IMPROVEMENT OF IRRIGATION EFFICIENCY IN PADDY FIELDS IN THE LOWER MEKONG BASIN PROJECT (IIEPF)

FONGSAMUTH PHENGPHAENGSY
Mekong River Commission, Operation Division - Agriculture, Irrigation and Forestry Program
184 Fa Ngoum Road Unit 18, Vientiane City, LaoPDR.Email:fongsamuth@mrcmekong.org

OKUDAIRA HIROSHI
Mekong River Commission, Operation Division - Agriculture, Irrigation and Forestry Program
184 Fa Ngoum Road Unit 18, Vientiane City, LaoPDR.Email:okudaira@mrcmekong.org

Abstract

Improving performance of irrigation schemes in the Lower Mekong Basin countries is an obvious issue for agricultural development for the region. Irrigation efficiency, which is an indicator of effective water resources management, of these schemes varies greatly between countries. The project of *Improvement of Irrigation Efficiency in Paddy Fields (IIEPF)* in the Lower Mekong Basin (LMB) considers the current situation and introduces up-to-date concepts in assessing irrigation efficiencies in order to produce guidelines to manage water resources more efficiently, sustainably and productively. The study not only focuses on efficiency, but covers all aspects of scheme improvement with three major objectives: (1) to appraise irrigation efficiencies (2) to enhance the capacity of stakeholders and (3) to produce guidelines for improving irrigation efficiency on paddy fields based on actual water use conditions in the LMB member countries. The project document has been finalized, and field observation and data collection will start from October 2006. Conveyance and overall system irrigation efficiencies will be analyzed, water productivity will be computed, and then recommendations will be made to improve the efficiency of water use. The FAO's Rapid Appraisal Process (RAP) will be applied as a tool to evaluate scheme performance as a part of the project's analysis. A set of guidelines will be produced as a main result of the project and it is expected to provide the managers of the irrigation schemes in the LMB with a framework to improve irrigation efficiencies and water productivity through improved irrigation management.

Keywords: irrigation efficiency, water balance, water distribution, paddy field, water productivity

INTRODUCTION

The Mekong River is one of the biggest international rivers in the Southeast Asia and exhibits high development potential. Water resources are widely used for various sectors including agriculture, which employs 85% of the total population in the Lower Mekong Basin countries, MRC-BDP [1]. Hence, further agricultural development is still required to feed the rapidly growing population of the region. Rice is the dominant crop here and represents the single biggest consumptive user of fresh water in the region. For the further development of water resources and efficient investments in irrigation, it is important to increase the effective use of water in paddy fields.

Lack of rainfall in the dry season and dry spells in the rainy season are, however, among the major constraints to regional rice production, and water productivity in paddy fields remains low. Improving the performance of irrigation schemes in the Lower Mekong Basin (LMB) countries is an obvious issue for agricultural development. Irrigation efficiency, which is an indicator of effective water resources management, of these schemes varies greatly between countries. A particularly concern is water shortage within irrigation scheme command areas, particularly in the dry season or in dry spells during the rainy season.

Improvement of efficiency can improved equity in water distribution and can minimize the gap between potential crop water requirements and actual water use. In consequence, it will lead to the determination of the effectiveness of water use and lead to the improvement the livelihood of people. Farmers can use lesser water or lower input in investment while obtaining higher production and remaining more water in the sources which can maintain the ecological cycle and environment of river basin.

However there are not enough reliable estimates of irrigation efficiencies and actual water use within the region to develop a reliable understanding of efficiency trends. Previous studies that have attempted such estimates have mainly analyzed field level efficiencies and lacked the use of modern and up- to-date concepts of irrigation efficiencies and water balance, FAO [2].

The project of Improvement of Irrigation Efficiency in Paddy Fields in the Lower Mekong Basin (IIEPF) considers the current scheme situation and introduces up-to-date concepts in assessing irrigation efficiencies in order to produce

guidelines to manage water resources efficiently, sustainably and productively. The assessment of irrigation efficiencies alone may not provide insights into how these can be improved. To cover all aspects of scheme improvement, objectives are set as follows:

1) to appraise irrigation efficiencies and irrigation systems in the selected pilot sites based on the up-to-date concepts,
2) to enhance the capacity of stakeholders in using up-to-date concepts of irrigation efficiency and water balance tools and procedures for their assessment, and
3) to produce guidelines for improving irrigation efficiency on paddy fields based on actual water use practices in the LMB member countries.

