Mekong River Commission

Programme to Demonstrate the Multi-Functionality of Paddy Fields over the Mekong River Basin

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Irrigation Water Use Assessment

Final Report

October 2005

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1. Introduction

This report describes the progress achieved during over three inputs by the Irrigation/GIS specialist Adrian Young with support from the GIS professional Ms Penroong Bamrungrach.

The inputs by Adrian Young and a summary of the work implemented during each input were:

Input 1: 1-18 May 2005

Review of available information, and data preparation of proposal to analyse irrigation Water Use. Preparation of a short and long term strategy to improve quality the irrigation information and irrigation water use information in the LMB.

Input 2: 27 June-15 July 2005 & 26/27th July

Preparation of the format and information for the water use analysis, analysis of data from experimental sites. Updating of the 2001 irrigation data base.

Input 3: 3-19th October 2005

Linking the various databases, preparing compilation formula, refining and running the final parts of the water use analysis, preparing the final report and database outputs.

Ms Penroong Bamrungrach worked part time on the assignment during May and July and full time under a SSA agreement for the 3rd input in October. The terms of reference for the assignments are given in Annex 7.

2. Background

The assignment forms as part of the programme to 'Demonstrate the Multi-Functionality of the Paddy Fields' (DMPF). The DMPF programme started in 2001 and has worked in a number of areas in relation to the Multi Functionality of the Paddy Fields. The aspects most relevant to this study have been:

- The water use aspects of the 'on farm experiments'.
- The compiled information on rice crop production
- The updating of the irrigation scheme database

3. Review of Available Data and other Related Programmes

Relevant Data

The information most relevant to assessing the irrigation water use includes:

- Data on the irrigation schemes
- Data on the area of irrigated rice and other crops in the schemes
- Evapotranspiration
- Rainfall
- Infiltration

- Irrigation efficiency factors
- Irrigation returns to the rivers
- Information on actual water use

Irrigation Scheme Database

The irrigation scheme database was collected and compiled under the MRC LRIAD project in 2000. The data was derived on data from water agencies in riparian countries and is based on an agreed standard format for the LMB. Under the DMPF project some updates on the schemes and updated attribute information was prepared in 2004. This has been reviewed and checked and a revised version of the database prepared based on the 2000 data but incorporating the 2004 updates.

The database provided spatial data from 4 countries and from the 2000 data included 12,000 schemes with a total estimated irrigable area of 8million hectares.

Irrigated Rice Crop Areas

Requirement

Compiling spatial estimation of the irrigated rice areas has been a key component of the analysis. Accurate data on the actual area of irrigated rice is not easy to measure on a large scale and a number of different data sources have been reviewed.

Irrigation Scheme Database

Inside the irrigation scheme database there are fields showing the area of wet, dry and 3rd season rice for each irrigation scheme. The accuracy is variable and there are very many schemes with 'no data'. From the available data in the irrigation data base the estimated irrigated total rice area was 2.8million ha in the wet season and 1.8 million ha in dry season.

Crop Statistics

Under the DMPF project one year's rice statistics by district have been collected. The total estimated wet season rice areas is 11 million ha, there is no differentiation between the irrigated and non-irrigated rice. The dry season rice area (which is likely in most cases to be irrigated) is 1.9million ha. Data includes planting and harvested areas. The year for which the statistics are derived is not defined. The crop statistics include information on crop planting dates by month. It is understood however that these have been generated from the wet and dry areas using factors to simulate the phasing of planting and harvesting.

Statistics by Province for has been collected covering the years 1985-2001, and has been used by the Decision Support Framework for their river modelling analyses.

Remote Sensing

A trial was conducted under the DPMF to assess remote sensing as a tool to assess rice areas. A trial was conducted in Takeo province. The results indicated some difficulties to accurately assess *irrigated rice.* The use of remote sensing in Cambodia is difficult due to the very subtle differences between irrigated and rain-fed rice especially in the wet season; also the amount of *other vegetation* in the areas of receding swamp areas complicated the assessment. The analysis was also hindered by the presence of about 15-20% cloud. At the time of this study there was no available analysis of rice areas from remote sensing except the data that has been incorporated into the land use mapping.

