Use of Water and Land for Food Security and Environmental Sustainability

By Datuk Ir. Hj. Keizrul bin Abdullah
President
International Commission on Irrigation and Drainage
ICID
15 September 2005

Legend says that King Nebuchadnezzar II built the Hanging Gardens of Babylon for his Persian wife, who missed the green hills of her native land. Gardens were so precious to the Persians that their word “paradise” meant “garden.” No trace remains of the gardens today, and we have only a few clues that they might have existed.

Although the gardens—if they existed—disappeared long ago, archaeologists have found the remains of an irrigation system in Babylon. It could have carried water to a garden built on the roof of a building.

Hanging Gardens of Babylon

Ancient Irrigation Systems

Water Wheel
### Irrigated and Drained Areas

<table>
<thead>
<tr>
<th>Continent</th>
<th>Irrigated Area Mha</th>
<th>Drained Area Mha</th>
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</thead>
<tbody>
<tr>
<td>Total -101 countries</td>
<td>262.10</td>
<td>171.39</td>
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<tr>
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<tr>
<td>Europe</td>
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<td>46.06</td>
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<tr>
<td>Oceania</td>
<td>2.66</td>
<td>2.17</td>
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<td>Africa</td>
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<tr>
<td>Asia</td>
<td>183.51</td>
<td>54.72</td>
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</tbody>
</table>

Ref: ICID 2004

### Water Withdrawals

- Irrigation water use efficiency generally low: 20% (paddy) to 90% drip
- Average for developing countries ~43%
- Irrigated Agriculture → guzzler of water
- Calls from NGOs for improvement in water productivity → water efficiency & higher crop yields

Ref: World Bank

Ref: ICID 2004
Over-irrigation resulting in ……

….. water-logged agricultural areas

….. and Desertification

Excessive pumping of groundwater

Fertilizer residue in return flow

Similarly drainage projects has many impacts
+ve, -ve / direct-indirect /On-site, Off-site/
Irrigation and drainage seen as polluters and cause of environmental degradation

Led to decline in irrigation and drainage investments

World Bank funding: US$ 700 - 800 m → US$ 200 - 300 m

Number of projects 20-25 → 5-6

New projects → Rehabilitation
Ref: Salah Darghouth, WB

**Irrigation Expansion**

- 1970-1980: 2.3%
- 1980-1990: 1.3%
- 1990-2000: 0.6%
- 2000-2025: 1.0%

Ref: Hopper

**Rate of Increase of Irrigated Area**

- World
- Developing Countries
- Developed Countries
- China
- India

**Poor Prospects for new Irrigation & Drainage Projects**

1. Rising capital cost
2. Low return on capital
3. Problem of operation and maintenance
4. Low efficiency of water use
5. Low level of water charges and revenues
6. Environmental impacts of projects (dams)
7. Degradation of natural resources

**Irrigated Agriculture at the crossroad**

**Is Irrigation a “Sunset” industry??**
Food shortage in 35 nations

ROME, Feb. — Thirty-five countries —½ of them in Africa — are facing severe food shortages because of war, poor rainfall and disease, a UN report released Monday said.

The report released by the Rome-based UN Food and Agriculture Organization said that in southern Africa food assistance had been rushed to people left homeless by severe flooding in eastern Zambia and parts of Angola, Namibia, Botswana and Zimbabwe.

In four UN agencies have an emergency operation worth $550 million (€477.7 million) to help feed more than 3.5 million people displaced by conflict, while in several western African countries hundreds of thousands are threatened by food deficits, said the report.

In Ethiopia could face a potential food deficit of up to four million tonnes of cereal this year, the agency says. However, a UN team was forced to halt its work in the country earlier this month after its helicopter workers were snatched by militia forces, said Sylvia Bokothera of the FAO in Rome.

In North Korea, 490,000 people have been forced to leave flooded areas, and 128,000 tonnes of aid has been shipped. In most cases, food aid is the only hope for the country, which is at the mercy of international aid agencies.

In Haiti, despite an improvement in the weather, the number of people who have been affected by flooding in the country has now reached 2.5 million. The government has appealed for international assistance, but so far only a few countries have responded.

In Africa, food prices have been rising, and many governments have imposed price controls to try to protect the poor. But in some cases, the controls have led to shortages and black markets.

