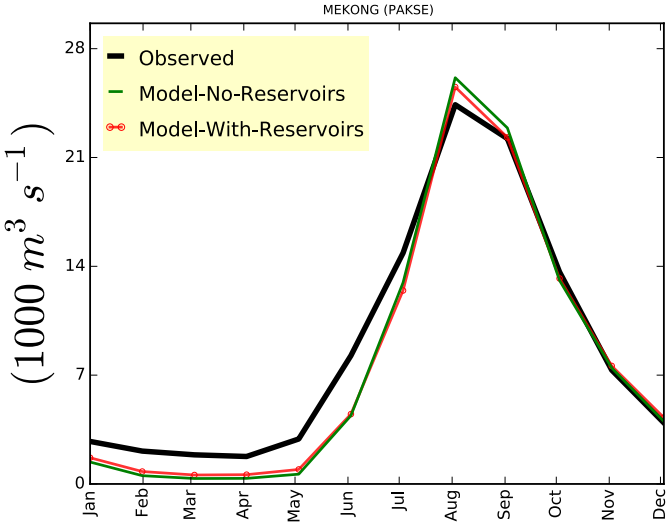
NASA

DAMS IN THE MEKONG

Pokhrel et al. (2018)



Pokhrel et al. 2012,

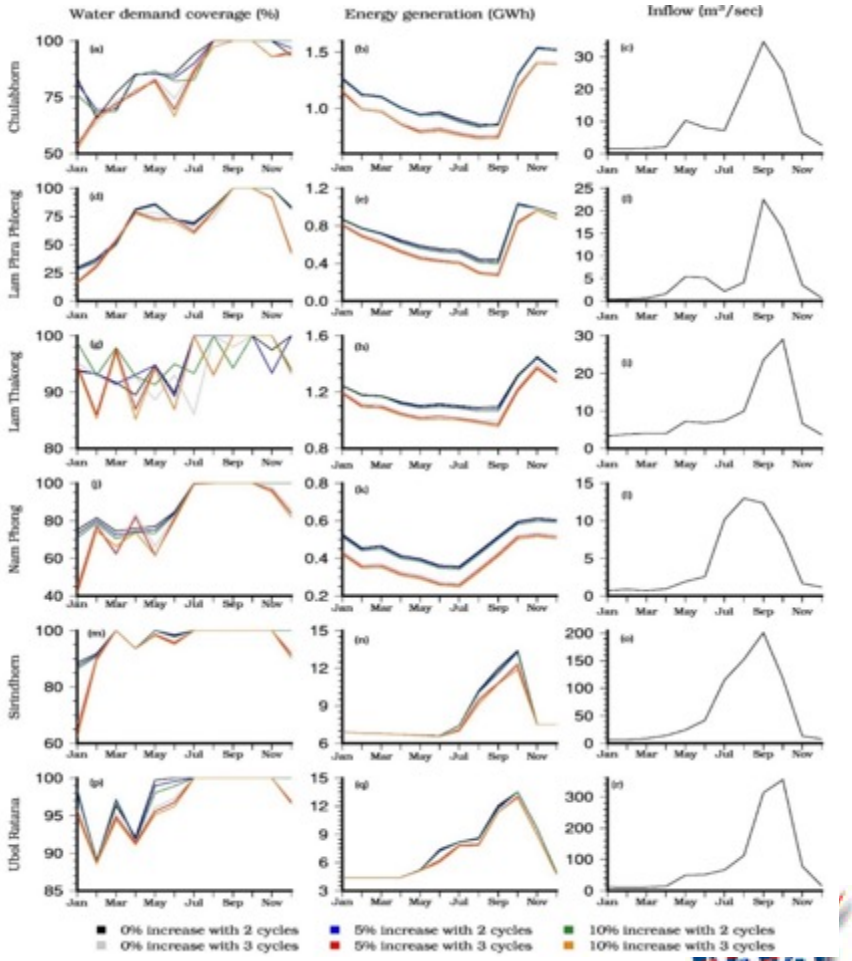


- Existing dams do not have significant impact on the flow in the mainstream
- Impacts on tributaries could be significant
- Future dams are likely to largely affect the mainstream flow

HYDROPOWER IN LMB

Management of the multipurpose dams demands the optimal balance between the supply and demand.

