Irrigation Efficiency and Water Productivity in Paddy Fields in the Lower Mekong River Basin

The 3rd SEAWF
Dept. of Irrigation & Drainage, Malaysia
22-27 Oct 2007

Fongsamuth Phengphaengsy
Okudaira Hiroshi
AIFP, MRC S

This study is a part of the project outputs of MRC project which is funded by MAFF, Japan with technical cooperation of FAO-RAP
Background
Objectives
Pilot Sites
Data Collection
Water Balance
Efficiency
Water Productivity
Conclusion
Project information
Background

- Agriculture employs > 80% of total population & is required to feed rapid growing population in the LMB region

- Rice is the dominant crop and single biggest consumptive user of fresh water
Background - Increasing Population

Source: FAO AQUASTAT & IWMI WATER-SIM simulation
Background - Increasing food demand

Agriculture, in the future, still needs to meet growing demand
Background

- Lack of rainfall in **dry season** and dry spells in **rainy season** are the major constraints to rice production and low water productivity
Background - Rice Planted Area & Rainfall

Rice Planted Areas

Rainfall

Legend:
- Country boundary
- Mekong boundary
- District boundary
- Water body
- Area of growing rice
  - 10 ha - 600 ha

Legend:
- Country boundary
- Mekong boundary
- Xinjiang boundary
- Vietnam boundary
- China boundary
- Thailand boundary
- Laos boundary
- Rainfall:
  - < 20
  - 20 - 40
  - 40 - 60
  - 60 - 80
  - 80 - 100
  - 100 - 200
  - 200 - 300
  - 300 - 400
  - 400 - 500
  - > 500
Background - Rice Planted Area & Rainfall

August

Rice Planted Areas

Rainfall
Background - Rice Planted Area & Rainfall

November
## Estimation of irrigation water use

<table>
<thead>
<tr>
<th>Annual water use (billion m³)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>2.7</td>
</tr>
<tr>
<td>Laos</td>
<td>3.0</td>
</tr>
<tr>
<td>NE Thailand</td>
<td>9.4</td>
</tr>
<tr>
<td>Vietnam Delta</td>
<td>26.3</td>
</tr>
<tr>
<td>Vietnam Highlands</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>LMB total</strong></td>
<td><strong>41.8</strong></td>
</tr>
</tbody>
</table>

- 8.8% of annual discharge (475 bill. m³)
MRC’s Strategic Plan 2006-2010 which supports the effective use of the Mekong's water and related resources to alleviate poverty while protecting the environment.

Efficient use of irrigation water is a priority if gains in crop production are to be realized.

Irrigation efficiency is an important indicator of effective water resource management.

A few analysis of efficiency in the region.
Project objectives

- to appraise irrigation efficiencies in selected irrigation systems
- to enhance the capacity of stakeholders in using up-to-date concepts of irrigation efficiency and water balance tools and procedures for their assessment
- to produce guidelines for improving irrigation efficiency on paddy fields based on actual water use practices in the LMB member countries
How to improve irrigation efficiency in the LMB?

Intensive Observation in Water Use

Observed Irrigation efficiency

Assessment of Management practices
Supplement by FAO’s RAP

Constraints

Guidance as Counter-measures

Scheme level Improvement

Application Basin-widely

Improve Irrigation Efficiency in LMB
Outcome

Improve livelihood of people

Maintain the ecology and environment of the river basin

Minimize gap between crop water requirement & actual water use

Effective of Water Use

Increase Efficiency and Water Productivity
Objectives for this analysis

- To examine actual conditions of water use in pilot schemes representing irrigation typology of the LMB
- To assess irrigation efficiency and water productivity in pilot schemes applying water balance approach at scheme level
- To understand the trend of efficiencies in the typical gravity irrigation system in the LMB region
Pilot Project

Num Houm

Huay Luang

Komping Pouy

Go Cong
Data Collection

Dry Season 2006-07

Flow measurement by Current Meter

- Measuring Inflow and outflow
- Monitoring water delivery in the scheme
- Conducting conveyance loss
- Calibrating Rated Section of Canal (H-Q curve)
Data Collection

