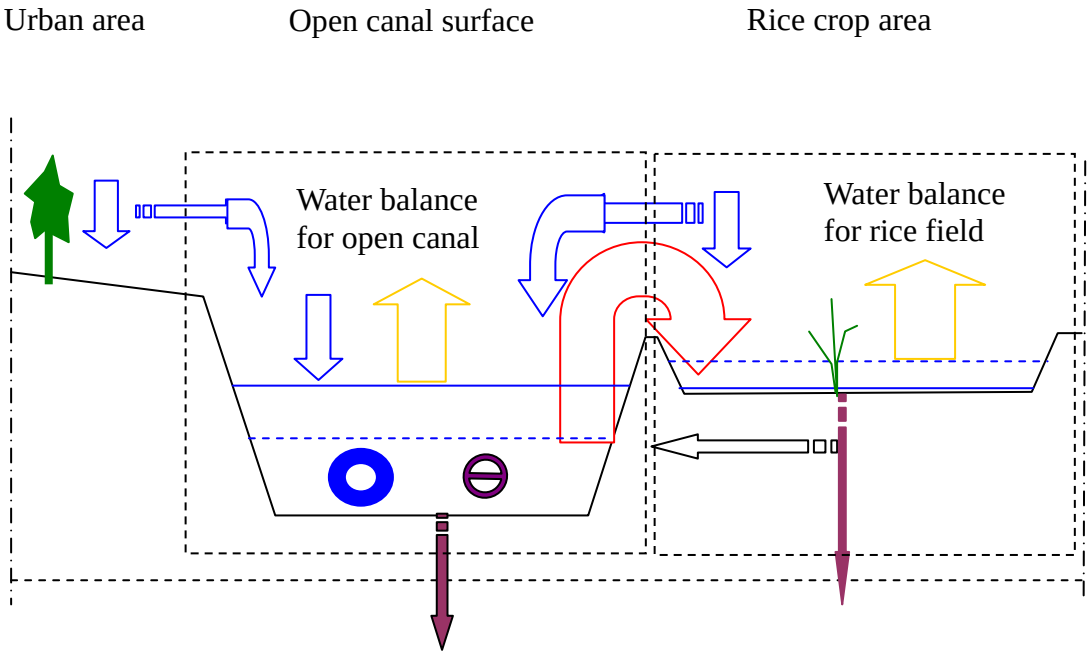
MEKONG RIVER COMMISSION
AGRICULTURE, IRRIGATION, AND FORESTRY PROGRAM

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

FINAL REPORT

FIELD OBSERVATIONS AND DATA ANALYSIS FOR IRRIGATION EFFICIENCY ON IIEPF

CASE STUDY IN THE MEKONG DELTA OF VIETNAM
GOCONG IRRIGATION PROJECT – TIEN GIANG PROVINCE



HO CHI MINH CITY, MAY 2008

MEKONG RIVER COMMISSION
AGRICULTURE, IRRIGATION, AND FORESTRY PROGRAM

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

FINAL REPORT

FIELD OBSERVATIONS AND DATA ANALYSIS FOR IRRIGATION EFFICIENCY ON IIEPF

CASE STUDY IN THE MEKONG DELTA OF VIETNAM
GOCONG IRRIGATION PROJECT - TIENGIANG PROVINCE

HO CHI MINH CITY, MAY 2008

TABLE OF CONTENTS

List of Figures

List of Photos

List of Tables

List of Appendices

Abbreviations

IIEPF: Improvement of Irrigation Efficiency on the Paddy Fields
RAP: Rapid Appraisal Process
MD: Mekong delta
HL6: Huonglo 6 (name of the local road at the area)
H-Q: Flow rating curve (Flow discharge Vs Water level)
H-W: Water level Vs Storage volume
m+MSL: elevation above the Mean Sea Level
CWR: Crop Water Requirement
IWR: Irrigation Water Requirement
IMC: Irrigation Management Company
SIWRR: Southern Institute of Water Resources Research
TOR: Term of Reference
MRCS: Mekong River Commission Secretariat
RRD: Red River Delta
W-S: Winter-Spring
S-A: Summer-Autumn
A-W: Autumn-Winter
FAO: Food and Agriculture Organization
VND: Vietnamese Dong
USD: United State Dollar
CAE: Command Area Efficiency
POW: Production of water
IM: Irrigation management
VWL: Vietnamese Water Law
MCM: Million Cubic Metter
IPM: Integrated Pest Management

1. Summary of major findings

Based on the results of field observation and data analysis, some basic information of the project area was found:

- 100% of irrigation area has relied on the water from the canal system;
- There was an average of 47 m length of the canal per ha of the cultivated area or 35 m length per ha in comparison to the overall natural area;
- Total irrigation surveyed area (707.3 ha) is higher than the reported area (667 ha) of about 40.3 ha. This difference may result from the estimated area at the beginning;
- The elevation of the rice crop area in the project area ranges from 0.75 to 1.35 m+MSL, of which the most common area has elevation ranges from 0.95 to 1.15 m+MSL (accounted for 73.3%). Therefore, improvement of water management in the project area should be taken into account this common area;
- Rice is the most common crop in the project area as it was accounted for more than 98.6% of the total cultivated area during three crops in 2007;
- An average area for each family is 0.58 ha, and an average of 86% of the income for the families is from the rice cultivation;

Based on the results of surveyed crop data analysis, some basic information was found:

- There was 4 main rice sowing durations for W-S rice crop: Rice was sowed in November accounted for 24.6%; from 1st to 10th of December accounted for 52.8%; 11th to 20th of December 19.0%; and the last duration of December accounted for 3.6%;
- There was 3 main rice sowing durations for S-A rice crop: Rice was sowed from 1st to 20th of May accounted for 40.06%; from 21st to 31st of May accounted for 53.68%; and the last rice seeds in June accounted for 6.26%;
- There was 3 main rice sowing durations for A-W rice crop: Rice was sowed from 15th to 31st of August accounted for 41.32%; from 1st to 10th of September accounted for 38.1%; and from 11th to 30th of September accounted for 20.59%;
- The average crop length of all rice varieties was 95 days for W-S and S-A and about 93 days for A-W crop.
- The highest yield production of rice crop was for W-S rice (4.93 ton/ha) and the lowest yield production of rice crop was for S-A rice (4.14 ton/ha);
- There was an average of 190 kg/ha of seeds used for W–S crop, 174 kg/ha for S-A and 188 kg/ha for A-W;
- The VD20 and 3536 was considered as the dominated rice varieties of the Longhai irrigation project it was accounted for more than 50% of the rice crop area;
- The average of benefit from rice cultivation over the year 2007 was about 566 USD/ha/crop, the highest benefit was 624 USD/ha come from A-W rice, the average of total expenditure for irrigation, pesticide and fertilizer was about 475 USD/ha/crop;
- The net income per person during 2007 in the project area was about 3.52 million VND/person or 219 USD/person;
- During W-S crop, there was an average of 17 irrigated times, 6 fertilized times and 5 used times for pesticides. During S-A crop, there was an average of 9 irrigated times, 4 fertilized times and 4 used times for pesticides. And during A-W

crop, there was an average of 8 irrigated times, 5 fertilized times and 5 used times for pesticides.

Based on the monitored data analyses, it was found that:

- The average of crop water requirement for the three rice crops in 2007 was 461 mm/ha, the highest crop water requirement was 497.0 mm/ha for W-S rice crop;
- The average of crop water requirement minus effective rainfall for the three rice crops in 2007 was 315 mm/ha, the lowest value was 206 mm/ha for S-A rice crop;
- The average of irrigation requirement for the three rice crops in 2007 was 580 mm/ha and the highest irrigation requirement was 835 mm/ha for W-S rice crop;
- Farmer used an average of 7,799 m^3/ha of water for W-S rice, 4,489.8 m^3/ha of water for S-A rice and 4,448.8 m^3/ha of water for A-W rice;
- Total irrigation water diverted to the system over the year 2007 in gravity condition was 12.17 MCM it was approximated equal to the total irrigation water requirement of the system (12.00 MCM);
- Overall command area efficiency at the field level in 2007 was about 56.6%, the highest command area efficiency at the field level was 61.5% for W-S rice crop;
- Overall command area efficiency at the system level in 2007 was about 54.5%, the highest command area efficiency at the system level was 90.9% for W-S rice crop, the lowest command area efficiency at the system level was 30.3% for A-W rice crop;
- The overall water productivities at system level in 2007 was 0.78 kg/m^3 and the actual water productivities at the field level was 0.81 kg/m^3;
- Pumping was main mean of irrigation for all rice crop in the Longhai project area, there was only 2.5 % of the total cultivated area could get gravity irrigation condition for a total of 2.5 months over the year;
- The participation of farmers on water management of the system play an importance role to improve management condition of the system, as farmers controlled the waste water disposed to the canal system that maintained a better water quality condition and saved an amount of water to improve stagnant condition of water.

2. Background

2.1. General information of irrigation in the country

The total cultivated area in Vietnam was accounted for about more than 6 million hectares, of which there is about 4 millions ha of paddy field. This paddy field is mainly distributed in the Red River Delta (0.85 million ha) and the Mekong delta (2.4 million ha). The rest is distributed in Saigon-Dongnai river basin and deltaic areas along the coast.

Irrigated agriculture plays an importance role for sustainable agriculture production of Vietnam. There was about 3.2 millions (80%) of paddy field was irrigated by all type of irrigation (gravity, pump and semi-gravity). The plan for 2030 was showed that agriculture would increase double. This extension of agriculture production would expect from the extension of the irrigated areas, the improvement of irrigation management and agriculture technologies. In which, more attention was paid for improvement of irrigation management, as an illustration for that the investment for improvement of foundation for irrigation systems was about 650 million USD during 1995 to 2000.

There was only about 2 million ha of irrigated area was fully irrigated. This was because of the uncompleted irrigation system or the degradation of the current irrigation systems and other issues related to operation and management.

Irrigated agriculture is mainly distributed in the Red River Delta (RRD), Mekong Delta (MD) and Saigon-Dongnai river basin. There is about 0.85 million ha of irrigated area in the RRD, 85% of the irrigated area was supplied by 31 irrigation systems and about 1,700 pumping stations. The main characteristic of irrigation system in the RRD is expended a large input for operation of pumps, it was accounted for 35% to 60% of the operation expend.

Mekong delta is newly developed area, from 1975 and especially there was an intensive investment to the delta from 1995 for irrigation development and salinity intrusion protection. As a result of that rice cultivated area was increased from 2.25 mil ha/year to 4.16 mil ha/year, one to two crops per year has turned to two to three crops per year and total agriculture production of the delta has increased from 6.3 million ton in 1985 to 17 million ton in 2000.

Different to the irrigation condition in the RRD, the Mekong delta is very flat plain area, average elevation is about 1m+MSL, therefore the large pumping irrigation system could not effective for irrigation in the delta. The main mean of irrigation in the Mekong delta is semi-gravity irrigation based on the tidal variation and the small pumps owned by each individual farmer. The irrigation development of the delta in the current situation is like to open possibility for the farmer to approach to the water resources and create a better condition for water resource management.

Based on the soil and water resources condition, irrigation development condition in the Mekong delta can be categorized into 4 zones (see Appendix 1): Zone 1, located at upper par of the delta and lies along the Mekong River where the soil and water resources condition is good, there is no natural restriction of water use in this area, improvement for irrigation in this zone is considerable easy; Zone 2, adjacent to zone

1, the condition of water here may not be impacted by the saline water every years, but some areas have acid sulfate soils condition, therefore the water quality is not much suitable for the irrigation during the dry season; Zone 3, adjacent to the coastal zone, this area has impacted seasonally by saline water and seemed that hardly to improve irrigation condition. Zone 4, coastal zone area, has impacted by saline water through the year.

2.2. General information of IIEPF project

2.2.1. Objectives, targets of the field work under IIEPF

"Field observations and data analysis" aims to analyze and document actual conditions regarding water use in selected irrigation schemes representing irrigation typology of the Mekong River Basin to support the objective of the "Improvement of Irrigation Efficiency on Paddy Fields in the Lower Mekong Basin" project of the MRCS.

2.2.2. Background of the pilot project

The Long Hai irrigation system is part of the Go Cong Irrigation project (Fig 1), which lies in coastal zone of the Mekong delta (Appendix 2). The project area is about 100 km from Ho Chi Minh City, with a total area of 948.6 ha, including two communes, Long Binh and Binh Tan, in Go Cong Tay district. The land elevation ranges from 0.75 to 1.35 m above MSL.

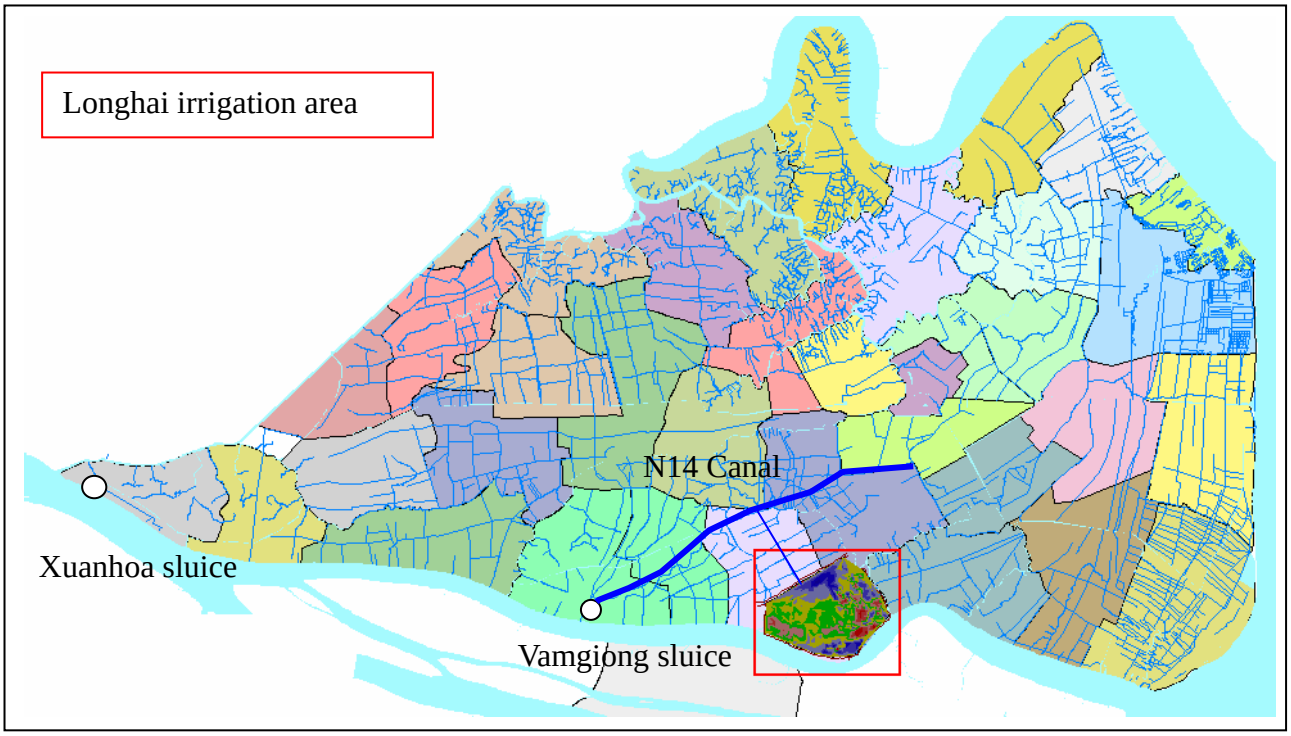


Fig. 1: Map of Gocong irrigation project and Longhai project area

The total agricultural area is about 707.3 ha, of which there is mainly rice field, upland crops area is changed from season to season depending on the demand of the market, e.g. during the crop seasons in 2007 the upland crops area varied from 2.5 ha to 10.2 ha only. 73.3% of the rice cultivated area has an elevation ranges from 0.95 to 1.15 m+MSL. There were 1,225 families in the project area with a

total of 6,176 people who mostly rely on agriculture cultivation (information was obtained from the surveyed data in 2007).

The system consists of 1 main secondary irrigation canal and 2 main sluices (HL6 and Longhai sluices, Fig. 2). There are total of 20 irrigation canals in the project area with a total length of 33.4 km, of which the Huonglo 6 canal (HL6 or Longhai canal) considered as the main secondary irrigation canal has about 4 km long and the other canals are considered as tertiary canals. All the junctions between the tertiary canals and the main irrigation canal are open link without sluice gate. This is considered as main characteristic of the canal system in the delta.

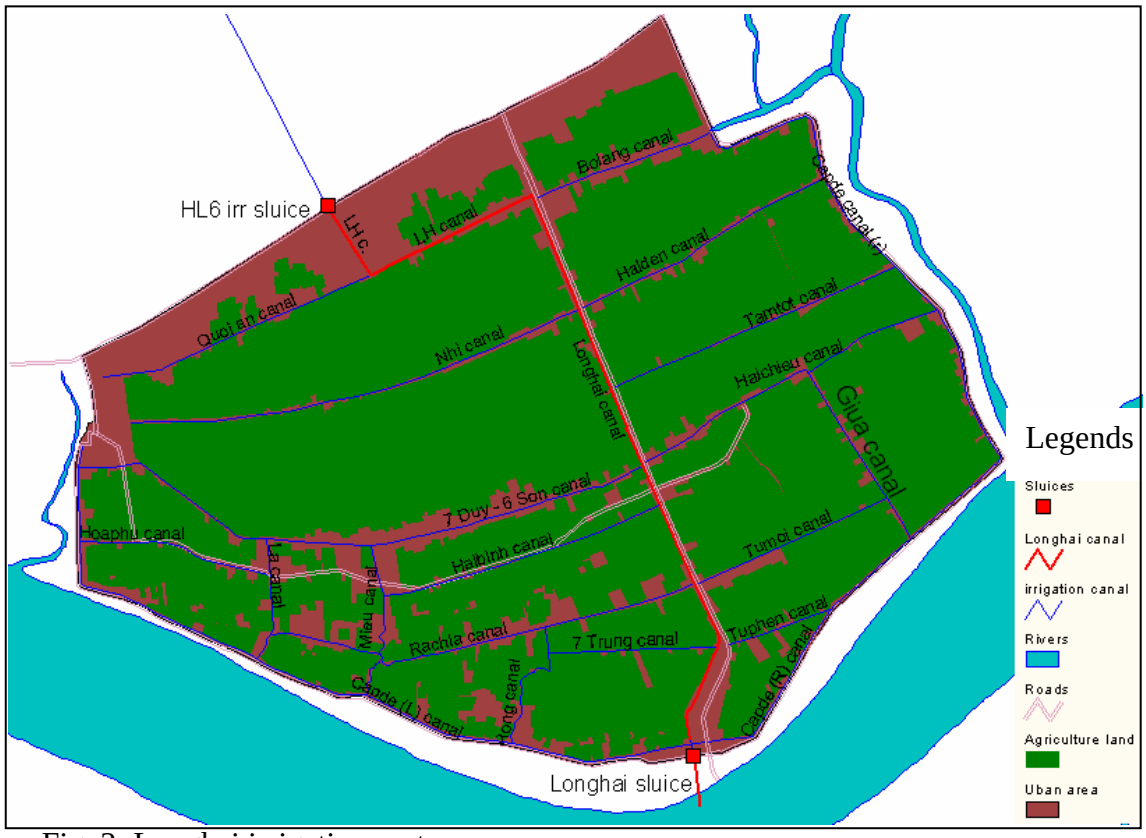


Fig. 2: Longhai irrigation system

In theoretical, the canal system could have a strong influence by the tidal variation and severely impact by saline water intrusion for 6 to 8 months per year, as tidal variation during the day from the South China Sea ranges from -1.8 m+MSL to 2 m+MSL. However, the system was bounded by the ring dike systems and the salinity intrusion protection sluice gates. Therefore, during operation of Xuanhoa and Vamgiong sluices the water level in the project area has slight influence by tidal variation of about 20 cm during the day. In case the Longhai sluice was operated to take the water from the river, the water level in the project area could have strong influence by tide and gravity irrigation could make for some part of the project area. Most of the time and the area are irrigated by pumps. Each farmer has their own pump and therefore they can use water when they need it.

It was considered that there are three main man-made sources of irrigation water supply to the project area:

- Water supply from the HL6 sluice: this source of water was diverted from the Main Canal 14 (Fig. 1), which is one of the main canals of the Gocong irrigation project, by gravity condition through the year. The Canal 14 receives water from the Xuanhoa and Vamgiong sluices;
- From Long Hai sluice. The main purpose of this sluice is for drainage and salinity intrusion prevention. It supplies also additional irrigation water to the area from August to November;
- The third sources of water supplied for the area was considered as the internal source of water which is the stored water on the canal system and the return flow from irrigated area.

During the dry season, there is only one main external source of irrigation water for the project area via the HL6 sluice. The fresh water divers into the area from the upper intakes of water (Xuanhoa and Vamgiong sluices, see Fig 1), during this period the Longhai sluice plays as a role for drainage only, the purpose is every 15 days or 2 weeks the sluice will be operated 1 time to release water from the project area to the river to avoid the stagnant condition of water.

During the wet season, when the condition of water on the Mekong River at location of Longhai sluice is good for agriculture cultivation (hopefully from August to December), in addition to the drainage function this sluice will be operated sometime to raise up the water level in the project area for gravity irrigation and improvement of water quality condition.

In practice, depend on the weather condition of the year, the Longhai sluice may be operated as planed of 15–day a time. A disadvantage situation of the Gocong irrigation project is in April the saline water intrudes further than the location of all the intakes of water for the Gocong project area, as a result of that all the intakes of water will be closed in this month. Therefore the stored waters on the canal have to be saved for using during the period and therefore no replacement of water did during by this month.

The irrigation system is managed by the Go Cong Irrigation Enterprise which operates the main sluices and maintains the irrigation canal system. Farmers manage the water on their fields by themselves as there is no water user group in the area. Pumps are main means of irrigation in the project area.

In present condition the project area could cultivate for 3 crops per year, they are Winter-Spring, Summer–Autumn and Autumn–Winter crop. The cropping pattern is 3 rice crops per year or 2 rice crops and 1 dry crop. Direct seeding is main practice for rice cultivation in the project area.

2.2.3. Why scheme was selected as the pilot project

Most canal systems in the delta are linked together and to natural rivers by open junctions or with gates. Therefore the irrigation system in the Mekong delta is generally an open irrigation system. Irrigation and drainage is combined in a very high density canal network, as can be seen from Longhai project area there is about 35 m long of the canal for 1 natural hectare. Therefore, it is not easy to monitor all inflow and outflow for an appropriate project size with an area of some thousand hectares and it may cost too much.

Based on the objective of the project and the financial condition, the Longhai irrigation system was selected for the studying purpose. It was located in the salinity intrusion area (zone 3 - appendix 1), the size and condition of the project is suitable with the identified criteria for the selection that given by the MRCS. This was also considered as an initial study for water use as system level in the Mekong delta.

The advantages of this site selection were:

- quite closed system, this would be good to calculate the water balance for the project and suitable for the financial condition;
- not so far from the Ho Chi Minh City where the main workgroup is based, this would be saved time for the work;
- has a good condition of water management and has some limitation of water resources due to the salinity intrusion condition, therefore further improvement of water management would be needed;
- strong commitment for coordination of the Irrigation management company;
- available data related to the objective of the study.

The limitations of the scheme were:

- The Mekong delta has total 2.4 million hectares of the irrigated area and the irrigation condition is variable from this place to other place, therefore a plot site study of 707 hectares could not represent to the whole irrigation condition of the Mekong delta. However due to the limitation of finance, this was considered as an initial study for water use and water management in the Mekong delta in general and in salinity intrusion area in particular.

3. Outline of field observation

3.1. Process of conducting field work

All the tasks were clearly described on the TOR for Vietnamese team. The list of all activities to fulfill the tasks was accepted through the endorsement of the technical proposal MRCS. The work plan of IIEPF for Longhai area was presented in Table 1.

Based on the work plan, there were 5 main tasks as listed below
- Preparation for data collection
- Assessment of water balance and irrigation efficiency
- Assessment of water productivity
- Scheme management appraisal
- Conducting RAPs

Data collection for the 5 main tasks above was combined together. It was simplified into some main field works as listed below:

- Available data collection: all related data required for the preparation of the schematic plan of irrigation system, command area map as well as for scheme management appraisal and RAPs were collected from IMC and additional survey.
- Flow measurement at HL6 and Longhai sluices: instead of daily flow measurement, the automatic water level gauging system was introduced to the project, hourly water level was recorded, the SIWRR team traveled monthly to the project to download the data and conduct related activities as presented on the work plan.
- Recording the irrigation application at 5 selected fields and water level change on the fields: 5 rice fields were selected; all irrigation applied for and drainage of water from these selected fields was recorded by the farmers. This task was conducted for 3 crops during 2007. The SIWRR team and IMC team were assisted the farmers to carryout this task and frequency checked the data.
- Record of the cropping pattern, crop calendar; the multiple use of water; obtained yield and value of all types of productions: All needed data and information was identified by the 2 working teams based on the requirement of the IIEPF project and the condition of the Longhai project area. The survey was conducted for 3 crops during 2007. The IMC team conducted the survey with assistance from the SIWRR team.
- Conducting RAPs: Basic data was collected during each crop season and final completion of the RAPs by the end of the project was made.

Two main working groups were established to implement the project: one from the SIWRR, this group was in charge for most of the office works. The field works for this group was mainly for equipment installation, data collection, conduction of trainings and some interview as well as for monitoring progress of the project; the second group from the IMC, this group carried out the field survey tasks with some necessary assistance from the SIWRR team. The office work of this group was mainly for data preparation, preparation of organization chart information and irrigation and management procedure.