Crop water requirement plays a dominant role by altering the demand and supply.



Venkat Sridhar, Ph.D., P.E., D. WRE

At Virginia Tech

MICHIGAN STATE UNIVERSITY

PRELIMINARY RESULTS (2)

Impacts on socioecological systems

MICHIGAN STATE UNIVERSITY

NASA

A MANUSCRIPT SUBMITTED ON "ECOSYSTEM SERVICES"

Reviewing Benefits and Costs of Hydropower Development: Evidence from the Lower Mekong River Basin

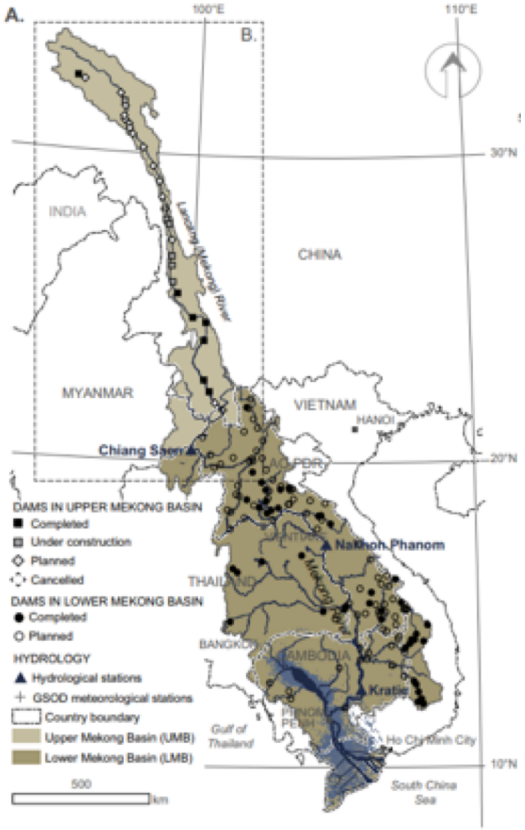
- Apisom Intralawan, Mae Fah Luang University
- Daniel B. Kramer, Daniel B. Ahlquist,William McConnell
  Michigan State University, USA
- Alex Smajgl and John Ward
  Mekong Region Futures Institute (MERFI), Bangkok, 10110 Thailand

MICHIGAN STATE UNIVERSITY

WIREs Wiley Interdisciplinary Reviews

NASA

HIGHLIGHTS



MICHIGAN STATE UNIVERSITY

NASA

Keys:
CS: MRC Council Studies; **MDS**: Mainstream Hydropower Studies
SEA: Strategic Environmental Assessment;
BDP2: Basin Development Plan Phase 2

HIGHLIGHTS

Table 1 Annual Benefit and Cost (Millions of US$/year)

Theme	CS (M3CC-M1 the effect of development scenario)	MDS (Scenario 2)	MRC - BDP2 (20 year plan incl. all dams + climate change)	SEA (Scenario 3)
Publication Year	2017	2015	2011	2010
Scope	11 mainstream and 103 tributary dams with climate change	11 mainstream and 72 tributary dams with no climate change	11 mainstream dams and 30 tributary dams, plus climate change	12 mainstream and 72 tributary dams with no climate change
Spatial Extent	Lower Mekong River Basin within 15 km corridor	Downstream floodplains of Cambodia and Vietnam. 106,350 km2	Lower Mekong River Basin within 15 km corridor	Lower Mekong River Basin
Temporal Extent	To 2040	To 2030	To 2030	To 2030
1.Hydropower, Water Flows & Water Levels	$ 9,396.1	Dry year: -54.44% in water volume; -1.12 meter in water level for 10 day interval at Kratie, Cambodia. Dry year: -36.07% in water volume and -0.12 m in water level for 10 day interval at Tan Chua, Vietnam.	$ 5,344.05	$ 3-4,000

