Sustainable Infrastructure and Asset Management

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What is Asset Management?

- The optimal allocation of the scarce budget between the new arrangement of infrastructure and rehabilitation/maintenance of the existing infrastructure to maximize the value of the stock of infrastructure and to realize the maximum outcomes for the citizens.
Asset management

- Pavement management (highway, runway)
- Railway management
- Bridge management
- Facility management
- Tunnel management
- Water supply system management
- Port facility management
- Embankment management
- Slope management
- River facility/Dam facility management
- Forest management
Dam Facility Management

- Long-term Sustainable Infrastructure

- Comprehensive management of sedimentation systems
  \(\text{(environmental change, ecological impacts, riverbed degradation, river morphology change, and coastal erosion)}\)

- Large-scale risks
  \(\text{(socio-economic change, volatility in sedimentation, green house effects)}\)
## Dam facilities based on renewal duration and management points

<table>
<thead>
<tr>
<th>Renewal duration</th>
<th>Facilities</th>
<th>Management points</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>Mechanical, Electrical, Architectural</td>
<td>Reduction of total cost of Inspection, Maintenance, Repair and</td>
<td>Improvement of service level, Technical Innovation</td>
</tr>
<tr>
<td>Several yrs - Several 10 yrs</td>
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<tr>
<td>Long</td>
<td>Reservoir (Sedimentation)</td>
<td>Renewal, Long Life, Reduction of Life Cycle cost</td>
<td>Renewal duration will be expanded by proper countermeasures</td>
</tr>
<tr>
<td>Several 10 yrs - Several 100 yrs</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Extra long</td>
<td>Dam body</td>
<td>Reduction of Inspection and Maintenance cost, Risk assessment</td>
<td>No Renewal will be necessary for extra long duration and present value of the renewal can not be evaluated</td>
</tr>
<tr>
<td>Occasional</td>
<td>Reservoir slope, Land slide, Earthquake</td>
<td>Inspection, Immediate action</td>
<td>Respond up to certain level during construction period</td>
</tr>
</tbody>
</table>
Hierarchical asset management cycles

Plan

See

Plan

See

Do

R/M strategies

Budget allocation benchmarking innovation

R/M activities

See

Do
Annual record of specific sediment yield can be plotted on log-normal probability paper using Weibull plot. 

\[ F(x) = i/(N+1) \]

**KAWAMATA dam (Tone River)**

- Annual record of specific sediment yield can be plotted on log-normal probability paper using Weibull plot.
Expected gross storage capacity change without sedimentation management

All new proposal and under construction projects included

Existing storage capacity

Japan

Chubu Region
Reservoir sedimentation in Sakuma dam

J-Power (EPDC)  
1956  Power generation  
Gravity concrete  Height=155.5 m
Future estimation of reservoir sedimentation in Sakuma dam
### Sedimentation management dams in Japan

