ASSESSING THE IMPACTS OF DAMS ON THE DYNAMIC INTERACTIONS AMONG DISTANT WETLANDS, LAND USE, RURAL COMMUNITIES IN THE LOWER MEKONG RIVER BASIN

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US Co investigators:
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Int’l Partners:
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**:

<table>
<thead>
<tr>
<th>Country</th>
<th>No. Planned dams</th>
<th>No. Proposed dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>China</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Laos</td>
<td>43</td>
<td>20</td>
</tr>
<tr>
<td>Myanmar</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Thailand</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>74</td>
<td>23</td>
</tr>
</tbody>
</table>

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

Social Impacts and Responses (LCLUC Task 3)

Ecosystem Functions
- Hydroperiod, phenology, thermal regulation and greenhouse gas emissions

Ecosystem Services
- Cropping potentials, biomass, NPP, and plant biodiversity

Wetland Dynamics
- Wetland types, structure, composition, area expansion/shrinking, and rate of change.

Ecological Functions and Services (LCLUC Task 2)

Societal Responses (LCLUC Task 3)
- 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

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
  - IDS: Basin scale, coarse resolution
  - LCLUC: Small watershed scale, fine resolution

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
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)
DAMS IN THE MEKONG

Pokhrel et al. (2018)

- 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
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
Preliminary Results (2)

Impacts on socioecological systems
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
HIGHLIGHTS
### Highlights

**Keys:**

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

<table>
<thead>
<tr>
<th>Theme</th>
<th>CS (M3CC-M1 the effect of development scenario)</th>
<th>MDS (Scenario 2)</th>
<th>MRC - BDP2 (20 year plan incl. all dams + climate change)</th>
<th>SEA (Scenario 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication Year</td>
<td>2017</td>
<td>2015</td>
<td>2011</td>
<td>2010</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>11 mainstream and 103 tributary dams with climate change</td>
<td>11 mainstream and 72 tributary dams with no climate change</td>
<td>11 mainstream dams and 30 tributary dams, plus climate change</td>
<td>12 mainstream and 72 tributary dams with no climate change</td>
</tr>
<tr>
<td><strong>Spatial Extent</strong></td>
<td>Lower Mekong River Basin within 15 km corridor</td>
<td>Downstream floodplains of Cambodia and Vietnam. 106,350 km²</td>
<td>Lower Mekong River Basin within 15 km corridor</td>
<td>Lower Mekong River Basin</td>
</tr>
<tr>
<td><strong>Temporal Extent</strong></td>
<td>To 2040</td>
<td>To 2030</td>
<td>To 2030</td>
<td>To 2030</td>
</tr>
</tbody>
</table>

**1. Hydropower, Water Flows & Water Levels**

- **CS:** $9,396.1
- **MDS:** 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.
- **SEA:** $5,344.05
- **BDP2:** $3-4,000
## 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 | -21,700 tons (Vietnam) and 41,000 tons (Cambodia) per year for 10 years. No effect estimated on crop area and crop calendar. |
| Riverbank production: | -$21 | -$4 |
| Nutrient replacement: | -$24 | NA |
| New irrigated production: | $15.54 | NA |

### 3. Reservoir fisheries
- **Included in 5**
- **NA**

### 4. Aquaculture
- **NA**
- **Little to no impact**

### 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

### 6. Wetlands (Natural Capital)
- **-$7,314.1**

(uncertainty range: min: -$4,761.8; max: -$9,865.9); includes 6, 7 & 9

<p>| Little to no change in extent | $16.29 | -$4 to 13.8 |</p>
<table>
<thead>
<tr>
<th>Highlight</th>
<th>Included in</th>
<th>Description</th>
<th>Cost/Benefit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Social/Cultural Impact</td>
<td>Included in 6</td>
<td>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)</td>
<td>4.3 million livelihoods threatened</td>
<td></td>
</tr>
<tr>
<td>8. Sediment &amp; Nutrients</td>
<td>Included in 13</td>
<td>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</td>
<td>Reduced sediment flow with adverse effects on wetlands, agriculture productivity, coastal fisheries</td>
<td>Sediment transport: - 75% from 160-165 to 42.8 million tons/year at Kratie Nutrient replacement: $ 24</td>
</tr>
<tr>
<td>9. Biodiversity &amp; Forest reduction</td>
<td>Included in 6</td>
<td>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.</td>
<td>-$ 67.62 (hotspot loss) -$ 60.61 (forest loss)</td>
<td>NA</td>
</tr>
<tr>
<td>10. Recession rice</td>
<td>Include in irrigated area</td>
<td>NA</td>
<td>$ 45.29</td>
<td>River bank gardens: -54% or -$ 21</td>
</tr>
<tr>
<td>11. Flood &amp; Drought protection</td>
<td>Floods: $ 125.5 Droughts: included in 2</td>
<td>NA</td>
<td>-$ 44.48</td>
<td>NA</td>
</tr>
<tr>
<td>Highlights</td>
<td>Cost</td>
<td>Description</td>
<td>Cost</td>
<td>Cost</td>
</tr>
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<td>------------------------------------------------</td>
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<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>12. Salinity mitigation</td>
<td>NA</td>
<td>Salinity intrusion: +7,550 km² (scenario 1), 0 km² (scenario 2), and 11,200 km² (scenario 3) +1.6 million people affected (Vietnam)</td>
<td>-$ 0.33</td>
<td>NA</td>
</tr>
<tr>
<td>13. Bank erosion losses</td>
<td>$ 347.7</td>
<td>5m of “deep scour” downstream of Kraite Bed degradation moves downstream at 1.5-2 km/year</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>14. Navigation</td>
<td>$ 5,003.3</td>
<td>Little to no economic loss. No impacts on mainstream from Kampong Kor to downstream of Phnom Penh and Vietnamese Delta region.</td>
<td>$ 10.43</td>
<td>NA</td>
</tr>
</tbody>
</table>
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.
Our team hopes to generate the needed information and knowledge to help develop pathways to improve dams (management) and reduce negative societal impacts.