No.	Activities	Hire work load	Working day SIWRR Field	Working day SIWRR Office	Working d IMC Field	Working d IMC Offic
I	**Preparation for data collection**					
1	Prepare schematic plan of irrigation system			5		5
2	Prepare scaled command area map		5	10	5	
3	Topographic map (scale 1:1000)	700 ha				
II	**Assessment of Water Balance & Irrigation Efficiencies**					
4	Inflow, outflow and irrigation application measurements					
	- installation of equipments		2			
	- 1 point of inflow & outflow measurements HL	*15 months*	15	30	15	
	- 1 point of inflow & outflow measurements at L	*6 months*	6	12	6	
	- 5 points of irrigation application measureme	*15 months*	5	2	5	
	- 5 points of monitoring the lift or depth of pu	*15 months*	5	2	5	
	- Produce H-Q curves of HL6 & LH gates		15	7	15	
5	Obtain rainfall and Eo data		3	6		
6	Calculate Eto of each crop			10		3
7	Calculate Etc of each crop			10		3
8	Identify actual irrigation areas within comand areas & mark o		5	5	30	5
9	Record cropping pattern and crop calendar		5	5	30	5
10	Record multiple use of irrigation water quantity		5	5	30	5
11	Record water lever changed in paddy fields (for mornitoring		5	10	10	10
12	Calculate total scheme water requirement			15		5
13	Calculate command area efficiency			6		
III	**Assessment of water productivity**					
14	Obtain yield & value of productions					
	- Yield and value of all kind productions (not only crop) in co		6	6	6	3
	- Price and amount of fuel consumed, yield and value of all		6	6	6	3
15	Calculate water productivity			6		6
IV	**Scheme management appraisal**					
16	Identify stakeholders for decision making on distribution of i		2	4	2	2
17	Draw organizational charts of stakeholders		1	4		2
18	Water allocation rules		1	4		2
19	Water distribution practice and operation of the irrigation sc		3	3	3	3
V	**RAPs**		6	9	6	9
VI	**Request of facilitation for technical bacstoping**		3	3	3	
20	**Coodination works and Reporting**			18		
	Total		**104**	**203**	**177**	**71**

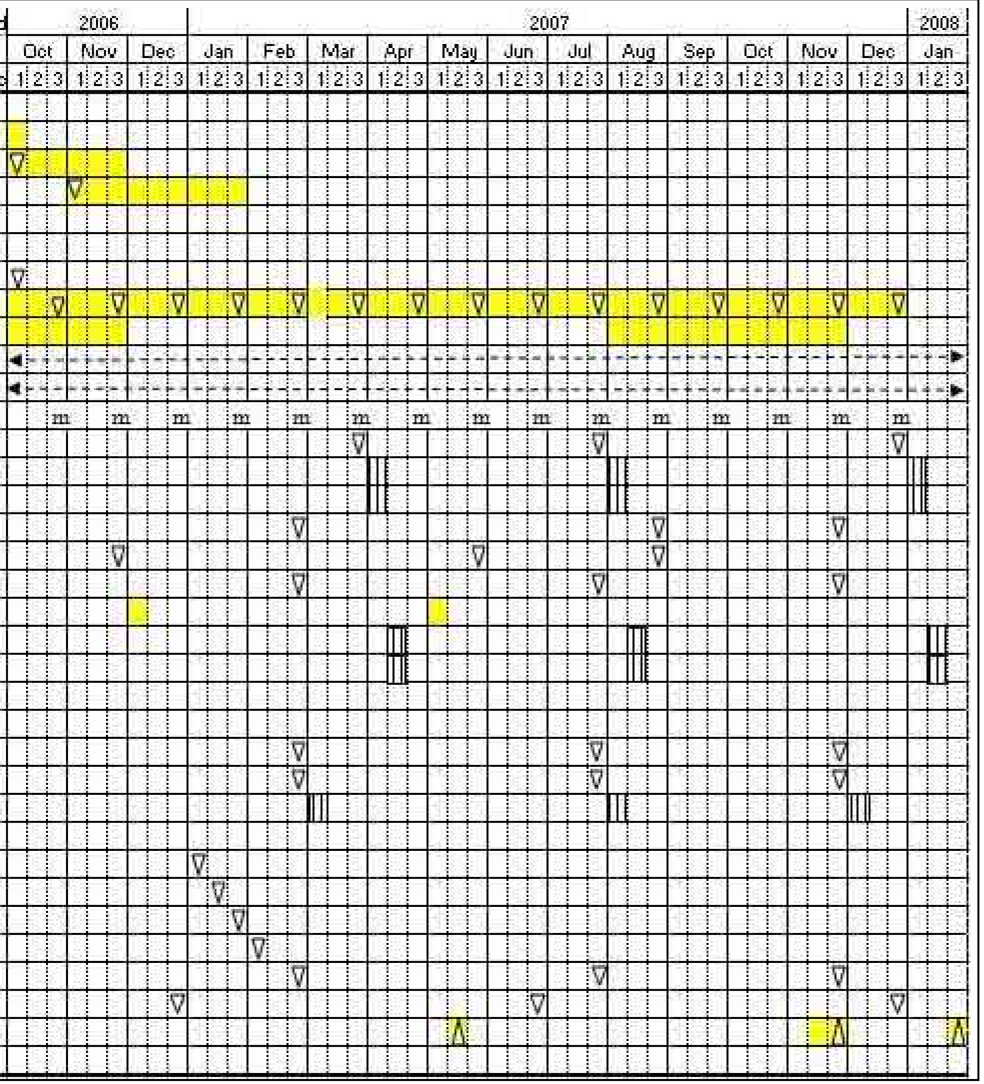


Table 1: Work-plan of IIEPF project in Longhai

All work activities have been proposed by SIWRR team, relevant training and introduction of each task and format of the survey form has been made by SIWRR team for the IMC team for further understanding. Therefore the concerned staffs understood the overall outcome of the project in general and outcome of their works in particular, a good result would expect.

The works that were carried out by the IMC team has been checked by the SIWRR team on monthly basis. Overall collected data was used to evaluate the water balance of the project area by SIWRR team.

3.2. Methods applied to conduct field work

3.2.1. Procedure, map, equipments preparation for field work

3.2.1.1. Irrigation system and command area map

Irrigation system and well as command area map has been digitized from the available maps with 1/5,000 and 1/25,000 scale. In addition, data and information collected from the topographic survey was used. The length of canal and command area was calculated from the digitized map with assistance from ARC/VIEW tools.

3.2.1.2. Preparation for flow measurement and water balance

As it was anticipated during the development of the technical proposal, it is not easy to measure the flow distribution for each irrigation canal, because: 1) the canals are open link to each other; 2) dimension of canal is very large in comparison with the actual dimension needs to convey its actual flow. E.g. the maximum flow for the Long Hai area may be 1 m^3/s. In total there was 20 tertiary canals, it means that average flow for each tertiary canal is 0.05 m^3/s. The average of cross-section area at the water level on the canal at 0.7 m+MSL is 6.0 m^2. This means that the average flow velocity is about 0.0083 m/s, which is very low flow velocity that accuracy of the current meter could not give the correct value.

This situation was recognized from the early stage, therefore it was suggested that the whole Long Hai irrigation area was considered as one irrigation block. There was only inflow and outflow from the project area at the HL6 and Long Hai sluices monitored.

Data logger and water level sensors were installed at the two main sluices (Long Hai and HL6) to record the water level at the upstream and downstream of the sluices. Flow discharge through the sluices was calculated by flow equations as described below.

- <u>For HL6 sluice</u>

HL6 sluice is a squared siphon (1.5m x 1.5m) across the HL6 road; it was introduced that the flow pass through the sluice would calculate by the flow equation of a pipe (Hydraulic Lecture of Hanoi Water Resources University).

$$Q_{HL6} = A * v = A * m * \sqrt{2g(H_u - H_d)}$$

Or $$v = m * \sqrt{2g(H_u - H_d)}$$

In which:

Q_{HL6}: flow discharge at HL6 sluice (m^3/s)

A: cross-section area of sluice

v: flow velocity through the cross-session of sluice (m/s)

m: flow coefficient

g: gravity acceleration (9.81 m/s^2)

Hu: water level at the upstream of sluice (m), neglected term of $v^2/2g$

Hd: water level at downstream of sluice (m)

Where:

Hu and Hd: recorded by data loggers

m: can be calculated by below equation, the velocity can be measured by current meter

$$m = v / \sqrt{2g(H_u - H_d)}$$

- Longhai sluice

The Longhai sluice is an open gate of 5 m wide; flow pass through the gate was calculated by the flow equation of weir:

$Q_{LH} = m * B * \sqrt{2g} * Ho^{3/2}$ if there is a free flow condition, and

$Q_{LH\ submurge} = m_{sub} * (2/3)^{1.5} * B * H_o * \sqrt{g(H_u - H_d)/(1-n)}$

in submerge flow condition.

Where

Ho = Hu - Hc

Ho: the depth of water above the cress level of the sluice

Hc: cress level of the sluice

Hu: upstream water level

m: flow coefficient of the weir

m_{sub}: submerge flow coefficient, normally < 1.

n: ratio of Hu/Hd

With a current meter supported by MRCS, flow measurement was conducted during each visit (monthly basic) therefore the flow coefficient for both sluices in free flow condition and submerge condition was obtained and therefore inflow and outflow was calculated.

3.2.1.3. Preparation to monitor the actual irrigation water

Different to the gravity irrigation in upper part of the basin, the irrigation systems in the Mekong delta could have many functions: irrigation and drainage; storage of water for further use; and navigation … Therefore the total diversion water to the project area does not mean for irrigation only. In order to evaluate the actual volume of water used for irrigation, a field monitoring was implemented at 5 selected fields.

Water level meters were installed on the canals and on the selected fields. The water level on the canal and the water level on the fields before and after the irrigation applied have been recorded. The irrigation depth of each time was

calculated from the water depth before and after the irrigation. Total irrigation applied was calculated by the following measure.

$$TIW5 = \sum_{j=1}^{5} \left(\sum_{i=1}^{n} (Aj * (\overline{Haj} - \overline{Hbj})_i \right))$$

Where:

TIW5: total irrigated water at 5 selected fields
j: selected field (j=1 to 5)
n,i: number of irrigated time and its order
Aj: irrigation area of selected field j;
$\overline{Haj}$ and $\overline{Hbj}$: average of water depth on the field j after and before each irrigation applied;

Each selected field was installed 5 water level meters to record the water level on the field before and after of each irrigation time. The $\overline{Haj}$ and $\overline{Hbj}$ was calculated from the recorded data at these 5 locations of water level meters.

$$\overline{Haj}, i = \frac{1}{5} * \sum_{k=1}^{5} Haj, i, k$$

and $$\overline{Hbj}, i = \frac{1}{5} * \sum_{k=1}^{5} Hbj, i, k$$

k: number of water level meter

Therefore, Actual applied irrigation water for 1 ha, TIW1ha, was evaluated from the result of irrigated water from the 5 selected fields

$$TIW1ha = \frac{TIW5}{\sum_{j=1}^{5} Aj}$$

The above evaluated result of actual applied irrigation for 1 ha was used as irrigation module for the whole project area.

3.2.1.4. Preparation of hydrological data collection

It was proposed on the technical proposal that the meteorological data (rainfall and evaporation) was obtained from My Tho station. However, during implementation of the project, it was recognized that the project area was too small in comparison with the Gocong irrigation project area, therefore the obtained data from My Tho station might not really be suitable for the requirement of the IIEFP project. Therefore, in addition for data obtained from My Tho, the rainfall and evaporation data was also monitored at the Longhai station. Rainfall was monitored by a rain gauge and evaporation was monitored by Piche pipe.

3.2.2. Method used to conduct water balance in the scheme

The sketch of water balance for Longhai irrigation project area was drawn as Fig. 3. Where the project area was simplified into three main areas: The open canal

area; the rice cultivation area; and the other land use area (road, upland crop and urban area).

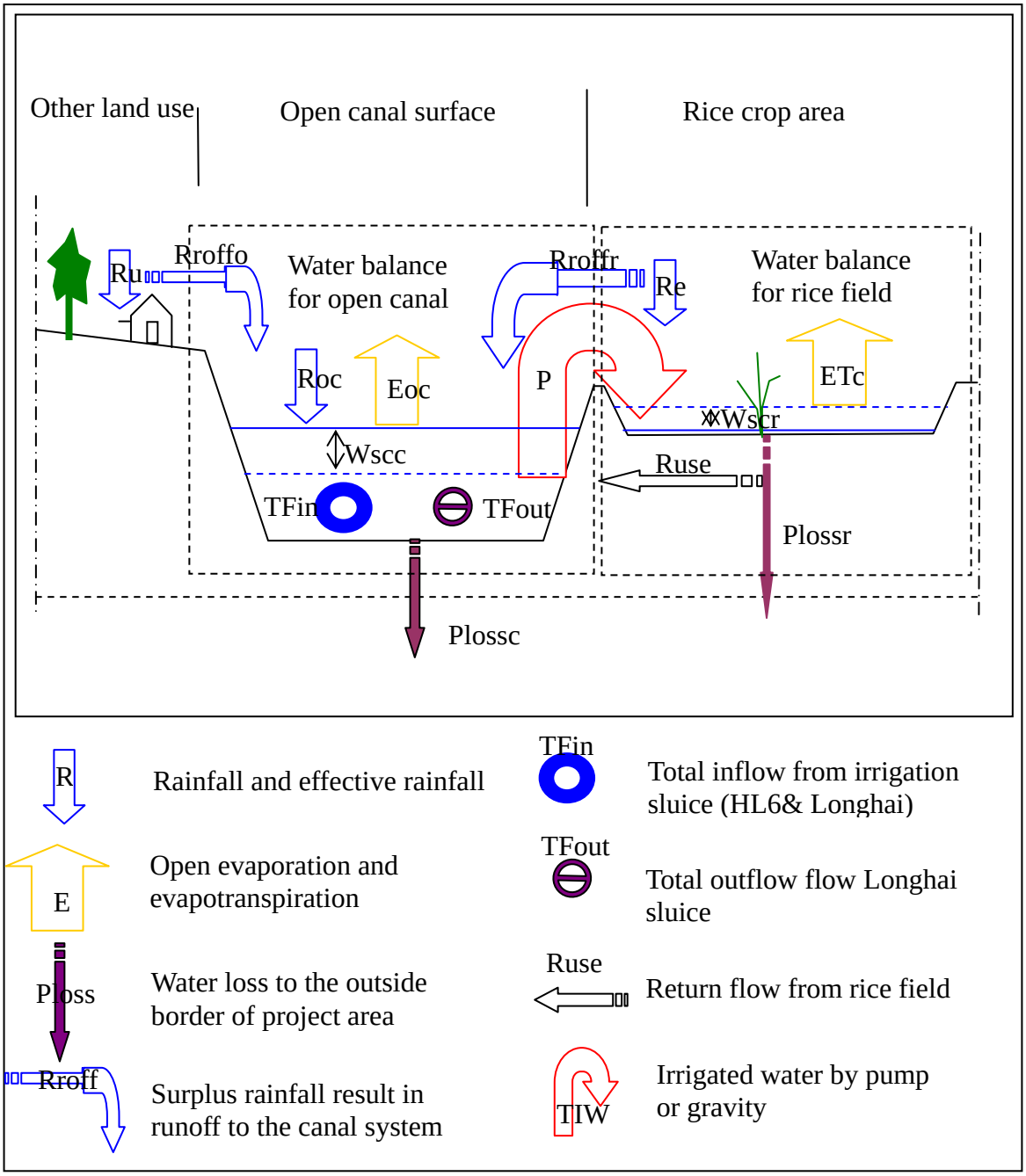


Fig. 3: Diagram of Water balance for Longhai irrigation project area

Water balance in the project area was simplified into two main parts: 1) water balance for open canal system; and 2) water balance for the rice field areas. The water balance for these two simplified areas was presented below.

3.2.2.1. Water balance for open canal area

The water balance for open canal system was calculated by equation (1):

1	TFin – TFout + Roc + Rroffo + Rroffr – Eoc – Plossc – Wscc – Ouse = IWused

Where:

- TFin: Total inflow from HL6 and Longhai sluices. This was calculated by this equation

$$TFin = Q_{HL6} * T + Q_{LH} * T$$

Where :

T: operated duration time during water balance calculation period(s)

Q_{HL6}, Q_{LH} : inflow from HL6 and Longhai sluices, calculated from recorded water levels by equation.

- TFout: total outflow pass through the Longhai sluice. This outflow was calculated as same as the inflow from the sluice into the project area, but the flow direction was in opposite way and the upstream water level was the water level in the project side.

$$TFout = Q_{LH} * T$$

- Roc: total rainfall to the open canal system area. Effective rainfall coefficient on the canal was set equal to 1.

Roc = TCSA * Total rainfall*10

Where:

TCSA[ha]: Total canal surface area (maximum canal surface area at elevation of the canal banks)

- Rroffo: Rainfall runoff from other lands. It was assumed that the surplus rainfall water onto other lands area would result in the rainfall runoff flow to the canal system.

Rroffo = TOA*(Total rainfall-Effective rainfall)*10

Where:

TOA: total other land area [ha]

The evaporation in Longhai area was evaluated of around 4 mm/day and infiltration rate was about 6 mm/day, therefore rainfall with a density of less than or equals 10 mm/day considered as effective rainfall and the surplus rainfall above 10 mm/day was considered as the rainfall runoff from other lands, therefore Rroffo was calculated by this equation

$$Rroffo = TOA * \sum_{i=1}^{T} (Pi - 10) * 10$$

Where: Pi: rainfall on the day i, T: times of the crops

- Rroffr: Rainfall runoff from rice fields. It was assumed that a daily rainfall density of less than or equals 5 cm not resulted in the rainfall runoff, as rice has been applied of submerged irrigation, therefore the surplus of rain water above 5cm/day was considered as the rainfall runoff from the rice fields

$$Rroffr = TRA * \sum_{i=1}^{T} (Pi - 50) * 10$$

Where:

TRA: total rice crop area [ha]

- Eoc: Open evaporation from the canal. It was calculated by this equation

$$Eoc = TCOWA * Eo*T*10$$

Where:

TCOWA: total canal open surface water area (as area at the actual water level, ha)

Eo: open water evaporation (mm/day)

T: Duration for calculation of water balance

10: conversion factor for volume in m^3

- Plossc: Percolation from the canal to the outside. In this calculation, it was assumed that the percolation from the canal to the outside area set equal to zero. Because: a) the canal area is rather small in comparison with the total area; b) the ground water level is quite close to the surface in the Mekong delta; the average of water level outside the project area was almost equal to the water level on the canal. Therefore the percolation can be neglected.

- Wscc: the change on the storage volume of canal. This was evaluated from the change of water level on the canal from the beginning of the crop season to the end of the crop season. The relation of the water level and the storage volume of water was obtained from the surveyed cross-section data of the canals.

- Ouse: Other water used. It was evaluated from the field survey data, all other kind of water use were recorded from field survey: e.g. domestic water use, water use for fishing and breeding…

- IWused: Irrigation water use. The calculated result from the left side of the equation (1) was considered as the irrigation water use during the calculation period. This was evaluated as the irrigation water use for the project area based on the water balance calculation method.

3.2.2.2. Water balance for rice crop area

It was found that the limitation of irrigation water use calculated by the water balance equation (1) is not taken into account the rotation of the return flow from the rice fields to the canal system. Therefore, to evaluate the rotation of this return flow for irrigation, a second water balance was made for the rice crop area by equation (2).

$$TIW - Tdf + Rer - Wscr - ETc = Plossr + Ruse \quad (2)$$

Where:

- TIW: total irrigated water for irrigation or total irrigation applied in overall of the project area.

$$TIW = TIW1ha * TA$$

Where:

TIW1ha: total irrigated water for one hectare of rice

TA: total irrigated area. This was evaluated as same as total rice crop area

- Tdf: Total drainage flow, similar for the total irrigation applied, water levels on the rice fields were recorded before and after each drainage period at 5 selected fields.

$$TDW1ha = \frac{TDW5}{\sum_{j=1}^{5} Aj} = \frac{\sum_{j=1}^{5}(\sum_{i=1}^{5} Aj * (\overline{Hbj} - \overline{Haj})i)}{\sum_{J=1}^{5} Aj}$$

and Tdf = TDW1ha * TA

Where:

TDW1ha: total drainage water for 1 ha

TDW5: total drainage water from 5 selected fields

- Rer: Effective rainfall on the rice fields, this was calculated by the method that introduced by FAO, (Pe = P*0.6-10 if P< 75 mm and Pe = P*0.8-25 if P>75 mm).

- Wscr: The change on the storage water on the rice field, the change of storage water on the field from the beginning to the end of each crop season. This data was based on the recorded water level at 5 selected fields.

- ETc: Evapotranspiration of rice, ETc was calculated by this equation:

ETc = ETo * Kc

Where:

ETo : reference crop evapotranspiration was calculated by Blaney-Criddle and Penman Monteith methods, detail of these methods please refer to the websites of FAO.

Kc : Crop factor, obtained from FAO

- Plossr : water loss from the rice fields to the outside due to depth percolation and leakage…

- Ruse: return flow from the rice field to the canal for reuse

It was recognized that the total irrigated water losses from the rice field (Plossr+Ruse) was unknown, however it can be evaluated from the result of left side of the equation (2).

The (Plossr+Ruse) evaluated by equation (2) for selected fields was considered as the actual percolation and leakage from the irrigated fields. As if there was no water on the field, there would be no water for percolation and leakage. The potential percolation and leakage would higher than that.

In other hand, the (Plossr+Ruse) was also evaluated from the recorded water level change of the field measured data at 5 selected fields. This was considered as the potential percolation and leakage from the rice fields, because it happened only if there was water on the field.

The difference between the volume of irrigation water use from the water balance calculation by equation (1) and the actual volume of water was pump from the canal for irrigation was probable the volume of the return flow water rotated within the system. Therefore, in comparison to the

result evaluated from the equation (2) the losses of water from the rice fields to the outside area, ‘Plossr’, was evaluated and ‘Ruse’ was found out.

3.2.2.3. Water balance duration calculation

Rice has been intensively cultivated in Longhai, the three rice crops are overlapping each other during the early stage of this crop season and the ending stage of previous crop season. Only in April was considered as there was no cultivation. It was not easy to identify the amount of diverted water for each separated crop season during the overlapping period, therefore an approximation of time was made for each crop season, the water balance for W-S was taken from December to March, S-A from May to August and A-W from September to November.

3.2.3. Record cropping pattern and crop calendars

Cropping pattern and crop calendar was obtained from the field surveyed data. The Longhai area has been cultivated for 3 crops per year, therefore the crop survey was conducted for 3 crops: W-S, S-A and A-W. The survey was made at two levels: farm level and ward level.

- At the farm level: a field survey for 120 farmer families, accounted for 10% of the total, distributed evenly within the project area was conducted. All information related to the families, the crops as well as multiple use of water were collected. The evaluated result from this survey was also evaluated as for the whole project area.
  - Crop yield for 1 ha of the project area equal to the average crop yield that evaluated from the farm level.
  - Crop area during each sowing period for the whole project area was evaluated from the result at farm level.
- At the ward level: all data and information was collected at each village, some information collected by field survey and interviewing. This data was used to check the evaluated result for the whole area come from 120 families.
  - It was recognized that, some data and information evaluated from 120 families was not suitable for the whole project area, e.g. other water use, other crop areas. There was not much other land use and other water use in the project area therefore this information was surveyed directly from the fields: recording the other land use area from each field; record other water use from water users.

3.2.4. Identify actual irrigated area

Under the irrigation practice in gravity irrigation system, in a condition of water shortage, the water may not reach the fields located at the tail end of the canal. As a result, actual irrigated area may be smaller than the planned area. The Longhai project area has different condition that all farmers have accessed to the canal system and the water is always available on the canal, farmers can take water whenever they need. Therefore the actual irrigated area was evaluated as same as the total crop area.

The total cultivated area was identified and digitized based on the available maps and topographic survey data. All of these layers were used as the baseline maps for the project area. Based on the crop survey for each crop in 2007, actual land use map for each crop was made as separated layers.

3.2.5. Record multiple use of irrigation waters

Multiple use of water in the project area was identified as following:

- Water use for other crops (upland crop).
- Water use for fish ponds
- Water use for breeding
- Water use as for industry or factories

Multiple use of water was carried out together with the field survey at the two levels and conducted 3 times during 2007.

3.2.6. Conduct pump efficiency test at 5 selected farmer's fields

The pumping water head was recorded; the fuel, expended time and the total volume of water pumps to the field were recorded. The capacity of the pump was also monitored. Therefore, efficiency was evaluated. All of this information was recorded for 3 crops during 2007.

A form survey data was made for each farmer to record all related information to evaluate the irrigation application and evaluate the pumping efficiency.

3.2.7. Produce H-Q curves at the main and important water gates

The difference of water level at the upstream and the downstream of the HL6 and the Long Hai sluices were calculated based on the recorded data by data loggers. The water flow velocity was measured by current-meters during each data collection. Rating curve was made for each sluice or flow coefficient was calculated.

3.2.8. Obtain all kinds of production

All kinds of production were estimated based on the result of the field survey and conducted 3 times a year together with other surveyed data. The survey was conducted at two levels: household level and the commune level.

3.2.9. Documentation of scheme management

In general, the water management of any irrigation project in Vietnam should follow the 'Vietnamese Water Laws'. However it depends on the situation of each irrigation system then the structure of scheme management may be a bit different one to another. All related documents were collected from the IMC for the following tasks.

- Identification of stakeholders for decision making on water management
- Identification and development of the management organizational chart
- Recording of procedures of water allocation
- Documentation of rules of water management of the system

As it was recognized at the early stage of the project, there was no water user group established in the project area. Therefore, in order to have a better understanding of the scheme management of the system as well as actual practice of system management some information was collected by interviewing the local people.

3.2.10. Conducting final RAP

Basic needed data for RAP was collected from each crop during the year. Additional information was obtained from the field surveys and interviews. The final RAP was filled with collected data and information.

4. Result of field observation data

4.1. Irrigation system surveyed and canal data analyzed

All irrigation canal system was digitized from the administrative map with a scale 1/5,000 and 1/25,000 with additional assistance from satellite image obtained from Google Earth. An ARCVIEW shape file was produced and the length of canals was calculated based on the digitized layer of the canal system. Map of the canal system was presented in Fig 2.

In addition, a cross section survey was conducted during topographic survey. Three cross sections, at the beginning, middle and the end of each canal, were measured and leveled with the same datum of the land elevation. Basic information of all irrigation canal system was presented in Table 2.

