Exploring Ways to Benchmark River Basin Performance

Chris Morris, Senior Water Resources Engineer

Where are we?

Overall basin performance Benchmarking

NARBO Benchmarking

Basin Status Benchmarking

Other areas..?
Citarum River Basin Strategic Planning Framework

VISION
“The government and community working together for clean, healthy and productive catchments and rivers, bringing sustainable benefits to all people of the Citarum River Basin

Main Key Areas (Pillars)
- Institutions and Planning for IWRM
- Water Resource Development and Management
- Water Sharing
- Environmental Protection
- Disaster Management

Supporting Key Areas (Foundation)
- Community Awareness and Participation
- Data and Information
## Constructing Roadmaps

### Existing Situation

**Lack of coordination among agencies**

**Serious problems of watershed degradation**

**Critical problems of water pollution**

**Problems with water delivery**

*etc, etc*

### Key Areas

<table>
<thead>
<tr>
<th>Institutions and Planning for IWRM</th>
<th>WR Development and Management</th>
<th>Water Sharing</th>
<th>Environmental Protection</th>
<th>Disaster Management</th>
<th>Community Empowerment</th>
<th>Data and Information</th>
</tr>
</thead>
</table>

### Time

- **Tranche 1**
- **Tranche 2**
- **Tranche 3**

### Objectives

- **Support for Institutional Strengthening**
- **Support for community-driven water management**
- **Sustainable Watershed Management Strategy**
- **Water Supply Options for Bandung**
- **Development of basin models and DST**
- **West Tarum Canal**

### Desired Situation

*“The government and community working together for clean, healthy and productive catchments and rivers, bringing sustainable benefits to all people of the Citarum River Basin.”*

- To have an effective coordination mechanism for water resources management in the Citarum River Basin.
- To have new or improved sources of water for irrigation, industry, hydropower, domestic, and other uses developed.
- To have an equitable water sharing arrangement among the upper and lower basin and transboundary water resources.
- To have forest protection measures in place and have no further reduction in the existing forest area.
- To have effective disaster preparedness plans in place for floods and mud flow events.
- To have a high level of awareness of local communities about conservation, utilization, and protection of natural resources.
- To have a comprehensive database on land and water resources in place and accessible to all that need it.
NARBO Benchmarking

- RBO Status
- RBO Governance

**Planning**
- Water Allocation
- Data Management

**River Basin Organization**
- Cost Recovery
- Financial Efficiency

**Internal Business Processes**
- HR Development
- Technical Development
- Organizational Development

**Finance**
- Customer Involvement
- Customer Feedback
- Environmental Audits
- Basin Livelihood

**Learning and Growth**

**Stakeholders**
The Design of a IWRM Basin Performance Benchmarking Program

Research, June 2007 to Feb 2008, by:
Kei Saiki, The University of Tokyo

Supported by:

Asian Development Bank
Balai Besar WS Citarum (Citarum RBO)
PJT 2, PJT 1, IWMI
Languan Lake Development Authority
Study outputs?

Design of a river basin performance benchmarking program

- performance indicator design,
- benchmarking guideline, and
- design of an output publication

Verification in 2 river basins
Verification process?

Self-Assessment → Peer Review → Plenary Mtg → Publication
IWRM Elements and Existing River Performance Benchmarking Systems

River Basin Organization
Stakeholder Participation
River Basin Planning
Public Awareness
Water Allocation
Water Rights
Wastewater Permits
IWRM financing
Economic Instruments
Regulations
Infrastructure for Multiple Benefits
Private Sector Contribution
Water Education

Watershed Management
Environmental Flows
Disaster Management
Flood Forecasting
Flood Damage Rehabilitation
Water Quality Improvement
Water Quality Monitoring
Wetland Conservation
Fisheries
Groundwater management
Water Conservation
Decision Support Information
Classification of indices

**Physical performance** ↔ **Human activities performance**

- Recreational water quality
- Flood vulnerability
- Chemical Spills
- Environmental Water Quality
- Biodiversity

- Raw water supply
  - (Flood Vulnerability)

[Image: Classification of indices diagram with categories]
Basin Status Benchmarking

