Global Water Resources

Will we have Enough!!!
World Population: 1950-2050

Source: U.S. Census Bureau, International Data Base 5-10-00.
Huge needs

- Water-related disease kills 1 child every 8!
- 50% of people LDCs suffer from water-related diseases
- 50% of population lacks adequate sanitation
- 1 billion people without safe water,
- 2 billion w/o sanitation,
- 4 billion w/o sewage treatment
- Contaminated water
  - causes 80% of developing world diseases
  - has pushed 20% of freshwater fish species to the edge of extinction
- Existing systems are run-down
- We need to provide sanitation for 1.2 millions and water for 600,000 additional persons/week for 15 years to meet MDG
A World of Salt
Total Global Saltwater and Freshwater Estimates

Saltwater 97.5%
1 365 000 000 km³

Freshwater 2.5%
35 000 000 km³

0.3% Lakes and river storage
30.8% Groundwater, including soil moisture, swamp water and permafrost
68.9% Glaciers and permanent snow cover

Since 1900 global population has tripled.
Water use has increased 6 times.
% Supply Withdrawn

**Freshwater Stress**

1995

2025

Water withdrawal as percentage of total available:
- Over 40%
- 20% - 10%
- 40% - 20%
- Less than 10%

## Per capita consumption of water/day

<table>
<thead>
<tr>
<th>Continent/Region</th>
<th>Liter/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>70</td>
</tr>
<tr>
<td>South America</td>
<td>183</td>
</tr>
<tr>
<td>Asia</td>
<td>226</td>
</tr>
<tr>
<td>Central America</td>
<td>231</td>
</tr>
<tr>
<td>Israel</td>
<td>240</td>
</tr>
<tr>
<td>Europe</td>
<td>337</td>
</tr>
<tr>
<td>USA</td>
<td>556</td>
</tr>
<tr>
<td>(Australia/NZ)</td>
<td>601</td>
</tr>
</tbody>
</table>

Domestic, Agriculture. Industrial consumption of water (m3/per capita/yr)

From Dr. Rick hardiman, Truman centre for Peace HUJI
### Table 3.3 Virtual Water Content of Selected Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Liters of water per kilo of crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1,150-1400</td>
</tr>
<tr>
<td>Rice</td>
<td>2,656-3400</td>
</tr>
<tr>
<td>Maize</td>
<td>450</td>
</tr>
<tr>
<td>Potatoes</td>
<td>160</td>
</tr>
<tr>
<td>Soybeans</td>
<td>2,300</td>
</tr>
<tr>
<td>Beef</td>
<td>15,977</td>
</tr>
<tr>
<td>Pork</td>
<td>5,906</td>
</tr>
<tr>
<td>Poultry</td>
<td>2,828</td>
</tr>
<tr>
<td>Eggs</td>
<td>4,657</td>
</tr>
<tr>
<td>Milk</td>
<td>865</td>
</tr>
<tr>
<td>Cheese</td>
<td>5,288</td>
</tr>
</tbody>
</table>

Source: Adapted from Hoekstra (2003)
No money

- Fiscal constraints
- Official aid stagnant (< $3bn/yr, WB $1bn)
- Public utilities unable to self-finance or to carry debt
- Private investment: a relative trickle so far
“Population growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst. Many more conflicts lie just over the horizon,”

“This is not an issue of rich or poor, north or south,” he said, pointing to examples of water problems in China, the United States, Spain, India, Pakistan, Bangladesh and the Republic of Korea. “All regions are experiencing the problem.”

(Mr. Ban Ki-moon, the UN Secretary-General (World Economic Forum, Davos, January 2008)
The Economic Value of Water
% water use Agriculture, Industry Domestic
Indicative Water Pricing Comparisons in Europe

- Netherlands
- France
- UK
- Greece
- Spain
- Austria
- Turkey
- Portugal
- Hungary

Euro/m³

Households | Industry | Agriculture
Pricing water

• Different water prices for:
  – Administrative Use
  – Domestic Use
  – Industrial Use
  – Business/service use
  – Special use (e.g. health clubs/spas)
  – Agricultural Use

• Considerations
  – Local situation (water availability and needs)
  – Socio-economic considerations (consider poor population)
  – Income difference (haves and have-not)
Factors affecting industry water tariffs

- Low tariffs encourage local industrial investment
- Low tariffs provide market competition (local and national)
Economic Value of Water
E.g. Hai River (most polluted water source in China)