Table 2: Summary of information for irrigation canal in the Longhai area

No	Canal	Length (m)	Bed elevation (m+MSL)	Surface width (m)	Surface area (m2)
1	7 Duy - 6 Son canal	2,820	-0.4	10.0	28,200
2	7 Trung canal	811	-0.4	5.0	4,055
3	Bolang canal	886	-0.7	13.0	11,518
4	Capde canal (left)	3,676	-0.2	18.0	66,168
5	Capde canal (right)	4,458	-1.2	22.0	98,076
6	Giua canal	904	-0.1	7.5	6,780
7	Haibinh canal	1,367	-0.2	8.5	11,620
8	Haichieu canal	1,557	-0.6	7.5	11,678
9	Haiden canal	1,301	-0.1	10.0	13,010
10	Hangnhi canal	2,191	-0.5	11.0	24,101
11	Huonglo 6 canal	4,050	-1.1	13.0	52,650
12	Hoaphu canal	915	-0.5	9.5	8,693
13	Hong canal	672	-0.3	7.0	4,704
14	La channel	591	-0.3	10.0	5,910
15	Mieu canal	833	-0.2	5.5	4,582
16	Quoian canal	1,353	-1.2	6.0	8,118
17	Rachla canal	2,087	-0.4	8.0	16,696
18	Tamtot canal	1,452	-0.1	9.0	13,068
19	Tumoi canal	1,004	-0.5	6.0	6,024
20	Tuphen canal	508	-0.1	8.0	4,064
	Total length	33,436			40 (ha)

Based on the above information of the canal system, a relation curve of the storage volume of water and the water level was produced in order to assist the water balance calculation for the project area as presented in Fig. 4. Detailed

calculation of this curve was referred to additional excel file named 'H-W_curve.xls'.

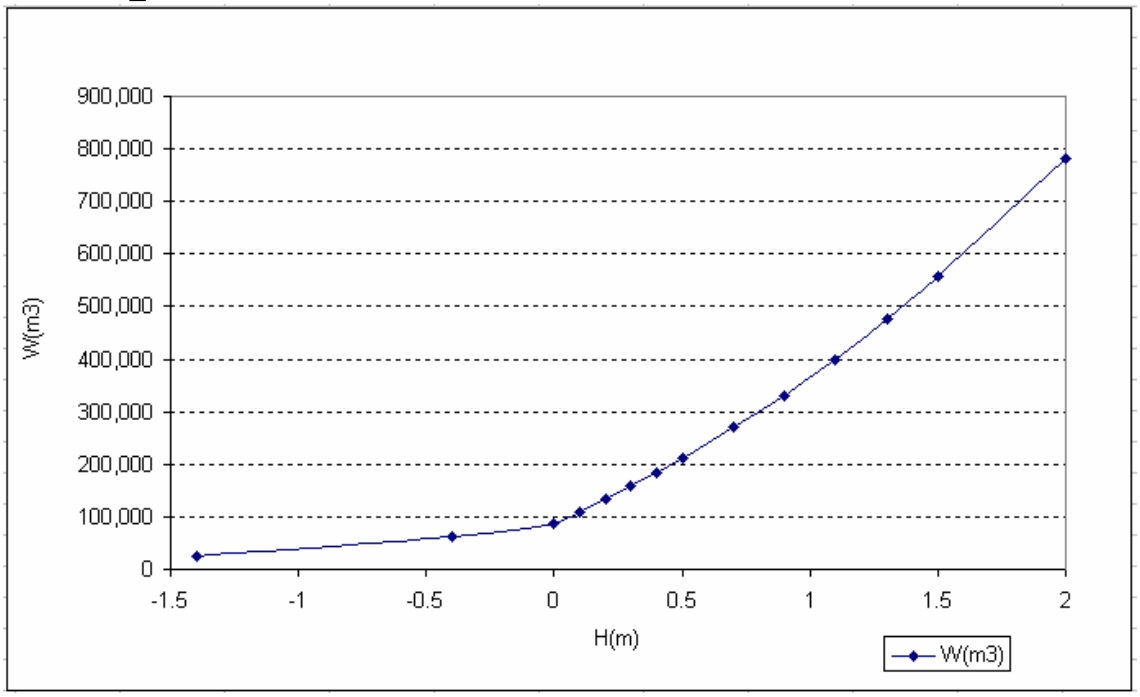


Fig. 4: H-W curve of canal system (Water level vs. Storage volume)

It was evaluated that the Long Hai irrigation canal system has a total storage capacity of 550,000 m^3 at the water level of 1.5 m+MSL and 350,000 m^3 at the water level of 1 m+MSL (see Fig.4).

There was two main irrigation sluices:

- The HL6 sluice (see Photo 1) is main irrigation sluice of the area located under local road HL6, the main dimension of the sluice is:
  - 1.5 m x 1.5 m rectangular sluice
  - -1.5 m+MSL of the crest level

Photo 1: A photo of HL6 sluice

- The Longhai sluice (See Photo 2): an open sluice gate functioned as the main drainage sluice of the project area, salinity intrusion protection sluice and as an intake during Aug. to Nov.
  - 5 m wide
  - -2.1 m+MSL of crest elevation

Photo 2: A photo of Longhai sluice

The HL6 sluice is considered as the under road sluice, therefore it was open in most of the time, during 2007 the HL6 was closed for only 32 days (see Appendix 17) for the operation of the Longhai sluice. The Longhai sluice was mainly closed for salinity intrusion protection purpose, From Dec 2006 to Dec 2007 there was 52 days of operation for drainage and taking water.

4.2 Preparation of scaled map of command area of the irrigation scheme

A scaled map of command areas was collected, however it was too old for the studying purpose. The situation in 2007 was very much different from the obtained map. With assistance from the satellite image and the topographic survey, a command area was digitized. Two shape files were produced for the project area, one file presenting the urban area and other file presenting the agriculture cultivated area.

Evaluated land use on the project area was shown on Table 3. Based on the surveyed data, 100% of the irrigated area was relied on the water from the canals, therefore it could be concluded that the actual irrigated area equals to the total agriculture area and rice crop area was the main irrigated area.

The cultivated area was divided by irrigation canals into some small zones. However, the command area by each irrigation canal was not clear due to the flat area and open link canal system. In this study, in order to facilitate the socio-economic and crop survey, the project area was simplified into 10 zones as showed in the Fig. 5. This was based on the canal boundary and ward boundary.

Table 3: Land use of the project area during 3 crop seasons in 2007

No	Land use type	Abbreviation	Area for each crop season (ha)			Remark
			W-S	S-A	A-W	
1	Agricultural area	TRA	707.3	707.3	707.3	Surveyed data
	- Rice crop	TRA	697.1	704.8	701.7	Surveyed data
	- Dry crop (water melon)		10.2	2.5	5.6	Surveyed data
2	Open canal system	TCSA	40.0	40.0	40.0	Calculated
	Open canal surface (at level of 0.8 m)	TCOWA	30.0	30.0	30.0	Calculated
3	Other land	TOA	201.3	201.3	201.3	Based on GIS data
	Total		948.6	948.6	948.6	Based on GIS data

Note: the 'Abbreviation' and its data presented in Table 3 were utilized for the water balance calculation.

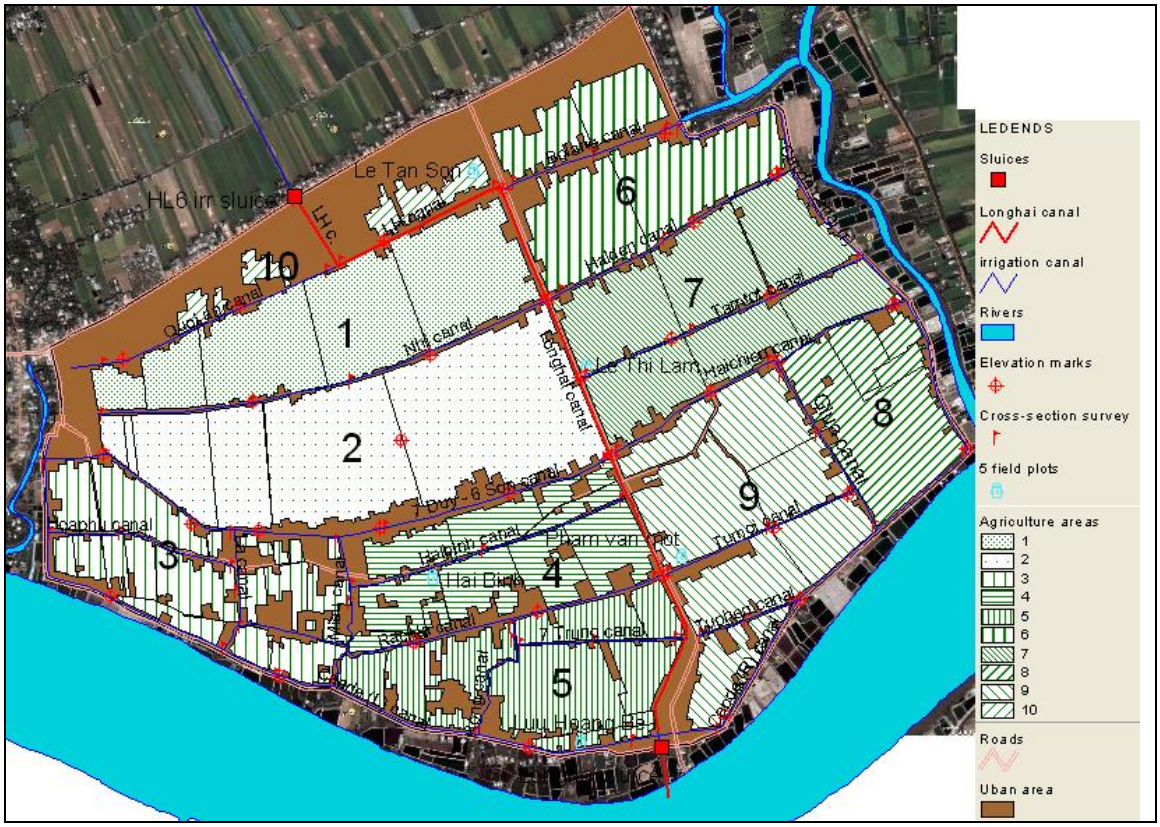


Fig. 5: Map of irrigation zones in Longhai project area

The basic information of these zones was given in Table 4.

Table 4: Basic information of crop area for each zone

ID of irrigation zone	Location	Area (m^2)
1	Longbinh village	876,547
2	Longbinh village	1,286,293
3	Longbinh village	594,324
4	Longbinh village	578,821
5	Longbinh village	653,017
6	Binhtan village	671,432
7	Binhtan village	926,494
8	Binhtan village	455,438
9	Binhtan village	909,033
10	Longbinh village	121,423
	Total area	**7,072,822**

4.3. Topographic survey map

Based on the topographic survey data, elevation map of the system was produced as presented in Fig 6. The classification of rice area by elevation was shown in Table 5. It was found that 34.4% of the total rice area has elevation below the 1m+MSL. The most common area has elevation from 0.95 to 1.15 m+MSL, was accounted for 73.3 % of the total rice area.

Table 5: Classification of rice crop area by elevation at Longhai

No	Elevation (m)	Area (ha)	% area	Sum of Area (ha)	Sum of % area
1	< 0.75	0.2	0.0	0.2	0.0
2	0.75- 0.80	3.2	0.5	3.4	0.5
3	0.80-0.85	14.2	2.0	17.6	2.5
4	0.85-0.90	34.1	4.9	51.7	7.4
5	0.90-0.95	58.2	8.3	109.9	15.8
6	0.95-1.00	129.6	18.6	239.5	34.4
7	1.00-1.05	142.3	20.4	381.8	54.8
8	1.05-1.10	161.8	23.2	543.6	78.0
9	1.10-1.15	77.4	11.1	621.0	89.1
10	1.15-1.20	46.6	6.7	667.6	95.8
11	1.20-1.25	21.4	3.1	689.0	98.8
12	1.25-1.30	6.0	0.9	695.0	99.7
13	1.30-1.35	0.9	0.1	695.9	99.8
14	> 1.35	1.2	0.2	697.1	100.0
	Total	697.1 ha	100%		

In comparison with the recorded water levels on the canal during 2007 crop seasons, it was found that there was only the area has the elevation less than 0.85 m+MSL could get gravity irrigation sometimes, hence it was accounted for 17.6 ha (2.5%) got gravity irrigation for 1,800 hours (2.5 months) approximately 20% of the times.

Therefore, gravity irrigation area for all rice crop seasons was negligible in Longhai irrigation area.

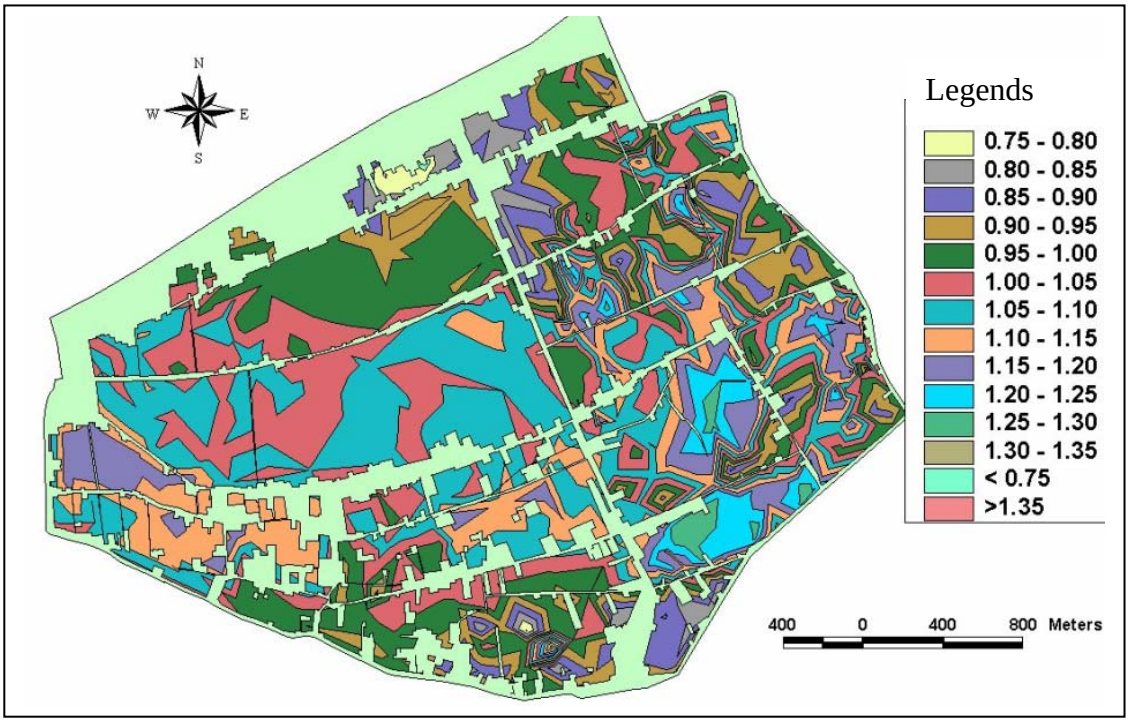


Fig. 6: Topographic map of Longhai project area.

4.4. Data of rainfall and evaporation, calculation of ETo and Pe

The rainfall and evaporation was obtained from My Tho station during November 2006 to Mar 2007 used for W-S crop, the measured data at Longhai during May to December 2007 was used for S-A and A-W crops. The basic climate information for each crop season was evaluated and presented in Table 6.

Table 6: Basic information climate data for each crop season

No	Items	Unit	Summary data for each crop season		
			W-S	S-A	A-W
1	Calculation period	Days	121 Dec-Mar	123 May-Aug	91 Sep-Nov
2	Total rainfall	mm	65.1	1047.9	490.3
3	Rainfall runoff from other lands	mm	26.5	629.9	224.6
4	Rainfall runoff from rice fields	mm	0	128.3	0
5	Total evaporation	mm	417.1	284.9	222.5

Note: detail of this data in appendix 7.

In order to have the best fit evapotranspiration for the Longhai project area, the reference crop evapotranspiration was calculated and checked by three methods given below.

- Blaney-Criddle: two input data was used for this method, the calculation with real sunshine data from the My Tho station (called ETo BL1) and the calculation with the recommended data obtain from the Global data (called ETo BL2);
- Penman Monteith (called ETo FAO) method;
- In addition, ETo was calculated from the measured evaporation from Longhai with a factor of 1.54 calculated from My Tho station, ETo = 1.54*Eo. (called ETo use).

The results of all ETo calculation were given in Appendix 8. Summary of the results were shown on the Fig. 7.

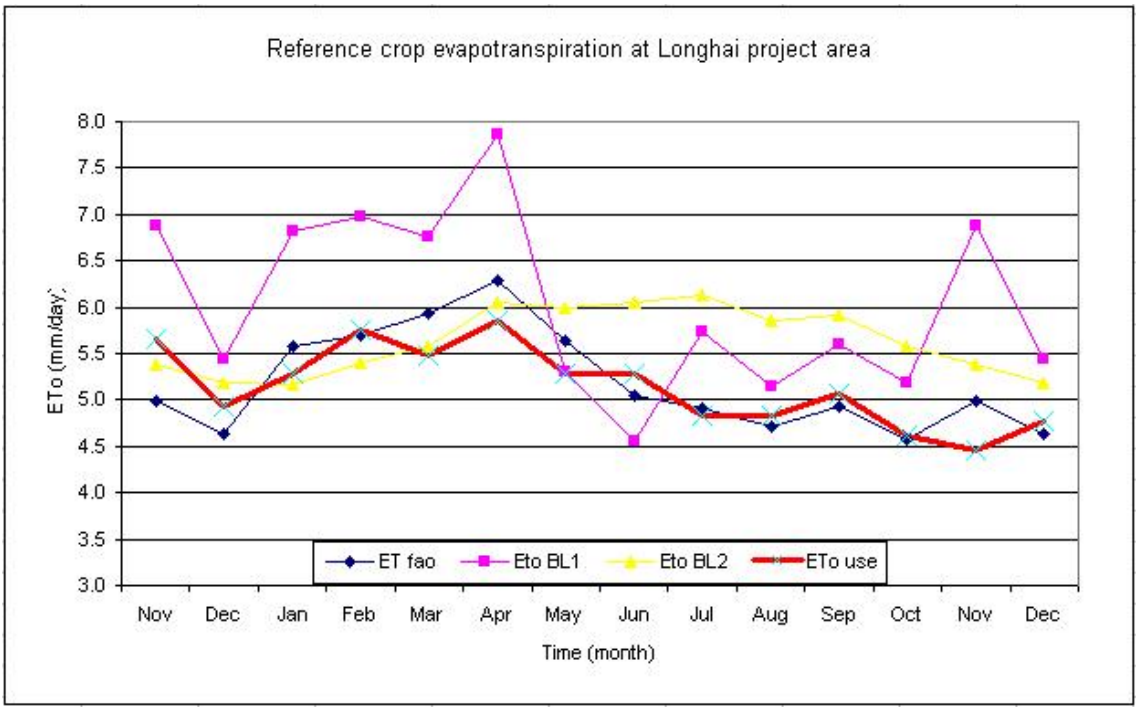


Fig. 7: Reference crop evapotranspiration at Long Hai project area

As seen from the figure, ETo was rather different from different calculation methods. The '**ETo use**' was driven by the recoded evaporation data at the project site has fallen in between the ranges of the results from other calculation methods, therefore it was introduced to use for calculation of crop water requirement in this study.

4.5. Water flow measurement

4.5.1. Water flow at HL6 sluice

The upstream and downstream water level at HL6 sluice was recorded by the data logger. These equipments were installed by December 2006 and hourly interval of water level was recorded. Monthly travel plan was implemented to download the data.

Flow measurement was measured for HL6 sluice by using the current-meter during each time for data collection (on monthly basis). Based on the flow monitored results and the recorded water level upstream and downstream of the sluice, the flow

coefficient for HL6 is evaluated as 0.42, detail of this calculation was given in Appendix 16.

During the W-S crop, the HL6 sluice has heavily impacted by vegetation deposited in both sizes of the HL6 sluice, therefore the flow calculation for this period was taken of 60% of the normal condition. The missing data in Dec 2006 was taken as same as the flow in Dec 2007. Summary of calculated flow at HL6 was presented in Table 7. Detail of this calculation was referred to additional excel file named HL6-flow-calculated.xls.

Table 7: Basis information and calculated flow at the HL6 sluice

No	Month	Average water level (cm)	Data available	Average discharge during measured period (cm)	Total water flow through HL6 sluice (m^3)	Total water flow during the crop season (m^3)	Crop season
(1)	(2)	(4)	(5)	(6)	(7)	(8)	
1	Dec-06		No data		*1,756,757*		
2	Jan-07	78.7	25-31 Jan	0.34	923,002		
3	Feb-07	57.5	Full	0.70	1,690,754		
4	Mar-07	43.3	Full	0.66	1,762,612	3,679,875	W-S
5	Apr-07	12.2	No				
6	May-07	49.7	Full	0.07	167,303		
7	Jun-07	74.4	Full	0.24	614,565		
8	Jul-07	78.8	Full	0.45	1,216,147		
9	Aug-07	67.1	Full	-0.18	-201,095	1,796,921	S-A
10	Sep-07	69.2	1-19 sep	0.41	646,728		
11	Oct-07	85.0	23-31 oct	-0.59	365,549		
12	Nov-07	69.1	Full	1.10	2,843,966	3,856,243	A-W
13	Dec-07	75.9	Full	0.66	1,756,757		
14	Jan-08	87.7	No data				

4.5.2. Water flow at Longhai sluice

The upstream and downstream water level at Longhai sluices was recorded by the water level sensors. These equipments were installed by December 2006 and hourly interval of water level was recorded. Photo 3 shows the data downloaded at Longhai station.

Photo 3: Data downloading from Longhai station

Flow measurement was measured for Longhai sluice by using the current-meter during its operation period. Based on the flow monitored results and the recorded water level upstream and downstream of the sluice, the flow coefficient for Longhai sluice was evaluated as 0.60 (see Appendix 18). However due to the Longhai sluice was very old design therefore the opening of the sluice gate was smaller than the width of the sluice, its ranges from 0 to 4 m depend on the difference of the water levels at the upstream and downstream of the sluice and this opening width of sluice was not recorded. Therefore the water flow of the sluice was obtained from the calculated flow by the IMC. Summary of calculated flow at Longhai was given in Table 8. Detail of this calculation was given in Appendix 19 and referred to additional excel file named LH-flow-calculated.xls.

Table 8: Basic information and calculated flow at the Longhai sluice

No	Month	Number of operation day (day)	Number of operation for irrigation	Total drainage water (m^3)	Drainage of water for each purpose		Total flow for irrigation (m^3)
					Due to rainfall (m^3)	On scheduled (m^3)	
1	Dec – 06	2	-	115,839	-	115,839	-
2	May – 07	5	-	651,091	437,763	213,328	-
3	Jun – 07	3	-	469,010	469,010	-	-
4	Jul – 07	4	-	459,249	-	459,249	-
5	Aug – 07	12	6	1,197,955	235,610	962,345	886,096
6	Sep – 07	9	4	1,096,966		1,096,966	788,252
7	Oct – 07	7	5	1,169,903	206,740	963,163	1,165,245
8	Nov – 07	7	-	821,177	315,937	505,240	-
9	Total	49	15	5,981,190	1,665,060	4,316,130	2,839,593
10	W-S			115,839	-	115,839	-
11	S-A			2,777,305	1,142,383	1,634,922	886,096
12	A-W			3,088,046	522,677	2,565,369	1,953,497

Remark:

- Data in rows 10 to 12 are the calculated volume of irrigation and drainage water for each crop season from Longhai sluice.
- 'On scheduled' operation means operation for replacement of stagnant condition of water.
- 49 operation times out of total 52 recorded were taken into account for water balance, 3 operation times were ignore as out of the water balance calculation period.

4.6. Actual irrigation applied

The actual irrigation water applied was recorded at 5 selected fields together with other related data. For detailed information was referred to additional excel files (\5-family\ and a separated folder for data of each crop season). The summary actual irrigation water applied as was shown in Table 9 and Appendix 10 and 11. It was found that the irrigation application has a large range from 5,040 m^3/ha to 9,360 m^3/ha for W-S, 2,111 m^3/ha to 8,252 m^3/ha for S-A and 1,566 m^3/ha to 8,341 m^3/ha for A-W. The average of irrigation application was about 7,799 m^3/ha for W-S, 4,489.8 m^3/ha for S-A and 4,448.8 m^3/ha for A-W.

It was found that the soil condition in Longhai area is silt-sandy soil and had impacted by salinity soil, therefore the infiltration rate is very high, the water on the rice field has gone after the irrigation for 1 day (see Appendix 21). The higher

infiltration rate would resulted in a higher irrigation requirement of the system, therefore in order to find the reasonable rate of infiltration for the calculation of irrigation water requirement of the system, two assumptions were made:

- The daily average of irrigation water between two irrigations was about 11.3 mm/day, Etc-Pe was about 5.0 mm, and it means that the infiltration was about 6.3 mm/day. This infiltration rate is considered as potential infiltration in the project area.
- Irrigation module for W-S rice crop is about 779.9 mm / 95days = 8.2 mm/day, hence by the same way as presented above the infiltration rate of 3.2 mm/day was evaluated. This was considered as the infiltration rate resulted from irrigation practice in Long Hai, therefore the 3.2 mm/day of infiltration was used for the calculation of scheme water requirement.

Table 9: Summary of irrigation water used at 5 selected pilots

Crop	No	Information	Unit	Family name					Average of 5 plots
				1	2	3	4	5	
				Diep	Son	Be	Binh	Mot	
W-S	1	Area	m2	3,358	4,968	2,701	5,757	7,257	4,808
	2	Amount of used water	m^3	3,143	2,504	2,468	4,139	6,002	3,651
	3	Water use/ha	m^3/ha	9,360	5,040	9,137	7,190	8,271	7,799
	4	Number of irrigation application	Time	17	14	18	23	13	17
	5	Daily average of irrigation	cm/day	1.25	0.73	1.33	1.26	1.06	1.13
S-A	6	Area	m2	3,358	4,968	5,000	5,757	7,257	5,268
	7	Amount of used water	m^3	709	995	2,229	3,071	3,445	2,090
	8	Water use/ha	m^3/ha	2,111	2,003	8,252	5,335	4,747	4,489.8
	9	Number of irrigation application	Time	6	4	15	12	8	9
	10	Amount of drainage water	m^3	146.7	651.5	466.0	-	267.0	306.2
	11	Drainage volume per ha	m^3/ha	437.0	1,311.4	1,725.3	-	367.9	768.3
A-W	12	Area	m2	3,358	4,968	2,701	5,757	7,000	4,757
	13	Amount of used water	m^3	526	808	1,459	4,802	3,716	2,262
	14	Water use/ha	m^3/ha	1,566	1,626	5,402	8,341	5,309	4,448.8
	15	Number of irrigation application	Time	5	3	11	12	7	8

Note: data obtained from Appendix 10 (10.1 to 10.3) and 11(11.1 to 11.3)

4.7. Record of cropping pattern and crop calendars

The basic information evaluated from data collected from 120 farmers during three rice crops in 2007 was presented in Table 10. Based on the surveyed crop data, W-S was simplified into 4 main grown durations: Rice grown in November accounted for 24.6% of the rice crop area, from 1st to 10th of December accounted for 52.8%, 11th to 20th of December 19.0% and the last duration of December accounted for 3.6%. S-A was simplified into 3 main grown durations: Rice grown in first 20 days of May accounted for 40.06% of the rice crop area, from 21st to 31st of May accounted for 53.68%, and the last grown duration in June accounted for 6.26%. A-W was simplified into 3 main grown durations: Rice grown in last 15 days of August accounted for 41.32% of the rice crop area, from 1st to 10th of September accounted for 38.10%, and the last grown duration in September accounted for 20.59%.