The report is the latest in a series of UN studies that have highlighted the severity of the food crisis, which affects more than 200 million people worldwide.
Disaster → Starvation

Extreme events: famines, wars

850 million

8%

92%

Chronic malnutrition

8%

850 million

• FAO → 850 million people undernourished
• 815 million in developing countries and 27 million in countries in transition
• 5 million children die annually from hunger
• In economic terms, developing countries lose $ billions in lost productivity and earnings

Smallholder farms: 50%
The rural landless: 22%
The urban poor: 20%

Chronically hungry

Forests dwellers, pastoralists, fishermen: 8%

Food Shortage

FOOD SECURITY

Food Security

- FAO definition → physical, social and economic access for all people to sufficient, safe and nutritious food for an active and healthy life
- At global level, ability to produce food > ability to get the food to those in need
- At regional/national level, there are discrepancies

In 1996 FAO → World Food Summit

- Objective → to get global commitment to eliminate hunger and malnutrition, and to achieve sustainable food security for all people
- World Food Summit and MDG goal → reduce by 50% by 2015
- Need to reduce by 22 million/yr c.f. current rate only 6 million/yr

Number of undernourished in the developing world: observed and projected ranges compared with the World Food Summit target

Net World Cereal Export Surplus in Million ton (T), or in % of Own Production (OP)

CHALLENGES AHEAD

1. Population Growth
UN: World is facing disaster

‘Population booming at unsustainable rate’

GLOBAL POPULATION 1960 - 2050

- 50% increase in population by 2050

WORLD POPULATION

Population

- 50% increase in population by 2050

POPULATION DISTRIBUTION

ASIA - Population vs Land Area

World - Population

60%

40%

ASIA

World - Land Area
Global Rice Outlook

International Rice Research Institute

1990 - 455.2 million tons
2020 - 781.3 million tons

- Increase of 40%
- Require additional 9.8 million ha of land
- Assuming yields of 3.2 tons of rice per ha.

POPULATION IN AGRICULTURE

Total population and population economically active in agriculture in year 2000

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Population (million)</th>
<th>Growth rates (% p.a.)</th>
<th>% of total population active in agriculture</th>
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<td>294.6</td>
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Population

- 50 % increase in population by 2050
- Rural - urban migration
- Declining role of agriculture (GDP, labour)
Population

- 50% increase in population by 2050
- Rural - urban migration
- Declining role of agriculture (GDP, labour)
- Changes in lifestyle

Lifestyle

- More disposal income → Change in diet, more consumption of meat
- Developed countries → 70-100 kg/p/yr
c.f. < 20 kg/p/yr in developing countries
- Developing world catching up
  China: 11 kg (1975) → 50 kg (2000)

Water to produce various consumables...

- 1 kg beef: 44,000 litres
- 1 doz. eggs: 8,400 litres
- 1 burger & fries: 7,900 litres

Water Requirement Equivalent

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<th>Food Product</th>
<th>Unit</th>
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<tr>
<td>Sheep and goats</td>
<td>head</td>
<td>500</td>
</tr>
<tr>
<td>Fresh beef</td>
<td>kg</td>
<td>15</td>
</tr>
<tr>
<td>Fresh lamb</td>
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<td>10</td>
</tr>
<tr>
<td>Fresh poultry</td>
<td>kg</td>
<td>6</td>
</tr>
<tr>
<td>Wheat</td>
<td>kg</td>
<td>1</td>
</tr>
<tr>
<td>Paddy</td>
<td>kg</td>
<td>2</td>
</tr>
<tr>
<td>Rice</td>
<td>kg</td>
<td>5</td>
</tr>
<tr>
<td>Palm oil</td>
<td>kg</td>
<td>2</td>
</tr>
<tr>
<td>Pulses, roots, tubers</td>
<td>kg</td>
<td>1</td>
</tr>
</tbody>
</table>

Lifestyle

- More disposal income → Change in diet, more consumption of meat
- Developed countries → 70-100 kg/p/yr
c.f. < 20 kg/p/yr in developing countries
- Developing world catching up
- Need to increase cereal production
  1.84 b tons → 2.8 b tons by 2030
  [50% food, 44% feed]

Challenges Ahead

1. Population Growth
2. Limited Water Resources
Freshwater resources the key to survival

Warning of the biggest threat to haunt the world this century

Population and temperature increase will result in water crisis. Water crisis will be a worldwide problem. The world population is increasing fast with the availability of more food. Temperature increase will lead to more water crisis. The availability of water will depend on rainfall and temperature. Both of these factors are more predictable with climate change. The result will be a water crisis.

