MRC Council Study: BioRA Indicators, Links and Focus Areas

Prepared by
BioRA Team

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• Indicators
• Links
• Focus Areas
BioRA Indicators

Detail in Technical Progress Report 1: Indicators and Site Selection

- Indicators are inputs to the DRIFT model
- Each indicator must have a describable relationship to the flow or sediment regime
- Indicators describe:
  - the flow regime of the river, e.g., duration of the dry season
  - ecosystem attributes; e.g., abundance of white fish
  - river-linked social attributes, e.g., riverbank gardens
- BioRA will predict how each indicator will change from baseline
DRIFT Water Quality Indicators

- Water Quality indicators are external indicators
  - Apply to all Focus Areas
- Derived from DSF:
  - Temperature - NO$_{2+3}$
  - pH - NH$_4^+$
  - DO - Si
  - Salinity/EC - PO$_4$
  - COD - TN and TP
- Calibration data set = MRC WQMN results
  - Summary information available (1985 – 2015)
  - 1985 – 2008 = Reference data set
- Additional water quality indicators identified as necessary
  - Herbicides
  - Insecticides

Examples of WQMN Results

- Time series and monthly trends available for WQMN parameters for representative site in each FA
- WQMN results include temporal changes
**Sediment Indicators**

- Sediment indicators are external & apply to all Focus Areas
- From DSF:
  - Sediment concentration (mg/L)
  - Sediment Load (t/day)
  - Sediment grain-size ($D_{50}$)
  - Onset of sediment delivery (week number)
  - Duration of sediment delivery (week number)
- Initial - TSS & SSC monitoring data from MRC
  - Daily time series based on rating curves
  - 1985 – 2008 = Reference data set

**Geomorphology Indicators**

- Linked to sediment indicators and hydraulics
- Reflect changes in habitats

Lois Koehnken, Toch Sophon and Bounheng Southichak provided input into the list for BioRA
Geomorphology indicators

- Erosion (bank / bed incision)
- Average bed sediment size (DRY)
- Average bed sediment size (WET)
- Availability of exposed sandy habitats on bars and banks in the dry season
- Availability of inundated sandy habitats on bars and banks in the dry season
- Availability of exposed rocky habitats in the dry season
- Availability of inundated rocky habitats in the dry season
- Depth of bedrock pools
- Water clarity

Geomorphology indicators, e.g.:
Availability of Sandy Habitat (2)

- Includes exposed and inundated sand bars, banks and sandy insets
- Important habitat for:
  - Vegetation
  - Macroinvertebrates
  - Fish
  - Herpetofauna
  - Birds

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Vegetation indicators

<table>
<thead>
<tr>
<th>Channel</th>
<th>Floodplain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent of upper bank vegetation cover</td>
<td>Extent of flooded forest cover</td>
</tr>
<tr>
<td>Extent of lower bank vegetation cover</td>
<td>Extent of herbaceous marsh vegetation</td>
</tr>
<tr>
<td>Extent of herbaceous marsh vegetation</td>
<td>Extent of grassland vegetation</td>
</tr>
<tr>
<td>Biomass of riparian vegetation</td>
<td>Biomass of riparian/aquatic cover</td>
</tr>
<tr>
<td>Biomass of algae (planktonic and benthic)</td>
<td>Biomass of cyanobacteria</td>
</tr>
<tr>
<td></td>
<td>Biomass of algae (planktonic and benthic)</td>
</tr>
<tr>
<td></td>
<td>Extent of Invasive riparian plant cover</td>
</tr>
<tr>
<td></td>
<td>Extent of floating and submerged invasive plant cover</td>
</tr>
</tbody>
</table>

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Macroinvertebrate indicators

- Identified from MRC bioassessment studies (2003-8).
  Taxa selected because of:
  - specificity to habitats likely to be influenced by changes in flow regime
  - importance to people
  - conservation significance
  - existing data and known indicator value
- Dr Bounnam Pathoumthong (NUL) who conducted the early littoral invertebrate surveys suggested many of the indicators
- Dr Ian Campbell added to and revised the list for BioRA

