Water-Energy-Food Nexus in Mekong Countries

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Global geOreferenced Database of Dams (GOOD²)
Global Reservoir and Dam Database (GRanD)
Future Hydropower Reservoirs and Dams (FHReD)

Global Dam Watch is an international collaboration between an expanding group of researchers who are passionate about understanding the costs and benefits of dams to our world.
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The largest Macro River Basins Fed by The Third Pole (MRB-TTP) in Asia
ASSESSING THE IMPACTS OF DAMS ON THE DYNAMIC INTERACTIONS AMONG 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:
• Challenges and Opportunities
  – Hydropower dams –
  – Huge impacts on water resources;
  – Significant implications to water-energy-food nexus;
  – Important socioeconomic consequences;
  – Very controversial in biological and ecological impacts;
  – Number of dams are increasing!
**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><strong>Totals</strong></td>
<td><strong>74</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

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

failed fish ladder

FREE THE RIVER

Fish catches:
Tradeoffs & Governance

- 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

Hydrological Processes
Spatio-temporal changes in river flow, floodplain inundation dynamics, groundwater, and reservoir storage

Ecological Processes
Lake phenology, water volume, quality and fish production, nutrient retention and greenhouse gas emissions

Drivers

Climate Change
Spatio-temporal variability in precipitation & temperature

Land Use/Cover Change
Agricultural intensification, irrigation & land use change
Fine and large-scale, recent & historical changes

Hydroelectric Dam Construction
Site characteristics, water storage and regulation of flows
Location and regulation
Surrounding LCLUC

Demographic Dynamics
Population size, household structure, livelihood systems
Ecosystem services trade-offs
Social motivation, consequences and adaptation strategies

Social Drivers of LCLUC
Local and use attributes and socioeconomic drivers of land use changes

Societal Responses
Typology of adaptation and mitigation

Tipping Points
Ecosystem services and human wellbeing across space and time

Synthesis and Strategies
Synthesis scenarios, planning, adaptation and future development strategies
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

BUT.... What about lakes and wetlands?

Pokhrel et al. 2012, 2015

(MEKONG)
Water Level estimates from remote sensing

From Co-I Nate Torbick
Tonle Sap Lake

Lin & Qi, 2017, ERL, 158: 24-32
ECOLOGICAL IMPLICATIONS

N$_2$O at P1 site

CO$_2$ at P1 site
TRADEOFFS AND SYNERGIES

Field survey to understand the impacts and responses
Table 1 Annual Benefit and Cost (Millions of US$/year)

<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>1. Hydropower, Water Flows &amp; Water Levels</td>
<td>$ 9,396.1</td>
<td>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.</td>
<td>$ 5,344.05</td>
<td>$ 3-4,000</td>
</tr>
</tbody>
</table>

**Keys:**
CS: MRC Council Studies; MDS: Mainstream Hydropower Studies
SEA: Strategic Environmental Assessment;
Phase 2 (BDP2) – Basin Development Plan Phase 2
<table>
<thead>
<tr>
<th></th>
<th>CS</th>
<th>MDS</th>
<th>SEA</th>
<th>BDP2</th>
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</thead>
<tbody>
<tr>
<td><strong>2. Irrigated</strong></td>
<td><strong>agriculture</strong></td>
<td>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.</td>
<td>$270.30</td>
<td>Riverbank production: -$21.00</td>
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<td>Total agriculture: $6,410.8</td>
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<td>Paddy production: -$4.00</td>
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<td></td>
<td>Irrigation: $1,228.3</td>
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<td>Nutrient replacement: -$24.00</td>
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<td>New irrigated production: $15.54</td>
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<td><strong>3. Reservoir</strong></td>
<td>fisheries</td>
<td>NA</td>
<td></td>
<td>$14</td>
</tr>
<tr>
<td></td>
<td>Included in 5</td>
<td></td>
<td></td>
<td>NA</td>
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<td><strong>4. Aquaculture</strong></td>
<td>NA</td>
<td>Little to no impact</td>
<td>$211.81</td>
<td>NA</td>
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<tr>
<td><strong>5. Capture</strong></td>
<td><strong>Fisheries</strong></td>
<td>Whitefish: -80-100%</td>
<td>-$1,220.0</td>
<td>-$476</td>
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<tr>
<td></td>
<td>-$658.2</td>
<td>Capture fisheries: -50%</td>
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<td>Total fish production: -614,000 tons</td>
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<td></td>
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<td>OAA: -45,000 tons (of total)</td>
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<td>Economically valuable: -315,000 tons (of total)</td>
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<td>Inland fisheries: -$580 (Vietnam)</td>
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<td></td>
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<td>Coastal fisheries: -50,000 tons or -$150</td>
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<td><strong>6. Wetlands</strong></td>
<td><strong>(Natural Capital)</strong></td>
<td>Little to no change in extent</td>
<td>$16.29</td>
<td>-$4 to 13.8</td>
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<td></td>
<td>-$7,314.1</td>
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<td>(uncertainty range: min: -4,761.8; max: -9,865.9); includes 6, 7 &amp; 9</td>
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</table>
CONCLUSIONS

• So far, we have seen a significant impacts of hydro dams on hydrological and ecological processes and ecosystem services
• Tradeoffs are obvious but we need to look at all possible tradeoffs across space and time as well.
• The WEF system in Mekong is complex but the Nexus approach seems to help address these pressing issues,
Thank You!