The main activities to be undertaken are data collection, analysis, consultation with riparian countries, and the establishment of guidelines. The project document has been finalized, and field observation and data collection will start from October 2006.

STUDY AREAS

Four irrigation schemes in LMB countries: Cambodia, Lao PDR, Thailand, and Vietnam were selected as pilot sites. The Huay Luang irrigation project was selected as pilot site in Udon Thani, Thailand, Num Houm irrigation project in Laos, Komping Pouy irrigation project in Cambodia, and Go Cong irrigation project in the Mekong Delta, Vietnam. Most schemes are gravity irrigation system except GoCong irrigation project in the Mekong delta which is operated and taking water by gates. These schemes were selected as the representation of typical irrigation gravity type, appropriate size of command areas, accessibility, and availability of relevant information.

METHODOLOGY

1. Data Collection

Existing data will be collected including schematic and scale command area maps, information related to water distribution practice, and organizational structures. Inflows and outflows of command areas will be recorded and measured to conduct water balance. Water discharge in the main, secondary, and tertiary canals will be measured to identify flow inside command areas. Other measurements, such as percolation, seepage and water levels in paddy fields and fish ponds will be conducted over the course of a year. Actual irrigated areas and cropping patterns will be recorded every month by water user groups and farmers. Paddy production will be determined by unit harvested and interviews with farmers. Finally, conveyance and irrigation efficiencies will be analyzed, water productivity will be computed, and then recommendations will be made to improve the efficiency of water use.

Field observation and data collection are planned to be conducted one year including dry and wet season in each selected irrigation scheme. The data collection will start from the dry season in the middle of October 2006. The main activities of field observation and data collection include:

(1) Produce schematic plans of irrigation system and scaled command area map of the irrigation scheme to identify point of flow measurement and indicating capacity and water discharge for all off takes of each canal;
(2) Identify the actual irrigated area in order to identify gaps between designed and actual areas for computing crop water requirement;
(3) Record multiple uses of irrigation water such as fishponds and domestic use for considering water use within command areas and will be used to compute total scheme water requirement;
(4) Record cropping patterns under different crops and crop calendars;
(5) Record water level changes in paddy field by installing wooden staff gauge in command areas for monitoring percolation in paddy fields;
(6) Obtain rainfall and evapotranspiration data in the project site or from the nearest meteorological station;
(7) Collect paddy production (yield) by gathering from Water User Groups and interviewing farmers and also cross check the data with unit harvest method in order to examine water productivity; and
(8) Record the data of stakeholders for decision making on distribution of irrigation water within schemes and produce organizational charts of stakeholders (irrigation managers, water users, others) involved in the decision making process.

The FAO's Rapid Appraisal Process (RAP) will be applied as a tool to evaluate scheme performance and it is planned to be conducted two times before project starting and after data collection period. Its results will be a part of project's results.

2. Conducting Water Balance

In order to improve irrigation efficiencies it is very important for managers of irrigation schemes to keep track of where the water is going within the gross command area or boundaries of the scheme. Water balance or water accounting could help the managers understand where the water within the command area of the scheme is actually going, which helps in correcting the management strategies. According to IWMI [3], water balance provides information about all inflows and outflows within a defined boundary and also provides different water efficiencies such as conveyance efficiency, delivery efficiency, and application efficiency, while taking into account the multiple uses of water within the scheme.

Figure 1 gives an example of different flows within a defined boundary and potential water use within the boundary which has been developed by IWMI. The inflows are divided into many uses within the command areas before drain out of the system.