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Macroinvertebrate indicators

<table>
<thead>
<tr>
<th>Insects on stones</th>
<th>Insects on sand</th>
<th>Dry season emergence</th>
<th>Burrowing mayflies</th>
<th>Snail abundance</th>
<th>Diversity of snails</th>
<th>Neotricula aperta</th>
<th>Bivalves abundance</th>
<th>Polychaet worms</th>
<th>Shrimps and crabs</th>
<th>Littoral invertebrate diversity</th>
<th>Benthic invertebrate diversity</th>
<th>Zooplankton abundance</th>
</tr>
</thead>
</table>

Macroinvertebrate indicators, e.g.:

**Neotricula aperta** = host of Schistosomaisis

![Diagram of Schistosomiasis lifecycle](Image)

- Sporocyst in snail
- Miracidia penetrate snail tissue
- Eggs hatch releasing miracidia
- Miracidia penetrate snail tissue
- S. japonicum
- S. mansoni
- Schistosomaisis
- Circulation
- Paired adult worms migrate to: venous plexus of bladder
- Migrate to portal blood in liver and mature into adults
- Cercariae lose tails during penetration and become schistosomulae
- Schistosomula becomes free-swimming cercariae
- Cercariae released by snail into water and free-swimming
**Fish indicators**

- Need to account for diversity of species – 800+ species
- Need to account for spatial and temporal distribution
- Need groupings that are responsive to pressures
- Adopted fisheries guild structure commonly used in this type of analysis

Ian Cowx, Kenzo Utsugi, So Nam, Kaviphone Phouthavong, Chaiwut Grudpun, Chea Tharith, Vu Vi An, Chavalit Vidthayanon, and others provided input into the list for BioRA

### Fish indicators

- Rithron resident species
- Main channel resident (long distant white) species
- Main channel spawner (short distance white) species
- Floodplain spawner (grey) species
- Eurytopic (generalist) species
- Floodplain resident (black fish)
- Estuarine resident species
- Anadromous species
- Catadromous species
- Marine visitor species
- Non-native species
**Fish indicators, e.g.: white fishes (2)**

**White fish**, undertaking long distance migrations, in particularly between lower floodplains and the Mekong mainstream and its major tributaries.

**37% of species richness**

**Contribution of fish guilds to catches**

White fish – highly vulnerable to loss of connectivity: 40 % catch [33 species] in Vietnam and 37% [37 species] in Cambodia.
**Herpetofauna indicators**

- Based on current knowledge of herpetofauna in the LMB and potential impacts of human activities in the basin
- Literature
- Consultation with regional specialists
- Taxa selected because of:
  - specificity to habitats likely to be influenced by changes in flow;
  - importance to people;
  - some knowledge of life histories.

Hoang Minh Duc and Sereywath Pich compiled the list for BioRA

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**What are Herpetofauna**

- Amphibians

- Reptiles
### Herpetofauna indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranid amphibians</td>
<td>These species are associated with water bodies for whole or part of their life-cycle.</td>
<td><em>Rana nigrovittata</em>&lt;br&gt;<em>Hoplobatrachus rugulosus</em></td>
</tr>
<tr>
<td>Aquatic serpents</td>
<td></td>
<td><em>Enhydris bocourti</em>&lt;br&gt;<em>Cylindrophis ruffus</em></td>
</tr>
<tr>
<td>Semi-aquatic serpents</td>
<td></td>
<td><em>Coelognathus radiatus</em></td>
</tr>
<tr>
<td>Aquatic turtles</td>
<td></td>
<td><em>Amyda cartilaginea</em>&lt;br&gt;<em>Malayemys subtrijuga</em></td>
</tr>
<tr>
<td>Semi-aquatic turtles</td>
<td></td>
<td><em>Cuora amboinensis</em></td>
</tr>
<tr>
<td>Amphibians for human use</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Aquatic/semi-aquatic reptiles for human use</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Species richness of riparian/floodplain amphibians</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Species richness of riparian/floodplain reptiles</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>
**Bird and mammal indicators**

