ASSESSMENT OF ENVIRONMENTAL FLOW BY HYDROLOGICAL APPROACH IN MYITNGE RIVER BASIN

Presenter
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Environmental flow

- Enough water that is left in the river, or release into it to manage downstream environmental, social and economic benefits. (Dyson et al., 2008)

- Quantity, quality and timing of water flows required to sustain freshwater, ecosystem and human livelihoods and well-being that depend on these ecosystem. (Richter et al., 2003)
## STUDY AREA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catchment area</strong></td>
<td>28206 km²</td>
</tr>
<tr>
<td>Annual mean discharge at dam site</td>
<td>483 m³/sec</td>
</tr>
<tr>
<td>Full supply level</td>
<td>EL 185 m</td>
</tr>
<tr>
<td>Minimum operation level</td>
<td>EL 150 m</td>
</tr>
<tr>
<td>Gross storage capacity</td>
<td>2611 MCM</td>
</tr>
<tr>
<td>Dead storage capacity</td>
<td>992.8 MCM</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>790 MW (197.5 x 4 units)</td>
</tr>
<tr>
<td>Maximum plant discharge</td>
<td>210 m³/sec</td>
</tr>
<tr>
<td>Rated head</td>
<td>91 m</td>
</tr>
<tr>
<td>Average Annual Energy</td>
<td>3550 GWh</td>
</tr>
</tbody>
</table>

\[\text{Data Length}\]

Before Dam 1981 2010
After Dam 2011 2017
Land Cover Changes of Myitnge River Upstream before and after Yeywa Dam Construction

- **Land Cover 2000 Before Dam**
- **Land Cover 2015 After Dam**

**Legend**
- Unknown
- Surface water
- Flooded forest
- Deciduous forest
- Evergreen broadleaf
- Evergreen needleleaf
- Evergreen mixed forest
- Mixed evergreen and deciduous
- Urban and Built up
- Cropland
- Rice paddy
- Barren
- Wetlands
- Grassland

- **195% increase Urban and Built Up**
- **34% decrease Surface Water**
- **33% decrease Urban and Built Up**
Downstream water body after dam decrease 34% of natural river body.
Hydrograph of Myitnge River without Yewa Dam (1982)

- **Flow (m$^3$/sec)**
  - 2500
  - 2000
  - 1500
  - 1000
  - 500
  - 0

- **Timeline**
  - 01-Nov
  - 01-Dec
  - 01-Jan
  - 01-Feb
  - 01-Mar
  - 01-Apr
  - 01-May
  - 01-Jun
  - 01-Jul
  - 01-Aug
  - 01-Sep
  - 01-Oct

- **Seasons**
  - Flood Season
  - Late Wet Season
  - High Flow Pulse

- **Flow Patterns**
  - Dry Season Low Flow
  - High Flow Pulse
adequate habitat for aquatic organisms

soil moisture for plants

recruitment of certain floodplain plant species

Low Flow
- Shape physical character of river channel, including pools, riffles
- Restore normal water quality conditions after prolonged low flows
- Replenish the ground water

High Flow
Deposit nutrients rich on floodplain and gravel and cobbles in spawning areas

Enable fish to spawn in floodplain, provide nursery area for juvenile

Recharge floodplain water table
Hydropower Impact on Flow after YEYWA Dam Construction

1. Many fluctuation
2. Seldom / Loss of floods
3. Less frequent high flow pulse
<table>
<thead>
<tr>
<th>Method Type</th>
<th>Example Methods</th>
<th>Data needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrological index method</td>
<td>• Tennant&lt;br&gt;• Tessman&lt;br&gt;• Flow Duration Curve (FDC)&lt;br&gt;• Global Environmental Flow Calculator (GEFC)&lt;br&gt;• Integrated Hydrologic Alteration (IHA)&lt;br&gt;• Dundee Hydrological Regime Assessment Method (DHRAM)</td>
<td>Historical flow records</td>
</tr>
<tr>
<td>Hydraulic rating method</td>
<td>• Wetted Perimeter&lt;br&gt;• R2 cross</td>
<td>Historical flow records&lt;br&gt;Hydraulic variables- single cross-section</td>
</tr>
<tr>
<td>Habitat simulation method</td>
<td>• In-Stream Flow Incremental Methodology (IFIM)&lt;br&gt;• Physical HABitat SIMulation model (PHABSIM)</td>
<td>Historical flow records&lt;br&gt;Hydraulic variables- multiple cross-section&lt;br&gt;Biological data</td>
</tr>
<tr>
<td>Holistic method</td>
<td>• Building Block Methodology (BBM)&lt;br&gt;• Downstream Response to Imposed Flow Transformation (DRIFT) `</td>
<td>Historical flow records&lt;br&gt;Hydraulic variables- multiple cross-section&lt;br&gt;Biological data&lt;br&gt;Ecological data</td>
</tr>
</tbody>
</table>

METHODOLOGY

- Data Availability

Hydrological Index Method
Environmental Flow

- Preliminary Level
  - Minimum flow
  - Tennant
  - Tessman
  - GEFC

- Management Level
  - Degree of Flow Alteration
  - IHA Software
## Global Environmental Flow Calculator (GEFC)