The above information was used to evaluate for the whole project area as presented in column (6) of Table 10. This classification of crop duration and crop area was used for the calculation of crop water requirement.

Table 10: Basic information evaluated from data collected from 120 farmers

	No	Items	Unit	Information from 120 selected farmers	Account in %, or area	Evaluated data for Longhai
	(1)	(2)	(3)	(4)	(5)	(6)
W-S	1	Average of length of crop	Day	95		95
	2	First crop grown	date	1-Nov		
	3	Last crop harvested	date	30-Mar		
	4	Total area grown in Nov	Ha	17.15	24.6%	171.5
	5	Area grow in 1-10th Dec	Ha	36.91	52.8%	368.1
	6	Area grow in 11-20th Dec	Ha	13.27	19.0%	132.4
	7	Area grow in last Dec	Ha	2.5	3.6%	25.1
	8	First crop harvested	date	7-Feb		
	9	Last crop harvested	date	30-Mar		
	10	Total area harvested in Feb	Ha	8.25	11.8%	
	11	Total area harvested in Mar	Ha	61.58	88.2%	
	12	Yield of W-S crop	Ton/ha	4.93		4.93
S-A	1	Average of length of crop	day	95		95
	2	First crop grown	date	02-May		
	3	Last crop harvested	date	16-Sep		
	4	Area grow in 1st-20th, May	ha	27.98	40.06%	282.3
	5	Area grow in later of May	ha	37.50	53.68%	378.3
	6	Total area grown in June	ha	4.37	6.26%	44.1
	7	First crop harvested	date	06-Aug		
	8	Last crop harvested	date	16-Sep		
	9	Total area harvested in Aug	ha	47.303	67.82%	
	10	Total area harvested in Sep	ha	22.446	32.18%	
	11	Yield of S-A crop	Ton/ha	4.14		4.14
A-W	1	Average of length of crop	day	93		93
	2	First crop grown	date	15-Aug		
	3	Last crop harvested	date	18-Dec		
	4	Area grow from 15/08 to 31/08	ha	28.859	41.32%	289.9
	5	Area grow from 1/09 to 10/09	ha	26.61	38.10%	267.3
	6	Area grow from 11/09 to 30/09	ha	14.38	20.59%	144.5
	7	First crop harvested	date	04-Nov		
	8	Last crop harvested	date	18-Dec		
	9	Total area harvested in Nov	ha	18.709	26.78%	
	10	Total area harvested in Dec	ha	51.14	73.22%	
	11	Yield of A-W crop	Ton/ha	4.48		4.48

4.8. Actual irrigated area

Total crop area in Longhai irrigation project evaluated from GIS data was 707.2 ha. Based on the surveyed data, all of this crop area irrigated from the canal, no claim of shortage of water was recorded during 2007, therefore the actual irrigated area was evaluated of 707.2 ha, most of the area was rice cultivation, there only a few hectares of dry crops as presented in Table 3.

4.9. Record of multiple use of irrigation waters

Based on the surveyed result of all crop season in 2007 at 2 levels, family level and ward level, it could be concluded that there was a negligible water use for other purposes in the project area in comparison with water use for rice cultivation. There was a maximum of 10.3 ha of other crops recorded. The other land use such as for jackfruit wasn't use water from the canal. There was no fish pond using the water from the canal, either.

4.10. Pumping efficiency evaluated at 5 selected farmers

Data and information need for evaluation of pump efficiency was recorded. Summary of this information was given in Table 11 and Appendix 11. Based on the recorded data, it was evaluated that the average of total expenditure for pump irrigation was about 506,864 VND/ha for W-S crop (accounted for 14% of the total expenditure), 260,807 VND/ha for S-A crop (10.4%) and 222,262 VND/ha for A-W crop (7.4%). Electronic pump could save 50% of the average cost for pumped irrigation.

As it was found that the volume of water use by farmers was different in thousands cubic meter per hectare and the average expenditure for pump irrigation was accounted for less than 15% of the total expenditure while the pump water head was not changed much during the year, therefore it could be concluded that the improvement of pumping efficiency by maintaining the high water level on the canal may not be useful as to introduce them the optimum water use for each crop and try to save the other expenditure.

4.11. All kinds of production obtained

All types of production were obtained from the two levels, household level and ward level, for three crops in 2007. All kind of production in the project area and other income was converted into VND and USD as shown in Table 11.

Table 11: Information and production of Longhai project area during 2007

No	Information	Unit	Crop season			Overall 2007
			W-S	S-A	A-W	
1	Area	Ha	697.1	704.8	701.7	
2	Yield	ton-ha	4.93	4.14	4.48	5
3	Total rice production	Ton	3,437	2,918	3,144	9,498
4	Total expenditure per ha	1000 VND/ha	7,329	7,581	8,015	7,642
		USD/ha	455.8	471.5	498.5	475
5	Total expenditure for pump per ha	1000 VND/ha	506,864	260,807	222,262	329,978
		USD/ha	32	16	14	21
6	Average benefit per ha	1000 VND/ha	9,958	7,295	10,028	9,094
		USD/ha	619.3	453.6	623.6	566
7	Total expenditure for project area	1000 VND	5,108,981	5,343,215	5,624,329	5,358,842
		USD/ha	317,723	332,290	349,772	333,261
8	Total expenditure for pump in project area	1000 VND	353,335	183,817	155,961	693,113
		USD/ha	21,974	11,431	9,699	43,104
9	Total benefit for project area	1000 VND	6,941,961	5,141,240	7,036,656	19,119,857
		USD/ha	431,714	319,729	437,603	1,189,046
10	% Benefit from other income in compare with from rice	%	3.7	17.7	21	14
11	Benefit from other activities	1000 VND	256,853	909,999	1,477,698	2,644,550
		USD	15,973	56,592	91,897	164,462
12	Total benefit of the project area	1000 VND	7,198,813	6,051,239	8,514,354	21,764,406
		USD	447,687	376,321	529,500	1,353,508
13	Population	person	6176	6176	6176	
14	Income for each	1000 VND/per	1,166	980	1,379	3,524
		USD/per	72	61	86	219

As can be seen from the above table, the net benefit from all kind of production in the Longhai project area was about 21.8 billions VND (1.36 millions USD). In which, net benefit from rice cultivation was about 19.1 billion VND (1.19 million USD) and net benefit from other activities was about 2.6 billion VND (164.5 thousand USD).

4.12. Documentation of scheme management

- Identification of stakeholders for decision making on water management

The stakeholder for decision making on water management was considered as the central office of the IMC with some involvements of the representative farmers. Before each crop season, the Gocong management board has invited the representative farmers of each village to come to the office for discussion and to make agreement on the water management strategy for the crop season. The basic command crop area was collected. The farmers were informed of the water condition for the following crop season, therefore the principle agreement of the water management strategy during the crop season was made. All information was sent to the central office of the IMC. The final decision was made after considering the water resource condition of the whole system. The approved plan may also be changed accordingly to meet the current situation of the water condition of the project area. In that case, the IMC (Gocong management board) would inform the farmers via the officers of the communes about the system operation schedule. This schedule would also be displayed on the information board of the communes and the management office of the sluice.

- Identification and development of the organization chart

The management organization chart of the IMC was shown in the Appendix 8 to 10. Based on the organization chart it was found that the Longhai irrigation project is a part of the Vamgiong sub-irrigation station, the irrigation management work at Longhai project area is considered as a part of the work that was taken by the persons in the 3 working teams: River and dike management team, irrigation management team and the management and maintenance team.

- Recording procedures of water allocation

The IMC got the certificate for ISO 9000 from 2005 for management. Therefore, each task has been formed following procedures. There was no procedure of water allocation to each farmer of each canal. The task of IMC is to ensure the water is always available on the canal for the farmers and the farmers can take water anytime they need. There is only the procedure of water allocation for the whole Longhai project area. The detailed procedure was attached to the Appendix 6. The procedure of water allocation for Longhai and HL6 sluice was simplified into these 5 steps as following based on the procedure:

1. planned crop area was collected and irrigation water requirement for the crop season was estimated, the condition of water resources and water supply was analyzed;
2. representative farmers were invited to the meeting organized by the Gocong management board, a basic agreement on water management for each crop season was made;

3. related data and information as well as basic agreement is sent to the central office of IMC for consideration in combination with the conditions of water resources of the overall irrigation system;
4. decisions was made by IMC central office and informed to the sub-management office (Gocong management board);
5. each operation, farmers receive the information via the village's office by hard copy and local radio broadcasting. This information is mainly the operation of the Longhai sluice (e.g. date and duration of each operation time and the reason to operate).

In practice, e.g. during the crop seasons in 2007 representative farmers were invited 2 times for decision making before W-S and S-A crops, the HL6 sluice was closed for 32 days for operation of Longhai sluice and the Longhai sluice was operated for 49 days, most of these operation decision was based on the operation schedule, these was about 14 operation days made because of heavy rainfall in the project area.

- Documentation of rules of water management of the system

Some Articles which related to the rule of water management presented here were borrowed from the 'Law on Water Resources' of Vietnam for further understanding of the rules and tasks for water management in the delta in general. The detailed articles are attached on the Appendix 12.

In the Article 1, individuals are entitled to exploit and use the water resource for domestic use and agricultural production. The Rights of organizations and individuals that exploit and use water resource is further described in the Article 22, Organizations and individuals that exploit and use water resource have the right to exploit and use water resource for purposes of domestic use, agriculture, forestry, and industrial production, mining, electricity generating, navigation, aquaculture, fishery, salt production, sport, recreation, tourism, medicine, health rehabilitation, scientific research and other purposes as prescribed by this Law and other provisions of law.

Organizations and individuals that exploit and use water resources must get permission from the competent State agencies. However, (a) to exploit and use surface and underground water of small scale for family use in living; and (b) to exploit and use sources of surface water and underground water of small scale for the family in agricultural, are not required as described in the Article 24.

The obligations of organizations and individuals that exploit and use water resources is described in the Article 23, To use water for the right purposes, economically, safely and efficiently; and in the Article 26, individuals exploiting and using water resource for agricultural production must take measures to save water, prevent and combat acidity and salinity, slushiness and erosion that may contaminate the water source.

As it was described by the law, based on the condition of water and topography in the Mekong delta in general and the project area in particular, most of water use is for domestic use and agricultural purpose, therefore there is no need for getting permission. The restriction for water use is described in article 23 and 26. However as the delta is very flat, all the leakage of water will be return into the main source of water therefore no restriction for water user was taken. In practice, farmers can take as much water as they need for their crop.

The main rule for water management is to ensure the availability of water on the canal system and to prevent the condition of system as described in the article 9, ‘It is strictly forbidden to undertake actions which cause the deterioration or serious depletion of the water resources, illegally obstruct the circulation of water, sabotage the works for the protection, exploitation and use of water resources, the prevention, combat against and overcoming of the harm caused by water and obstruct the right of all organizations and individuals to exploit and use water resources legally.’

The water delivered to the system via Longhai and HL6 sluices was in charge by the IMC and no further operation rules was made by the IMC. The farmer shares the water on the canal by themselves. As water was always available on the canal and farmers can pump the water to their field any time needed. No illegal water use was recorded in the project area and no claim of the shortage of water for irrigation was recoded during the crop season.

In case of severe shortage of water, it was reported that pumps may be used to bring the water from outside into the project area, however not any shortage of water ever happened.

4.13. Conducting RAPs

Basic information of all crops in 2007 was recorded and filled in the RAP. The evaluated result of Longhai irrigation project by RAP was attached to Appendix 22, For detail was referred to RAP-LongHai-2008-final.xls file.

5. Analysis, results and discussions

5.1. Crop water requirement

The crop water requirement was calculated by this equation:

$$CWR = \sum(ETci * Ti)$$

And Total crop water requirement (TCWR) for crop growing in each period was calculated by this equation

$$TCWRj = CWRj*Aj*10$$

Irrigation water requirement was calculated by the water balance equation as described here:

$$IWR = ETc - Pe + IL + LPW$$

Total irrigation water requirement (TIWR) for crop growing in each period was calculated by this equation

$$TIWRj = IWRj*Aj*10$$

Where:

ETci : Evapotranspiration for each duration

Ti: Duration of development stage i (10 days basic interval of the month: 1^{st} to 10^{th}, 11^{th} to 20^{th} and 21^{st} to the end of the month)

Pe : Effective rainfall, calculated by FAO

IL : Infiltration and leakage, a value of 3.2 mm/day was obtained from item 4.6

CRW: Crop water requirement

IWR : Irrigation water requirement

LPW: Land preparation water

Aj: crop area during each growing stage j, j=4 for W-S and j=3 for S-A and A-W

10: conversion factor to m^3

In which :

$$ETc = ETo * Kc$$

ETo : Obtained from ETo-use in item 4.4

Kc : Crop factor, obtained from FAO

Based on evaluated result of the crop calendar in 2007 as presented in item 4.7 W-S was clarified into 4 growing durations, S-A and A-W was clarified into 3 growing durations. The irrigation water requirement and crop water requirement for each rice crop growing durations was calculated based on the above equation. The summary of calculated result was shown in Table 12. The detail of calculated results was attached on the Appendix 9.1 to 9.10. Where, the total crop water requirement of the system was calculated by this equation:

$$CWR\_S = \sum_{i}^{n} CWR\_cri * Acri$$

Where:

CRW_S: crop water requirement of the scheme

CRW_cri: crop water requirement of crop i

n: number of the classified rice crops in the project area based on the growing duration
i: crop number, i=1..n
Acri: Total area of the crop i

As presented in Table 12, the crop water requirement and irrigation water requirement for W-S was the highest, the irrigation water requirement for S-A rice crop was the lowest. Total crop water requirement of the system was about 3.47 million m^3 in W-S, 3.24 million m^3 in S-A and 3.01 million m^3 in A-W. The total irrigation water requirement of the system was about 5.85 million m^3 in W-S, 2.42 million m^3 in S-A and 3.73 million m^3 in A-W

Table 12: Crop water requirement of the Longhai project area during year 2007

Crop season		Grown duration	% crop area (%)	Crop area (ha)	Crop water requirement (mm)	Crop water requirement –Pe (mm)	Irrigation water requirement (mm)	Total crop water requirement (m^3)	Total crop water requirement - Pe (m^3)	Total irrigation water requirement (m^3)
Abbreviation				TA	CWR	CWR-Pe	IWR	TCWR	TCWR-Pe	TIWR
W-S	Nov	1st-30th	24.6	171.5	503.0	450.9	834.9	2,530,090	2,268,027	4,199,547
	Dec	1st - 10th	52.8	368.1	495.6	485.8	837.8	2,456,194	2,407,625	4,152,137
	Dec	11th - 20th	19.0	132.4	499.0	497.6	852.8	660,921	659,066	4,255,472
	Dec	21st - 31st	3.6	25.1	490.5	490.5	813.7	123,094	123,094	3,991,199
	Evaluated for W-S			697.1	497.0	481.2	834.8	3,470,741	3,343,471	16,598,354
	Daily average (mm/day)				5.2	5.0	8.8			
S-A	May	1st - 20th	40.1	282.3	466.0	194.9	278.4	2,171,560	908,234	1,297,344
	May	21st - 31st	53.7	378.4	454.3	239.1	381.8	2,063,885	1,086,231	1,734,517
	June	1st-30th	6.3	44.1	456.0	185.0	426.7	2,079,360	843,600	1,945,752
	Evaluated for S-A			704.8	458.8	206.3	362.3	6,314,805	2,838,065	4,977,613
	Daily average (mm/day)				4.8	2.2	3.8			
A-W	Aug	15th - 31st	41.3	289.9	435.4	225.1	481.9	1,895,732	980,085	2,098,193
	Sep	1st - 10th	38.1	267.3	424.8	258.6	555.5	1,804,550	1,098,533	2,359,764
	Sep	11th - 30th	20.6	144.5	423.3	287.4	589.7	1,791,829	1,216,564	2,496,200
	Evaluated for A-W			701.7	427.8	257.0	542.4	5,492,111	3,295,182	6,954,157
	Daily average (mm/day)				4.6	2.8	5.8			

5.2. Actual irrigation water applied

The actual irrigation water applied was evaluated from the monitoring data at 5 selected fields as presented in item 4.6. This evaluated data was used to calculate the total irrigation water of the system as presented in Table 13**.** Total irrigation water of the system was about 5.43 billion m^3 for W-S crop, 3.16 billion m^3 for S-A crop and 3.12 billion m^3 for A-W crop. Total irrigation water used for Longhai project area during 2007 was about 11.72 billion m^3.

Table 13: Total irrigation water applied for irrigation in Longhai project area

No	Information	Abbr.	Unit	Crop season		
				W-S	S-A	A-W
1	Crop Area	TA	ha	697.1	704.8	701.7
2	Water use/ha	TIW1ha	m^3/ha	7,779	4,489.8	4,448.8
3	Total irrigation water applied	TIW	m^3	5,436,371	3,164,411	3,121,723

5.3. Total scheme water requirement

The evaluation of the total scheme water requirement was given in Table 14. As can be seen from the table, total irrigation requirement of the scheme was about 5.85 billion m^3 for W-S crop, 2.42 billion m^3 for S-A crop and 3.73 billion m^3 for A-W crop. Total irrigation requirement of the scheme during 2007 was about 12.00 billion m^3.

Table 14: Evaluation of scheme water requirement

No	Information	Unit	Crop season			Overall year 2007
			W-S	S-A	A-W	
(1)	Total irrigation requirement of the scheme (TIWR)	m^3	5,849,141	2,418,768	3,733,806	12,001,715
(2)	Total irrigation water applied of the scheme (TIW)	m^3	5,436,371	3,164,411	3,121,723	11,722,505
3	(2)/(1)*100	%	92.9	130.8	83.6	97.7

It was found that the irrigation water applied of the scheme was almost met the irrigation requirement of the scheme (97.7%) and irrigation water applied even higher the irrigation requirement during S-A crop, this means the effective rainfall in irrigation practice may smaller than the calculated effective rainfall in this study.

5.4. Water balance

5.4.1. Water balance on the canal area

The water balance on the canal area was calculated by the equation (1)

$$TFin - TFout + Roc + Rroffo + Rroffr - Eoc - Plossc - Wscc - Ouse = IWused \quad (1)$$

Basic information was collected from the previous calculations, the total irrigation water used that evaluated from the equation (1) was calculated and given on Table 15.

Table 15: Calculation of water balance on the canal

No	Information	Abbr.	Unit	Crop season			Overall 2007
				W-S	S-A	A-W	
1	Area	TA	ha	697.06	704.8	701.7	701.2
2	Water use/ha	TIW1ha	m^3/ ha	7799	4489.8	4448.8	16.338
(3)	Total irrigation water applied	TIW	m^3	5,436,371	3,164,411	3,121,723	11,722,505
4	Irrigation water requirement per ha	IWR	mm/ ha	835	362	542	1,740
5	Irrigation water requirement of the scheme	TIWR	m^3	5,849,141	2,418,768	3,733,806	12,001,715
6	Total outflow from Longhai sluice	TFout	m^3	115,839	2,777,305	3,088,046	5,981,190
7	Total inflow from Longhai sluice	TFin L.hai	m^3	0	886,096	1,953,497	2,839,593
8	Total inflow from HL6 sluice	TFin HL6	m^3	3,679,875	1,796,921	3,856,243	9,333,038
9	Open evaporation from the canal	Eoc	m^3	125,130	85,470	66,750	277,350
10	Total rainfall to the open canal	Roc	m^3	26,040	419,160	196,120	641,320
11	Rainfall runoff from rice fields	Rroffr	m^3	0	907,466	0	907,466
12	Rainfall runoff from other lands	Rroffo	m^3	53,345	1,267,989	452,120	1,773,454
13	Change on storage volume of canal	Wscc	m^3	-131,236	277,894	-52,886	93,772
(14)	Irrigation water used evaluated from equation (1)	IWused	m^3	3,649,527	2,136,962	3,356,069	9,142,559
15	Irrigation water used per ha	IWused/ ha	m^3/ ha	5,236	3,032	4,783	13,039
16	Ratio (14)/(3)*100	IWused/ TIW	%	67.1	67.5	107.5	78.0

Remark: The Wscc obtained from Appendix 20.

It was found that the irrigation water used, IWused, evaluated by equation (1) was accounted for 78% of the total irrigation water applied. The difference in 22% between irrigation water used evaluated by equation (1) and irrigation water used evaluated from 5 selected fields may be the accuracy of the calculation or the irrigation water applied was return to the irrigation system and reused for irrigation by pumps.

5.4.2. Water balance for the rice field

$$TIW - Tdf + Rer - Wscr - ETc = Plossr + Ruse \quad (2)$$

Water balance for the rice field was applied for the 5 selected fields as given in Table 16.

Table 16: Calculation of water balance on the rice field

No	Information	Unit	W-S	S-A	A-W
1	Irrigation applied per ha (TIW)	m^3/ha	7,799	4,490	4,449
(2)	Irrigation module per day (TIW/day)	mm/day	8.2	4.7	4.7
3	Average of (ETc-Pe) per day	mm/day	5	2.2	2.8
4	Drainage water, Tdf	mm/day	0	0.8	0
5	Storage water changed, Wscr	mm/day	0	0	0
(6)	Plossr+Ruse	mm/day	3.2	1.7	1.9
7	(6)/(2)*100	%	39.1	35.8	40.2

As can be seen from the above table, the average of infiltration and leakage (equal to Plossr+Ruse) at 5 selected fields was about 3.2 mm/day for W-S, accounted for 39% of the total irrigation, 1.7 mm/day for S-A crop and 1.9 mm/day for A-W crop.

5.5. Identify and estimate actual irrigated area

100% or rice crop area was evaluated as actual irrigated area, it means that 707.2 ha was irrigated and 17.6 ha (2.5%) could get gravity irrigation for about 2.5 months during the year 2007.

5.6. Pump efficiency at 5 selected farmers' fields

No evaluation for pump efficiency was made because some situations were not recognized well in advance, such as:

- Unidentified pumps: All of pumps were partial made by manual factories and the engine was almost too old.
- The recorded data could not show clearly the differences of the pumped water volume with the differences of water head at a same pumping period.

In other point of view as presented in previous letters, the improvement of pump efficiency would not benefit much as the water head was not changed much during the year and the expenditure for pumping wasn't accounted much while the irrigated water taken by farmers was a very large variation from this farm to other farm.

5.7. Overall command - area efficiency

The command area efficiency was calculated by suggested bellowing equation:

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

Based on the above equation we found that If the total water diverted to users is too much higher than the amount of total scheme water requirement minus effective rainfall this means that the efficiency of the system is too low and in the other hand if the total water diverted to users is smaller than the amount of total scheme water requirement minus effective rainfall means there is shortage of water for irrigation.

As it was presented before the letters, the irrigation system in the Mekong delta has multiple functions, e.g. for conveyance of irrigation water, for navigation and storage of water as well. Therefore the total diverted water to users was not mean for irrigation only, hence in this study the total diverted water to users was understood as to total diverted water to the rice fields by pump or total diverted water to the system through the LH6 and Longhai sluices. The amount of total scheme water requirement minus effective rainfall was understood as the total irrigation water requirement of the scheme and the total crop water requirement of the system-Pe.

Based on the calculated data in previous items, the command area efficiency was calculated and given on the Table 17.

Table 17: Evaluation of overall command-area efficiency

No	Information	Abbr.	Unit	Crop season			Overall 2007
				W-S	S-A	A-W	
(1)	Total crop water requirement –Pe	CRW-Pe	m3	3,343,471	1,536,513	1,759,001	6,638,985
(2)	Total irrigation waters requirement	IWR	m3	5,849,141	2,418,768	3,733,806	12,001,715
3	Diverted water via Longhai sluice		m3	-	886,096	1,953,497	2,839,593
4	Diverted water via HL6 sluice		m3	3,679,875	1,796,921	3,856,243	9,333,038
(5)	Total diverted to system	TFin		3,679,875	2,683,017	5,809,740	12,172,631
(6)	Total water applied to fields by pump	TIW	m3	5,436,371	3,164,411	3,121,723	11,722,505
(7)	CEA=(1)/(5)*100		%	90.9	57.3	30.3	54.5
(8)	CEA=(1)/(6)*100		%	61.5	48.6	56.3	56.6
9	CEA=(2)/(5)*100		%	158.9	90.2	64.3	98.6
10	CEA=(2)/(6)*100		%	107.6	76.4	119.6	102.4

Based on the above results of the command area efficiency, it was found that due to the complicated irrigation system in the Mekong delta from different points of view, there was different command area efficiency evaluated. It was suggested that the presented command area efficiency in row (8) was evaluated as for irrigation practice in the Mekong delta at field level and the presented command area efficiency in row (7) was evaluated as the command area efficiency at the system level.

5.8. Water productivities

The productive of water (POW) was estimated by the following two equations:

POW = Total production/ volume of diverted water (3)

POW = Total production/volume of irrigated water (4)

Where, the POW calculated by equation (3) was considered as the POW of the system level and the POW calculated by equation (4) was considered as the actual productive of water at the field level.

Table 18: Evaluation of water productivities

No	Information	Abbr.	Unit	Crop season			Overall 2007
				W-S	S-A	A-W	
(1)	Average of rice yield per ha		Ton/ ha	4.93	4.14	4.48	13.6
(2)	Diverted water per ha through HL6 and Longhai	TFin/ha	m^3/ ha	5,279.1	3,806.8	8,279.5	17,365.4
(3)	Diverted water to field by pump	TIW/ha	m^3/ ha	7,799.0	4,489.8	4,448.8	16,738
4	POW=(1)/(2)*1000		Kg/ m^3	0.93	1.09	0.54	0.78
5	POW=(1)/(3)*1000		Kg/ m^3	0.63	0.92	1.01	0.81

Based on the calculated result given on the above table, it was found that the average water productivity is about 0.78 kg/m^3 at system level and 0.81 kg/m^3 at the field level.