Drinking water production cost 0.75 USD/m³
– Average Economic Value: 6 USD/m³
– Industry 30.5 USD/m³
– Construction 26.5 USD/m³
– Agriculture 1-2 USD/m³
  • Rice: 0.2 USD/m³
  • Vegetables: 1.8 USD/m³
Agricultural tariffs

- Tariff very low, (0.1 USD/m3)
- based on area not volume,
- difficult to collect
- Socio-economic implications
- Water pollution – fertiliser efficiency
- Reliability of supply
<table>
<thead>
<tr>
<th>Percentile of the Cost of Water</th>
<th>Depth of Water (m)</th>
<th>Average Cost of Water (CNY/m³)</th>
<th>Water Use (m³/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wheat</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Average</td>
<td>31</td>
<td>0.24</td>
<td>4,608</td>
</tr>
<tr>
<td>2. 0-25%</td>
<td>14</td>
<td>0.08</td>
<td>6,433</td>
</tr>
<tr>
<td>3. 26-50%</td>
<td>21</td>
<td>0.20</td>
<td>5,285</td>
</tr>
<tr>
<td>4. 51-75%</td>
<td>52</td>
<td>0.30</td>
<td>2,934</td>
</tr>
<tr>
<td>5. 76-100%</td>
<td>53</td>
<td>0.56</td>
<td>2,154</td>
</tr>
<tr>
<td><strong>Maize</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Average</td>
<td>34</td>
<td>0.24</td>
<td>2,019</td>
</tr>
<tr>
<td>2. 0-25%</td>
<td>20</td>
<td>0.06</td>
<td>2,255</td>
</tr>
<tr>
<td>3. 26-50%</td>
<td>34</td>
<td>0.16</td>
<td>2,094</td>
</tr>
<tr>
<td>4. 51-75%</td>
<td>57</td>
<td>0.26</td>
<td>1,463</td>
</tr>
<tr>
<td>5. 76-100%</td>
<td>68</td>
<td>0.52</td>
<td>1,119</td>
</tr>
<tr>
<td><strong>Cotton</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Average</td>
<td>51</td>
<td>0.29</td>
<td>1,241</td>
</tr>
<tr>
<td>2. 0-25%</td>
<td>41</td>
<td>0.14</td>
<td>2,322</td>
</tr>
<tr>
<td>3. 26-50%</td>
<td>46</td>
<td>0.23</td>
<td>931</td>
</tr>
<tr>
<td>4. 51-75%</td>
<td>47</td>
<td>0.33</td>
<td>994</td>
</tr>
<tr>
<td>5. 76-100%</td>
<td>108</td>
<td>0.51</td>
<td>978</td>
</tr>
</tbody>
</table>

Source: Huang et.al 2007
Agricultural Tariff – What happens if it increases?

- **Wheat**
- **Maize**
- **Cotton**

Cost/m³ over time:
- Year 1: 6,000 m³
- Year 2: 5,000 m³
- Year 3: 4,000 m³
- Year 4: 3,000 m³

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Maize</th>
<th>Cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Dr. Rick Hardiman, Truman Centre for Peace, HUJI
Impact of higher water prices on crop production

Source: Huang et al. 2007)
Amount Paid for Water and Willingness to Pay for Irrigation of Wheat

Volumetric vs. Area based water measurement

• Volumetric at Main/lateral Canals

• Area based at sub-lateral and below
Irrigation efficiency

Irrigation efficiency = 0.35-0.40

Irrigation efficiency = 0.7-0.9
Agricultural Water Coupons and the Market Economy

- Allocation of fixed volume of water to Water User Associations and its members (farmers)
- Sell accordingly to Market price like stock exchange
- Funds channelled through bank
- Problem – will it create a desert?
Domestic Water Tariffs: Main issues

- Water and waste water tariffs still too low
  - Water price varies by county/municipality 70% of counties less than 0.2 USD/m³
  - 66% of water supply companies make a loss (2 million USD)

- Companies unable to make a profit

- Companies semi-government: accounts do not consider: amortization, salaries, depreciation of equipment, land costs, power costs

- Cannot increase price because of income disparity

- Default of payment by poorer counties
Domestic water and waste water tariffs vs. Income

Table 3: Comparison of economic development and water price among different small towns in Yunnan in 2004