Land Use Mapping

Various land use maps have been prepared and are available in the MRC archives. Under the DMPF some additional land use maps have been prepared. The maps define the rice growing areas and in some areas (Vietnam Mekong Delta) do differentiate between the irrigated and non-irrigated rice lands. There appears to quite a good correlation between the statistical rice data and land use areas

- For Cambodia Land Use Paddy is 3.2 million ha, from the statistics wet season rice cropped is 2.2 million~ probably not all paddy fields are planted.

- For the Vietnam Delta Paddy is Land Use is 2.4 million paddy (1.5million irrigated and 0.85 million rainfed) –the area planted from the statistics is 2.5 million ~ a reasonable correlation.

It is concluded that the land use mapping can provide useful support information especially to help establish the spatial information of the rice areas.

Assessment of Rice Cropping Areas

The totals between the statistics data and the irrigation scheme data are shown in Table 1.

The district statistics do not differentiate between irrigated and rain-fed rice but assuming dry season rice to be irrigated, or at least marginally irrigated it is possible to compare the two information sources by aggregating irrigation scheme data by district. In most districts there appeared to be quite a poor correlation with the exception of the Vietnam Delta.

Table 1 Comparison of Rice Data

	Data from the Spatial Irrigation Scheme Database					Data from District Statistics			
Location	Number of Schemes	Area of Wet season Irrigation(ha)	Area of Dry Season Irrigation (ha)	Area of 3rd Season Irrigation (ha)	Irrigated Area	Area_wet	Area_dry	ratio irr-dbase/stat-wet season	ratio irr-dbase/stat dry season
Laos	2532	224,232	151,940	0	224,232	627,562	91,798	0.36	1.66
Thailand(total)	8764	-	-	-	5,544,605	5,649,007	125,803	0.06	0.57
RID(med/large)	731	330,056	72,140	0	330,056				
RID(small)	5498				1,393,641				
DEDP	1072				3,232,423				
MOI	1463				588,485				
Cambodia	1012	248,842	181,506	0	392,117	2,118,632	284,613	0.12	0.64
Vietnam delta	120	1,964,223	1,358,669	281,497	1,964,223	2,496,464	1,421,089	0.79	0.96
Vietnam Highlands	76	36,008	7,290	-	36,008	133,446	44,639	0.27	0.16
Total	12,248	2,803,361	1,771,545	281,497	8,161,185	11,025,111	1,967,942	0.25	0.90

Crop statistics are collected by the District Government offices; data collection and compilation is carried out with quite limited resources and consequently they do have some limitations in accuracy. The data is not spatially defined and any analysis by scheme or catchment would involve some form of spatial cutting and apportioning of data spatially. This has been the method used for the DSF project where provincial rice information was assigned to small catchments.

Evapotranspiration:

Reasonable data for has been compiled from the riparian countries for the DSF modelling exercise and at most sites included around 16 years of data. The IQQM model accesses ETo from the nearest or nearest reliable station. The DSF evapotranspiration data has been used for the analysis.

Evapotranspiration data was compiled for the experimental farm sites with data accessed from the nearest climate station. The data was short term but was used for the analysis of the experimental sites described in Annex 2.

Infiltration

Infiltration is a key parameter to estimation of crop water use. The DSF analysis used the MRC (LRIAD) soil map as the basic source of soil information. The soil map identified the soil series using FAO standard soil classifications. The DSF analysis linked the soil classification with the US database of 20,000 US soils and the FAO-ISRC global soil database to provide information on Hydrologic soil Group, Universal Soil Loss Equation, Saturated Hydraulic Conductivity and Soil Horizon data. The data was used in the assessment of storm runoff and infiltration. For the IQQM model seepage estimates of 1-2mm/day were adopted based on estimates from various sources.

Rainfall

Rainfall data is available for approximately 877 rainfall stations in the basin. The DSF has analysis has applied this data to generate rainfall for 266 simulated stations for each of the DSF sub basin. This simulated rainfall has gone through a process of gap filling and screening of poor quality data. The generated monthly rainfall data has been incorporated into the GIS under the DMPF programme and has been used for the analysis

Irrigation Efficiencies

These include the application efficiencies, conveyance efficiencies. The DSF project used empirical factors based on norms from FAO and other institutions. The efficiencies appeared rather high for the largely old and frequently poorly maintained schemes that occur in many of the schemes in the basin.

Irrigation Return Flows

The DSF analysis received from the riparian countries empirical values for river recharge. These coefficients were applied to various crop schedules. The return coefficient reflects the portion of the water abstracted from the river that is returned to the river as return flow. The values from the DSF study have been used in the analysis.