Growing Demand for Water

GLOBAL POPULATION 1960 - 2050

Ref: UN

Freshwater availability per capita 1950 - 2050

Growing Demand for Water

Dry spell can hit Kedah’s 63,000 padi farmers soon

By Abdul Razak Ahmad

The dry spell is hitting the Kedah farmers hard. The lack of rain has caused a decrease in the water levels at the reservoirs. This has resulted in a decrease in the water availability for the farmers. The farmers are facing difficulties in water management, leading to a decrease in the production of padi. The dry spell is expected to continue, causing further problems for the farmers.

Water Crisis

Senior citizens hard hit by water rationing

The lack of water has caused a decrease in the availability of water for the senior citizens. Water rationing has been imposed in the area, causing difficulties for the elderly. The government has implemented measures to ensure the availability of water for all citizens, including the elderly. The situation is expected to improve as the dry spell subsides.
To meet 2025 food production levels need ~ 2,000 cubic km of additional irrigation water (24× annual flow of Nile River)

By 2025, ~2.7 billion people (1/3 world population) facing severe water shortage

Chronic competition for water expected
Challenges Ahead

1. Population Growth
2. Limited Water Resources
3. Limited Land Resources

Land Utilisation

- 1.5 billion ha used for crop production
- Crop production areas growing @ 1.3 % per yr vs 2.2 % during past 30 years
- Arable land per capita decreasing from 0.3 ha (1989-91) to 0.2 ha (2000-2002)

Arable land (ha/person)

Ref: World Bank

Land Utilisation

- 1.5 billion ha used for crop production
- Crop production areas growing @ 1.3 % per yr vs 2.2 % during past 30 years
- Arable land per capita decreasing from 0.3 ha (1989-91) to 0.2 ha (2000-2002)
- Expansion of land base to marginal lands

Hills cleared for agriculture

...... and rice cultivation
Marginal soils utilised for Agriculture

MARGINAL SOILS AND LOW-LYING AREA
Require Intensive Infrastructure
Low Productivity

• 1.5 billion ha used for crop production
• Crop production areas growing @ 1.3 % per yr vs 2.2 % during past 30 years
• Arable land per capita decreasing from 0.3 ha (1989-91) to 0.2 ha (2000-2002)
• Expansion of land base to marginal lands
• Regional differences

Limited Arable Land and Competition for other Usage

Cropland in use and total suitable land (million ha)

Ref: FAO data and Fischer et al. (2000)

1. Providing Irrigation and Drainage

FEEDING THE WORLD
**Irrigation and drainage infrastructure reduce risk from water-related hazards.**

- **WORLD FOOD PRODUCTION**
  - Irrigated: 40%
  - Non-Irrigated: 17%

**Dry Season - Water Scarcity**

**Canals supply water**

**Wet Season - Water Logging**

**Drains remove excess water**
Infrastructure

- Irrigation and drainage infrastructure reduce risk from water-related hazards
- Infrastructure necessary for assured water supply, multiple cropping / yr

Multiple cropping = Multiple production

Better water management - improve yields

More intensive cropping density

Figure 3. Typical response to water for cereal crops

Source: Kawasugi
Effect of Improved Drainage on Yields

U - UNDRAINED  
S - SURFACE DRAINAGE  
SS - SUBSURFACE DRAINAGE  
C - COMBINATION  

Source: Agri Drainage Bulletin 871-98

Effect of Drainage Intensity on Yields

Source: Agri Drainage Bulletin 871-98

Average Yields

Average yield (tons/ha) of rice, wheat, maize, 1960 and 1994

<table>
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<td>Sub-Saharan Africa</td>
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<td>0.93</td>
<td>0.77</td>
<td>1.61</td>
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<td>1.76</td>
<td>2.55</td>
<td>3.43</td>
<td>8.68</td>
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</table>

Infrastructure

- Irrigation and drainage infrastructure reduce risk from water-related hazards
- Infrastructure necessary for assured water supply, multiple cropping / yr
- Better water management - improve yields
- Salinization affects 1-1.5 million ha / yr, need for drainage