<table>
<thead>
<tr>
<th>EMC</th>
<th>Management Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Natural</td>
<td>Not allow new water projects (dams, diversions, etc.)</td>
</tr>
<tr>
<td>B. Slightly Modified</td>
<td>Allow water supply schemes or irrigation development</td>
</tr>
<tr>
<td>C. Moderately Modified</td>
<td><strong>Multiple disturbances associated with the need for socio-economic development, eg: dams, diversions, habitat modification and reduced water quality.</strong></td>
</tr>
<tr>
<td>D. Largely Modified</td>
<td>Significantly disturbances associated with water resources development, including dams, diversion, transfers, habitat modification and water quality degradation</td>
</tr>
<tr>
<td>E. Seriously Modified</td>
<td>High human population density and extensive water resources exploitation</td>
</tr>
<tr>
<td>F. Critically Modified</td>
<td>This status is not acceptable from the management perspective.</td>
</tr>
</tbody>
</table>

**Ecological Description**

- Basic ecosystem functions are still intact
- Some sensitive species are lost and/or reduced in extent.
Minimum Environmental Flow (m³/sec)

- **Natural Flow**
- **Tessman**
- **Tennant**
- **GEFC**
- **Release Flow**

Discharge (cumecs)

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recommended Environmental Flow

Discharge (cumecs)

- Natural Flow
- Environmental Flow by GEFC
The target of environmental flow is that the released hydrograph falls within the limited flow regime from natural hydrograph after fulfill the minimum environmental flow requirement.
Environmental Flow

Preliminary Level
- Minimum flow

Management Level
- Degree of Flow Alteration

Tennant
- Tessman
- GEFC
- FDC

IHA Software
Environmental Flow Assessment in Management Level

Indicators of Hydrological Alteration (IHA)

- Total of 67 statistical parameters
- 34 Environmental Flow Component (EFC)
- 33 IHA

1. Low flow
2. Extreme low flow
3. High flow
4. Small flood
5. Large flood

- Magnitude
- Duration
- Timing
- Frequency
- Rate of change

To quantify the flow alteration degree before and after dam construction
Comparison of Existing Released Flow with Recommended Flow

Monthly Low Flow (m³/sec)

- Minimum Recommend
- Existing
- Maximum Recommend

Discharge (m³/sec)

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
### 33 Integrated Hydrologic Alteration parameters

<table>
<thead>
<tr>
<th>Monthly Water Condition</th>
<th>Extreme Water Condition</th>
<th>Extreme Water Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1-day minimum</td>
<td>Date of minimum</td>
</tr>
<tr>
<td>Feb</td>
<td>3-day minimum</td>
<td>Date of maximum</td>
</tr>
<tr>
<td>Mar</td>
<td>7-day minimum</td>
<td>High and Low Pulses</td>
</tr>
<tr>
<td>Apr</td>
<td>30-day minimum</td>
<td>Low pulse count</td>
</tr>
<tr>
<td>May</td>
<td>90-day minimum</td>
<td>Low pulse duration</td>
</tr>
<tr>
<td>Jun</td>
<td>1-day maximum</td>
<td>High pulse count</td>
</tr>
<tr>
<td>Jul</td>
<td>3-day maximum</td>
<td>High pulse duration</td>
</tr>
<tr>
<td>Aug</td>
<td>7-day maximum</td>
<td>Water Condition Changes</td>
</tr>
<tr>
<td>Sep</td>
<td>30-day maximum</td>
<td>Rise rate</td>
</tr>
<tr>
<td>Oct</td>
<td>90-day maximum</td>
<td>Fall rate</td>
</tr>
<tr>
<td>Nov</td>
<td>Number of zero day</td>
<td>Number of reversals</td>
</tr>
<tr>
<td>Dec</td>
<td>Base flow index</td>
<td></td>
</tr>
</tbody>
</table>

**Integrated Hydrologic Alteration**

- 11 High Alteration
- 9 Moderate Alteration
- 12 Low Alteration
A single integrated index, $D$, which is the average value of 32 degree of alteration for the 32 IHA parameters

$$D = \left( \frac{1}{32} \sum_{n=1}^{32} D_i^2 \right)^{1/2}$$

Degree of Hydrologic alteration $D = 67\%$

Moderate Alteration: nearly High alteration

0-33\% = low alteration (L)
34-67\% = moderate alteration (M)
68-100\% = high alteration (H)
The objective of environmental flows is not reproduced a natural flow regime in whole, but rather to achieve a flow regime that maintains the essential processes required to support healthy river ecosystems.
Conclusion

- According to the existing condition, the released flow is fulfill the minimum environmental flow requirement.

- The degree of flow alteration after post-dam years due to existing hydropower policy is 67% that is a large scale. The river channel, habitats and aquatic species can be much negative impacts due to severely changed.

- So the reservoir operation rule should be developed for the benefit of hydro balancing between water user and environment by modifying the released flow condition.
THANK FOR YOUR ATTENTION