Actual Water Use

The DSF analysis assesses the irrigation water requirement. The irrigation water requirement is based on agricultural research and is the water required to provide optimum yield. Farmers use water according to what is available and their traditional understanding of rice growing techniques, these often differ considerably from the ‘calculated requirements’.

The DMPF Water Use Analysis is to prepare estimates *actual irrigation water use* rather than *irrigation water requirements.* Without access to significant real water allocation data from monitoring of scheme abstractions and cropped areas it will be necessary to resort to a more theoretical analysis supported by some field information from sample areas.

The DMPF established eight on farm experimental sites, two in each of the riparian countries. At each site monitoring of water use was made over 1 or 2 crop seasons as well as information on the soils and other data. The data from these sites has been analysed to try to

assess the actual water use which could be applied to the wider basin area. The assessment of the experimental sites is described in Annex 2.

Irrigation Water Requirement Analysis Carried Out by DSF.

A comprehensive estimate of irrigation water requirements have been carried out by the DSF modelling team using the IQQM software in 2003/04[1]. The IQQM programme is a powerful model used in the Murray Darling Basin. The model has been adapted to meet some of the requirements of the LMB including multiple cropping.

The model is capable of carrying out a very rigorous analysis but the output quality is limited by availability of reasonable quality data; mainly accurate information on cropped areas, real estimates of water use and infiltration The IQQM works by calculating abstractions within small sub-basins and applying the data to node points which are located at the lower intersection of the river and the sub basin. The analysis is described in detail in a technical note[2]

The IQQM model calculates the irrigation demand based on the following inputs:

- Time series of daily climatic inputs
- Crop and supply efficiency factors-including crop factors, irrigation return flows, on farm losses, supply system escape flows and the supply system losses.
- Rice ponding depths
- Irrigation area characteristics-irrigation areas, crop mix, planting dates, soil moisture capacities and seepage and runoff efficiencies.

The output is an estimated irrigation diversion demand based on the estimated crop water requirements plus the losses.

One disadvantage of the IQQM software is that although the node points can be geo reference it is however basically a schematic programme and is without a direct Arc View interface.

The basin modelling team have incorporated the irrigation water use information as part of the broader water use model which clearly has the capacity to analyse the data and can provide a great deal of hydrological information for river water balances including irrigation scheduling. Its format is based on a schematic information map and there are limitations how easily the data can be accessed or applied outside the river modelling section.

Unlike the IQQM model, the SWAT model that was used for the main river modelling applications has an ArcView interface. The SWAT model has capabilities (presently not activated) to undertake the work presently being carried out by the IQQM model.

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[1] Mekong River Commission Decision Support Framework Volume 11 Technical Reference Report Halcrow March 2004.

[2] IQQM Technical Note for the WUP-A project

4. Methodology Used to Assess Irrigation Water Use in the LMB

Alternative Approaches

Two options were considered to evaluate the irrigation water use.

1. *To adjust the available data and input it into the IQQM software and running the IQQM programme to carry out the analysis.* This was a possible approach; however the transfer process is difficult requiring quite major adjusting of the data and adjustments to the model. The output would have some limitations due to the lack of a GIS interface of the software. The output would be per 'DSF Sub Basin' where as the DMPF planning needs would be better met by an analysis of the irrigation schemes.

2. *To build up the data to assess irrigation water use in a series of GIS layers.* Attributes from the various layers can be analysed to calculate the water use. Nearly all the information related to water use including the spatial scheme irrigation databases, climate, rice areas others are all based on a GIS system. Clearly any outputs of the analysis in a GIS format would have significant advantages of compatibility with other databases and ease of access to other users outside the modelling team. The GIS analysis based on irrigation scheme could be easily aggregated to total water use by 'DSF Sub basin'.

It would appear that the long-term requirement is a hydraulic modelling programme with compatibility with ArcView to allow input data directly from the GIS and also to provide output data in a GIS format. The advantage of an analysis by scheme allows calibration with real scheme data to be carried out.

Analysis of Irrigation Water Use based on GIS layers

After some discussion it was agreed to base the analysis on GIS system using ArcView. The relatively low accuracy of the data did not justify a very rigorous approach at this stage, and the evaluation used only the basic parameters and a simple analyses.

The 'basic water use unit' is the irrigation scheme and the analysis has incorporated the data from the 12,700 irrigation schemes in the irrigation scheme database. To calculate the irrigation water use other databases have been developed and incorporated into the analysis.