Figure 2 shows the component of flows of water balance which was developed by Facon et al. [4]. The boundary is set in 3 dimensions and the component of flows includes:

- Surface inflow and lateral inflow into the system and diversions within the system
- Groundwater use within the scheme
- Recirculation and reuse of the drainage water
- Crop water requirement within the scheme
- Water requirement by the other uses of water
- Rainfall within the command area of the scheme and potential evapotranspiration (ETo)

Since the lateral ground water inflow and outflow are difficult to monitor in practical, a simple water balance concept shown in Figure 3 was developed and applied for the IIEPF project in consultation with FAO. Inflow into command areas and outflow of command areas will be measured. The inflow includes water diverted to command areas, precipitation, natural flow entering into command areas, ground water circulated within and delivered from outside of command areas. Outflow of command areas like evapotranspiration, committed water and drain out water will be also measured and recorded.

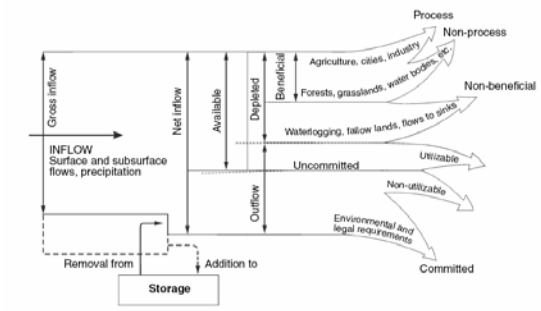

Figure 1: Water balance concept by IWMI

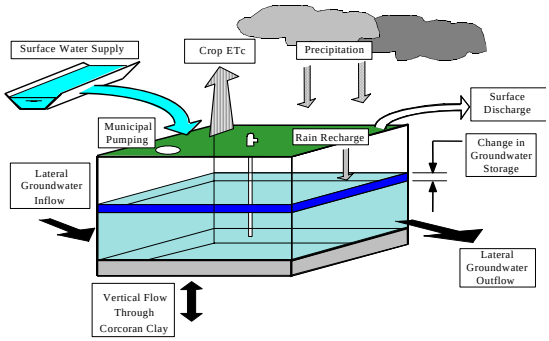

Figure 2: Water balance concept by FAO

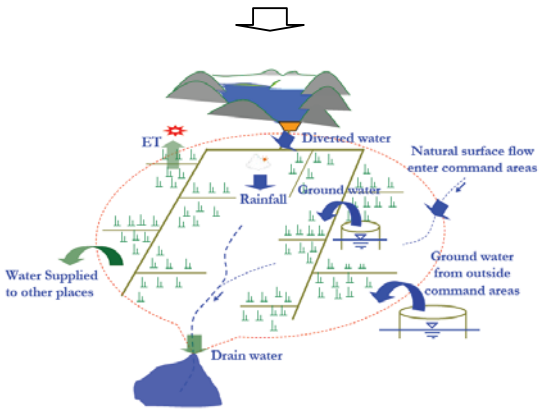

Figure 3: Water balance concept applied for IIEPF project

This approach to assess efficiencies is different from the classical approach in the sense that this considers water as "loss" only when it is not used for beneficial evapotranspiration or it flows to the sink and could not be of any use even to the sink.

According to Figure 3, water balance for IIEPF project is defined as follows

$$AWS = (P+DIV+CS)-(ET+N+C)$$

Where

AWS	=	Available water supply within command areas
P	=	Total precipitation
DIV	=	Diversions or surface inflows from irrigation canal and natural flows into the command areas
CS	=	Changes in storage or recharge of water within and outside command areas
ET	=	Evapotranspiration
N	=	Non- utilizable water supply (drain water or flood water to sinks)
C	=	Committed flows to the other areas, for example legally or conventionally committed outflows from command areas to outside command areas

3. Total Scheme Water Requirement

Total scheme water requirement considers multiple uses of water within command areas such as water use for paddy, non-paddy crops and water use for fish pond. The total scheme water requirement will be calculated based on consultation with the FAO as follows.

Total scheme water requirement = Paddy crop water requirement + non-paddy crop water requirement + fish pond water requirement

Note that for practical reasons, water requirements for paddy and fishponds both consider percolation. For non-paddy crops, percolation will be assumed to be miner and will be neglected.

