Moving Towards Integrated Management of the Plateau Lakes in Yunnan Province, China: Lessons for Planning and Finance

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Yunnan, the pivotal land that links the Asian hinterland and South Asia sub-continent and Indo-Chinese Peninsular, is a plateau mountainous province in the Southwest China. It has total land area of 394,000 km² with 94% of mountainous area and only 6% of flatland.
On such mountainous area, water system are complicated and there are over 600 rivers, larger or small, widely distributed vertically and horizontally throughout the whole province, belonging to six river systems:

- Jinsha River (upper reaches of the Yangtze River),
- Nanpan River (upper reaches of the Pearl River),
- Lancang River (the upper reaches of the Mekong River),
- Yuan Jiang (upper reaches of the Red River),
- Nujiang (the Salwen River,) and
- Yinowadi River,
Plateau Lakes

Yunnan is also one of the Provinces in China with numerous lakes. There are about 40 lakes with water surface area of larger than 1 square kilometres inlaid on such highland area.

• The total lake surface area in Yunnan Province: 1066 km²;
• Total drainage basin area of about 9000 km²;
• Water resources in lakes: 30 billion m³ (13.5 % of total water resource in Yunnan Province);
Plateau Lakes

Historically, the socio-economy in Yunnan was developed along the river banks and lake basins. Lakes are vital to the local economic development process. They are critical elements of hydrological system, form vital ecosystems for aquatic biodiversity; and provide livelihood and social, economic and aesthetic benefits that are essential for improving the quality of life of the basin communities. These lakes used for various purposes, including industrial and agricultural water supply, water storage regulation, flood control, aquaculture, climate regulation, navigation and tourism and, even for drinking water.
The nine big plateau lakes are distributed in 17 counties/cities that belong to 5 prefectures/municipalities (including Kunming, Dali, Yuxi, Lijiang, Honghe). There are reputed as the “mother lake” by local people.
Dianchi Lake, in Kunming
Erhai Lake, in Dali
Chenhai Lake, in Lijiang
Xinyung Lake in Yuxi

Yangzonghai Lake In between Kunming and Yuxi

Yilong Lake in Honghe
<table>
<thead>
<tr>
<th>Name</th>
<th>River system</th>
<th>Location</th>
<th>Drainage Basin area (km²)</th>
<th>Water inflow ($10^8$ m³)</th>
<th>Average Width (km)</th>
<th>Max Depth (m)</th>
<th>Average Depth (m)</th>
<th>Water surface area (km²)</th>
<th>Average water resources ($10^8$ m³)</th>
<th>Storage Volume ($10^8$ m³)</th>
<th>Surface water Elevation (m)</th>
<th>Population</th>
<th>GDP (million)</th>
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<tbody>
<tr>
<td>Dianchi Lake</td>
<td>Jingsha River</td>
<td>Kunming</td>
<td>2920</td>
<td>5.7</td>
<td>10.5</td>
<td>10.9</td>
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<td>300</td>
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<td>12.9</td>
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<td>Yongsheng</td>
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<td>212</td>
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<td>Jiangchuan</td>
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<td>1.1</td>
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<td>37</td>
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<td>31</td>
<td>0.44</td>
<td>1.1</td>
<td>1412</td>
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<td>Lugu Lake</td>
<td>Jingsha River</td>
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<td>22.5</td>
<td>2690.7</td>
<td>3000</td>
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</table>
Important Role and Four Supportive Functions of the Nine Plateau Lakes

• Supporting the development of metropolis. Four cities (Kunming, Dali, Yuxi, Lijiang) out of the five key umbilicus cities in Yunnan Province rely on lakes and their resources to a great extent.

• Supporting the development of agriculture (particularly intensive and modern farming activities). Lake drainage basins are often the main grain production basis in Yunnan.

• Supporting the development of tourism; Lakes and their drainage basin endowed with the rich resources, beautiful landscape, colourful ethnic culture, historic heritage have high potentiality for tourism development.

• Supporting the development of special local industrial products. About 70% of large and medium sized industries / enterprises are located in the nine lake drainage basins.
Important Role and Four Supportive Functions of the Nine Plateau Lakes (cont.)

In the 9 Plateau Basin:
• Area: 9 lake basins area = 2.1% of the Province total land area
• Population in the 9 lake Basins = 9.3% of that of the province
• GDP generated in the 9 lake basins = 34% of that of the whole Province
• Social economic impact on environment: 9 lake basin bear ≈ 1/3 of the province
• Environmental stress in the 9 lake basins >average level of the province
Main Environmental Stresses of the Nine Plateau Lakes

1. Water Pollution

- location of lakes: lower reaches or nearby urban
- 9 lakes received: 289 million m³ of wastewater accumulatively in 2000, 40% to that of the Province
- lakes water quality:
  - used to be clean,
  - now, five lakes was below Class III, three lakes were worse than Class V. ½ of the 9 lakes failed to satisfy the designated functions.
  - now some lakes suffer from eutrophication, algae blooming
# Main Environmental Stresses of the Nine Plateau Lakes