To carry out linkages and calculations between the various databases, use was made of the 'Access Programme' query facility.

Preparation of the 2004 Irrigation Scheme Spatial Database

The updated data received from the riparian countries has been reviewed and the data has been formatted into the agreed MRC standard. The result is a database based on the 2000 data with updates where new information has been provided.

Rice Cropping Areas

Two sources of rice crop areas were available; 1/ rice crop areas included in the irrigation scheme databases as well as 2/ from the crop statistics. These two data sources were reviewed and (with the exception of the Vietnam delta area) there appeared to be fairly major differences in the dry season rice areas (which were assumed to be irrigated). The approach to estimate the rice areas for each scheme is described in Table 2 below.

Table2: Approach to Estimation of Irrigation Rice Areas

Country	Approach to estimating the rice areas
Laos	There was poor correlation between the statistical data and the irrigation database data. The area of rice data from the irrigation scheme database had been recently compiled from the district offices and was reported to be up to date and reasonably accurate. It was therefore proposed to use the area of wet and dry season rice from the database.
Vietnam Delta	Updated information on the area of rice was available from the irrigation scheme database and was in good agreement with the statistical information. The irrigation scheme database data appeared up to date and correct and was used for the assessment.
Vietnam Highlands	The irrigation scheme database had very limited data on the irrigation areas and no data on rice areas. The dry season rice area for each district from the statistics was allocated to equally to each scheme located in the district. The wet season rice area was taken as two times the dry season area.
Thailand	The Thailand irrigation scheme database was very lacking in scheme area or rice area data. Many schemes only had the scheme area (area_irr). To estimate the dry season rice area, the data from the statistics was allocated to the schemes inside the district in proportion to the irrigation scheme area up to a maximum of the scheme area. Many schemes have no information on area and no rice area has been allocated to these schemes. The wet season rice area based on the same method as the dry season up to a maximum value of 0.9 times the scheme area.
Cambodia	There appeared to be fairly large discrepancies between the dry season rice area from the statistics and the aggregated dry season area from the scheme database. The statistics were by district but appeared in many cases to be only proportioned from the provincial data. The dry season irrigation area from the schemes appeared quite reasonable however the total for the country was only 168,000ha as opposed to 242,000ha in the statistics. This may reflect the rather large areas of marginally irrigated crops. It was decided to use the data from the irrigation scheme database.

Cropping schedules database

A cropping schedule database has been developed for the various cropping patterns found in the LMB. These have been largely based on the cropping patterns developed for the DSF programme but some adjustments and refinements. A phasing of the planting has been incorporated into the schedule. The database has been compiled based on the 19 cropping schedules. An example schedule sheet is shown in Figure 1 below. The schedule includes the portion of area planted, the crop phase, the crop coefficients, infiltration, and ponding factors. The schedules are presented and described in full in Annex 1

Figure 1 Example Cropping Schedule

	`	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Laos North & Central													
LW1 Wet Season													
Crop schedule_1								P	C	C	C	C	H
Crop schedule_2							P	C	C	C	C	H	
Crop schedule_3						P	C	C	C	C	H		
LD Dry Season													
Crop schedule_1		P	C	C	C	H							
Crop schedule_2		C	C	C	H								P
Crop schedule_3		C	C	H								P	C
Wet Season													
Portion of area-1								0.2	0.2	0.2	0.2	0.2	0.2
Portion of area-2							0.6	0.6	0.6	0.6	0.6	0.6	
Portion of area-3						0.20	0.2	0.2	0.2	0.2	0.2		
Crop Area		**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.8**	**1.0**	**1.0**	**1.0**	**1.0**	**0.8**	**0.2**
Kc _1								1.18	1.02	1.03	1.05	1.00	0.84
Kc_2							1.18	1.02	1.03	1.05	1.00	0.84	
Kc_3						1.18	1.02	1.03	1.05	1.00	0.84		
Weighted Kc_wet		**0.00**	**0.00**	**0.00**	**0.00**	**1.18**	**1.14**	**1.05**	**1.03**	**1.04**	**0.98**	**0.88**	**0.84**
Infiltration_factor		0	0	0	0	0.2	0.2	1	1	1	0.8	0.2	0
Ponding_factor		0	0	0	0	0.2	0	0.8	0	0	0	0	0
Dry Season													
Proportion of area-1		0.2	0.2	0.2	0.2	0.2							
Proportion of area-2		0.6	0.6	0.6	0.6								0.6
Proportion of area-3		0.2	0.2	0.2								0.2	0.2
Proportion Total		**1.0**	**1.0**	**1.0**	**0.8**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.8**
Kc _1		1.2	1.07	1.01	1.05	0.88							
Kc_2		1.07	1.01	1.05	0.88								1.2
Kc_3		1.01	1.05	0.88								1.20	1.07
Weighted Kc_dry		**1.08**	**1.03**	**1.01**	**0.92**	**0.88**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.20**	**1.17**
Infiltration_factot		1	1	0.8	0.2	0	0	0	0	0	0	0.2	0.8
Ponding_factor		0.2	0	0	0	0	0	0	0	0	0	0.2	0.6