<table>
<thead>
<tr>
<th>Item</th>
<th>Shiping County</th>
<th>Luxi County</th>
<th>Ninglang County</th>
<th>Luchun County</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP (10^4 Yuan)</td>
<td>120834</td>
<td>144857</td>
<td>57279</td>
<td>34989</td>
</tr>
<tr>
<td>Per capita GDP (Yuan)</td>
<td>4145</td>
<td>3848</td>
<td>2421</td>
<td>1699</td>
</tr>
<tr>
<td>Average salary (Yuan)</td>
<td>12546</td>
<td>13127</td>
<td>12489</td>
<td>10260</td>
</tr>
<tr>
<td>Domestic water price (Yuan/m³)</td>
<td>2.00</td>
<td>1.84</td>
<td>0.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table 5: Proportion of water price and wastewater tariff in the household income in the demo sites and other cities

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Lijiang</th>
<th>Binchuan</th>
<th>Shangri-La</th>
<th>Western region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chongqing</td>
</tr>
<tr>
<td>Water price (%)</td>
<td>1.5</td>
<td>2.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Wastewater tariff (%)</td>
<td>0.3</td>
<td>--</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Total (%)</td>
<td>1.8</td>
<td>2.5</td>
<td>1.1</td>
<td>2.6</td>
</tr>
</tbody>
</table>

- ADB/WB estimates tariff maximum is 3-5% of household income
- In Israel about 2% of income

From Dr. Rick hardiman, Truman centre for Peace HUJI
Percentage of income spent on domestic water supply + wastewater treatment for poor and average income households
Tariffs and subsidies (Chongqing)

• Poor Family (100 USD/month) consume 8 m³/month, receive subsidy 5 USD/month;
• Rich Family (1000 USD/month) consume 30 m³/month, receive subsidy 30 USD/month;
• Public spent more on bottled water than on water fee due to concerns of water quality
• Chongqing Water tariffs and the haves and have-nots
  – Unemployment 4-5%
  – Poor (under 80 USD/month) 28%
Tiered Domestic water pricing/household

**Lijiang**

- **1\(^{st}\) block**: 25 m\(^3\) = 0.2 USD/m\(^3\)*
- **2\(^{nd}\) block**: 26-35 m\(^3\) = 0.3 USD/m\(^3\)
- **3\(^{rd}\) block**: ≥ 35 m\(^3\) = 0.4 USD/m\(^3\)

*based on 40 l/person/day

WHO

**Israel**

- **1\(^{st}\) block**: 8.5 m\(^3\)/mth = 1.5 USD/m\(^3\)
- **2\(^{nd}\) block**: 9-18 m\(^3\)/mth = 2.5 USD/m\(^3\)
- + fine
No money

– Fiscal constraints
– Official aid stagnant (< $3bn/yr, WB $1bn)
– Public utilities unable to self-finance or to carry debt
– Private investment: a relative trickle so far
Foreign Investment in Water supply and waste water treatment

- Caution of foreign companies managing water resources
- BOT (Build Operate and Transfer, 20 years
- No guarantee of collecting fees hence contract with municipality
- Contract for Water Supply + piping network (every 1% leakage reduced = 1% profit)
- Main interest in large cities not in rural poor
- Will not invest in 3rd tier cities
- Investment slow due to:
  - (i) poor returns (tariff collection,
  - (ii) respect of contract agreement
Privatisation of the water sector and Policy Considerations

• Access of public utilities to foreign companies

• Market-oriented
  – Reasonable price
  – Reasonable profit

• Privatization (Foreign and local investment)
Industrial: 0.7-0.35 USD/m³
Domestic: 0.3-0.15 USD/m³
Agricultural: 0.01 USD/m³
Major water consumers: metallurgy, timber processing, paper and pulp, petroleum and chemical industries.

*The value of water!!*

From Dr. Rick hardiman, Truman centre for Peace HUJI
### Table 3.2 Wastewater Treatment Cost for Major Industrial and Domestic Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Treatment cost (yuan/m³)</th>
<th>USD/m³ Treatment Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal mining and washing</td>
<td>2.00</td>
<td>0.30</td>
</tr>
<tr>
<td>Food processing</td>
<td>3.20</td>
<td>0.40</td>
</tr>
<tr>
<td>Food manufacturing</td>
<td>1.95</td>
<td>0.30</td>
</tr>
<tr>
<td>Beverage manufacturing</td>
<td>1.65</td>
<td>0.25</td>
</tr>
<tr>
<td>Textile manufacturing</td>
<td>2.50</td>
<td>0.35</td>
</tr>
<tr>
<td>Paper and paper products manufacturing</td>
<td>2.50</td>
<td>0.35</td>
</tr>
<tr>
<td>Raw chemical materials and products</td>
<td>3.70</td>
<td>0.55</td>
</tr>
<tr>
<td>Petrochemicals</td>
<td>3.80</td>
<td>0.60</td>
</tr>
<tr>
<td>Medicines manufacturing</td>
<td>1.90</td>
<td>0.30</td>
</tr>
<tr>
<td>Chemicals manufacturing</td>
<td>3.70</td>
<td>0.55</td>
</tr>
<tr>
<td>Chemical fibers manufacturing</td>
<td>2.80</td>
<td>0.35</td>
</tr>
<tr>
<td>Non-metallic mineral products</td>
<td>2.65</td>
<td>0.35</td>
</tr>
<tr>
<td>Iron and steel smelting and pressing</td>
<td>3.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Power generation and heating</td>
<td>2.00</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Water Entitlements and Trading WET (Australia)
Water Entitlements and Trading