<table>
<thead>
<tr>
<th>Classification</th>
<th>Place</th>
<th>Details of sediment control measures</th>
<th>Examples in Japan</th>
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</thead>
<tbody>
<tr>
<td>Reducing sediment flowing into reservoirs</td>
<td>Upstream reservoirs</td>
<td>Reduction of sediment production by hillside and valley works, Regulation of reservoirs and sediment by erosion control dams and slit dams, Reduction of discharged sediment and river course stabilization by channel works</td>
<td>Sabo area, Changing from sediment check dams to sediment control dams (slit dams)</td>
</tr>
<tr>
<td></td>
<td>End of reservoirs</td>
<td>Sediment check dam</td>
<td>Miwa Dam, Koshibu Dam, Nagashima Dam, Matsukawa Dam, Yokoyama Dam 57 dams</td>
</tr>
<tr>
<td>Sediment routing</td>
<td>End of reservoirs</td>
<td>Sediment bypass</td>
<td>Asahi Dam, Miwa Dam, Koshibu Dam, Matsukawa Dam, Yokoyama Dam</td>
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<td></td>
<td>Inside reservoirs</td>
<td>Sediment sluicing</td>
<td>Sabaishigawa Dam, Dashidaira Dam-Unazuki Dam (Coordinated sluicing)</td>
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<td></td>
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<td>Non-gate bottom outlets (natural flushing)</td>
<td>Masudagawa Dam</td>
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<td></td>
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<td>Density current venting</td>
<td>Koshibu Dam, Futase Dam, Kigawa Dam</td>
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<td>Sediment flushing</td>
<td>Inside reservoirs</td>
<td>Drawdown flushing</td>
<td>Katagiri Dam</td>
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<td></td>
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<td>Partial flushing without drawdown</td>
<td>Yahagi Dam</td>
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<td></td>
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<td>Sediment flushing outlet</td>
<td>Dashidaira Dam-Unazuki Dam (Coordinated flushing)</td>
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<td></td>
<td></td>
<td>Sediment scoring gate</td>
<td>Senzu Dam, Yasuoka Dam</td>
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<tr>
<td></td>
<td></td>
<td>Sediment scoring pipe</td>
<td>Ikawa Dam</td>
</tr>
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<td></td>
<td></td>
<td>Recycling for concrete aggregate</td>
<td>Miwa Dam, Koshibu Dam, Sakuma Dam, Hiraoka Dam, Yasuoka Dam</td>
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<td></td>
<td></td>
<td>Soil improving material, Farm Land filling, Banking material</td>
<td>Miwa Dam, Yanase Dam</td>
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<td>Sediment replacing inside reservoir</td>
<td>Sakuma Dam</td>
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<tr>
<td></td>
<td></td>
<td>Sediment supplying to downstream rivers</td>
<td>Akiba Dam, Futase Dam, Miharu Dam, Nagayasuguchi Dam, Nagashima Dam</td>
</tr>
</tbody>
</table>
Reservoir sedimentation

Excavated and utilized for Kobe Airport
Development of efficient and environmentally compatible sediment management techniques

- "Take", "Transport" and "Discharge"
  - Sediment flushing/sluicing and sediment bypassing should be introduced more.
  - The sediment trucking and supply, and the Hydro-suction Sediment Removal System (HSRS) need to be improved furthermore and introduced as supplementary measures.
Asset management

- Life cycle cost (LCC) minimization
  Rehabilitation and Maintenance
  from proactive maintenance to preventive maintenance

- Operation, Replacement, Expansion, Removal, Real Option
Asset management technology 1

- Inspection technology
- Inventory Database
- Tool box
- Performance curve (Markov matrix)
- LCC evaluation (Markov decision model)
- Computer systems
Asset management technology 2

- Process evaluation/reengineering
- Policy evaluation (outcome/output/input)
- Performance-based asset management contract
- Citizen participation
Two-staged project

$t_0$ → $t_1$ → $t_2$

Cost

- 30 billion JPY
- 70 billion JPY

$\{30 \text{ billion JPY, 70 billion JPY}\}$

100 billion JPY

Benefit

three scenarios

- $\frac{1}{3}$ 18 billion JPY
- $\frac{1}{3}$ 90 billion JPY
- $\frac{1}{3}$ 0 billion JPY
Cost-benefit analysis

\[ B = \frac{1}{3} \times 180 + \frac{1}{3} \times 90 + \frac{1}{3} \times 0 = 90 \]

\[ C = 100 \]

\[ B - C = 90 - 100 = -10 \text{ decline} \]
Real Option

Additional cost  70 billion JPY

\[
B - C = 180 - 70 = 110 \quad \text{Scenario 1}
\]

\[
B - C = 90 - 70 = 20 \quad \text{Scenario 2}
\]

\[
B - C = 0 - 70 = -70 \quad \text{Scenario 3} \quad \rightarrow \quad \text{decline}
\]

\[
\frac{1}{3} \times 110 + \frac{1}{3} \times 20 + \frac{1}{30} \times 0 = 43.3
\]

Real Option = 43.3 - 30 = 13.3 > 0  \quad \text{investment}
Life cycle course decision making as a real option
integrity

responsibility

accountability