- Water Utilization
  - Recreational Water Quality
  - Raw Water Quantity
- Disaster Vulnerability
  - Flood Vulnerability
  - Chemical Spills
- Environmental Management
  - Environmental Water Quality
  - Biodiversity
## Recreational Water Quality

### Fecal Coliforms

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal coliforms (count / 100ml)</td>
<td>&lt; 200</td>
<td>&lt; 1,000</td>
<td>&lt; 2,000</td>
<td>&lt; 10,000</td>
<td>10,000 &lt;</td>
</tr>
</tbody>
</table>

**Definition of Water Quality Score**

- **4;** Fine quality; Suitable for recreational use
- **3;** Fair quality; Acceptable for recreational use
- **2;** Moderate quality; Acceptable for fish farming and animal husbandry
- **1;** Poor quality; Limited agricultural use
- **0;** Highly polluted quality; Dangerous for any use

[Water Utilization](#)
## Raw Water Supply

### Water Supply / Planned Ratio

**Supply Planned Ratio Index**

\[
SPR = \frac{1}{N} \sum \left( \frac{O}{P} \right)_i
\]

- Where:
  - \( SPR \): Supply Planned Ratio Index
  - \( N \): Number of planning segments in a year
  - \( O \): Observed amount of water supply
  - \( P \): Planned amount of water supply
  - \( i \): Planning segment

### Water Utilization

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASPR</strong></td>
<td>97.5% &lt;</td>
<td>95% - 97.5%</td>
<td>92.5% - 95%</td>
<td>90% - 92.5%</td>
<td>&lt; 90%</td>
</tr>
<tr>
<td><strong>MSPR</strong></td>
<td>95% &lt;</td>
<td>90% - 95%</td>
<td>85% - 90%</td>
<td>80% - 85%</td>
<td>&lt; 80%</td>
</tr>
</tbody>
</table>

ASPR: Annual average SPR  
MSPR: Minimum SPR throughout a year
Flood Vulnerability Index

\[ FVI = \frac{1}{N} \sum \left( \frac{D}{P} \right) \]

Where:

- \( FVI \) = Flood Vulnerability Index
- \( N \) = Target period [year]
- \( D \) = Number of people killed in flood events in a year in the target catchment
- \( P \) = Population within the catchment in a year

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people killed per million</td>
<td>( FV &lt; 0.30 )</td>
<td>&lt; 1.00</td>
<td>&lt; 4.00</td>
<td>&lt; 10.0</td>
<td>10.0 ( \leq FV )</td>
</tr>
</tbody>
</table>
## Chemical Spills

### Cadmium

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium (mg/L)</td>
<td>&lt; 0.003</td>
<td>0.003 - 0.01</td>
<td>0.01 - 0.05</td>
<td>0.05 - 0.15</td>
<td>0.15 &lt;</td>
</tr>
</tbody>
</table>

### Zinc

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (mg/L)</td>
<td>&lt; 0.03</td>
<td>0.03 - 0.05</td>
<td>0.05 - 0.12</td>
<td>0.12 - 0.20</td>
<td>0.20 &lt;</td>
</tr>
</tbody>
</table>

**Definition of Water Quality Score**

4; Safe water with toxic substances kept in safe level  
3; Safe water with toxic substances kept in acceptable level  
2; Water with toxic substances in alarming level  
1; Water with toxic substances in dangerous level  
0; Water with toxic substances in catastrophic level
# Environmental Water Quality

## Dissolved Oxygen

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen (mg/L)</td>
<td>7.0 &lt;</td>
<td>5.0 – 7.0</td>
<td>3.0 – 5.0</td>
<td>1.0 – 3.0</td>
<td>&lt; 1.0</td>
</tr>
</tbody>
</table>

## Total Phosphorus

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus (mg/L)</td>
<td>&lt; 0.04</td>
<td>&lt; 0.2</td>
<td>&lt; 1.0</td>
<td>&lt; 5.0</td>
<td>5.0 &lt;</td>
</tr>
</tbody>
</table>

## Ammonia Nitrogen

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Nitrogen (mg/L)</td>
<td>&lt; 0.20</td>
<td>0.20 - 0.50</td>
<td>0.50 - 1.0</td>
<td>1.0 - 2.0</td>
<td>2.0 &lt;</td>
</tr>
</tbody>
</table>
Biodiversity

Where:

\[ BDI_i = \frac{Obs_i}{Exp_i} \times 100 \]

- **BDI** = Biodiversity Index
- **Exp** = Expected number of species at selected sites in the catchment
- **Obs** = Observed number of species at selected sites in the catchment
- **i** = Elements to be assessed i.e. fish, macro-invertebrate, and aquatic plants.