- ETc
- Percolation
- Rainfall
Water Balance Concept

- Surface Water Supply
- Crop ETc
- Precipitation
- Municipal Pumping
- Rain Recharge
- Lateral Groundwater Inflow
- Vertical Flow Through Corcoran Clay
- Change in Groundwater Storage
- Surface Discharge
- Lateral Groundwater Outflow

Source: FAO
Available water supply within command area (m3) = (Rainfall (m3) + Intake from main canal (m3) + Natural flow entering command area (m3) + Deep ground water from inside and outside command into the command area (m3) - Changes in storage or recharge of percolation and ground water use (m3) - Evapo-transpiration (m3) - Percolation (m3) - Drain water to sinks outside and without reuse or non-utilizable water supplies (m3) - Committed flows to the other areas, for example legally or conventionally committed outflows from command areas to outside (m3))
**Water Supply & Drainage**

- **Nam Houm (Laos)**
  - Water supply
  - 83% by main intake
  - 17% by natural streams
  - Much water drain out

- **Huay Luang (Thailand)**
  - Peak supply at land prep.
  - Approx. 20% by rainfall

- **Komping Pouy (Cambodia)**
  - High peak at land prep.
  - Huge drain out at same time
Rainfall
more in lower basin
peak Apr - May

ETc
higher than standard in L
clear variation in T.

Percolation
high-initial, low-late in L
constant in T.
big fluctuation in C.
**Water Requirement**

**Paddy**

\[ WR_p = ET_0 \times k_c + P + LP \]

**Non-paddy crops**

\[ WR_n = ET_0 \times k_c \]

**Fishpond**

\[ WR_f = ET_0 \times k_c + P \]

**Total Scheme Water Requirement**

\[ SWR = \sum_{i=1}^{n} \int_{j=1}^{m} WR_{ji} \times A_{ji} \]

- \( ET_0 \): Potential or reference evapo-transpiration in mm/d
- \( K_c \): Crop coefficient (dimensionless)
- \( LP \): Land preparation in mm/d
- \( P \): Percolation in mm/d
- \( i \): Type of agricultural activity (e.g. paddy, non-paddy, fish farming)
- \( j \): Day
- \( m \): Number of days
- \( n \): Number of agricultural activities practiced within command area
- \( WR_{ji} \): Water requirement (mm/day x 10^{-3}) of crop type (i) at the day (j)
- \( A_{ji} \): Actual cultivated area (m²) of crop type (i) at the day (j)
Overall Command Area Efficiency

\[ E_{overall} = \frac{SWR - ER}{WDF} \times 100 \]

\[ ER = \sum_{i=1}^{n} [10 \times A_i \times (1 - 0.006 R_i) R_i] \]

\[ WDF = (I \times E_c + N) - (D + C) \]

Where

- \( E_{overall} \): Overall Command Area Efficiency (%)
- \( SWS \): System Water Supply (m³)
- \( ER \): Effective Rainfall (m³), from FAO
- \( WSF \): Water Delivery to the Fields (m³)
- \( A \): Progress planted Area (ha)
- \( I \): Intake water through main canal (m³)
- \( N \): Total natural flows entering command area (m³)
- \( D \): Drain water to sinks outside and without reuse or non-utilizable water supplies (m³)
- \( C \): Committed flows to other areas (e.g. legally or conventionally committed outflows from command areas to outside (m³))
**Overall Command Area Efficiency**

- **High efficiency in pilot sites** compared with existing info. (40-50% in Laos), (40-60% in NE Thailand)
- **High efficiency in Numhoum in Laos**, although poor infrastructure. The active water management at on farm level by WUG
- **Among pilot sites, low efficiency in Komping Pouy (Cambodia)** - too large capacity of main canal which take much water into system