MICHIGAN ST
UNIVERSI

HIGHLIGHTS

2. Irrigated agriculture	Total agriculture: $ 6,410.8 Irrigation: $ 1,228.3	Rice production: -552,500 tons (Vietnam) and -203,300 tons (Cambodia) per year for 10 years Maize production: -21,700 tons (Vietnam) and 41,000 tons (Cambodia) per year for 10 years. No effect estimated on crop area and crop calendar -$ 426 (Cambodia) -$ 250 million (Vietnam) in fisheries and farming sectors	$ 270.30	Riverbank production: -$ 21 Paddy production: -$ 4 Nutrient replacement: $ 24 New irrigated production: $ 15.54
3. Reservoir fisheries	Included in 5	NA	$ 32.59	$ 14
4. Aquaculture	NA	Little to no impact	$ 211.81	NA
5. Capture Fisheries	-$ 658.2	Whitefish: -80-100% Capture fisheries: -50% Total fish production: -614,000 tons OAA: -45,000 tons (of total) Economically valuable: -315,000 tons (of total) Inland fisheries: -$ 580 (Vietnam) Coastal fisheries: -50,000 tons or -$ 150	-$ 1,220.0	-$ 476
6. Wetlands (Natural Capital)	-$ 7,314.1 (uncertainty range: min: -4,761.8; max: -9,865.9); includes 6, 7 & 9	Little to no change in extent	$ 16.29	-$ 4 to 13.8

HIGHLIGHTS

7. Social/Cultural Impact	Included in 6	Major and concentrated. Fish consumption: -26 kg/person/yr (Cambodia) -120 kg/fisher/yr (Cambodia) 100 highly affected communes in An Giang and Dong Thap with greater than 10% loss of net income (Vietnam)	4.3 million livelihoods threatened	
8. Sediment & Nutrients	Included in 13	Silt and clay transport: -59-66% at Kratie Sediment transport and accretion at river mouths: - 4-12 m/yr P transport: -49 to 56% N transport: -58 to 62% at Kratie	Reduced sediment flow with adverse effects on wetlands, agriculture productivity, coastal fisheries	Sediment transport: - 75% from 160-165 to 42 million tons/year at Kratie Nutrient replacement: $ 24
9. Biodiversity & Forest reduction	Included in 6	Fish: -10% of species Large population declines of surviving migratory fish. Extinction of Irrawaddy dolphin Reduction in distribution and population of mussels and reduction in drift of invertebrates Little to no impact of open water and floodplain wetlands extent of dependent species. Moderate impacts on biodiversity due to changes in primary productivity, riverine habitat, and loss of coastal wetlands.	-$ 67.62 (hotspot loss) -$ 60.61 (forest loss)	NA
10. Recession rice	Include in irrigated area	NA	$ 45.29	River bank gardens: -54% or -$ 21
11. Flood & Drought protection	Floods: $ 125.5 Droughts: included in 2	NA	-$ 44.48	NA

HIGHLIGHTS

12. Salinity mitigation	NA	Salinity intrusion: +7,550 km2 (scenario 1), 0 km2 (scenario 2), and 11,200 km2 (scenario 3) +1.6 million people affected (Vietnam)	-$ 0.33	NA
13. Bank erosion losses	$ 347.7	5m of "deep scour" downstream of Kraite Bed degradation moves downstream at 1.5-2 km/year	Reduced wet season flow may reduce bank erosion, but "river regime change" will increase bank erosion"	NA
14. Navigation	$ 5,003.3	Little to no economic loss. No impacts on mainstream from Kampong Kor to downstream of Phnom Penh and Vietnamese Delta region.	$ 10.43	NA

MICHIGAN STATE UNIVERSITY

NASA

Next

- Field surveys in this summer
- Continue integration of land use, hydrological modeling and social analysis.
- A summer workshop (June 10-12, 2019) on hydrological modeling comparison focusing on uncertainties.

MICHIGAN STATE UNIVERSITY

NASA

Mekong researchers seek ways to improve dams

From Bangkokpost, March 18, 2018

16 Mar 2018 at 14:21 791 viewed 0 comments

WRITER: THOMSON REUTERS FOUNDATION

19 Like Tweet

Our team hopes to generate the needed information and knowledge to help develop pathways to improve dams (management) and reduce negative societal impacts.

Thank You!