Salinisation of Soils on Irrigated Lands

<table>
<thead>
<tr>
<th>Country</th>
<th>Irrigated Land Damaged by Salt (million Ha)</th>
<th>Total irrigated Land Damaged by Salt (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>7.0</td>
<td>17</td>
</tr>
<tr>
<td>China</td>
<td>6.7</td>
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<tr>
<td>Pakistan</td>
<td>4.2</td>
<td>26</td>
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<tr>
<td>USA</td>
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<td>23</td>
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<tr>
<td>Uzbekistan</td>
<td>2.4</td>
<td>60</td>
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<td>Iran</td>
<td>1.7</td>
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<td>Turkmenistan</td>
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<td>80</td>
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<td>Egypt</td>
<td>0.9</td>
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<td>Subtotal</td>
<td>28.1</td>
<td>21</td>
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<tr>
<td>World Estimate</td>
<td>47.7</td>
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</tbody>
</table>
Subsurface Drainage - Tile Drains

- Irrigation and drainage infrastructure reduce risk from water-related hazards
- Infrastructure necessary for assured water supply, multiple cropping / yr
- Better water management - improve yields
- Salinization affects 1-1.5 million ha / yr, need for drainage
- Gradual shift in thinking

Some Good News !!!!

Lending for Irrigation & Drainage (FY 2005-06)

I&D portfolio composition per sector
- I&D
- Public Administration, Law & Justice
- Other Agricultural Sectors
- Transport/Roads & Highways
- Water Supply/Sanitation/Flood Protection
- Health & Education
- Other

Ref: Salah Darghouth, WB
Meeting The Challenges

1. Providing Irrigation and Drainage
2. Improving Water Use Efficiency

More Crop Per Drop
More Crop Less Drop

More Crop Per Drop
More Crop Less Drop

Less Drop
Improving Water Efficiency

WSSD Plan of Action
• “To develop integrated water resource management and water efficiency plans by 2005”
WSSD Plan of Action

- “To develop integrated water resource management and water efficiency plans by 2005”

2.5% of existing infrastructure needs to be rehabilitated or replaced each year (207 million ha)

Improving Water Efficiency

More efficient irrigation systems

Recycling Irrigation Supply using Pumps

Sprinklers for rice in Brazil

Water use reduced to one quarter (¼) cf. flood irrigation
LESS DROP

Improving Water Efficiency

Systems

Improving O&M

Water and Land

Sept 2005

Better operation to reduce losses

Control Room

Benchmarking

- Comparing and assessing scheme's performance
- Improve weaknesses
- Learn, borrow, adapt best management practices

Cost Recovery

- Wastage because of little or no water recovery cost from farmers
- Where available, quantum low and inadequate
- Need adequate and appropriate charges, with measurement system

Water and Land

Sept 2005
“Irrigation Modernisation is a process of technical and managerial upgrading of irrigation scheme combined with institutional reforms with the objective to improve resource utilisation (labour, water, economic, environmental) and water productivity.”

Institutional Reforms

- Wider stakeholders' participation
- Water user groups, Farmers Associations
- Turnover programs
- Dialogues
- Capacity building

Meeting The Challenges

1. Providing Irrigation and Drainage
2. Improving Water Use Efficiency
3. Rain-fed Areas

World Food Production

17% Non-Irrigated
40% Irrigated
83% Non-Irrigated
60% Rain-fed

Ref: Postel
Rain-fed Areas

- Represents 87% of cropped land
- Small improvement → large impact
- Subjected to risk of water related hazards
- Providing basic infrastructure
- Small scale projects

Meeting The Challenges

1. Providing Irrigation and Drainage
2. Improving Water Use Efficiency
3. Rain-fed Areas
4. Technology

Technology

- R&D

R & D

- Water use efficiency
- Waste water treatment
- Improved Hydraulic structures
- Decision support systems
- Unconventional water (eg. desalinization)
- Renewable energy

Technology

- R&D
- Improvements to systems and processes

Telemetric water level station
Technology

- R&D
- Improvements to systems and processes
- Field application / best practices

New High Yielding Variety

• R&D
• Improvements to systems and processes
• Field application / best practices
• Better management models
Objective:
Development and integration of remote sensing, GIS, GPS and related technologies for efficient and precision plantation management to increase national rice and oil palm production and quality of environment.