- Based on current knowledge of ecology in the LMB and potential impacts of human activities in the basin
  - Reference to literature
  - Discussion / consultation with regional experts (national counterparts, NGO representatives, academics, authors of specialist papers on taxa):
    - Will Duckworth, Sarah Brook, Andrea Claasen, Hoang Minh Duc, Frederic Goes, Tom Gray, Simon Mahood, Philip Round, Robert Steinmetz and
  - Tony Stones, Phaivanh Phiapalath and Luu Hong Truong compiled the list for BioRA

**Bird indicators**

<table>
<thead>
<tr>
<th>Medium ground-nesting channel species</th>
<th>River tern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lapwing</td>
</tr>
<tr>
<td>Large tree-nesting waterbirds</td>
<td>White-shouldered ibis</td>
</tr>
<tr>
<td>Bank-/hole-nesting species</td>
<td>Pied kingfisher</td>
</tr>
<tr>
<td>Flocking non-aerial passerine of tall graminoids</td>
<td>Baya weaver</td>
</tr>
<tr>
<td>Large ground-nesting species of floodplain wetlands</td>
<td>Sarus crane</td>
</tr>
<tr>
<td></td>
<td>Bengal florican</td>
</tr>
<tr>
<td>Large species using bank-side forest</td>
<td>Lesser Fish Eagle</td>
</tr>
<tr>
<td></td>
<td>Grey-headed Fish Eagle</td>
</tr>
<tr>
<td>Rocky-crevice nester in channels</td>
<td>Wire-tailed swallow</td>
</tr>
<tr>
<td>Dense woody vegetation / water interface</td>
<td>Masked finfoot</td>
</tr>
<tr>
<td>Small non-flocking land bird of seasonally-flooded vegetation</td>
<td>Jerdon’s bushchat</td>
</tr>
<tr>
<td></td>
<td>Mekong wagtail</td>
</tr>
<tr>
<td></td>
<td>Manchurian reed warbler</td>
</tr>
</tbody>
</table>
Bird indicators, e.g.: Medium ground-nesting channel species - River Tern: (*Sterna aurantia*)

Inhabits rivers and freshwater lakes, also occurring rarely on estuaries, and breeds on sandy islands (del Hoyo *et al*. 1996), as a solitary or loosely colonial sandbar nester. It feeds predominantly on fish, small crustaceans and insects. River terns formerly associated with a group of Mekong Irrawaddy Dolphins in Ban Hangkhone, Siphandone wetland (I. Baird *pers. com*. 1996).

Mammal indicators

- Irrawaddy dolphin
- Otters
- Wetland ungulates
### Relation to proposed MRC framework

<table>
<thead>
<tr>
<th>Wetland area</th>
<th>MRC indicator</th>
<th>BioRA indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flooded forest area</td>
<td>• Extent of flooded forest</td>
</tr>
<tr>
<td></td>
<td>Flooded marshes</td>
<td>• Extent of herbaceous marsh vegetation</td>
</tr>
<tr>
<td></td>
<td>Inundated grasslands</td>
<td>• Extent of grassland vegetation</td>
</tr>
<tr>
<td></td>
<td>Inundated rice fields</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Disconnected wetlands</td>
<td>• Extent of floodplain pools</td>
</tr>
<tr>
<td>River channel condition and habitats</td>
<td>Availability of sandbars</td>
<td>• Availability of exposed sandy habitats on bars and banks in the dry season</td>
</tr>
<tr>
<td>River channel condition and habitats</td>
<td>Availability of rocky habitat including rapids</td>
<td>• Availability of inundated rocky habitats in the dry season</td>
</tr>
<tr>
<td>River channel condition and habitats</td>
<td>Number of deep pools</td>
<td>• Depth of bedrock pools</td>
</tr>
</tbody>
</table>
| River channel condition and habitats | Percentage cover of riparian vegetation within river channels | • Extent of upper bank vegetation cover  
• Extent of lower bank vegetation cover |
|              | Total sediment extraction      | NA: Included in CS scenarios                 |