4. Conveyance Efficiency

An estimate of the amount of water that is "lost" or mismanaged in the conveyance system is required for effective management decisions and equitable water distribution. Thus it is important to know where the water is going within the conveyance system. Conveyance loss tests will be conducted using long reaches at three levels of canals: main, second and tertiary canals and can be computed from Wahaj [5].

$$\text{Conveyance Loss} = Q_{in} - Q_{out} \quad \text{and} \quad Q_{out} = \sum_{1}^{n} q_n + Q_{outflow}$$

$$\text{Converyance Efficiency} = \frac{\sum_{1}^{n} q_n + Q_{Outflow}}{Q_{in}}$$

Where

Q_{in}	= Diverted water into canal where conducting conveyance test
$Q_{outflow}$	= Water flowing out of the canal section on which conveyance losses tests are conducted
q_n	= Water diversions out from offtake along canals

5. Overall Project Command Area Efficiency

With the concept of water balance, inflow and outflow are computed and once conveyance efficiency is calculated, overall project command areas efficiency will be computed as follows.

$$\text{Overall Project Command Area Efficiency} = \frac{\text{Total scheme water requirement - Effective rainfall}}{\text{Total water delivered to users}} \times 100$$

Total water delivery to users = (Total inflow) * (Conveyance efficiency) – (Committed flows downstream) – (Flows to sink or Drain out)

Committed flows are considered if the conveyance network of the selected irrigation scheme is transporting water to downstream of the irrigation scheme command area.

6. Water Productivity

According to Burt and Styles [6], water productivity can be assessed as yield per unit of water diverted and yield per water consumption. Paddy yield will be collected from each Water User Group (WUG), interviewing farmers and cross check with unit harvested method. Water diverted and water consumption values are obtained by conducting water balance.

$$\text{Water Productivity for system} = \frac{\text{Paddy Yield}}{\text{Water Diverted}}$$

$$\text{Water Productivity for command areas} = \frac{\text{Paddy Yield}}{\text{Water Consumption}}$$

7. Scheme Management Appraisal

The assessment of irrigation efficiencies alone may not provide insights into how the performance of irrigation schemes can be improved. To cover all aspects of scheme improvement, it is intended to identify management aspect by the following steps.

- Identify stakeholders for decision making on distribution of irrigation water within the scheme in order to understand different processes of scheme management and later for implementation of improvement plans
- Examine the organizational structures of stakeholders (irrigation managers, water users, others) involved in the decision making of the scheme management including structure of identified stakeholders' formal or informal organizations, for example Project authority, Water Users Association, etc. which will help to identify the right level for intervention in terms of capacity development and implementation of improvement plans.
- Examine procedure of water allocation such as water ordering by farmers and water supplying by the project level, and also identifying the rules or regulations regarding water allocation for different users within the irrigation scheme. These rules, formal or informal, will provide the basis for water distribution practices, and thus to a certain extent, influences irrigation efficiencies. The official rules and actual procedures followed by the project authorities to allocate water will be documented as part of the data collection work. The main questions that need to be identified for these issues are:
    - What are the official water distribution rules used in the project?
    - What are the actual water distribution practices in the project?
    - What are the official rules and procedures to operate irrigation facilities?
    - What are the actual operation and procedures to operate irrigation facilities?
    - What criteria are used by the project authorities to allocate water to different uses/ users? (for example to paddy fields versus other crops, versus fishpond)
    - Do project authorities allocate water differently to different parts of the command area (for example along the head reaches and the tail reaches)?
    - Is the criteria used by the project authorities in practice different from the official criteria (or official rules)? If yes then what are the difference between the criteria practically used and officially adopted for water allocation?
    - Is water allocated differently over time (for example in dry and wet seasons or within the wet season when there is not enough water available)?