## 1. Water Pollution (cont.)

<table>
<thead>
<tr>
<th>Lake</th>
<th>Designated Water Function</th>
<th>Quality assessment</th>
<th>Transparency</th>
<th>Eutrophic index</th>
<th>Main pollutant</th>
<th>Pollution extent</th>
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<tr>
<td>Dianchi-inner lake</td>
<td>V</td>
<td>&gt;V</td>
<td>0.57</td>
<td>79.18</td>
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<td>Dianchi-outer lake</td>
<td>V</td>
<td>&gt;V</td>
<td>0.51</td>
<td>64.3</td>
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<tr>
<td>Yangzonghai</td>
<td>II</td>
<td>&gt;V</td>
<td>3.22</td>
<td>32</td>
<td>As</td>
<td>Heavily polluted</td>
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<tr>
<td>Erhai</td>
<td>II</td>
<td></td>
<td>1.63</td>
<td>36.8</td>
<td>—</td>
<td>Good quality</td>
</tr>
<tr>
<td>Fuxian</td>
<td>I</td>
<td></td>
<td>4.48</td>
<td>19.49</td>
<td>—</td>
<td>Excellent quality</td>
</tr>
<tr>
<td>Xingyun</td>
<td>III</td>
<td>&gt;V</td>
<td>0.62</td>
<td>63.8</td>
<td>TN</td>
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</tr>
<tr>
<td>Jilu</td>
<td>III</td>
<td>&gt;V</td>
<td>0.91</td>
<td>58.93</td>
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<td>Chenghai</td>
<td>III</td>
<td>III</td>
<td>3.0</td>
<td>29.8</td>
<td>—</td>
<td>Good quality</td>
</tr>
<tr>
<td>Lugu</td>
<td>I</td>
<td>II</td>
<td>11.0</td>
<td>4.9</td>
<td>—</td>
<td>Excellent quality</td>
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<tr>
<td>Yilong</td>
<td>III</td>
<td>V</td>
<td>1.08</td>
<td>53.67</td>
<td>TN, COD₉₉</td>
<td>Heavily polluted</td>
</tr>
</tbody>
</table>
Main Environmental Stresses of the Nine Plateau Lakes

2. Ecological Deterioration

• Reduced forest coverage 28.6% lower than provincial average (about 50%)

• Soil erosion: maximum 64.6%, average 45%, low 20%.

• Lake shoreline and wetland disappearing

• Weak self-purification capacity
Main Environmental Stresses of the Nine Plateau Lakes

3. Water Scarcity, Low Storage Capacity and Water Supply short of Demand

Plateau lakes are generally tectonic fault lakes. Most of them are closed or semi-closed lakes. They are no sufficient water from transit rivers to replenish the lakes water:

• Per capita water resources (m3/year/person)

<table>
<thead>
<tr>
<th></th>
<th>the nine lakes average</th>
<th>Province average</th>
<th>national average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>98 ~1379</td>
<td>5,890</td>
<td>2,480</td>
</tr>
</tbody>
</table>

• evaporation from lake surface > precipitation

• lower regulating capacity of shallow lakes, flooding in the wet year and drought in the dry year

• water withdrawn from lake exceed water availability
Main Environmental Stresses of the Nine Plateau Lakes

4. Irrational Economic Development Weakened Lakes’ Economic and Ecological Functions

The serious soil erosion, land reclamation for farming have led to the siltation of the lake beds, reduction of lake volumes and shrinkage of the lake area and accelerated lakes process towards marsh lands:

• Dianchi Lake: used to be 1000 m² big and 50 m deep (3 million yr ago), now 300 m² and 4.4 m deep, with reduced storage volume of 210 million m³ and sedimentation of over 50 million m³.

• Erhai Lake: lowered water level (maximum difference was 2.44 meters) due to operation of 4 cascade hydro-power stations

• Yilong Lake: reduced water surface area from 36 km² (in 1950s) to 30 km², keep lowering of water level
Actions Taken for lakes
Environmental Protection

- Setting up a organizational framework (leading groups and work units at both provincial level and local level)
- Improving legal framework, “one ordinance for one lake” practiced
- Developing comprehensive plan: each lake developed its “plan for comprehensive water pollution prevention and control” once in every five years to guide the investment and actions
- Enhanced investment input: establishment of special funds for the nine lakes: (50 million from provincial revenue plus local counterpart fund each year); completed 2.989 billion RMB (1996-2000) and 4.08 billion RMB (2001-2005)
Actions Taken for lakes
Environmental Protection

• Input includes:
  – Control of point pollution sources (urban sewage, industrial effluents,
  – Control of non-point pollution sources through rural sanitation program: eco-latrines and bio-gas tanks, compost system, rural waste collection and disposal, and balanced application of fertilizers on farmland
  – Removal of internal sources: contaminated sediment dredging
Actions Taken for lakes
Environmental Protection

- Input includes:
  - Urban domestic solid waste collection, transfer and disposal
  - Water regulation: in the basin or inter-basin water diversion
  - Cleansing of rivers flowing into the lake
  - Ecological conservation and rehabilitation, reforestation prohibiting illegal mining, returning farmland, fishponds to the lake, re-establishment of wetland along the lake shorelines
  - Pilot works for testing and popularization of new technology
Examples of Some Achievements

Construction of sewage treatment plants:

A total of 14 domestic solid waste sanitary disposal sites with disposal capacity of 3818 t/a constructed in the 9 lake basin
Examples of Some Achievements (cont.)