### Links in BioRA

**BioRA Assessment Framework**
**Example of links: Geomorphology - erosion**

- Includes changes to banks and river bed
- Negative erosion is deposition
- Linked to:
  - Shear stress
  - Duration of wet
  - Sediment load
  - Sediment concentration
  - Onset sediment delivery
  - Duration sediment delivery
  - Sediment grain-size
  - Within day range of discharge
  - Biomass on bank
Connectivity (mainly fish)

Zone A

Zone B

Zone C

Lateral connectivity

Longitudinal connectivity (Mainstem)

Longitudinal connectivity (Tributary)

% change as a result of reduced connectivity

Indicators and Linked Indicators

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## BioRA Focus Areas

### Establish nodes

<table>
<thead>
<tr>
<th>Tier</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>International borders</td>
<td>Add node at each international border</td>
</tr>
<tr>
<td>2</td>
<td>Hydrological zones</td>
<td>Add node at downstream end of each Hydrological Zone</td>
</tr>
<tr>
<td>3</td>
<td>Geomorphological zones</td>
<td>Add node at downstream end of each Geomorphological Zone</td>
</tr>
<tr>
<td>4</td>
<td>Tributaries</td>
<td>Add node upstream of each major tributary</td>
</tr>
<tr>
<td>5</td>
<td>Conservation hotspots</td>
<td>Add node upstream and downstream of conservation hotspots</td>
</tr>
<tr>
<td>6</td>
<td>Mainstem fish migration pathways</td>
<td>Add node in mid-point of fish migratory pathways.</td>
</tr>
<tr>
<td>7</td>
<td>Inundation bands</td>
<td>Add node to represent the lowest extent of each inundation band in Tonle Sap Great Lake</td>
</tr>
<tr>
<td>8</td>
<td>Salinity</td>
<td>Add nodes at extent of flood and drought salinity intrusion</td>
</tr>
<tr>
<td>9</td>
<td>Existing water-resource developments</td>
<td>Add node upstream and downstream of locations of major existing water resource developments, plus navigation and sand mining</td>
</tr>
<tr>
<td>10</td>
<td>Planned water-resource developments</td>
<td>Add a node at the upstream limit of major dam infrastructure, mines, towns, agricultural areas, etc.</td>
</tr>
<tr>
<td>11</td>
<td>Socio-economic zones</td>
<td>Add node at downstream end of each Socio-economic Zone</td>
</tr>
<tr>
<td>12</td>
<td>Rationalisation</td>
<td>1. Remove nodes that &lt;10 km (river length) apart.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Remove nodes at tributaries unimportant for sediment and fish.</td>
</tr>
</tbody>
</table>
Characterise nodes (biophysical) and delineate BioRA zones

BioRA Focus areas (FAs)
Focus areas

- 8 focus areas
- Based on IBFM zones

BioRA zones

<table>
<thead>
<tr>
<th></th>
<th>BioRA zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mekong River from the border with China to Pak Beng</td>
</tr>
<tr>
<td>2</td>
<td>Mekong River from downstream of the Nam Beng to upstream of Vientiane</td>
</tr>
<tr>
<td>3</td>
<td>Mekong River from Vientiane to Nam Kam</td>
</tr>
<tr>
<td>4</td>
<td>Mekong River from Nam Kam to Stung Treng</td>
</tr>
<tr>
<td>5</td>
<td>Mekong River from Stung Treng to Phnom Penh</td>
</tr>
<tr>
<td>6</td>
<td>Tonle Sap River from Phnom Penh to the Tonle Sap Great Lake</td>
</tr>
<tr>
<td>7</td>
<td>Tonle Sap Great Lake</td>
</tr>
<tr>
<td>8</td>
<td>Mekong Delta from the Cambodian/Viet Nam border to the sea</td>
</tr>
</tbody>
</table>

The RTWG is specifically requested to:

- Take note of the progress of the work on BioRA indicators, links and focus areas
- Provide feedback and guidance on indicators
- Provide feedback and guidance on the focus areas
Thank you