<table>
<thead>
<tr>
<th>Pilot schemes</th>
<th>Scheme Water requirement (MCM)</th>
<th>Effective rainfall (MCM)</th>
<th>Water delivery to the fields (MCM)</th>
<th>Overall command area efficiency (%)</th>
<th>Canal type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numhoum (Laos)</td>
<td>9.30</td>
<td>0.12</td>
<td>13.02</td>
<td>70.52</td>
<td>Earth</td>
</tr>
<tr>
<td>Huay Luang (Thailand)</td>
<td>24.94</td>
<td>0.69</td>
<td>33.80</td>
<td>71.74</td>
<td>Concrete lining</td>
</tr>
<tr>
<td>Komping Pouy (Cambodia)</td>
<td>18.52</td>
<td>0.66</td>
<td>28.48</td>
<td>62.73</td>
<td>Earth</td>
</tr>
</tbody>
</table>
## Water Productivities

### Production:
- Paddy
- Non-paddy crops
- Fish
- etc.

### Water Productivity (WP)

\[
WP = \frac{\text{Value of total output (USD)}}{\text{AWS (m}^3\text{)}}
\]

**AWS**: Available Water Supply

**High WP** in schemes practicing multi-agriculture activities

**Low WP** in schemes taking much water and depending mostly on single paddy crop

### Production Type

<table>
<thead>
<tr>
<th>Pilot scheme</th>
<th>Production Type</th>
<th>Yield (T/ha)</th>
<th>% of Planted area</th>
<th>AWS (MCM)</th>
<th>Water Productivity (USD/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numhoum Laos (Laos)</td>
<td>Paddy</td>
<td>3.88</td>
<td>97.35</td>
<td>15.08</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>Vegetable (cucumber)</td>
<td>2.54</td>
<td>1.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fish</td>
<td>4.07</td>
<td>1.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huay Luang Thailand</td>
<td>Paddy</td>
<td>3.50</td>
<td>62.82</td>
<td>28.30</td>
<td>0.123</td>
</tr>
<tr>
<td></td>
<td>Vegetable</td>
<td>18.28</td>
<td>32.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fish and lotus</td>
<td>10.25</td>
<td>4.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Komping Pouy Cambodia</td>
<td>Paddy</td>
<td>3.71</td>
<td>99.50</td>
<td>29.96</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>Vegetable (sweet corn)</td>
<td>2.30</td>
<td>0.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

- High efficiency observed in scheme of good irrigation schedule and strong application of PIM with high degree of water delivery monitoring and evaluation

- Low efficiency caused by inappropriate hydraulic structure design, poor irrigation schedule and weakness of WUG on water delivery

- High productivity appeared with scheme practicing multi-agriculture activities

- Study will continuously examine wet-season crops in the pilot sites with emphasizing on irrigation schedule and PIM

- Water balance at scheme level counts additional water use for irrigation and is suited for efficiency at the Basin level, but not for each level of canals within system
## Project Time Frame

<table>
<thead>
<tr>
<th>Stage</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3rd</td>
<td>4th</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Preparation stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional Workshop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheme Appraisal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site selection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field observation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review documents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drafting guidelines</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finalizing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2006 Year 2007

#### Crop calendar and irrigation schedule

<table>
<thead>
<tr>
<th>Location</th>
<th>F: Field, O: Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kompong Pouy (Cambodia)</td>
<td></td>
</tr>
<tr>
<td>Nam Houn (Laos)</td>
<td></td>
</tr>
<tr>
<td>Huay Luang (Thailand)</td>
<td></td>
</tr>
<tr>
<td>Go Cong (Vietnam)</td>
<td></td>
</tr>
</tbody>
</table>

#### Monitoring plan

<table>
<thead>
<tr>
<th>Location</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kompong Pouy (Cambodia)</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Nam Houn (Laos)</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Huay Luang (Thailand)</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Go Cong (Vietnam)</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>
for more Info.

Future Publication:
- Guidelines
- Technical training manual
- Published papers

Completed Publication:
- Project Brochure
- Project document
- Project technical concept
- RAP report
- Posters

http://www.mrcmekong.org/programmes/AIFP
Thank you for your kind attention