8. Rapid Appraisal Process (RAP)

The Rapid Appraisal Process (RAP) was jointly developed by the Irrigation Training and Research Centre (ITRC) of California Polytechnic University and Food and Agriculture Organization (FAO) in the late 90's and since then has been successfully used by FAO and the World Bank in various Asian countries to appraise several irrigation projects. The methodology uses modern concepts of canal operation and water use efficiencies and is based on the understanding that the irrigation systems are operated under a set of physical and institutional constraints and with a certain resource base. Key performance indicators from RAP help to organize perceptions and facts, hence they facilitate informed decisions regarding the potential for water conservation within a project, specific weakness in project operation, management, resources, and hardware, and specific modernization actions that can be taken to improve project performance. The RAP also provides initial indicators that could be used as benchmarks to compare the improvements in the performance of the system once the modernization plans are implemented. A good assessment of the current

situation gives a clear idea on where situation must be improved and helps in prioritizing the areas for improvements. The RAP could also be used to compare the performance of the different projects.

RAP is applied as an assessment tool for IIEPF projects to evaluate system performance. It is conducted in each selected irrigation scheme twice during the project's life: once at the beginning of the project, before the field data measurement starts, and second time when field data measurement ends. The monitoring data for one year round will be used to fill the missing values when RAP is conducted for the first time. Training is provided to the team of each member country regarding techniques for conducting RAP with instructions and consultations of senior water management officers from FAO under cooperation between MRC and FAO. The results of internal and external indicators of RAP will provide useful information for IIEPF including

- Water allocation and distribution practices,
- Operation rules and procedures,
- Irrigation efficiencies (conveyance, field, overall project efficiencies),
- Water productivities,
- Project cost recovery,
- Physical infrastructure (hardware) of the system, and
- Involvement of water users in the decision making process (stakeholders involvement).

9. Establishment of Guidelines

A set of proposed guidelines will be established in close collaboration with and input from FAO and it expected to include three main parts: introduction, assessment, and improvement. It will be produced based on the main analysis result obtained and consultation with riparian countries regarding the actual situation and constraint. The establishment of guideline is expected to follow the following procedures:

- Review of existing document
- Identifying best practice
- Capacity development requirement assessment of the managers in order to be able to use the guidelines
- Draft institutional, managerial and technical guidelines
- Discussion of draft guidelines at regional workshop
- Finalization of guidelines

EXPECTED MAJOR OUTPUT

The guidelines will be produced as a main output of the project. A set of guidelines is expected to provide the managers of the irrigation schemes in the Lower Mekong Basin countries with a framework to improve irrigation efficiencies and water productivity through improved irrigation management. The guidelines will be a reference for the scheme manager to operate their scheme more appropriately and use water more effectively. The recommendations will be proposed to improve system management based on analysis data and information obtained.

ACKNOWLEDGEMENTS

The IIEPF project has been supported by Ministry of Agriculture, Forestry and Fishery, Japan and implemented by the Agriculture, Irrigation and Forestry Program (AIFP), Operations Division (OPD), MRC.

REFERENCES

[1] Mekong River Commission- Basin Development Plan, "*Social Atlas of the Lower Mekong Basin"*, Phnom Penh, Cambodia, (2003).

[2] Food and Agriculture Organization of the United Nations-FAO, "*Modernization of Irrigation Schemes: Past Experiences and Future Options"*, Proceedings of the Expert Consultation, Bangkok, Thailand,(1996).

[3] International Water Management Institute-IWMI, "*Water Accounting for Integrated Water Resources Management"*, Battaramulla, Sri Lanka, (2000).

[4] Facon T.G. and Burt C.M. (2003), *Power Point Presentation- Training Workshop on Irrigation Modernization, Management Improvement and Benchmarking for NIA's Technical Staff*, Food and Agriculture Organization of the United Nations-FAO and Irrigation Training Research Center of California Polytechnic University, USA.

[5] Wahaj R., "*Backstopping Note for Improvement Irrigation Efficiency in paddy fields in the Lower Mekong River Basin (IEPF)")*, MRC and FAO cooperation, AIFP/OPD, Vientiane, Laos, (2005).

[6] Burt C.M. and Styles S.W., "*Modern water Control and Management Practices in Irrigation: Impact on Performance"*, Water Reports # 19, FAO, IPTRID, and World Bank, Room, Italy, (1999).