Use of Technology - Precision Farming

Technology

- R&D
- Improvements to systems and processes
- Field application / best practices
- Better management models
- Capacity building, humanware, TOT

Meeting The Challenges

1. Providing Irrigation and Drainage
2. Improving Water Use Efficiency
3. Rain-fed Areas
4. Technology
5. Integrated Approach
Looking Beyond The Canal

- Role of Irrigated Agriculture goes beyond commodity production

Irrigation scheme → Product

Product → Food, Income

Food, Income → Quality of life, Contribution to GDP
Looking Beyond The Canal

• Role of Irrigated Agriculture
• Externalities

Externalities

• Irrigated agriculture will always generate externalities
• Eliminate or compensate by internalising the externalities

Looking Beyond The Canal

• Role of Agriculture in economy
• Externalities
• Multiple roles → Multi-functional roles of irrigated agriculture, including providing environmental services

Creation of rural employment

Green lung - aesthetic

Aesthetic - Landscape
80-90 percent of NO₃-N is removed when contaminated water passes through paddy field.
**Environment friendly - Migratory birds**

**Looking Beyond The Canal**
- Role of Agriculture in economy
- Externalities
- Multiple roles
- An integrated approach

**Integrated Approach**
- Holistic view
- Hardware & software

**Food Security and Society**

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**Hardware**
- Infrastructure
- Technology

**Software**
- Institutions, laws
- Governance

**Integrated Approach**
**Integrated Approach**

- Holistic view
- Hardware & software
- Integration within scheme
- Integration within river basin
- Irrigation and Drainage as a component of IWRM

**Irrigation & Drainage Water Structures**

**Irrigation & Drainage System - Egypt**

**The IWRM Process**

Ref: GWP
**Water and Land**

**IWRM PERSPECTIVE**

- **Principles**
  - Economic Efficiency
  - Equity
  - Environmental Sustainability

- **Structure**
  - Enabling Environment
  - Institutional Frameworks
  - Management Instruments

Balance ‘Water for Food’ and ‘Water for Nature’

Ref: GWP

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**ICID’s Country Policy Support Program (CPSP)**

A Schematic model

Ref: GWP

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**Introduction to THE DRAINFRAME APPROACH**

Ref: Safwat Abdel-Dameem, WB

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**Meeting The Challenges**

1. Providing Irrigation and Drainage
2. Improving Water Use Efficiency
3. Rain-fed Areas
4. Technology
5. Integrated Approach
6. ICID Strategies for Food Security

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**ICID Strategies For Global Food Security**

<table>
<thead>
<tr>
<th>Category of countries*</th>
<th>Food Self-sufficiency</th>
<th>Economic Status (GNP)</th>
<th>Population</th>
<th>Status of WRD</th>
<th>Governance</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Deficient</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Deficient</td>
<td>Aid, Investment, Develop Water Resources, Improve Efficiency, Population Control</td>
</tr>
<tr>
<td>II</td>
<td>Deficient</td>
<td>High</td>
<td>Low</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Virtual Water - Import</td>
</tr>
<tr>
<td>III</td>
<td>Sufficient</td>
<td>Low and Low</td>
<td>High</td>
<td>Medium</td>
<td>Evolving</td>
<td>Investment, Develop Water Resources, Improve Efficiency, Population Control</td>
</tr>
<tr>
<td>IV</td>
<td>Surplus</td>
<td>High</td>
<td>Low</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Trade - Export</td>
</tr>
</tbody>
</table>

* Categories of countries arranged from Deficiency to Surplus food self-sufficiency.

Category I : Many countries in Sub-Saharan Africa
Category II : Saudi Arabia, Japan etc.
Category III : India, China etc.
Category IV : USA, Canada etc.
CONCLUSION

• Food Security - Pressing problems to be solved
  • Population growth
  • Food production needs
  • Water issues
  • Environmental issues

Conclusion

• Food Security - Pressing problems to be solved
  • Irrigation and Drainage → Significant factor in meeting challenges
  • Need to improve on water use efficiency
  • More Crop Less Drop

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Conclusion

• Food Security - Pressing problems to be solved
  • Irrigation and Drainage → Significant factor in meeting challenges
  • Need to improve on water use efficiency
  • Holistic approach → Look beyond the canal / drain

Use of Water and Land for Food Security and Environmental Sustainability
Dujiangyan Irrigation System
Celebrated 2260th anniversary in 2004

Truly irrigation and drainage can be sustainable!!