The highest water productivity at system level was for S-A rice crop as there was much effective rainfall for rice and the lowest water productivity was for A-W rice crop as additional water was diverted to the system in order to create a good condition of water for the next W-S rice crop.

5.9. Water management project appraisal

Different than the gravity irrigation system, irrigation system should be operated to divert enough water for irrigation requirement. The role of water management in the Mekong delta is to ensure the availability of water in the canal for irrigation. In the coastal zone where there was a shortage of water, the roles of water management are: to ensure that no salt water intrudes inland; to maintain a good water quality condition inside the area as to replace the stagnant condition of water if needed; and to divert as much water as possible to the project area.

Based on the evaluated results of command area efficiency it was found that the system has a very low CAE during the wet seasons (S-A and A-W), it was ranged from 30% to 57%, as there was too much diverted and drained water for the improvement condition of water quality on the system. However, in term of water quality control it means that the system was operated well as water quality and quantity of the system was controlled and W-S rice crop was secured.

There was no claim for shortage of water during the year 2007 and no inundation and salinity intrusion impacts to the project area either. The Longhai sluice was operated for 49 days during 3 crop seasons for irrigation and drainage purposes. There is about 14 additional operation days for drainage of heavy rainfall water to avoid the inundation damage to the crop in the area.

It was found that the storage of water on the canal system play an important role for regulation of water in the project area as the design irrigation module for irrigation system was about 1 l/s/ha, it means that the maximum irrigation flow in Longhai project area was about 0.7 m^3/s while the average water flow diverted to the area by HL6 sluice was about 0.32 m^3/s. The storage of water on the canal system was about 87,000 m^3 at the water level of 0 m+MSL and 300,000 m^3 at water level of 0.8 m+MSL, therefore this storage water could maintain an irrigation flow of about 1 to 3.5 m^3/s, it means that it was secured the demand on irrigation water by farmers at any time.

Overall water management project appraisal it was found that the Gocong irrigation project in general and Long hai irrigation area has a good management structure. As an illustration for that the IMC got the ISO 9000 certificate from 2005. Therefore, procedure for each task has been made and each staff has their clear tasks. In addition to that, the participation of farmers on water management of the system plays an importance role to improve management condition of the system such as controlling disposed waste water to the canals, saving water for treatment of stagnant condition.

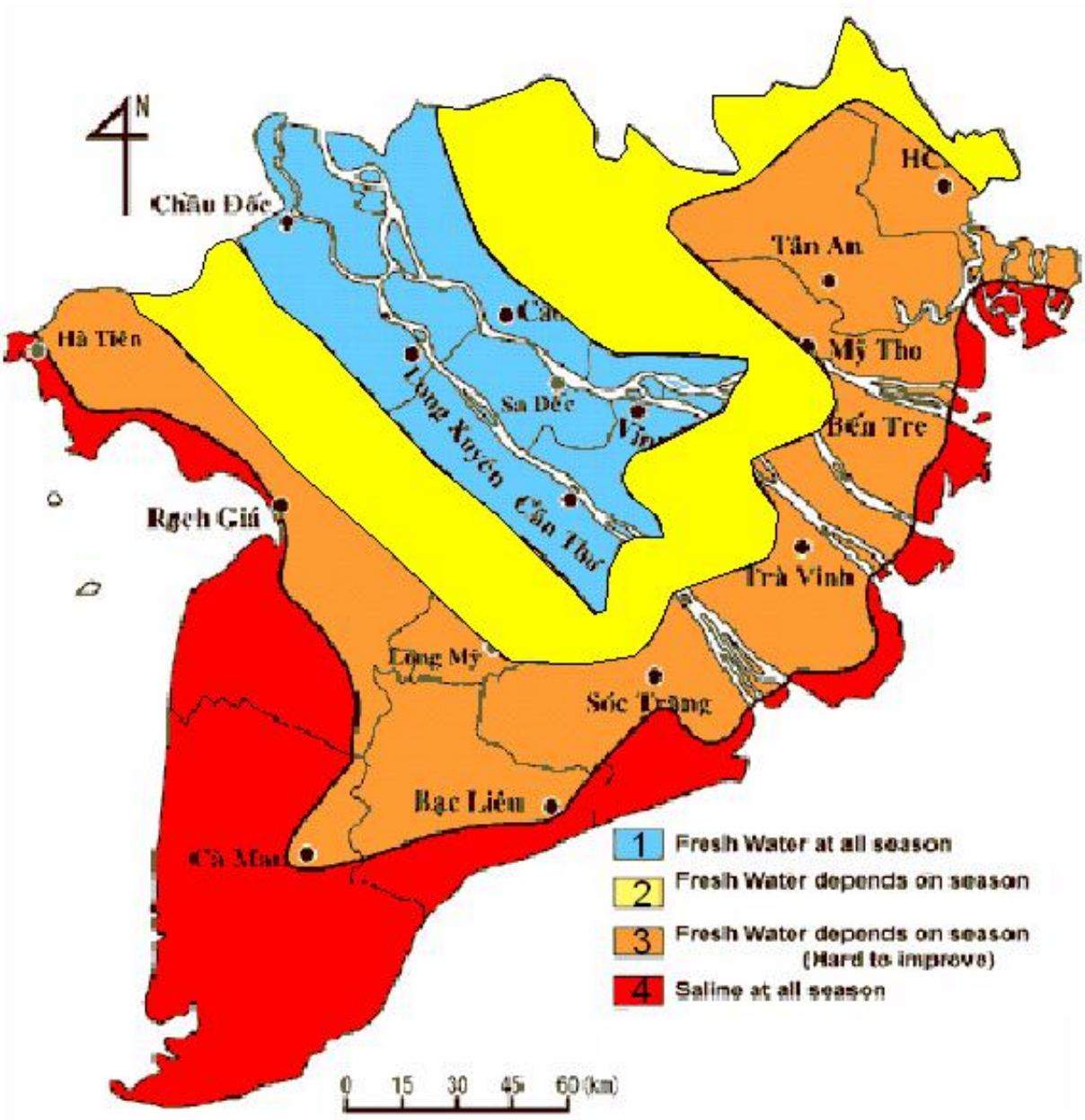
6. Recommendation

Based on the result of ‘field observation and data analysis’ in Longhai irrigation project area the following recommendation was made

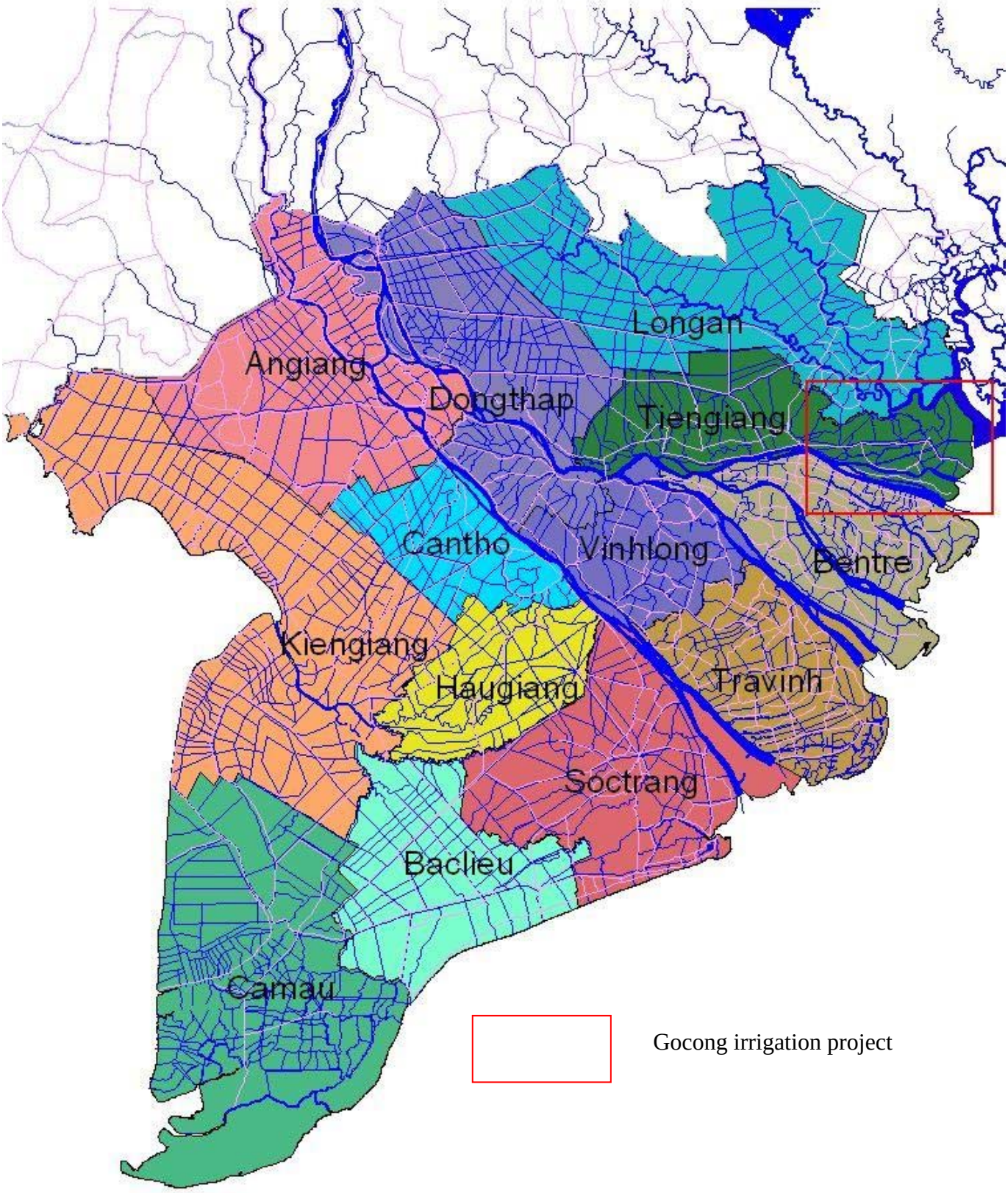
- The irrigation water applied to the rice crop was very different from this farm to other farm as the knowledge and their experiences were not at the same level. Some farmers took water more than two to three times as needed in comparison with the calculated crop water requirement, therefore to improve irrigation efficiency of the system the basic irrigation knowledge and experience need to be introduced to farmers;
- The irrigation expenditure was not counted much in comparison with the total expenditure, therefore to extend the benefit from rice cultivation to the farmers the IPM may need to be introduced;
- This study was considered as the initial study for improvement of irrigation efficiency for coastal zone in the Mekong delta, therefore it is recommended that a similar study could make for the other areas in the Mekong delta.

7. Appendices

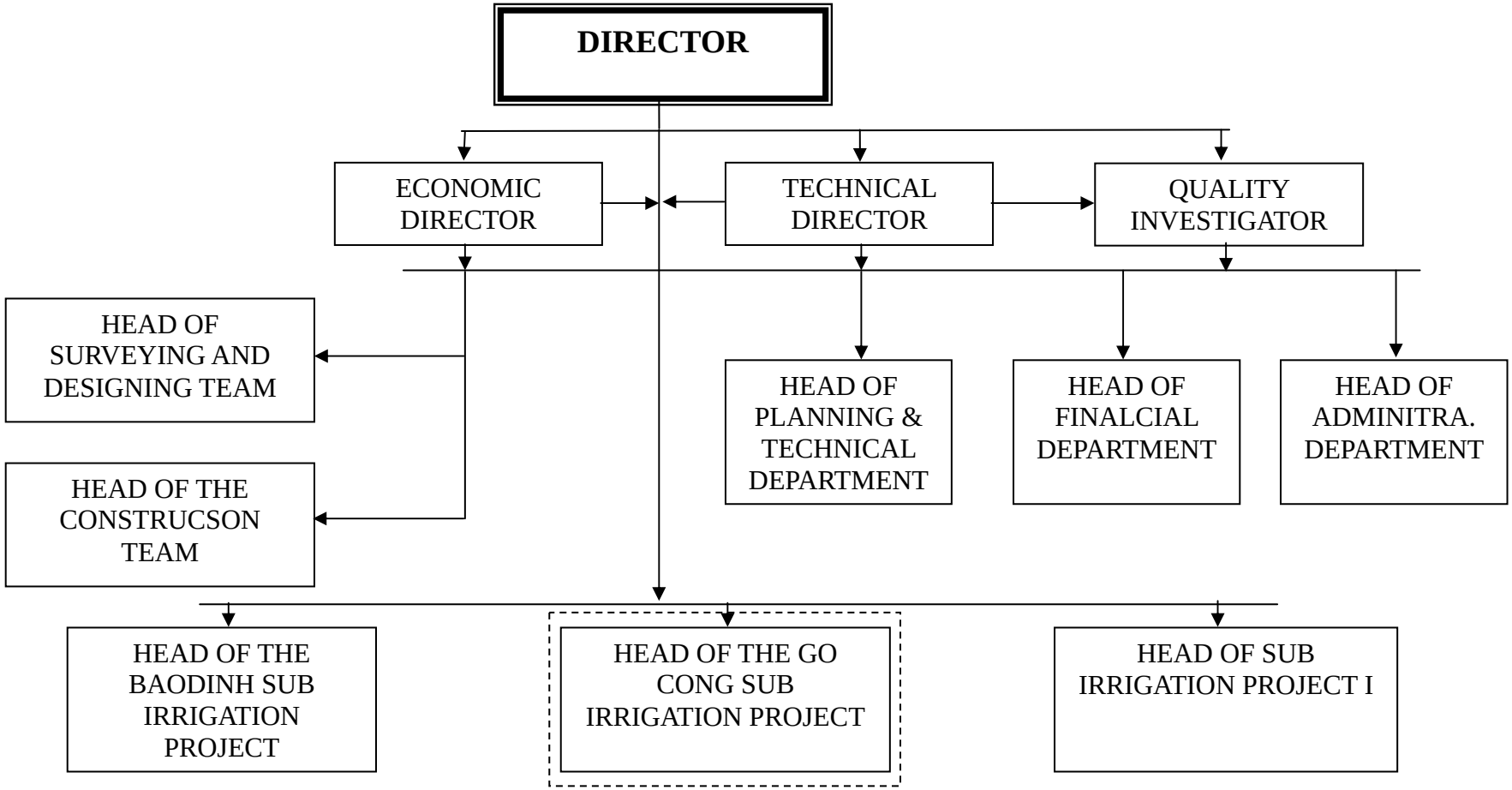
Appendix 1: Sketch for potential water resources management in the Mekong delta



Appendix 2: Administrative map of the Mekong delta

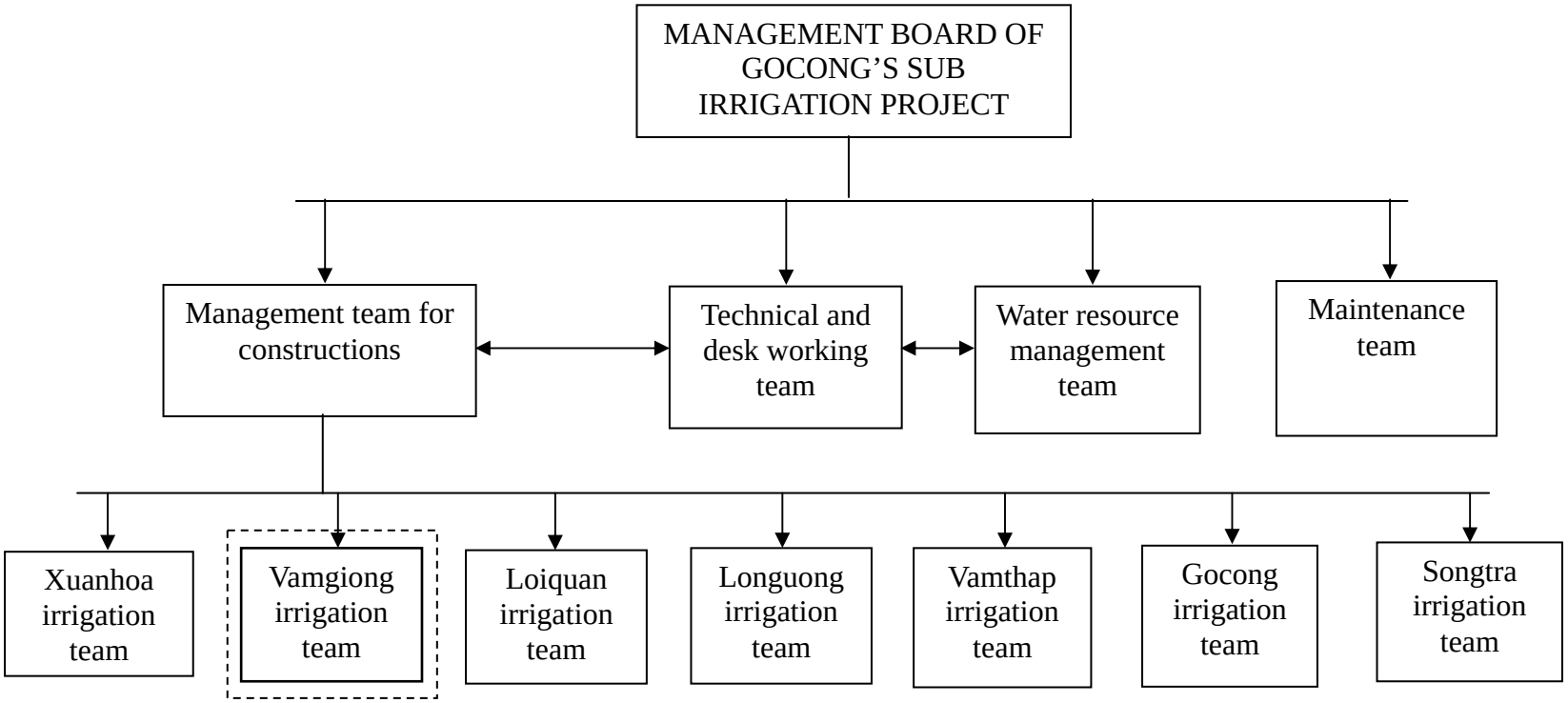


Appendix 3: Flow chart of the Tien Giang irrigation company



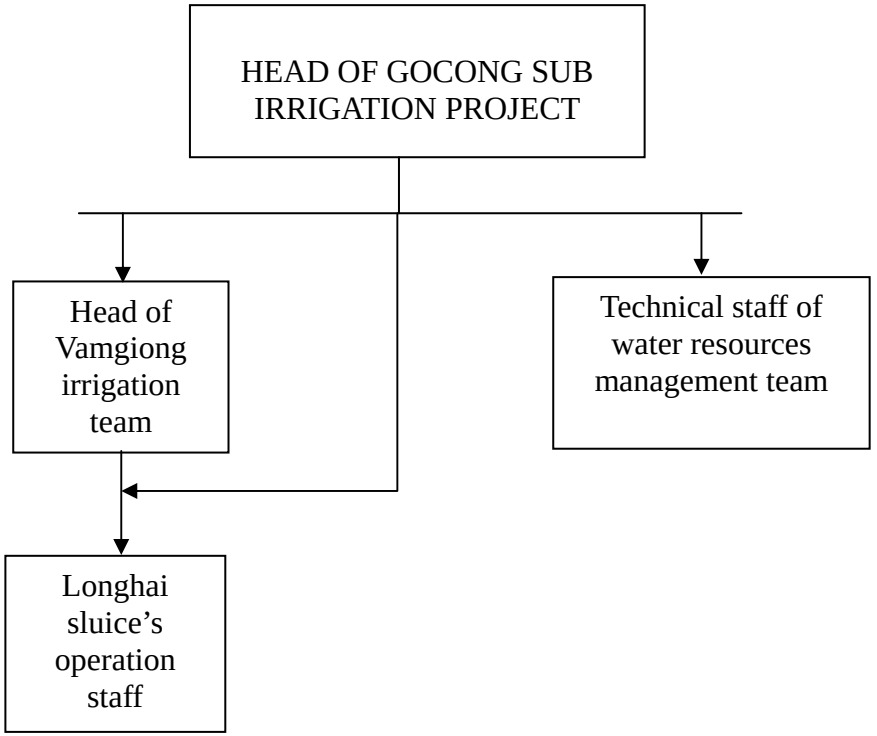
Note: Gocong sub irrigation project is the direct management board of Long hai irrigation area

Appendix 4: Flow chart of the Gocong sub irrigation project



Note: Longhai irrigation area is managed by of Vamgiong irrigation team

Appendix 5: Flow chart of irrigation management in the Longhai irrigation area



Appendix 6: Procedure for making operation schedule and implementation

Item No	Contents of work	Responsible to	Frequency	References/ refer to/ according to
5.1.1	Necessary data collection for making operation schedule of the head works/sluices: - Based on the present hydro and meteorological data and historical data (water level, salinity, pH, rainfall…) - Present agriculture cultivation and planned for next crop - Draft operation schedule made by direct irrigation staffs of the each irrigation zone - Weather forecasting result	Technical staffs	- Daily - 10, 15 or 30-day interval	- Reference to the tidal variation of Vungtau station - Rules for monitoring of hydro-meteorological data
5.1.2	- Making a draft operation schedule of the irrigation project - Review of the draft operation schedule	- Technical staffs - Management board of the sub irrigation projects	- 10, 15 or 30-day interval	BM 01/KTCT-QT7.0
5.1.3	- Send the final draft of operation schedule to the Planning and Technical Department	Technical staffs	Half month basic, on the 12^{th} and 27^{th}	BM 01/KTCT-QT7.0
5.1.4	- Receiving the Final operation schedule from the Planning and Technical Department	- Management board of the Irrigation company	Half month basic, on the 14^{th} and $29(28)^{th}$	BM 07/KTCT-QT7.0
5.1.5	- Organizing for Implementation of the final operation schedule - Inform the operation schedule to communes and villages - Implementation of the operation schedule - Take notes and update related information for operation of the construction.	- Head of the sub irrigation project - Irrigation staffs - Irrigation staffs - Technical and irrigation staffs	As scheduled	Guideline for operation of each sluice BM 02/KTCT-QT7.0 BM 03/KTCT-QT7.0

Appendix 6: Procedure for making operation schedule and implementation (Continues)

Item No	Contents of work	Responsible to	Frequency	References/ refer to/ according to
5.1.6	In case of emergency: typhoons, floods and any damage - Report the problem to the management board of the sub irrigation project - Estimates the level of the damage - Proposed measure for maintenance - Decision making for measure o For a normal problem o For critical problem: report the proposed measure to the irrigation company - Implementation - Inspection for the implementation result - Check and take over	- Irrigation and Technical staff - Irrigation Staff - Irrigation and Technical staff - Management board of sub irrigation project - Irrigation and Technical staff - Technical staff - Inspector	As frequency of problems	- Based on the guideline 359 dated 01/4/2005 - Notification to deal with natural disaster (flood and typhoon) events - BM 04/KTCT-QT7.0
5.1.7	Store as archives - The draft of operation schedule - Final operation schedule - Flow sheets - Detail flow sheets - Record of the maintenance of the problem	- Technical staffs	As frequency of problems	BM 01/KTCT-QT7.0 BM 07/KTCT-QT7.0 BM 02/KTCT-QT7.0 BM 03/KTCT-QT7.0 BM 04/KTCT-QT7.0

Appendix 7: List of articles related to the water use in the Vietnam Water Laws

Article 1. - Ownership of water resource

1. The water resource comes under the ownership of the entire people under the unified management of the State.

2. Organisations and individuals are entitled to exploit and use the water resource for life and production. At the same time they have the responsibility to protect the water resource, prevent, combat and overcome the harmful effect caused by water as prescribed by law. The State protects the legitimate interests of organisations and individuals in the exploitation and use of the water resource.

Article 9.- Acts under strict ban
It is strictly forbidden to undertake acts which cause the deterioration or serious depletion of the water resource, illegally obstruct the circulation of water, sabotage the works for the protection, exploitation and use of water resource, the prevention, combat against and overcoming of the harm caused by water and obstruct the right of all organisations and individuals to exploit and use water resource lawfully.

Article 22.- Rights of organisations and individuals that exploit and use water resource
Organisations and individuals that exploit and use water resource have the following rights:
1. They have the right to exploit and use water resource for purposes of living, agricultural, forestry, and industrial production, mining, electricity generating, water transport, aquaculture, sea fishery, salt making, sport, recreation, tourism, medicine, health rehabilitation, scientific research and other purposes as prescribed by this Law and other provisions of law.
2. They are entitled to benefit from the exploitation and use of water resource, to assign, lease, legate and mortgage their properties for investment in the exploitation and use of water resource, and to develop water resource as prescribed by this Law and other provisions of law.

Article 23.- Obligations of organisations and individuals that exploit and use water resource.
1. Organisations and individuals that exploit and use water resource have the following obligations:
a/ To fully carry out the provisions of law on water resource;
b/ To use water for the right purposes, economically, safely and efficiently;
c/ To supply information with a view to inventoring and evaluating water resource when requested;
d/ Not to cause obstruction or damage to the legitimate exploitation and use of water resource by other organisations and individuals.
e/ To protect the water resource under exploitation and use;
f/ To fulfil their financial obligation, to compensate for the damage caused by themselves in the exploitation and use of water resource as prescribed by law.

Article 24.- Issuing permits for exploitation and use of water resource
1. Organisations and individuals that exploit and use water resources must get permission from the, competent State agencies except the cases stipulated in Item 2 of this Article.
2. Cases in which permission is not required:
a/ To exploit and use sources of surface water and underground water of small scale for family use in living;
b/ To exploit and use sources of surface water and underground water of small scale for the family in agricultural, forestry production, aquaculture, small industry and handicraft production, hydropower generation and other purposes;

Article 26.- Exploitation and use of water resource for agricultural production
1. The State shall invest in and support the exploitation and use of water resource for agricultural production.
2. Organisations and individuals exploiting and using water resource for agricultural production must take measures to save water, prevent and combat acidity and salinity of water, slushiness and erosion without polluting the water source.
3. Organisations and individuals can only exploit and use waste water after ensuring that the quality of water meet the prescriptions of the competent State agency for agricultural production.