Evapotranspiration

Daily evapotranspiration data ETo for 38 climate stations was obtained from the DSF programme these were converted into monthly evapotranspiration and linked with the locations of the climate stations into a GIS shape file. The data was interpolated to create a grid map of monthly evapotranspiration for the whole basin. The actual evapotranspiration for each irrigation scheme was derived by means of a spatial join to the monthly ETo GIS shapefile derived from the grid map.

Effective Rainfall

Average rainfall data was obtained from the DSF. This is the simulated data for 266 stations used in the DSF model. The data has been linked with the locations and converted into a GIS shape file.

The average rainfall has been converted to effective rainfall based on information from the FAO paper 25 Effective Rainfall. The paper referred to empirical methods used in Vietnam as shown in the Table 3 below.

Table 3: Effective Rainfall for Rice in Vietnam from FAO paper 25

Period	**% taken as effective**	**Average rainfall range during period in Mekong Delta (mm/month)**
April-September	75	57-244
October	65	294
November	80	142
December-March	90	39-13

From the table above the factors assessed as appropriate for the LMB water use analysis are shown in Table 4 below.

Table 4: Relationship between Average and Effective Rainfall

Average monthly rainfall(mm/month)	**% taken as effective**
<50	90
51-100	85
101-150	80
151-250	75
>250	65

The data was interpolated to create a grid map of effective rainfall for the whole basin. The actual effective rainfall for each irrigation scheme was derived by means of a spatial join to the monthly effective rainfall GIS shapefile derived from the grid map.

Infiltration

The infiltration rate is a key parameter in estimation of the irrigation water use. Infiltration depends on the soils hydrologic conditions. The soils map developed under the LRIAD programme prepared a comprehensive classification of the soils in the LMB. This has been linked to the FAO_ISRC global soil database and the USDA global database. The resultant soil database classes all the soils into four hydrologic groups A, B, C, and D. The database shows a number of soil hydraulic properties including the percentage of clay and the 'Average value of Saturated Hydraulic Conductivity'.

These did not provide an absolute value of the likely infiltration in the paddy fields. To obtain a relationship the infiltration information from the DMPF experimental sites was examined and the site locations linked to the soil database. Based on this infiltration values for the groups B, C and D were obtained. There was no site representing Group A soils which clearly much

higher infiltration rates. A value of 8mm/day has been assumed for the Group 'A' soils. The soil hydrologic groups and proposed infiltration values are shown in Table 5 below.

Table 5: Soil Hydrologic Groups and Proposed Infiltration Values.

Soil Hydrologic Group	**Description**	**Average value of Saturated Hydraulic Conductivity Ks mm/hour**	**Average Clay Content %**	**Relevant DMPF experimental site**	**Proposed infiltration value for the analysis mm/day**
A	Soils with high infiltration rates	113	3.2	None	8
B	Soils with moderate infiltration rates	5.5	28	Laos	4
C	Soils with slow infiltration rates	4.9	28	Thailand	3
D	Soils with very slow infiltration rates	3.8	34	Vietnam Cambodia	2

Ponding and Land Preparation

A review of the water requirements for land preparation has been carried out for the experimental farm sites monitoring data. It appears that most of the field monitoring of water use did not include the water requirements for initial ponding for land preparation. From the monitoring it is evident that at all sites ponding depths at all the sites were quite variable depending on the irrigation availability-there was no evidence of increased ponding depth being applied during the growing period. The allocation for land preparation and initial ponding is shown in table 6 below.