WET

- Water rights are allocated to Administrative Areas (AAs)
- Certain amount of water must be reserved for ‘Environmental Flow’
- Issue Water Extraction Permit
- Remaining water volume can be used or sold to other AAs
- Funds collected can be used to invest in upgrading water distribution system e.g. irrigation, pollution etc and therefore save on water
- Hence agric./household/industry will not suffer
Availability for trade = Total volume of flow –
Environmental flow – AA water demand
Environmental flow

Maximum Level of Exploitation to ensure Environmental Flow

1997 Yellow River dry 226 days

Songhua Liao Hai Yellow Huai Yangtze S.E. Pearl S.W. N.W.

- Songhua River: 19%
- Liao River: 101%
- Hai River: 40%
- Yellow River: 76%
- Huai River: 53%
- Yangtze River: 17%
- South East China Rivers: 16%
- Pearl River: 17%
- South West China Rivers: 41%
- North West China Rivers: 1%
Environmental Flow

Step 1: Identify the key river assets

Step 2: Determine if flow, or lack of flow, is a major constraint upon these assets

Step 3: Determine the environmental flow requirements for these assets

Step 4: Determine options to meet the environmental flow requirements

Step 5: Set monitoring requirements to check implementation and effectiveness

1.1 What are environmental river assets and values?
1.2 How are river assets and values identified?
1.3 How can river assets and values be prioritised?

2.1 How have flow regimes changed?
2.2 What are the other issues related to water resource development and management?
2.3 What are other threats to river assets and values?

3.1 What are the key flow components that sustain/restore important assets?
3.2 How can flow recommendations for key flow components be developed?
3.3 How can relationships between river flows and ecological outcomes be validated?

4.1 How can constraints be modified to provide environmental flows?
4.2 How are the options for providing environmental flows determined?
4.3 How are environmental flows incorporated into regulation?

5.1 How are environmental flow provisions monitored?
5.2 How is the effectiveness of environmental flow provisions assessed?
Environmental flow (40%)

Maintaining basic river function:

- drying-up,
- water for self-purification,
- flushing sediments
- survival of aquatic species
- flow to lakes and wetlands
- flow at river mouth (includes water demand for flushing, sediment, protect harbour, diluting salt water and preventing tide, protecting species at river month.)
Example B

Flow regime

- Low flows
  - Maintain pools
    - Fish Migration
- High flows
  - Inundate riffles
    - Fish Spawning
- Flow pulses
- Floods
  - Scouring and sediment removal
    - Maintenance of benthic habitats
  - Invertebrate food source
    - Maintenance of adult fish populations

Conceptual flow diagram of the influence of flow on fish. Low flows maintain critical deep pool habitats for large bodied species during the dry season. High flows during the wet season maintain fish passage over riffles. High flow pulses trigger fish spawning and migration. Pulses and floods maintain river habitats and, scour and remove sediments for benthic invertebrates food sources.
Groundwater

Water tables are plunging in places like Limdi, Saurashtra. Six out of 10 borewells dug in north Gujarat and Saurashtra-Kutch region yield no water even at a depth of 1,200 ft. Over 2.5 crore people in Gujarat are now in distress.

From Dr. Rick hardiman, Truman centre for Peace HUJI
Dams
The Good, the Bad and the Ugly
Distribution of Large Dams by Geographical Area

- Asia: 39%
- South America: 3%
- Africa: 5%
- North America: 32%
- Europe: 19%
- Australia - Asia: 2%
Let’s Dam the Mekong
The Benefits We Receive From Dams

- Water supply – domestic, agricultural & industrial
- Flood control
- Hydropower
- Inland navigation

Recreation is usually included in all projects
Miaohe village – leaving home
Dams and the Environment

“A balance is needed”
So... what to do??

- Use combination of policy, economics and technology
  - Agriculture – increase efficiency
  - Industry – reduce pollution
  - Use water tariffs and private enterprise
- Desalination??