Appendix 8: Calculation of reference crop evapotranspiration

1 By PENMAN-MONTEITH method
With the based data information obtained from My Tho station

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmax	31.7	32	34.2	35.6	35	33.9	33.9	33.1	33.9	32.8	33	32
Tmin	19.9	20.2	20.7	23.6	23.2	21.9	23.1	22.9	23	22.1	22.1	19.9
RHmean	77.8	80.8	84.9	83.4	83.7	88.1	89.0	89.3	88.4	88.0	85.1	82.8
RHmin	51.7	53.7	53.0	55.7	56.3	58.5	62.0	63.5	61.4	61.3	58.9	54.4
Wind(km/d)	532.3	569.0	554.6	509.8	524.0	613.4	535.1	576.9	498.2	462.7	483.8	401.3
Sun hours	8.2	8.4	7.9	8.7	5.9	5.2	6.5	5.9	6.4	6.0	8.0	6.5
Eto (FAO)	5.6	5.7	5.9	6.3	5.6	5.0	4.9	4.7	4.9	4.6	5.0	4.6

2 By Blaney-Criddle Method: ETo = p (0.46 T mean + 8)

2.1 With the based data information obtained from My Tho station

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
T mean	25.8	26.1	27.5	29.6	29.1	27.9	28.5	28.0	28.5	27.5	27.6	26.0
p My Tho	0.34	0.35	0.33	0.36	0.25	0.22	0.27	0.25	0.27	0.25	0.33	0.27
Eto (BC1)	6.8	7.0	6.8	7.9	5.3	4.5	5.7	5.2	5.6	5.2	6.9	5.4

2.2 With the based data information obtained from My Tho station and by the users guide of the method

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
T mean	25.8	26.1	27.5	29.6	29.1	27.9	28.5	28.0	28.5	27.5	27.6	26.0
p Global	0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.28	0.28	0.27	0.26	0.26
Eto (BC2)	5.2	5.4	5.6	6.1	6.0	6.0	6.1	5.8	5.9	5.6	5.4	5.2

3 Maximum and minimum ETo from 3 calculation methods

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Eto min	5.2	5.4	5.6	6.1	5.3	4.5	4.9	4.7	4.9	4.5	5.0	4.6
Eto max	6.8	7.0	6.8	7.9	6.0	6.0	6.1	5.8	5.9	5.6	6.9	5.4

4 Evaporation obtain from My Tho station and measured at Long Hai station

Time	2006		2007											
Station	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Eo My Tho	3.1	2.7	2.9	4.0	4.2	5.0	3.0	3.0	3.0	3.0	2.5	2.5	2.5	2.9
Eo L. Hai	3.7	3.2	3.4	3.7	3.6	3.8	2.4	2.4	2.2	2.2	2.3	2.1	2.9	3.1

Remark: Eo : evaporation measured by Piche pipe

5 ETo: reference crop evapotranspiration used for the calculation

Time	2006		2007											
Station	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Eo My Tho	5.7	4.9	5.3	5.8	5.5	5.85	5.28	5.28	4.84	4.84	5.06	4.62	4.46	4.77

Remark: a factor of 1.54 was used to calculate the ETo from Eo of Longhai station

Appendix 9: Calculation for crop water requirement

9.1 : CALCULATION FOR CROP WATER REQUIREMENT

Winter-Spring Crop water requirement at Longhai project area

Start growing in November 2006

Crop duration: 95 days

Accounted crop area: 24.6% of the total rice crop area

ITEMS	UNIT	Nov			Dec			Jan			Feb			Mar		
Duration (Ti)	day	10	10	10	10	10	11	10	10	11	10	10	8	10	10	11
Eto	mm/day	5.7	5.7	5.7	4.9	4.9	4.9	5.7	5.7	5.7	5.8	5.8	5.8	5.5	5.5	5.5
Kc		0.35	0.35	0.75	0.85	0.98	0.98	1.15	1.08	1.08	0.75	0.5	0.25	0	0	0
ETc	mm/day	2	2	4.28	4.17	4.78	4.78	6.56	6.13	6.13	4.35	2.9	1.45	0	0	0
Rainfall	mm/duration	84.1	10.2	0	30.7	19	0	10.5	0	0	0	0	0	0	0	6.3
Effective rainfall	mm	42.3	0	0	8.4	1.4	0	0	0	0	0	0	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	20.0	20.0	42.8	41.7	47.8	52.6	65.6	61.3	67.4	43.5	29.0	11.6	0.0	0.0	0.0
Crop water require.-Pe	mm/duration	-22.3	20.0	42.8	33.2	46.4	52.6	65.6	61.3	67.4	43.5	29.0	11.6	0.0	0.0	0.0
Irrigation water	mm/duration	9.7	52.0	74.8	65.2	78.4	87.8	97.6	93.3	102.6	75.5	61.0	37.2	0.0	0.0	0.0
Total crop requirement	mm/season	503.0														
Total crop require.-Pe	mm/season	450.9														
Total irrigation	mm/season	834.9														

Where: Pe = 0.6 P-10 if $\sum Pi < 75$ mm and Pe = 0.8 P-10 if $\sum Pi > 75$ mm

9.2 : CALCULATION FOR CROP WATER REQUIREMENT

Winter-Spring Crop water requirement at Long hai project area

Start growing during 1st to 10th December 2006

Crop duration: 95 days

Accounted crop area: 52.8% of the total rice crop area

ITEMS	UNIT	Nov			Dec			Jan			Feb			Mar		
Duration (Ti)	day	10	10	10	10	10	11	10	10	11	10	10	8	10	10	11
ETo	mm/day	5.7	5.7	5.7	4.9	4.9	4.9	5.7	5.7	5.7	5.8	5.8	5.8	5.5	5.5	5.5
Kc		0	0	0	0.35	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75	0.25	0
ETc	mm/day	0	0	0	1.72	3.43	3.68	4.56	5.56	6.56	6.67	6.24	5.80	4.13	1.38	0
Rainfall	mm/duration	84.1	10.2	0	30.7	19	0	10.5	0	0	0	0	0	0	0	6.3
Effective rainfall	mm	42.3	0	0	8.4	1.4	0	0	0	0	0	0	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	17.2	34.3	40.4	45.6	55.6	72.1	66.7	62.4	46.4	41.3	13.8	0.0
Crop water requirement-	mm/duration	0.0	0.0	0.0	8.7	32.9	40.4	45.6	55.6	72.1	66.7	62.4	46.4	41.3	13.8	0.0
Irrigation water	mm/duration	0.0	0.0	0.0	40.7	64.9	75.6	77.6	87.6	107.3	98.7	94.4	72.0	73.3	45.8	0.0
Total crop requirement	mm/season	495.6														
Total crop requirement -	mm/season	485.8														
Total irrigation	mm/season	837.8														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.3 : CALCULATION FOR CROP WATER REQUIREMENT

Winter-Spring Crop water requirement at Long hai project area

Start growing during 11th to 20th December 2006

Crop duration: 95 days

Accounted crop area: 19% of the total rice crop area

ITEMS	UNIT	Nov			Dec			Jan			Feb			Mar		
Duration (Ti)	day	10	10	10	10	10	11	10	10	11	10	10	8	10	10	11
ETo	mm/day	5.7	5.7	5.7	4.9	4.9	4.9	5.7	5.7	5.7	5.8	5.8	5.8	5.5	5.5	5.5
Kc		0	0	0	0	0.35	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75	0.25
ETc	mm/day	0	0	0	0	1.72	3.43	4.28	4.56	5.56	6.67	6.67	6.24	5.50	4.13	1.38
Rainfall	mm/duration	84.1	10.2	0	30.7	19	0	10.5	0	0	0	0	0	0	0	6.3
Effective rainfall	mm	42.3	0	0	8.4	1.4	0	0	0	0	0	0	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	0.0	17.2	37.7	42.8	45.6	61.1	66.7	66.7	49.9	55.0	41.3	15.1
Crop water require.-Pe	mm/duration	0.0	0.0	0.0	0.0	15.8	37.7	42.8	45.6	61.1	66.7	66.7	49.9	55.0	41.3	15.1
Irrigation water	mm/duration	0.0	0.0	0.0	0.0	47.8	72.9	74.8	77.6	96.3	98.7	98.7	75.5	87.0	73.3	50.3
Total crop requirement	mm/season	499.0														
Total crop require.-Pe	mm/season	497.6														
Total irrigation	mm/season	852.8														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.4 : CALCULATION FOR CROP WATER REQUIREMENT

Winter-Spring Crop water requirement at Long hai project area

Start growing during 21st to 31st December 2006

Crop duration: 95 days

Accounted crop area: 3.6% of the total rice crop area

ITEMS	UNIT	Nov			Dec			Jan			Feb			Mar		
Duration (Ti)	Day	10	10	10	10	10	11	10	10	11	10	10	8	10	10	11
ETo	mm/day	5.7	5.7	5.7	4.9	4.9	4.9	5.7	5.7	5.7	5.8	5.8	5.8	5.5	5.5	5.5
Kc		0	0	0	0	0	0.40	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75
Etc	mm/day	0	0	0	0	0	1.96	3.99	4.28	4.56	5.66	6.67	6.67	5.91	5.50	4.13
Rainfall	mm/duration	84.1	10.2	0	30.7	19	0	10.5	0	0	0	0	0	0	0	6.3
Effective rainfall	mm	42.3	0	0	8.4	1.4	0	0	0	0	0	0	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	0.0	0.0	21.6	39.9	42.8	50.2	56.6	66.7	53.4	59.1	55.0	45.4
Crop water require.-Pe	mm/duration	0.0	0.0	0.0	0.0	0.0	21.6	39.9	42.8	50.2	56.6	66.7	53.4	59.1	55.0	45.4
Irrigation water	mm/duration	0.0	0.0	0.0	0.0	0.0	56.8	71.9	74.8	85.4	88.6	98.7	79.0	91.1	87.0	80.6
Total crop requirement	mm/season	490.5														
Total crop require.-Pe	mm/season	490.5														
Total irrigation	mm/season	813.7														

Where: Pe = 0.6 P-10 if $\sum Pi < 75$ mm and Pe = 0.8 P-10 if $\sum Pi > 75$ mm

9.5 : CALCULATION FOR CROP WATER REQUIREMENT

Summer-Autumn Crop water requirement at Longhai project area

Start growing during 1st to 20th May 2007

Crop duration: 95 days

Accounted crop area: 41.1% of the total rice crop area

ITEMS	UNIT	May			Jun			Jul			Aug			Sep		
Duration (Ti)	day	10	10	11	10	10	10	10	10	11	10	10	11	10	10	10
ETo	mm/day	5.3	5.3	5.3	5.3	5.3	5.3	4.8	4.8	4.8	4.8	4.8	4.8	5.1	5.1	5.1
Kc		0.35	0.35	0.75	0.85	0.98	0.98	1.15	1.08	1.08	0.75	0.50	0.25	0.00	0	0
ETc	mm/day	1.86	1.86	3.98	4.51	5.17	5.17	5.52	5.16	5.16	3.60	2.40	1.20	0	0	0
Rainfall	mm/duration	100.3	135.4	108.1	33.5	15.8	170.5	82.3	36.8	55.7	111.1	21.5	176.9	70.9	63.2	48.2
Effective rainfall	mm	55.2	83.3	61.5	10.1	0.0	111.4	40.8	12.1	23.4	63.9	2.9	116.5	32.5	27.9	18.9
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	18.6	18.6	43.7	45.1	51.7	51.7	55.2	51.6	56.8	36.0	24.0	13.2	0.0	0.0	0.0
Crop water require.-Pe	mm/duration	-36.7	-64.8	-17.8	35.0	51.7	-59.7	14.4	39.5	33.3	-27.9	21.1	-103.3	0.0	0.0	0.0
Irrigation water	mm/duration	-4.7	-32.8	17.4	67.0	83.7	-27.7	46.4	71.5	68.5	4.1	53.1	-68.1	0.0	0.0	0.0
Total crop requirement	mm/season	466.0														
Total crop require.-Pe	mm/season	194.9														
Total irrigation	mm/season	278.4														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.6 : CALCULATION FOR CROP WATER REQUIREMENT

Summer-Autumn Crop water requirement at Longhai project area

Start growing during 21st to 31st May 2007

Crop duration: 95 days

Accounted crop area: 53.7% of the total rice crop area

ITEMS	UNIT	May			Jun			Jul			Aug			Sep		
Duration (Ti)	day	10	10	11	10	10	10	10	10	11	10	10	11	10	10	10
ETo	mm/day	5.3	5.3	5.3	5.3	5.3	5.3	4.8	4.8	4.8	4.8	4.8	4.8	5.1	5.1	5.1
Kc		0	0	0.35	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75	0.25	0.00	0
ETc	mm/day	0	0	1.855	3.71	3.98	4.24	4.68	5.52	5.52	5.16	4.80	3.60	1.28	0.00	0
Rainfall	mm/duration	100.3	135.4	108.1	33.5	15.8	170.5	82.3	36.8	55.7	111.1	21.5	176.9	70.9	63.2	48.2
Effective rainfall	mm	55.24	0	61.48	10.1	0	111.4	0	12.08	23.42	63.88	2.9	116.52	32.54	27.92	18.92
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	20.4	37.1	39.8	42.4	46.8	55.2	60.7	51.6	48.0	39.6	12.8	0.0	0.0
Crop water require.-Pe	mm/duration	0.0	0.0	-41.1	27.0	39.8	-69.0	46.8	43.1	37.3	-12.3	45.1	-76.9	-19.8	0.0	0.0
Irrigation water	mm/duration	0.0	0.0	-5.9	59.0	71.8	-37.0	78.8	75.1	72.5	19.7	77.1	-41.7	12.2	0.0	0.0
Total crop requirement	mm/season	454.3														
Total crop require.-Pe	mm/season	239.1														
Total irrigation	mm/season	381.6														

Where: Pe = 0.6 P-10 if $\sum Pi < 75$ mm and Pe = 0.8 P-10 if $\sum Pi > 75$ mm

9.7 : CALCULATION FOR CROP WATER REQUIREMENT

Summer-Autumn Crop water requirement at Longhai project area

Start growing during 1st to 30th June 2007

Crop duration: 95 days

Accounted crop area: 6.3% of the total rice crop area

ITEMS	UNIT	May			Jun			Jul			Aug			Sep		
Duration (Ti)	Day	10	10	11	10	10	10	10	10	11	10	10	11	10	10	10
Eto	mm/day	5.3	5.3	5.3	5.3	5.3	5.3	4.8	4.8	4.8	4.8	4.8	4.8	5.1	5.1	5.1
Kc		0	0	0	0.35	0.35	0.75	0.85	0.98	0.98	1.15	1.08	1.08	0.75	0.50	0.25
Etc	mm/day	0	0	0	1.855	1.86	3.98	4.08	4.68	4.68	5.52	5.16	5.16	3.83	2.55	1.28
Rainfall	mm/duration	100.3	135.4	108.1	33.5	15.8	170.5	82.3	36.8	55.7	111.1	21.5	176.9	70.9	63.2	48.2
Effective rainfall	mm	55.24	0	61.48	10.1	0	111.4	0	12.08	23.42	63.88	2.9	116.52	32.54	27.92	18.92
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	18.6	18.6	39.8	40.8	46.8	51.5	55.2	51.6	56.8	38.3	25.5	12.8
Crop water require.-Pe	mm/duration	0.0	0.0	0.0	8.5	18.6	-71.7	40.8	34.7	28.1	-8.7	48.7	-59.8	5.7	-2.4	-6.2
Irrigation water	mm/duration	0.0	0.0	0.0	40.5	50.6	-39.7	72.8	66.7	63.3	23.3	80.7	-24.6	37.7	29.6	25.8
Total crop requirement	mm/season	456.0														
Total crop require.-Pe	mm/season	185.0														
Total irrigation	mm/season	426.7														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.8 : CALCULATION FOR CROP WATER REQUIREMENT

Autumn-Winter Crop water requirement at Longhai project area

Start growing during 15th to 31st August 2007

Crop duration: 93 days

Accounted crop area: 41.3% of the total rice crop area

ITEMS	UNIT	Aug			Sep			Oct			Nov			Dec		
Duration (Ti)	Day	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11
ETo	mm/day	4.8	4.8	4.8	5.1	5.1	5.1	4.6	4.6	4.6	4.5	4.5	4.5	4.8	4.8	4.8
Kc		0.00	0.35	0.35	0.75	0.85	0.98	0.98	1.15	1.08	1.08	0.75	0.50	0.25	0.00	0.00
ETc	mm/day	0.00	1.68	1.68	3.83	4.34	4.97	4.49	5.29	4.95	4.84	3.38	2.25	1.20	0.00	0.00
Rainfall	mm/duration	111.1	21.5	176.9	70.9	63.2	48.2	131.8	48.1	48.5	58.4	19.4	1.8	0	0	0
Effective rainfall	mm	63.88	2.9	116.52	32.54	27.92	18.92	80.44	18.86	19.1	25.04	1.64	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	16.8	18.5	38.3	43.4	49.7	44.9	52.9	54.4	48.4	33.8	22.5	12.0	0.0	0.0
Crop water require.-Pe	mm/duration	0.0	13.9	-98.0	5.7	15.4	30.8	-35.6	34.0	35.3	23.3	32.1	22.5	12.0	0.0	0.0
Irrigation water	mm/duration	0.0	45.9	-62.8	37.7	47.4	62.8	-3.6	66.0	70.5	55.3	64.1	54.5	44.0	0.0	0.0
Total crop requirement	mm/season	435.4														
Total crop require.-Pe	mm/season	225.1														
Total irrigation	mm/season	481.9														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.9 : CALCULATION FOR CROP WATER REQUIREMENT

Autumn-Winter Crop water requirement at Longhai project area

Start growing during 1st to 10th September 2007

Crop duration: 93 days

Accounted crop area: 38.1% of the total rice crop area

ITEMS	UNIT	Aug			Sep			Oct			Nov			Dec		
Duration (Ti)	Day	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11
ETo	mm/day	4.8	4.8	4.8	5.1	5.1	5.1	4.6	4.6	4.6	4.5	4.5	4.5	4.8	4.8	4.8
Kc		0.00	0.00	0.00	0.35	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75	0.25	0.00
ETc	mm/day	0.00	0.00	0.00	1.79	3.57	3.83	3.68	4.49	5.29	5.18	4.84	4.50	3.60	1.20	0.00
Rainfall	mm/duration	111.1	21.5	176.9	70.9	63.2	48.2	131.8	48.1	48.5	58.4	19.4	1.8	0	0	0
Effective rainfall	mm	63.88	2.9	116.52	32.54	27.92	18.92	80.44	18.86	19.1	25.04	1.64	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	17.9	35.7	38.3	36.8	44.9	58.2	51.8	48.4	45.0	36.0	12.0	0.0
Crop water require.-Pe	mm/duration	0.0	0.0	0.0	-14.7	7.8	19.3	-43.6	26.0	39.1	26.7	46.7	45.0	36.0	12.0	0.0
Irrigation water	mm/duration	0.0	0.0	0.0	17.3	39.8	51.3	-11.6	58.0	74.3	58.7	78.7	77.0	68.0	44.0	0.0
Total crop requirement	mm/season	424.8														
Total crop require.-Pe	mm/season	258.6														
Total irrigation	mm/season	555.5														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

9.10: CALCULATION FOR CROP WATER REQUIREMENT

Autumn-Winter Crop water requirement at Longhai project area

Start growing during 11th to 30th September 2007

Crop duration: 93 days

Accounted crop area: 20.6% of the total rice crop area

ITEMS	UNIT	Aug			Sep			Oct			Nov			Dec		
Duration (Ti)	Day	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11
ETo	mm/day	4.8	4.8	4.8	5.1	5.1	5.1	4.6	4.6	4.6	4.5	4.5	4.5	4.8	4.8	4.8
Kc		0.00	0.00	0.00	0.00	0.35	0.70	0.75	0.80	0.98	1.15	1.15	1.08	1.00	0.75	0.25
ETc	mm/day	0.00	0.00	0.00	0.00	1.79	3.57	3.45	3.68	4.49	5.18	5.18	4.84	4.80	3.60	1.20
Rainfall	mm/duration	111.1	21.5	176.9	70.9	63.2	48.2	131.8	48.1	48.5	58.4	19.4	1.8	0	0	0
Effective rainfall	Mm	63.88	2.9	116.52	32.54	27.92	18.92	80.44	18.86	19.1	25.04	1.64	0	0	0	0
Infiltration and leakage	mm/day	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Crop water requirement	mm/duration	0.0	0.0	0.0	0.0	17.9	35.7	34.5	36.8	49.3	51.8	51.8	48.4	48.0	36.0	13.2
Crop water require.-Pe	mm/duration	0.0	0.0	0.0	0.0	-10.1	16.8	-45.9	17.9	30.2	26.7	50.1	48.4	48.0	36.0	13.2
Irrigation water	mm/duration	0.0	0.0	0.0	0.0	21.9	48.8	-13.9	49.9	65.4	58.7	82.1	80.4	80.0	68.0	48.4
Total crop requirement	mm/season	423.3														
Total crop require.-Pe	mm/season	287.4														
Total irrigation	mm/season	589.7														

Where: Pe = 0.6 P-10 if $\sum$Pi < 75 mm and Pe = 0.8 P-10 if $\sum$Pi > 75 mm

Appendix 10: Basic information evaluated from the data colleted at 5 field plots

10.1: Basic information evaluated from the data colleted at 5 field plots for W-S crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Area	m2	3,358	4,968	2,701	5,757	7,257	4,808
3	Variety	kg	OM2517	95-20	VD20	404	VD20	
4	Date of seeding		13-Dec	17-Dec	20-Dec	10-Dec	2-Dec	
5	Amount of seeds	kg	80	80	40	120	140	92
6	Date of harvesting		23-Mar	25-Mar	26-Mar	20-Mar	10-Mar	
7	Length of crop	day	101	99	97	101	99	99
8	Total production	kg	1,815	2,334	1,215	2,850	3,500	2,343
9	Amount of water used	m3	3,143	2,504	2,468	4,139	6,002	3,651
10	Number of irrigation application	time	17	14	18	23	13	17
11	Number of fertilizer used	time	7	6	6	5	6	6
12	Number of pesticide used	time	7	5	6	2	6	5
13	Type of pump		oil	oil	oil	electric	oil	
14	Expenditure for pump	VND	253,300	154,400	191,140	133,400	384,500	223,348
15	Expenditure for fertilizer	VND	701,000	882,000	631,720	1,050,000	1,417,000	936,344
16	Expenditure for pesticide	VND	309,000	315,000	459,000	120,000	1,624,000	565,400
17	Total expenditure	VND	1,263,300	1,351,400	1,281,860	1,303,400	3,425,500	1,725,092
18	Price of rice	VND/kg	3,000	5,000	4,500	5,000	4,500	4,400
19	Benefit	VND	3,941,700	9,918,600	4,005,640	12,346,600	11,694,500	8,381,408

10.2: Basic information evaluated from the data colleted at 5 field plots for S-A crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Area	m2	3,358	4,968	5,000	5,757	7,257	5,268
3	Variety	kg	3536	VD 20	VD20	3536	3536	
4	Date of seeding		18-May	23-May	20-May	25-May	17-May	
5	Amount of seeds	kg	70	80	40	130	140	92
6	Date of harvesting		15-Aug	29-Aug	25-Aug	18-Aug	19-Aug	
7	Length of crop	day	90	99	98	86	95	93.6
8	Total production	kg	1,679	2,583	1,050	2,303	2,757	2,074
9	Amount of water used	m3	709	995	2,229	3,071	3,445	2,090
10	Number of irrigation application	time	6	4	15	12	8	9
11	Number of fertilizer used	time	4	6	5	4	3	4.4
12	Number of pesticide used	time	4	6	6	2	3	4.2
13	Type of pump		oil	oil	oil	electric	oil	
14	Expenditure for pump	VND	140,880	68,400	138,440	86,100	232,500	133,264
15	Expenditure for fertilizer	VND	493,400	805,000	669,400	1,509,000	693,000	833,960
16	Expenditure for pesticide	VND	172,000	372,000	371,000	340,000	426,000	336,200
17	Total expenditure	VND	806,280	1,245,400	1,178,840	1,935,100	1,351,500	1,303,424
18	Price of rice	VND/kg	5,000	6,000	6,000	5,000	5,000	5,400
19	Benefit	VND	7,588,720	13,806,600	4,813,220	8,970,400	12,433,500	9,522,488

10.3: Basic information evaluated from the data colleted at 5 field plots for A-W crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Area	m2	3,358	4,968	2,701	5,757	7,000	4,757
3	Variety	kg	3536	VD 20	VD20	2717	3536	
4	Date of seeding		04-Sep	08-Sep	10-Sep	23-Aug	27-Aug	
5	Amount of seeds	kg	70	70	40	140	140	92
6	Date of harvesting		07-Dec	11-Dec	17-Dec	22-Nov	27-Nov	
7	Length of crop	day	95	95	99	92	93	94.8
8	Total production	kg	1,847	2,732	1,215	2,800	3,640	4,247
9	Amount of water used	m3	526	808	1,459	4,802	3,716	2,262
10	Number of irrigation application	time	5	3	11	12	7	7.6
11	Number of fertilizer used	time	6	4	5	4	4	4.6
12	Number of pesticide used	time	3	7	8	3	4	5
13	Type of pump		oil	oil	oil	electric	oil	
14	Expenditure for pump	VND	78,500	58,400	113,000	84,000	137,000	94,180
15	Expenditure for fertilizer	VND	219,000	730,000	866,000	1,093,000	1,334,000	848,400
16	Expenditure for pesticide	VND	167,000	664,000	297,000	460,000	685,000	454,600
17	Total expenditure	VND	464,500	1,452,400	1,276,000	1,637,000	2,156,000	1,397,180
18	Price of rice	VND/kg	5,000	6,000	6,000	5,000	5,000	5,400
19	Benefit	VND	8,770,000	14,942,000	6,014,000	12,363,000	16,044,000	11,626,600

Appendix 11: Basic information evaluated from the colleted data at 5 filed plots and converted per ha