Table 6: Water Allocation for Land Preparation and Initial Ponding

	Cropping Schedule		**Initial land preparation and Ponding Depth(mm)**
1.	CD1-Cambodia Dry Season 1	Land preparation uses receeding flood water	0
2.	VD-Vietnam Dry	Land preparation water requirement reduced due water from receeding flood	100
3	VW3-Single Rice Crop	High water table and land preparation mainly by rainfall	100
4	All Other Areas		200

Conveyance Losses

Water losses from the supply canals are significant and will depend on the size of the scheme and the soil conditions. The conveyance losses include losses due to inefficiencies of water distribution as well as losses from leakages from the canals. Most of the schemes are quite old and in need of maintenance so it is estimated that actual losses are quite high.

In areas of high water table it is estimated that the conveyance losses would be significantly lower and lower factors have been applied to reflect this situation. No basin wide data on the depth to the water table exists so the following zones have been assumed to have high water table:

- Cambodia flood zone
- Vietnam Delta

The estimated factors for conveyance losses are shown in Table 7 below.

Table 7: Estimated Conveyance Losses

	Main canal loss factor	**Secondary canal loss factor**	**Tertiary and quarternary canal loss factor**	**Combined Loss Factors**		
Soil Hydrologic group				**Large schemes >750ha (P,S,T &Q canals)**	**Medium schemes 150-750ha (S,T & Q canals)**	**Small Schemes (T&Q canals)**
A	0.65	0.65	0.60	0.25	0.39	0.60
B	0.70	0.70	0.65	0.32	0.46	0.65
C	0.75	0.75	0.70	0.39	0.53	0.70
D	0.80	0.80	0.75	0.48	0.60	0.75
Reduced Factors for Schemes with High Water Table						
A	0.80	0.80	0.80	0.51	0.64	0.80
B	0.85	0.85	0.85	0.61	0.72	0.85
C	0.90	0.90	0.90	0.73	0.81	0.90
D	0.95	0.95	0.95	0.86	0.90	0.95

Irrigation Water Requirements

The irrigation water requirements for each scheme have been based on the standard crop water requirements analyses following the FAO and other standard guidelines. The key parameters are:

- Evapotranspiration
- Infiltration
- Land preparation and ponding
- Effective Rainfall
- Conveyance Losses

The formulae used in the analysis are shown in Annex 4. A summary of the analysis approach is given in Figure 1.

Irrigation Return Factors

The quantity of irrigation water returning to the river has been based on the factors given in the DSF report. A simple spatial database of irrigation return factors for each of the different cropping schedules has been prepared. These have been assigned to each scheme by linking the irrigation schedule of each scheme with the irrigation return database.

Other Irrigation Requirements

Non Rice Crops

The DSF study identified a number of non rice crops as being irrigated during the dry season. These are vegetables (in Laos) and Ground Nut, Kenef, Mungbean, Maize and Soya (in Thailand), there are no reported non rice crops in Vietnam or Cambodia. The accuracy of the data is uncertain. From the DSF study it is seen that Kenef is primarily grown in the wet season and therefore its irrigation requirement is considered minimal and has therefore has not been incorporated into the analysis. As the water use by non-rice crops is quite low and the accuracy of the crop areas is not certain it, only a very simple analysis has been carried out. The details of the analysis are given in Annex 4.

Fish Ponds

Although many small individual fish ponds rely on rainfall, there are significant areas of fish ponds relying on fresh water from the irrigation schemes; the area is increasing rapidly especially in the Vietnam Coastal Area. The estimated areas of fish ponds are summarised in Table 8.

Table 8: Estimated area of fish ponds

Country	**Estimated Area of Fish Ponds (ha) in LMB**	**Estimated percentage of area being brackish-water**	**Data source**
Vietnam Delta	208,292	97%	Vietnam country information
Thailand	25,862	0%	MRC Fisheries Programme
Laos	5,150	0%	“ “
Cambodia	315	0%	“ “

For Vietnam the area of fish ponds have been identified irrigation each scheme. By linking the information with the known salinity isohaline it can be seen that nearly all of the ponds are brackish-water ponds.

There is limited information on the locations of the ponds in Thailand, Cambodia and Laos and it has been assumed that these would primarily be located on the heavier soils. (class C & D). The water use for fish ponds is for evaporation, infiltration as well as water exchange the details of the analysis is given in Annex 4.