西园隧道

截污工程

Water regulation
Examples of Some Achievements (cont.)

Contaminated sediment dredging to remove internal pollution sources
Examples of Some Achievements (cont.)

Rural sanitation activities for agricultural runoff control
Examples of Some Achievements (cont.)

Villagers participate in discussion of re-forestation for soil erosion control
Lessons for Planning

All the actions were taken based on:

- improved awareness of the importance, complexity, and difficulties of lakes and their environmental management,

- improved planning based on the better diagnosis of the lake environmental stresses
Plateau lake basins management in Yunnan has been through following progression:

• **From simple action towards planned action**
  - Actions are resources exploitation-driven before environmental degradation
  - Diverting pollution sources out or treatment:
    - industrial pollution sources, and urban serage
    - after pollution became significantly visible
Lessons for Planning

Plateau lake basin management in Yunnan has been through following progression:

• From sector planned action towards integration of sectors planned action by taking the basin as a whole
  - Industrial pollution control plan, urban master plan, water conservancy plan forestry plan, etc. prepared separately
  - Integration of these plans by taking the lake basin as a whole
  - Five-Year Plan for Water Pollution Prevention and Control Lake Basin prepared once in every five years for each lake
Lessons for Planning

Plateau lake basin management in Yunnan has been through following progression:

• From short-term and mid-term plan towards long-term plan
  - Implementation of Five-Year Plans for Water Pollution Prevention and Control in Lake Basins
  - Evaluation of the implementation performance
  - Long-term plan preparation for some lakes:
    • *Mid-Term to Long-Term plan for Water Pollution Prevention and Control* and a *Master Scheme for Water Pollution Prevention and Control* for Dianchi Lake
    • Long-term Plan for Environmental Protection and Water Pollution Control in Erhai Lake Basin (2003-2020)
Lessons for Planning

Plateau lake basin management in Yunnan has been through following progression:

• Future: towards long-term lake basin management master plan
  - A long-term master plan for integrated water and environment management, balancing environment protection and socio-economic development to achieve balanced economic, environmental and social outcomes is necessary for those lakes which are located nearby the urban area and suffering from serious pollution, and the actions taken did not result significant positive impact.
Lessons for Planning

Plateau lake basins management in Yunnan has been through following steps:

• Future: towards long-term lake basin management master plan
  - The lake basin master plan:
    • is to be developed prepared on the basis of the sector plans for the balanced development between economic development and environment protection;
    • both point and non-point pollution sources from cities and counties as well as the rural areas of the lakes will have to be addressed under the plan, though the non-point pollution control has a less priority in the government’s 11th five-year plan for pollution control;
    • the issues on both water quality and water quantity as well as social and economic activities will have to be addressed and analyzed together in order to have a balanced social, economic and environment outcomes for the Lake Basins; and
    • both engineering measures and demand management measures will be considered, with a focus on demand management measures
Lessons for Financing

From single fund source towards widened channels for financing

- In 1980s and early 1990s, the financing channel simple and narrow:
  - Industries follow “polluter pays principle” to install pollution treatment facility;
  - Central and local governments financial revenue for the establishment of urban environmental infrastructures.
Lessons for Financing

From single fund source towards widened channels for financing

• Since later 1990s, with more policies granted from central and local governments, more financing channels were available. Additional funds include:
  - loan borrowings from World Bank, Asian Development Bank, and bilateral government;
  - loan from the State Development Bank of China or state bounds and commercial banks;
  - donations from State Bonds and from social donations;
  - tariff revenues from charging waste water and domestic waste and water resources.
Lessons for Financing

From single fund source towards widened channels for financing

- Since 2000, in addition to above financing source, two special funds were available:
  - Yunnan Government established a special fund of 50 million RMB per annum, which was increased to 60 million per annum since 2006.
  - Central government established special funds for water pollution control since 2006 to which Yunnan can apply to manage plateau lakes. In the new twenty first century, BOT, BT, were also introduced as well to have attracted more financers.
Lessons for Financing

- With the widening of financing channels, funds inputs in the plateau lake management are also increased step by step:

9th-five year  10th-five year  11th-five year  
¥2.898 billion  ¥4.08 billion  ¥7.0 billion