11.1: Basic information evaluated from the colleted data at 5 filed plots and converted per ha for W-S crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Amount of seeds	Kg/ha	238	161	148	208	193	190
3	Total production	Kg/ha	5,405	4,698	4,498	4,950	4,823	4,875
4	Amount of water used	m3/ha	9,360	5,040	9,137	7,190	8,271	7,799
5	Expenditure for pump	VND/ha	754,318	310,789	707,664	231,718	529,833	506,864
6	Expenditure for fertilizer	VND/ha	2,087,552	1,775,362	2,338,837	1,823,867	1,952,597	1,995,643
7	Expenditure for pesticide	VND/ha	920,191	634,058	1,699,371	208,442	2,237,839	1,139,980
8	Total expenditure	VND/ha	3,762,061	2,720,209	4,745,872	2,264,026	4,720,270	3,642,488
9	Price of rice	VND/kg	3,000	5,000	4,500	5,000	4,500	4,400
10	Benefit	VND/ha	12,452,948	20,770,129	15,496,631	22,488,449	16,982,913	17,638,214

11.2: Basic information evaluated from the colleted data at 5 filed plots and converted per ha for S-A crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Amount of seeds	Kg/ha	208	161	80	226	193	174
3	Total production	Kg/ha	5,000	5,199	2,100	4,000	3,799	4,020
4	Amount of water used	m3/ha	2,111	2,003	4,458	5,335	4,747	4,490
5	Expenditure for pump	VND/ha	419,535	137,681	276,880	149,557	320,380	260,807
6	Expenditure for fertilizer	VND/ha	1,469,327	1,620,370	1,338,800	2,621,157	954,940	1,600,919
7	Expenditure for pesticide	VND/ha	512,210	748,792	742,000	590,585	587,019	636,121
8	Total expenditure	VND/ha	2,401,072	2,506,844	2,357,680	3,361,299	1,862,340	2,497,847
9	Price of rice	VND/kg	5,000	6,000	6,000	5,000	5,000	5,400
10	Benefit	VND/ha	22,598,928	28,688,808	10,242,320	16,638,701	17,133,113	19,060,374

11.3: Basic information evaluated from the colleted data at 5 filed plots and converted per ha for A-W crop

No	Information	Unit	Family number					Average
			1	2	3	4	5	
1	Name		Diep	Son	Be	Binh	Mot	
2	Amount of seeds	Kg/ha	208	141	148	243	200	188
3	Total production	Kg/ha	5,500	5,500	4,498	4,864	5,200	8,239
4	Amount of water used	m3/ha	1,566	1,626	5,402	8,341	5,309	4,449
5	Expenditure for pump	VND/ha	233,770	117,552	418,364	145,909	195,714	222,262
6	Expenditure for fertilizer	VND/ha	652,174	1,469,404	3,206,220	1,898,558	1,905,714	1,826,414
7	Expenditure for pesticide	VND/ha	497,320	1,336,554	1,099,593	799,027	978,571	942,213
8	Total expenditure	VND/ha	1,383,264	2,923,510	4,724,176	2,843,495	3,080,000	2,990,889
9	Price of rice	VND/kg	5,000	6,000	6,000	5,000	5,000	5,400
10	Benefit	VND/ha	26,116,736	30,076,490	22,265,827	21,474,726	22,920,000	24,570,756

Appendix 12: Basic information evaluated from the data collected at 120 farmers

12.1: Basic information evaluated from the data collected at 120 farmers during W-S 2007

No	Information	Unit	Name of rice varieties					Total/ or Average
			VD20	3536	OM	2717	Others	
1	Area	ha	37.7	15.3	5.5	4.5	7.0	69.8
2	% area	%	54	21.9	7.9	6.4	9.8	100
3	Average area per family	ha						0.58
4	Average of Yield	Ton/ha	4.9	4.7	5.2	5.6	4.9	5.06
5	Average expenditure	VND/ha	7,583,963	7,663,484	6,777,839	6,767,951	6,539,794	7,328,907
6	Average of benefit	VND/ha	11,840,038	7,810,680	7,955,018	9,106,201	8,478,747	9,958,343
7	Average expenditure	USD/ha	472	477	422	421	407	456
8	Average of benefit	USD/ha	736	486	495	566	527	619

12.2: Basic information evaluated from the data collected at 120 farmers during S-A 2007

No	Information	Unit	Name of rice varieties					Total/ or Average
			VD20	3536	OM	2717	504	
1	Area	ha	31.0	20.4	6.6	9.3	2.5	69.8
2	% area	%	44.4	29.2	9.5	13.3	3.5	100.0
3	Average area per family	ha						0.58
4	Average of Yield	Ton/ha	4.2	3.9	4.1	4.5	5.1	4.4
5	Average expenditure	VND/ha	8,567,051	7,601,155	6,739,765	7,529,634	7,468,293	7,581,180
6	Average of benefit	VND/ha	9,996,736	5,906,780	6,242,294	6,088,858	8,238,374	7,294,608
7	Average expenditure	USD/ha	533	473	419	468	464	471
8	Average of benefit	USD/ha	622	367	388	379	512	454

12.3: Basic information evaluated from the data collected at 120 farmers during A-W 2007

No	Information	Unit	Name of rice varieties					Total/ or Average
			VD20	3536	OM	2717	504	
1	Area	ha	35.0	24.0	2.1	5.2	3.6	69.8
2	% area	%	50.1	34.4	3.0	7.4	5.1	100.0
3	Average area per family	ha						0.58
4	Average of Yield	Ton/ha	4.4	4.4	4.5	4.9	4.9	4.6
5	Average expenditure	VND/ha	9,115,714	8,030,738	7,743,810	7,419,612	7,766,574	8,015,290
6	Average of benefit	VND/ha	10,863,860	9,952,393	7,927,619	11,783,373	9,612,813	10,028,012
7	Average expenditure	USD/ha	567	499	482	461	483	498
8	Average of benefit	USD/ha	676	619	493	733	598	624

Appendix 13: Climate data at My Tho and Long Hai station

13.1: Climate data obtained at My Tho station

Date	Rainfall (mm)						Evaporation (mm*10)						Effective rainfall (mm)					
Month	X	xi	xii	I	ii	iii	x	Xi	xii	i	ii	iii	x	xi	xii	i	ii	iii
1	1.2						36	22	24	25	33	38	0	0	0	0	0	0
2	23.5			1.7			13	17	34	25	31	42	13.5	0	0	0	0	0
3	0.1	40.6					22	17	34	19	34	41	0	30.6	0	0	0	0
4	5.7	35.1					24	13	43	21	28	36	0	25.1	0	0	0	0
5	33.9		29.2	7.7			13	14	18	7	40	36	23.9	0	19.2	0	0	0
6	4.7			0.9			13	27	21	21	47	40	0	0	0	0	0	0
7	25.1		0.1	0.2			16	24	16	16	52	37	15.1	0	0	0	0	0
8		5.5					31	23	30	15	57	34	0	0	0	0	0	0
9	16.6	2.9					12	24	22	23	52	45	6.6	0	0	0	0	0
10	22.1		1.4				16	34	18	24	47	48	12.1	0	0	0	0	0
11	12.6		0.3				12	36	25	30	46	57	2.6	0	0	0	0	0
12			17.3				18	35	13	28	48	56	0	0	7.3	0	0	0
13	5						21	30	21	32	46	49	0	0	0	0	0	0

14		7.3					23	27	28	23	35	41	0	0	0	0	0	0
15		2.9					24	22	31	26	35	45	0	0	0	0	0	0
16							24	33	20	38	38	35	0	0	0	0	0	0
17							20	43	34	29	33	40	0	0	0	0	0	0
18							15	35	29	30	34	44	0	0	0	0	0	0
19							29	37	26	46	29	48	0	0	0	0	0	0
20							30	36	31	45	35	50	0	0	0	0	0	0
21							31	33	20	42	32	44	0	0	0	0	0	0
22							26	39	24	45	45	39	0	0	0	0	0	0
23						5.2	29	39	33	36	34	28	0	0	0	0	0	0
24						0.2	34	42	31	35	39	34	0	0	0	0	0	0
25							36	35	44	32	36	35	0	0	0	0	0	0
26	15.8						30	36	22	34	45	33	5.8	0	0	0	0	0
27	10.9					0.9	23	35	34	27	44	34	0.9	0	0	0	0	0
28							18	34	24	34	49	45	0	0	0	0	0	0
29							24	36	32	34		55	0	0	0	0	0	0
30							23	37	29	34		55	0	0	0	0	0	0
31							9		27	33		36	0	0	0	0	0	0
Sum	177.2	94.3	48.3	10.5	0	6.3	22	31	27	29	40	42	80.5	55.7	26.5	0.0	0.0	0.0
Sum10st	132.9	84.1	30.7	10.5	0	0												
Sum10nd	17.6	10.2	17.6	0	0	0												
Sum10rd	26.7	0	0	0	0	6.3												

Where: Sum10st: sum of rainfall from first 10 days; Sum10nd: sum of rainfall from 11th -20th ; and Sum10rd: sum of rainfall from 21st to 31st

13.2: Climate data monitored at Longhai station

Date	Rainfall (mm)								Evaporation							
Month	V	VI	VII	VIII	IX	X	XI	XII	V	VI	VII	VIII	IX	X	XI	XII
1	28		17.6	3.7		2.8	14.8		4.2	2.7	1.9	2	2.8	2.6	2.3	3.2
2		5		2.5	37	31			3	1.7	1.7	1.6	0.9	1.6	2.7	3
3			2.6	17.2		7.9			3	2.5	2	1.7	2.6	2.2	2.2	3.6
4			27.2	0.6			29		2.8	2.9	1.9	2	0.9	1.9	1.8	2.7
5		28.5				31.9			2.8	2.4	1.6	2.5	3.1	1.4	2.5	3.8
6			15.2			3.2			2.7	2.6	1.4	2.7	3.1	1.6	2.9	3.9
7	0.7		2.1						2.8	1.8	2	2.8	2.5	2.2	2.2	3.4
8	5		2.6	19.8	1.5				2.8	3.3	2.2	1.9	3.1	2.1	3.7	3.4
9	6.6			41.4	27.5	42.5			2.1	3.3	2.9	0.5	2.8	2.3	3.8	4.5
10	60		15	25.9	4.9	12.5	14.6		1	3.4	2.3	1	1.9	1.5	2.5	3.7
11	9.5		9.6		12	30.7	16.4		1.8	3.6	2.5	2.2	1.8	1.2	1.6	2.5
12	78.5		1.2		2	1.5			1.6	3.7	3	2.2	2.5	2	2.6	3.9

13	14		2.5			2.8			1.4	3.8	2	2.2	2.3	2.6	3	3
14	15				2.5	1.6			0.6	3.8	2.5	3.2	2.1	2.4	3.1	3.4
15		14.4	14		25.5				1.4	3	1.9	3.6	1.7	2.7	3.1	3.4
16	5.4				8.5	5.5			2.2	2.5	1.4	1.6	2.5	2.4	3.5	3.5
17			0.6						2.2	2.4	2	3	2.5	2.1	3	3.1
18	13				7.5	6	3		2.1	2.8	2.4	3	1.9	1.8	2.6	2.9
19			8.9		3.2				3	2.2	2	3.1	2.4	3.6	1.9	3.2
20		1.4		21.5	2				3	2.6	2.9	2.4	2.6	1.4	3	3.2
21	1.6			15.5	4.1				2.8	2.9	2.4	2.5	1.5	2.6	3.6	3.1
22	4.4	113.2							2.8	0.9	2.4	2.6	3.3	3.4	3.1	2.9
23		15.9							3.8	0.9	1.8	3	3.2	2.6	3.3	2.9
24	0.8					10.5			2.6	1.9	2.8	3.5	3.1	2.3	3	3.6
25		1.6		68.1	3.7	13.5			2.8	1.2	3.4	2	2.3	1.4	2.6	2.6
26		20			2.9				3.4	1.1	2.7	2	2.5	1.7	2.8	2.6
27	6.5	13		31.3	19.7				2.2	2.1	2.4	1.4	2.4	2.1	3.2	2
28	58.5			22	11	24.5	1.8		1.5	1.5	2.1	1.8	1.4	1.9	3.1	1.6
29	7.3			2.2	6.8				1.3	1.6	2.6	2.2	2	2.2	3.4	2
30	2	6.8	46.7	5.3					2.4	1.8	1.6	1.6	2.7	2	3.7	3
31	27		9	32.5					1.7		2.5	1.2		2.5		3
Sum	343.8	219.8	174.8	309.5	182.3	228.4	79.6	0	73.8	72.9	69.2	69	70.4	66.3	85.8	96.6
each crop	1047.9				490.3				284.9				222.5			
Sum10st	100.3	33.5	82.3	111.1	70.9	131.8	58.4	0								
Sum10nd	135.4	15.8	36.8	21.5	63.2	48.1	19.4	0								
Sum10rd	108.1	170.5	55.7	176.9	48.2	48.5	1.8	0								

13.3: Rainfall runoff from rice field and other land use during S-A and A-W crop season at Longhai station

Date	Rainfall runoff from other land use (mm)								Rainfall runoff from rice crop (mm)							
Month	V	VI	VII	VIII	IX	X	XI	XII	V	VI	VII	VIII	IX	X	XI	XII
1	18	0	7.6	0	0	0	4.8	0	0	0	0	0	0	0	0	0
2	0	0	0	0	27	21	0	0	0	0	0	0	0	0	0	0
3	0	0	0	7.2	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	17.2	0	0	0	19	0	0	0	0	0	0	0	0	0
5	0	18.5	0	0	0	21.9	0	0	0	0	0	0	0	0	0	0
6	0	0	5.2	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	9.8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	31.4	17.5	32.5	0	0	0	0	0	0	0	0	0	0
10	50	0	5	15.9	0	2.5	4.6	0	10	0	0	0	0	0	0	0
11	0	0	0	0	2	20.7	6.4	0	0	0	0	0	0	0	0	0

12	68.5	0	0	0	0	0	0	0	28.5	0	0	0	0	0	0	0
13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	4.4	4	0	15.5	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	11.5	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	5.5	0	0	0	0	0	0	0	0	0	0	0	0
22	0	103.2	0	0	0	0	0	0	0	63.2	0	0	0	0	0	0
23	0	5.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
25	0	0	0	58.1	0	3.5	0	0	0	0	0	18.1	0	0	0	0
26	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	3	0	21.3	9.7	0	0	0	0	0	0	0	0	0	0	0
28	48.5	0	0	12	1	14.5	0	0	8.5	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	36.7	0	0	0	0	0	0	0	0	0	0	0	0	0
31	17		0	22.5		0		0	0		0	0		0		0
Sum	214	145	75.7	195.2	72.7	117.1	34.8	0	47	63.2	0	18.1	0	0	0	0
Sum by crop	629.9				224.6				128.3				0			

Appendix 14: Basic information evaluated from data collected at 120 farmers for all varieties

14.1: Basic information evaluated from data collected at 120 farmers for all varieties: W-S crop

No	Items	Unit	Information	Account in %, USD or area
1	Average of length of crop	day	95	
2	Total of benefit from rice	VND	685,819,380	42,650
3	Total benefit from other	VND	25,170,400	1,565
4	Contribution of income from rice cultivation	%	96.46	
5	First crop grown	date	1-Nov	
6	Last crop harvested	date	30-Mar	
7	Total area grown in Nov	ha	17.15	24.6%
8	Total area grown in Dec	ha	52.68	75.4%
9	% area grow in first 10 days in Dec	ha	36.91	52.8%
10	% area grow in 11-20th in Dec	ha	13.27	19.0%
11	% area grow in last 10 days in Dec	ha	2.5	3.6%
12	Date of > 30% area grown	date	2-Dec	33.0%
13	Date of > 50% area grown	date	5-Dec	56.0%
14	Date of > 70% area grown	date	10-Dec	77.0%
15	Date of 100% area grown	date	31st Dec	
16	First crop harvested	date	7-Feb	
17	Last crop harvested	date	30-Mar	
18	Total area harvested in Feb	ha	8.25	11.8%
19	Total area harvested in Mar	ha	61.58	88.2%
20	Date of > 30% area harvested	date	6-Mar	31.0%
21	Date of > 50% area harvested	date	10-Mar	56.0%
22	Date of > 70% area harvested	date	15-Mar	74.0%
23	Yield of crop in Nov	Ton/ha	4.8	
24	Yield of crop in Dec	Ton/ha	5.0	
25	Expenditure of crop in Nov	VND/ha	6,878,812	428
26	Expenditure of crop in Dec	VND/ha	7,464,420	464
27	Benefit of crop in Nov	VND/ha	10,012,166	623
28	Benefit of crop in Dec	VND/ha	9,942,138	618

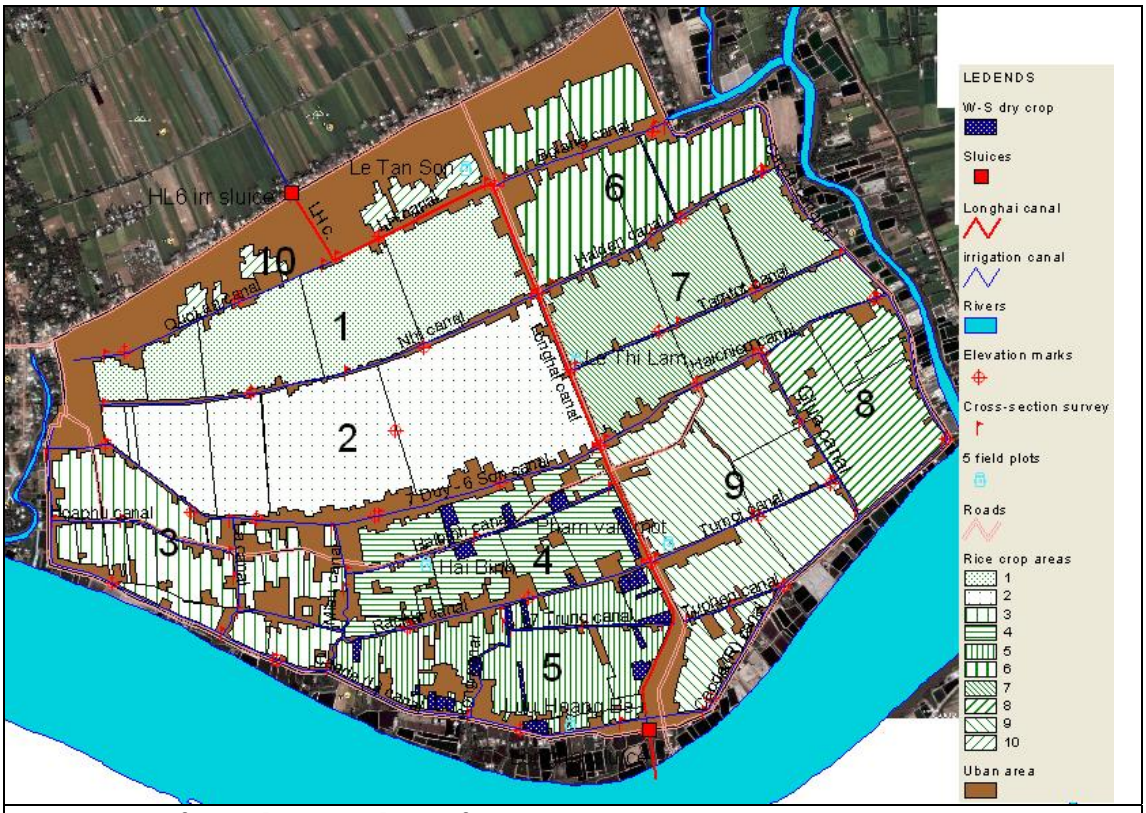
14.2: Basic information evaluated from data collected at 120 farmers for all varieties: S-A crop

No	Items	Unit	Information	Account in %, USD or area
1	Average of length of crop	day	95	
2	Total of benefit from rice	VND	549,173,100	34,153
3	Total benefit from other	VND	97,020,000	6,034
4	Contribution of income from rice cultivation	%	85.0	
5	First crop grown	date	02-May	
6	Last crop harvested	date	16-Sep	
7	Total area grown in May	ha	65.5	93.7%
8	Total area grown in June	ha	4.4	6.3%
9	% area grow in first 10 days in May	ha	0.7	1.1%
10	% area grow in 11-20th in May	ha	27.3	39.0%
11	% area grow in last 10 days in May	ha	37.5	53.7%
12	Date of > 30% area grown	date	20-May	40.0%
13	Date of > 50% area grown	date	23-May	51.1%
14	Date of > 70% area grown	date	26-May	72.8%
15	Date of 100% area grown	date	16-Jun	
16	First crop harvested	date	06-Aug	
17	Last crop harvested	date	16-Sep	
18	Total area harvested in Aug	ha	47.3	67.8%
19	Total area harvested in Sep	ha	22.4	32.2%
20	Date of > 30% area harvested	date	20-Aug	41.8%
21	Date of > 50% area harvested	date	25-Aug	50.8%
22	Date of > 70% area harvested	date	02-Sep	73.0%
23	Yield of crop in Aug	Ton/ha	4.1	
24	Yield of crop in Sep	Ton/ha	4.24	
25	Expenditure of crop in Aug	VND/ha	7,697,165	479
26	Expenditure of crop in Sep	VND/ha	8,469,126	527
27	Benefit of crop in Aug	VND/ha	7,016,385	436
28	Benefit of crop in Sep	VND/ha	9,679,990	602

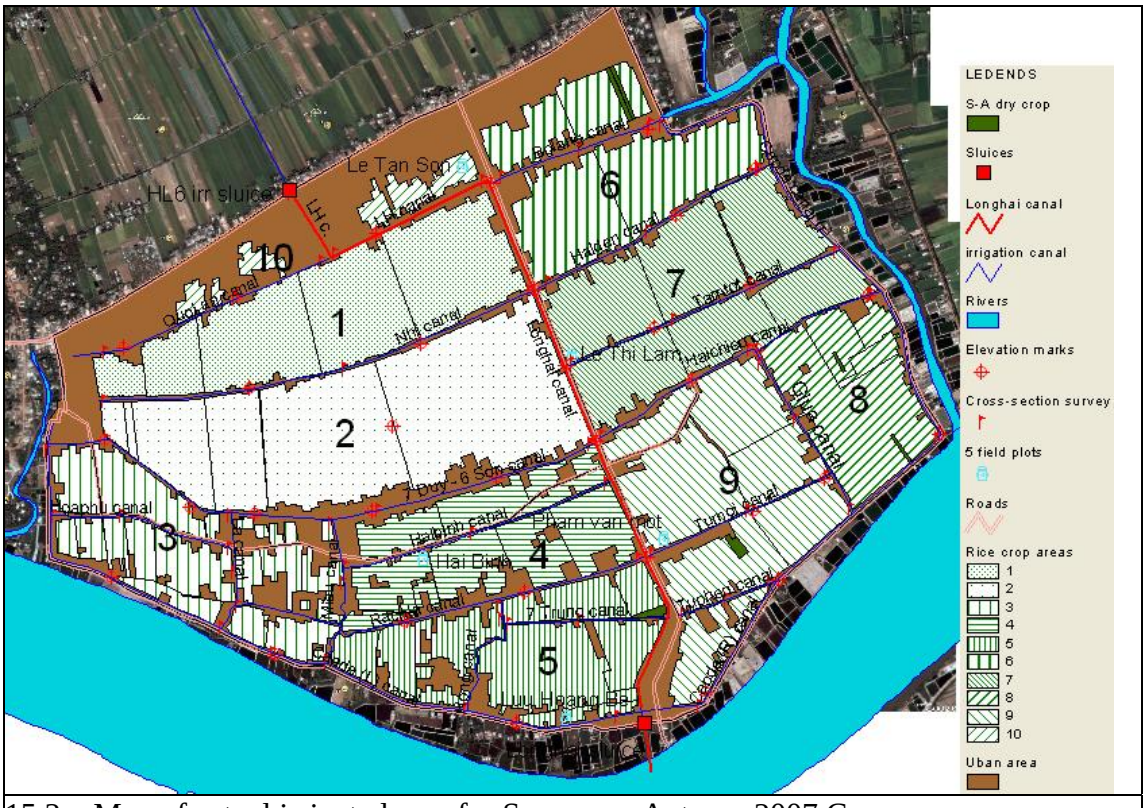
14.3: Basic information evaluated from data collected at 120 farmers for all varieties: A-W crop

No	Items	Unit	Information	Account in %, USD or area
1	Average of length of crop	day	93	
2	Total of benefit from rice	VND	731,024,471	45,462
3	Total benefit from other	VND	153,330,000	9,535
4	Contribution of income from rice cultivation	%	82.66	
5	First crop grown	date	15-Aug	
6	Last crop harvested	date	18-Dec	
7	Total area grown in Aug	ha	28.9	41.3%
8	Total area grown in Sep	ha	41.0	58.7%
9	% area grow from 15/08 to 31/08	ha	28.9	41.3%
10	% area grow from 1/09 to 10/09	ha	26.6	38.1%
11	% area grow from 11/09 to 30/09	ha	14.4	20.6%
12	Date of > 30% area grown	date	30-Aug	41.3%
13	Date of > 50% area grown	date	5-Sep	56.5%
14	Date of > 70% area grown	date	10-Sep	80.1%
15	Date of 100% area grown	date	30-Sep	
16	First crop harvested	date	4-Nov	
17	Last crop harvested	date	18-Dec	
18	Total area harvested in Nov	ha	18.7	26.8%
19	Total area harvested in Dec	ha	51.1	73.2%
20	Date of > 30% area harvested	date	1-Dec	31.4%
21	Date of > 50% area harvested	date	6-Dec	53.8%
22	Date of > 70% area harvested	date	13-Dec	73.6%
23	Yield of crop in Nov	Ton/ha	4.41	
24	Yield of crop in Dec	Ton/ha	4.51	
25	Expenditure of crop in Nov	VND/ha	8,184,296	509
26	Expenditure of crop in Dec	VND/ha	8,642,143	537
27	Benefit of crop in Nov	VND/ha	9,945,224	618
28	Benefit of crop in Dec	VND/ha	10,677,102	664