<table>
<thead>
<tr>
<th>Score</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI (%)</td>
<td>75 &lt;</td>
<td>50 - 75</td>
<td>25 - 50</td>
<td>0 - 25</td>
<td>0</td>
</tr>
</tbody>
</table>
## Available data

<table>
<thead>
<tr>
<th>Sub-Indicator</th>
<th>Citarum River Basin</th>
<th>Laguna Lake Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Coliforms</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>ASPR</td>
<td>○</td>
<td>×</td>
</tr>
<tr>
<td>MSPR</td>
<td>○</td>
<td>×</td>
</tr>
<tr>
<td>FVI</td>
<td>△</td>
<td>○</td>
</tr>
<tr>
<td>Cadmium</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Zinc</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>×</td>
<td>○</td>
</tr>
<tr>
<td>NH4-N</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fish O/E</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Invertebrates O/E</td>
<td>△</td>
<td>×</td>
</tr>
<tr>
<td>Aquatic Plants O/E</td>
<td>△</td>
<td>×</td>
</tr>
<tr>
<td>Key Performance Area</td>
<td>Maximum Score</td>
<td>Basin Score</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Water Utilization</td>
<td>4.0</td>
<td>0.5</td>
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<tr>
<td>Water Quality</td>
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<tr>
<td>Fecal Coliforms</td>
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<td>1.0</td>
</tr>
<tr>
<td>Raw Water Supply</td>
<td>4.0</td>
<td>0.0</td>
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<tr>
<td>ASPR</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>MSPR</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Disaster Vulnerability</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Flood Vulnerability</td>
<td>4.0</td>
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<tr>
<td>FVI</td>
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<td>4.0</td>
</tr>
<tr>
<td>Chemical Spills</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Environmental Conservation</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>4.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Fish O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Invertebrates O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Aquatic Plants O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Average Score</td>
<td>4.0</td>
<td>(1.50)</td>
</tr>
<tr>
<td>Category</td>
<td>Score</td>
<td>Average Score</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------</td>
<td>---------------</td>
</tr>
<tr>
<td>Water Utilization</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Fecal Coliforms</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Raw Water Supply</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>ASPR</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>MSPR</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Disaster Vulnerability</td>
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<td>2.75</td>
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<td>Flood Vulnerability</td>
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<td>2.0</td>
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<tr>
<td>FVI</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Chemical Spills</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Cadmium</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Environmental Conservation</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>4.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>NH$_4$-N</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Fish O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Invertebrates O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Aquatic Plants O/E</td>
<td>4.0</td>
<td>N.A.</td>
</tr>
<tr>
<td>Average Score</td>
<td>4.0</td>
<td>(2.00)</td>
</tr>
</tbody>
</table>
An Example of a Basin Performance Report Diagram
Expected Output of Benchmarking Recommendations

1. Basin performance report
2. Set basin performance targets
3. Set next benchmarking program
4. Recommendation for data management system improvement
Reinforcement

Why Benchmarking?

A process of continuous improvement through:

- comparison with peer RBOs, and
- comparison with the same RBO in different timeline.

Detect the gaps for sound investment

Not a solution, but a tool
Key Lessons and Issues from Implementation

Benchmarking program side

• Data availability
• Adequacy of grading threshold values

RBO side

• Strong commitment
• Institutional arrangement
• Constraints
time and capacity
Technical Issues raised

Elements

- Sediment problem
- Forestry (land use)
- Groundwater management
- Solid waste management

Definition

- Raw water supply
- Flood vulnerability

Threshold Values

- Single or multiple
“Basin Performance”
Future Research

Water-related
Water quality,
Water supply,

Expansion
Infant mortality
Literacy
Livelihoods
For More Information

Chris Morris, cmorris@adb.org

Kei Saiki, c370071@yahoo.co.jp