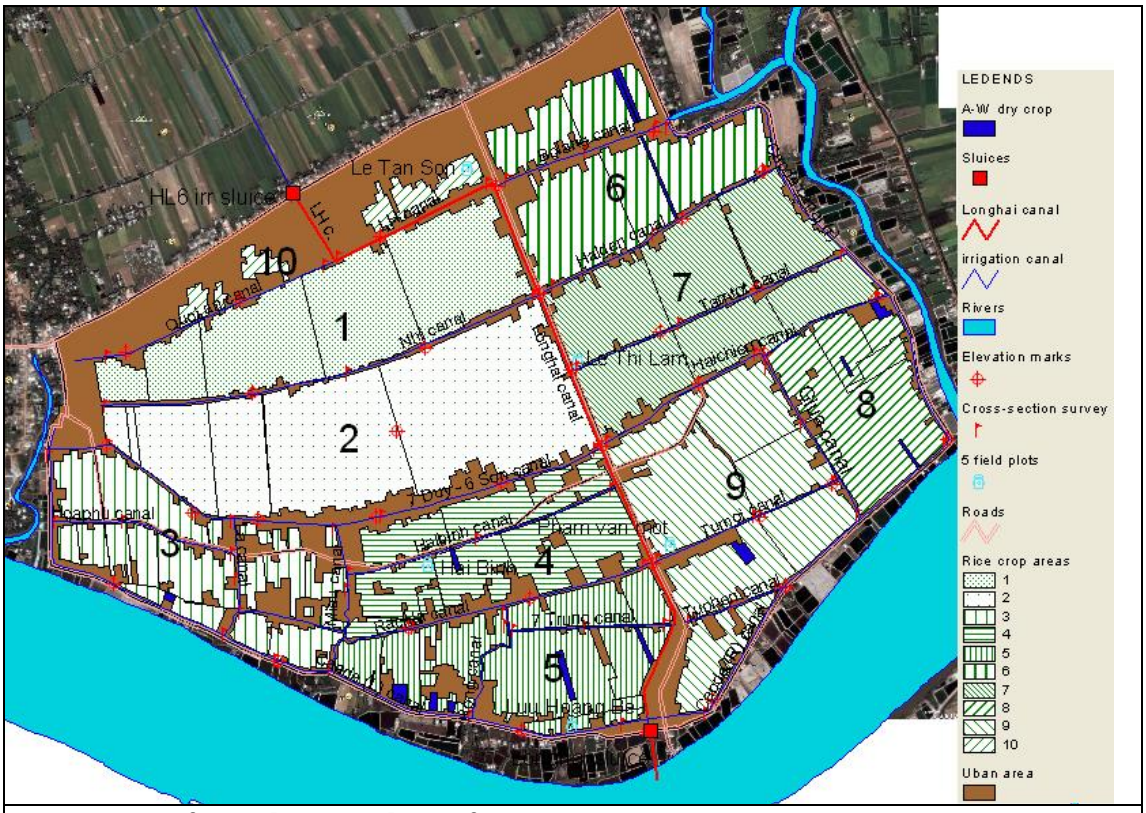
Appendix 15: Map of actual irrigated area for each crop season



15.1 : Map of actual irrigated area for Winter- Spring 2006-2007 crop



15.2 : Map of actual irrigated area for Summer – Autumn 2007 Crop



15.3 ： Map of actual irrigated area for Autumn – Winter 2007 crop

Appendix 16: Flow coefficient calculated for HL6 sluice

No	Date	Time	Hu (cm)	Hd (cm)	Hu-Hd (m)	Velocity at depth (m/s)			Average velocity (m/s) (V02+2*V06+V08)/4	m
						0.2H	0.6H	0.8H		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	20-Jul-2007	13h38	74.0	60.4	0.136	0.42	0.58	0.38	0.49	0.30
2		14h38	74.1	61.6	0.125	0.20	0.34	0.14	0.26	0.16
3		15h38	74.8	63.0	0.118	0.35	0.51	0.86	0.56	0.37
4		16h17	75.1	63.8	0.113	0.22	0.50	0.73	0.49	0.33
5		16h33	75.0	64.1	0.109	0.33	0.65	0.65	0.57	0.39
6	21-Jul-2007	8h25	78.6	72.9	0.057	0.35	0.68	0.87	0.65	0.61
7		8h45	78.8	71.5	0.073	0.19	0.67	0.97	0.63	0.52
8		9h05	79.0	70.1	0.089	0.22	0.67	0.97	0.63	0.48
9		9h25	78.9	69.3	0.096	0.25	0.75	0.95	0.68	0.49
10		10h00	78.8	68.6	0.102	0.25	0.73	0.96	0.67	0.47
11		10h30	78.2	67.9	0.104	0.34	0.75	0.86	0.68	0.47
12		10h50	77.7	67.2	0.105	0.40	0.75	0.80	0.68	0.47
13		11h12	77.7	66.5	0.112	0.19	0.73	0.93	0.65	0.44
	Average									**0.42**

Remark: there is submerged flow condition only

Appendix 17: Operation schedule of HL6 sluice during 2007

No	Type of operation	Duration (day)	From	To	Remark
1	Closed	4	7 Aug 2007	10 Aug 2007	Operation of Longhai sluice
2	Closed	16	12 Aug 2007	27 Aug 2007	Operation of Longhai sluice
3	Closed	12	31 Aug 2007	11 Sep 2007	Operation of Longhai sluice

Remark: other period was fully open

Appendix 18: Flow coefficient calculated for Longhai sluice

No	Date	Time	Hu (cm)	Hd (cm)	Hu-Hd (m)	Velocity at depth (m/s)			Average velocity (m/s) (V02+2*V06+V08)/4	m
						0.2H	0.6H	0.8H		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	4-Dec-2007	7h50	2.19	2.12	0.07	0.88	1.10	1.31	1.10	0.60
2		8h00	1.96	1.81	0.15	0.94	1.77	1.86	1.58	0.59
3		8h10	1.92	1.76	0.16	1.07	1.77	1.95	1.64	0.59
4		8h20	1.84	1.70	0.14	1.62	1.92	1.83	1.82	0.70
5		8h30	1.80	1.63	0.17	1.74	2.04	2.04	1.97	0.69
6		8h40	1.74	1.58	0.16	1.58	1.65	1.62	1.62	0.58
7		9h00	1.64	1.51	0.13	1.40	1.43	1.58	1.46	0.58
8		9h10	1.52	1.42	0.10	1.37	1.40	1.31	1.37	0.62
9		9h20	1.45	1.35	0.10	1.31	1.07	1.25	1.17	0.53
10		9h50	1.33	1.26	0.07	1.43	1.10	1.01	1.16	0.63
11		10h00	1.23	1.16	0.07	1.18	1.30	1.15	1.23	0.67
12		10h20	1.19	1.12	0.07	1.17	1.27	1.13	1.21	0.66
13		10h30	1.16	1.10	0.06	1.10	1.31	1.11	1.21	0.71
14		10h50	1.11	1.06	0.05	1.11	1.02	1.03	1.05	0.67
15		11h10	1.06	1.01	0.05	1.16	1.15	0.97	1.11	0.71
16		11h20	1.05	0.99	0.06	1.11	1.10	0.98	1.07	0.63
17		11h45	1.03	0.98	0.05	1.05	1.00	0.90	0.98	0.63
18		11h55	1.00	0.96	0.04	1.05	0.96	0.97	0.98	0.71
19		12h10	1.07	1.02	0.05	1.02	1.00	0.91	0.98	0.63
20		12h20	1.14	1.07	0.07	0.95	0.97	0.85	0.93	0.51
21		12h30	1.18	1.12	0.06	0.90	0.87	0.85	0.87	0.51
22		12h40	1.30	1.24	0.06	0.86	0.81	0.84	0.83	0.49
23		12h50	1.46	1.42	0.04	0.57	0.66	0.55	0.61	0.44
24		13h00	1.70	1.68	0.02	0.47	0.41	0.34	0.41	0.41
	Average									**0.60**

Remark: there is submerged flow condition only

Appendix 19: Inflow and Outflow for Longhai sluice obtained from IMC

Date	Type of operation	Opening width (m)	Flow (cms)	Flow duration(min)	Total flow in period Q*T*60(m3)	Total inflow during operation time	Total outflow during operation time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
01/12/2006	D	1.00	3.01	270	48,689		59,165
		3.80	1.75	100	10,476		
11/12/2006	D	1.00	2.42	330	47,977		56,674
		3.80	1.12	130	8,697		
11/05/2007	D	1.00	3.27	540	106,182		113,469
		3.40	1.19	75	7,287		
12/05/2007	D	1.00	3.47	400	83,392		99,859
		3.80	2.03	135	16,467		
13/05/2007	D	1.00	6.04	390	141,406		182,553
		3.90	4.42	155	41,147		
14/05/2007	D	1.00	5.33	270	86,366		113,327
		3.90	3.91	115	26,961		
	D	1.00	3.00	330	59,421		68,279
		3.60	1.64	90	8,858		
15/05/2007	D	1.00	3.46	270	55,987		73,604
		3.50	2.18	135	17,617		
22/06/2007	D	1.00	6.54	295	115,700		212,415
		3.90	5.29	305	96,715		
23/06/2007	D	1.00	4.10	340	83,629		108,476
		3.90	2.86	145	24,847		
	D	1.00	3.89	230	53,689		78,875
		3.90	2.80	150	25,186		
24/06/2007	D	1.00	3.17	280	53,257		69,244
		3.60	1.99	134	15,987		
04/07/2007	D	1.00	4.57	215	58,933		70,519
		3.60	3.33	60	11,586		
05/07/2007	D	1.00	3.77	490	110,906		127,229
		3.80	2591.00	105	16,323		
11/07/2007	D	1.00	3.37	505	102,068		118,961
		3.80	2.25	125	16,893		
19/07/2007	D	1.00	3.95	220	52,132		67,009
		3.60	2.76	90	14,877		
	D	1.00	2.84	360	61,310		75,531
		3.60	1.69	140	14,221		
02/08/2007	D	1.00	4.27	245	62,754		79,140
		3.70	3.03	90	16,386		
02/08/2007	D	1.00	2.84	290	49,350		64,330
		3.60	1.66	150	14,980		
07/08/2007	D	1.00	2.77	370	61,555		80,461
		3.65	1.66	190	18,906		

Appendix 19 : Inflow and Outflow for Longhai sluice obtained from IMC (continues)

Date	Type of operation	Opening width (m)	Flow (cms)	Flow duration(min)	Total flow in period Q*T*60(m3)	Total inflow during operation time	Total outflow during operation time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	I	2.00	4.45	220	58,686	72,621	
		3.60	3.32	70	13,935		
08/08/2007	I	3.00	12.21	160	117,223	131,763	
		3.90	4.04	60	14,540		
11/08/2007	D	1.00	4.06	200	48,698		60,754
		3.80	2.87	70	12,056		
12/08/2007	D	1.00	2.62	380	59,835		75,133
		3.60	1.42	180	15,298		
13/08/2007	I	1.50	9.52	220	125,626	179,086	
		3.80	7.43	120	53,460		
17/08/2007	D	1.20	7.12	210	89,615		122,496
		3.80	4.06	135	32,881		
	D	1.70	4.06	290	70,587		91,408
		3.60	2.31	150	20,821		
18/08/2007	I	2.00	11.03	255	168,750	232,315	
		3.90	8.83	120	63,565		
21/08/2007	D	2.00	7.31	390	170,997		195,863
		3.60	1.97	210	24,866		
	I	2.00	5.44	180	58,774	65,203	
		3.60	2.68	40	6,429		
26/08/2007	D	3.00	14.68	165	145,358		174,856
		3.90	6.15	80	29,498		
27/08/2007	D	2.80	9.78	405	237,770		253,514
		3.90	2.39	110	15,744		
28/08/2007	I	2.00	10.22	260	159,364	205,108	
		3.90	6.93	110	45,744		
01/09/2007	D	2.00	9.96	275	164,262		202,875
		3.90	4.95	130	38,613		
03/09/2007	D	1.60	5.32	230	73,406		85,895
		3.60	2.78	75	12,489		
05/09/2007	I	2.00	10.00	170	102,019	163,708	
		3.90	5.71	180	61,689		
10/09/2007	D	2.00	8.39	220	110,795		131,691
		3.80	3.59	95	20,896		
11/09/2007	D	1.00	5.59	240	80,499		106,037
		3.90	3.87	110	25,538		
	I	2.00	10.42	220	137,527	178,888	
		3.90	8.62	80	41,361		
15/09/2007	D	2.00	10.50	250	157,566		203,744
		3.90	5.70	135	46,178		
17/09/2007	D	1.00	3.39	300	60,931		79,966
		3.80	2.12	150	19,035		

Appendix 19 : Inflow and Outflow for Longhai sluice obtained from IMC (continues)

Date	Type of operation	Opening width (m)	Flow (cms)	Flow duration(min)	Total flow in period Q*T*60(m3)	Total inflow during operation time	Total outflow during operation time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
17/09/2007	I	2.00	7.70	240	110,863	137,035	
		3.90	6.23	70	26,172		
21/09/2007	D	1.40	4.70	440	124,140		139,809
		3.90	1.74	150	15,669		
	I	2.80	11.88	355	253,055	308,621	
		3.90	6.86	135	55,566		
26/09/2007	D	2.00	8.10	190	92,374		104,027
		3.90	3.24	60	11,653		
	D	1.00	2.88	180	21,083		42,922
		3.40	1.41	140	11,839		
01/10/2007	D	1.00	2.95	370	65,593		82,866
		3.80	1.69	170	17,273		
	I	2.00	9.48	170	96,665	136,531	
		3.90	7.82	85	38,866		
06/10/2007	D	2.00	6.69	960	385,277		400,544
		3.80	1.82	140	15,267		
	I	2.00	11.08	280	186,171	236,418	
		3.90	9.31	90	50,247		
10/10/2007	D	2.00	9.55	305	174,710		206,740
		3.80	4.11	130	32,030		
11/10/2007	D	1.00	3.20	270	51,880		64,551
		3.60	1.84	115	12,671		
	I	2.00	7.58	235	106,846	138,571	
		3.90	5.88	90	31,725		
17/10/2007	D	2.00	8.07	290	140,396		164,537
		3.80	2.87	140	24,141		
17/10/2007	I	2.00	10.67	320	204,868	270,654	
		3.90	9.14	120	65,786		
21/10/2007	D	2.00	6.31	320	121,212		131,108
		3.80	1.50	110	9,896		
	I	2.00	11.73	400	281,581	383,071	
		3.90	9.95	170	101,490		
31/10/2007	D	1.80	5.86	305	107,218		119,557
		3.80	1.47	140	12,339		
05/11/2007	D	2.00	11.77	160	112,982		177,187
		3.80	6.69	160	64,205		
	D	1.00	6.64	230	91,660		138,750
		3.80	5.06	155	47,091		
06/11/2007	D	1.00	5.45	170	55,610		79,336
		3.80	3.77	105	23,726		
07/11/2007	D	1.00	5.08	230	70,159		91,801
		3.80	3.61	100	21,642		

Appendix 19 : Inflow and Outflow for Longhai sluice obtained from IMC (continues)

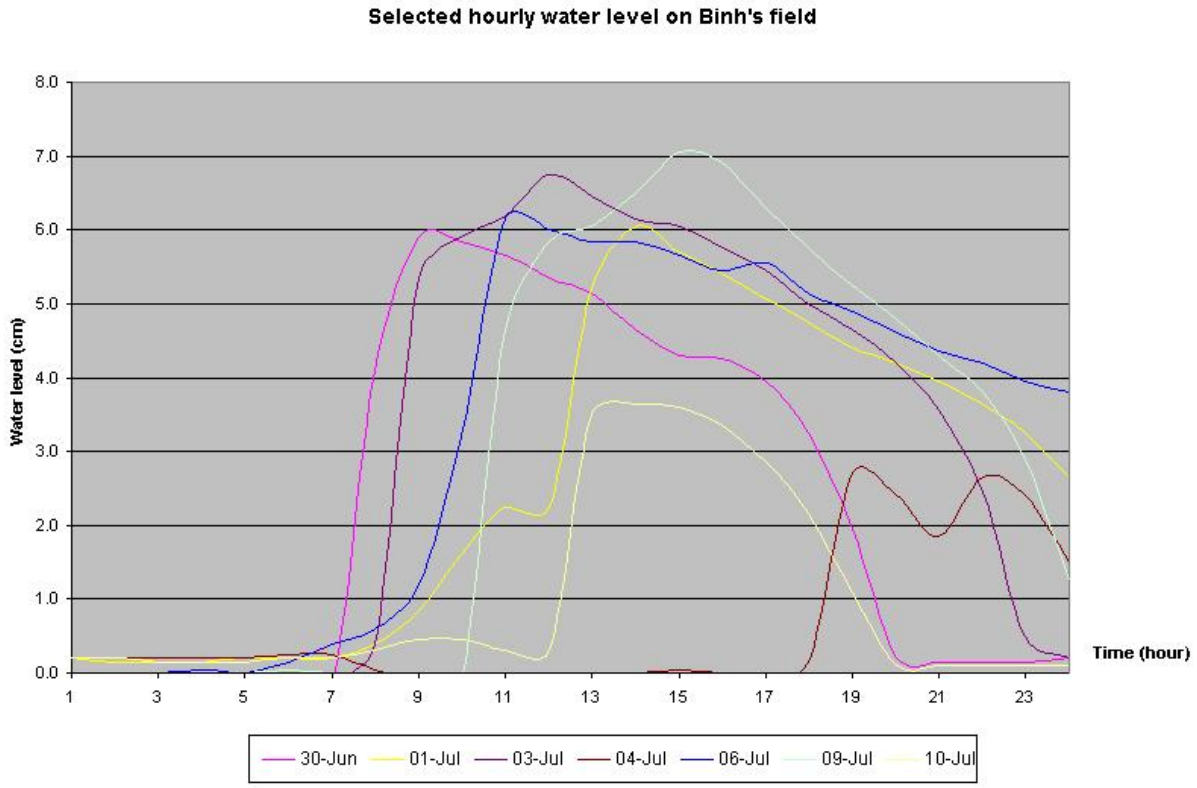
Date	Type of operation	Opening width (m)	Flow (cms)	Flow duration(min)	Total flow in period Q*T*60(m3)	Total inflow during operation time	Total outflow during operation time
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
11/11/2007	D	1.00	6.03	170	61,496		77,714
		3.80	4.51	60	16,218		
13/11/2007	D	1.00	3.40	325	66,290		77,420
		3.80	1.86	100	11,130		
20/11/2007	D	1.00	5.12	190	58,362		85,175
		3.80	3.58	125	26,813		
27/11/2007	D	1.00	3.85	350	80,861		93,794
		3.80	2.40	90	12,933		

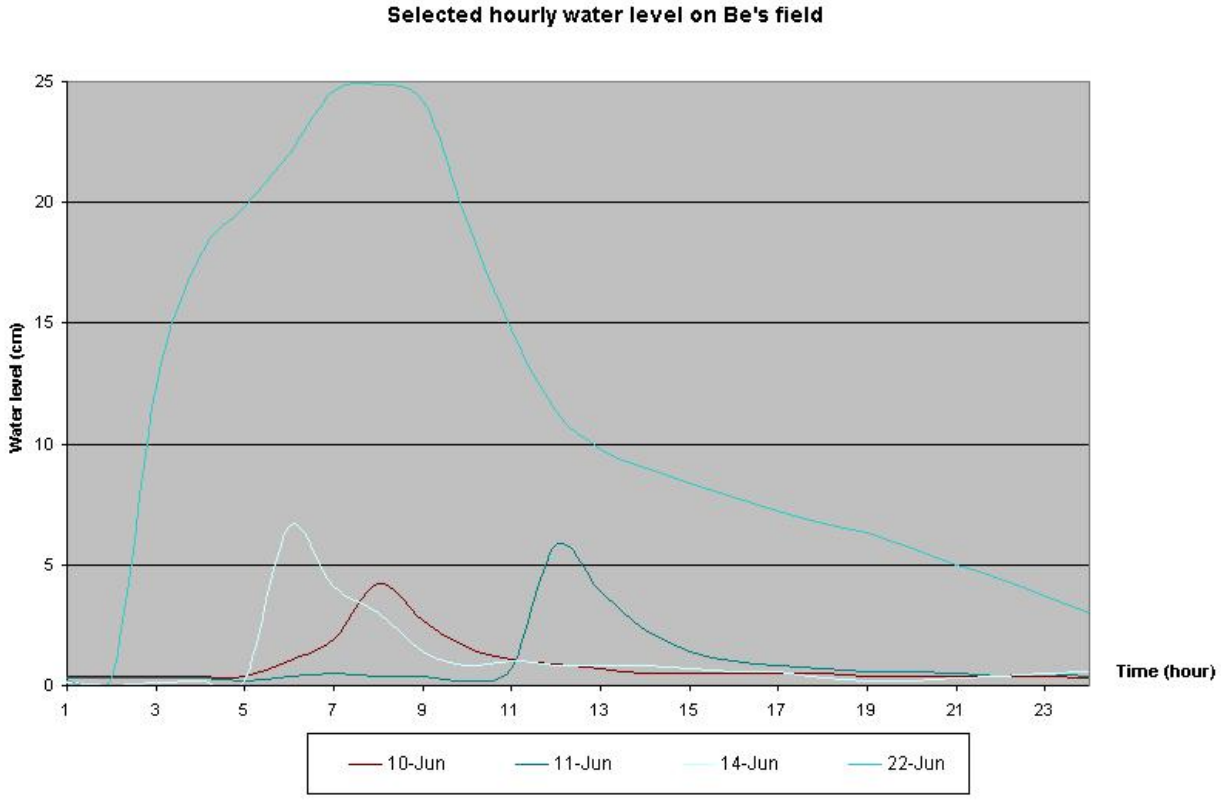
Remark: The above calculated flow published by IMC
D: for drainage purpose
I: for irrigation purpose

Appendix 20: Change of stored water in canals during crop seasons in 2007

No	Crop season	Duration from to	Canal water level (m)	Storage water on canal (m3)	Changed on Storage (Wscc) (m3)
1	W-S	1 Dec 2006	0.80	300,007	-131,236
		31 Mar 2007	0.34	168,772	
2	S-A	1 May 2007	0.00	87,220	277,894
		31 Aug 2007	1.00	365,115	
3	A-W	1 Sep 2007	1.00	365,115	-52,886
		31 Nov 2007	0.77	312,229	

Appendix 21: Selected hourly water level on the rice fields





Appendix 22: Evaluated result of Longhai irrigation project by RAP

	A	B	C
1	Project:	Long hai - Gocong	
2	Date:	01-Jan-08	
3			
4		* The following are data items that have been defined by the IPTRID Secretariat in the publication	
5		"Guidelines for Benchmarking Performance in the Irrigation and Drainage Sector", December 2000.	
6		* "DI 12" refers to "Data Item No. 12" of the IPTRID Guidelines	
7		* "RAP 9" refers to a Data Item that was collected or computed in Worksheet 4.External Indicators, but was not specified by IPTRID; however, that value is needed for the IPTRID computations	
8		* These values have been imported from other worksheets	
9			
10		Value	Description
11	DI 1	9	Delivery of external surface irrigation water to users - using stated conveyance efficiency, MCM
12	DI 2	15	Surface irrigation water inflow from outside the command area (gross at diversion and entry points), MCM
13	DI 3	707	Physical area of cropland in the command area (not including double cropping), ha
14	DI 4	2,104	Irrigated crop area in the command area, ha
15	DI 5	27	Total external water supply - including gross precipitation and net aquifer withdrawl, but excluding internal recirculation, MCM
16	DI 8	20	Flow rate capacity of main canal(s) at diversion point(s), cms
17	DI 9	2	Peak gross irrigation requirement, including all inefficiencies, cms
18	DI 10	12	Gross annual volume of irrigation water entitlement, MCM
19	DI 10	15	Gross maximum flow rate entitlement of the project, cms
20	DI 10a	77	Average percentage of the entitlement that is received, %
21	DI 12	11,748	Gross revenue collected from water users, including in-kind services. $US
22	DI 13	8,229	Total management, operation and maintenance cost of project. $US
23	DI 14	2,895	Total annual (Project + WUA) expenditure on system maintenance. $US
24	DI 15	3,469	Total cost of personnel in the project and WUAs, $US
25	DI 16	6	Total number of personnel employed by the Project and WUAs
26	DI 17	6,578	Gross revenue that is due from the water users, $US
27	DI 18	8,498	Gross annual agricultural production, tons
28	DI 19	3,544,101	Total annual value of agricultural production at the farm gate, $US
29	DI 20	12	Total annual volume of water consumed by the crops (ET) - MCM
30	DI 21	0.6	Average irrigation water salinity, dS/m
31	DI 21	0	Average drainage water salinity, dS/m
32	DI 22	0	Biological load (BOD) of the irrigation water, average mgm/l
33	DI 22	0	Biological load (BOD) of the drainage water, average mgm/l
34	DI 23	0	Chemical Oxygen Demand (COD) of the irrigation water, average mgm/l
35	DI 23	0	Chemical Oxygen Demand (COD) of the drainage water, average mgm/l
36	DI 24	0	Change in water table depth over the last 5 years, m
37	DI 25	0	Average annual depth to the water table, m
38	DI26	0	Differences in the volume of incoming salt and outgoing salts
39	RAP 9	0	Total annual NET groundwater pumping, MCM
40	RAP 20	3	Crop ET - Effective Rainfall, MCM
41	RAP 31	51	Field Irrigation Efficiency, %
42	RAP 15	87	Estimated conveyance efficiency for pumped aquifer water, %
43			
44		Values for DI 18 must be extracted from Table 10 on each INPUT-Year"X" worksheet	
45			
46			
47		IPTRID Indicators (computed from the values above)	
48		**Note IPTRID indicators may not equal the RAP indicators of the same name because the RAP indicators reflect recent USA understanding of terminology for transferrable indicators.	
49		21,299	Annual irrigation water delivery per unit command area (m^3/ha)
50		7,161	Annual irrigation water delivery per unit irrigated area (m^3/ha)
51		60	Main system water delivery efficiency, %
52		2.2	Annual relative water supply ***does not include rice deep perc.***
53		1.2	Annual relative irrigation supply ***does not include rice deep perc.***
54		8.91	Water delivery capacity
55		77	Security of entitlement supply, % received
56		1.4	Cost recovery ratio
57		0.25	Maintenance cost to revenue ratio
58		12	Total MOM cost per unit area (US$/ha)
59		578	Total cost per person employed on water delivery (US$/ha)
60		1.7859375	Revenue collection performance
61		0.0085	Staffing numbers per unit area (Persons/ha)
62		0.00130	Average revenue per cubic meter of irrigation water supplied (US$/$m^3$)
63		3,544,101	Total annual value of agricultural production (US$)
64		5,011	Output per unit serviced area (US$/ha)
65		1,685	Output per unit irrigated area (US$/ha)
66		0.2353	Output per unit irrigation supply (US$/$m^3$)
67		0.2839	Output per unit water consumed (US$/$m^3$)