Water exchange has a large influence on the water use. For the inland freshwater ponds-a few semi intensive ponds would be exchanging 10% per day-but most of the low intensity ponds would be less than 1% per day.

The brackish-water fish ponds in the delta traditionally exchange water at the spring tides and would exchange typically 5%-10% per day for six days per month-this is an equivalent of 1-2% per day over the whole period-assuming that during the critical dry season months that the fresh water to salt water ratio would be between 1:2 and 1:3 the fresh water exchange requirement for the tidal ponds would appear to be between 0.3% to 1% per day. A number of the higher intensity ponds would appear to be exchanging water on a daily basis which would increase the water usage.

A figure of 1% per day has been taken as representative of the fresh water exchange requirements for the fish ponds in both the brackish as well as the fresh water zones.

Water Use

Concept of Water Use

The DMPF project objective is to estimate *actual irrigation water use* rather than *irrigation water requirements.* Without access to any significant real water allocation data it has been necessary to resort to an empirical approach supported some limited field information from the results of the 'on farm experiments'.

Actual irrigation water use is influenced by the physical and other factors. Physical factors include the reliability of the rainfall and irrigation, type of irrigation, the rice variety, yields, soils etc. Other factors include the social, traditional, educational and financial background of the farmer. All these to some affect the actual water used by farmers and also by the schemes. It is clear that it is not appropriate to classify the rice as simply 'irrigated' or 'non-irrigated'.

For the analysis it is proposed to relate water use and water requirements as below.

Irrigation Water Use = Calculated Irrigation Water Requirement x Water Use Factor

To develop appropriate water use factors an approach has been made to try to examine the various irrigation conditions in the basin and to develop parameters to relate the water requirements to water use.

Water Use Factors for Rice

It is recognised that there are very many different irrigation water use regimes in the basin. As a first step it is proposed to limit the water use regimes to six classes. The six classes of Water Use Regime are described in Table 9 below. The water use factors that have been allocated to each Water Use Regime have been derived from information from the experimental farms and some other empirical data. The analysis is described in detail Annex 3. In addition the following parameters have been used to help identify appropriate water use factors.

- Pumped schemes-the high costs of pumping water almost invariably reduces the volume of water a farmer uses for irrigation. For scheme with pumping a lower WUF has been used than for gravity schemes.

- Low yields can result from a wide range of factors including soils, pest, lack of fertilisers etc. One factor that can affect yield is low water applications. For schemes which have low dry season yields (derived from the crop statistics) a slightly lower WUF has been used.

Table 9: Water Use Regimes and Factors

Water Use Regime	**Type**	**Description**	**Schemes**	**Estimated water use factors (WUF)**
1	Rainfed	Shallow brief irregular ponding based on rainfall	Not included in data base	0
2	Rainfed	Some ponding due to higher water tables and lower infiltration soils or more regular rainfall patterns-some very occasional irrigation.	Some schemes in the database should be in this category due to lack of water, poor physical condition etc. There is however is insufficient information to make the selection	0.1
3	Occasional supplementary irrigation.	Similar to 2 but some irrigation is provided from run-off or portable pumps that can provide supplementary water from time to time during periods of drought. The amount of water is often limited.	Vietnam delta coastal area –with marginal irrigation.(cropping schedule VW2)	0.6
4	Recession irrigation	The recession of floods waters provide a major contribution to the rice water requirements - some supplementary irrigation is provided from reservoirs or pumping from drains	Schemes in Cambodia flood zone	0.6
5	Intermittent Irrigated	Ponding in the rice fields is provided by rain and intermittent irrigation. These conditions would be found in pumped schemes or gravity schemes with some water shortages or limited water management.	Pumped irrigation schemes. Gravity schemes with dry season yields of less than 3tons/ha.	0.8
6	Irrigated	Irrigation is regular and effective throughout the growing seasons.	Gravity irrigation schemes with yields greater than 3 tons/ha.	0.9

Water Use Factors for Non Rice Crops

The water use non rice crops have been considered the same as for the rice crops.

Water Use Factors for Fish Ponds

The water use factors for fish ponds are difficult to assess. Many of the ponds rely very much on rainfall and would use little or no irrigation water. In pump irrigation schemes due to costs it is unlikely that the farmers would actually use the pumped irrigation water for fish ponds. The exception being the coastal brackish-water fish ponds that mainly use high spring tides to supplement and exchange water. Water use factors that have been used for fish ponds are shown in Table 10 below

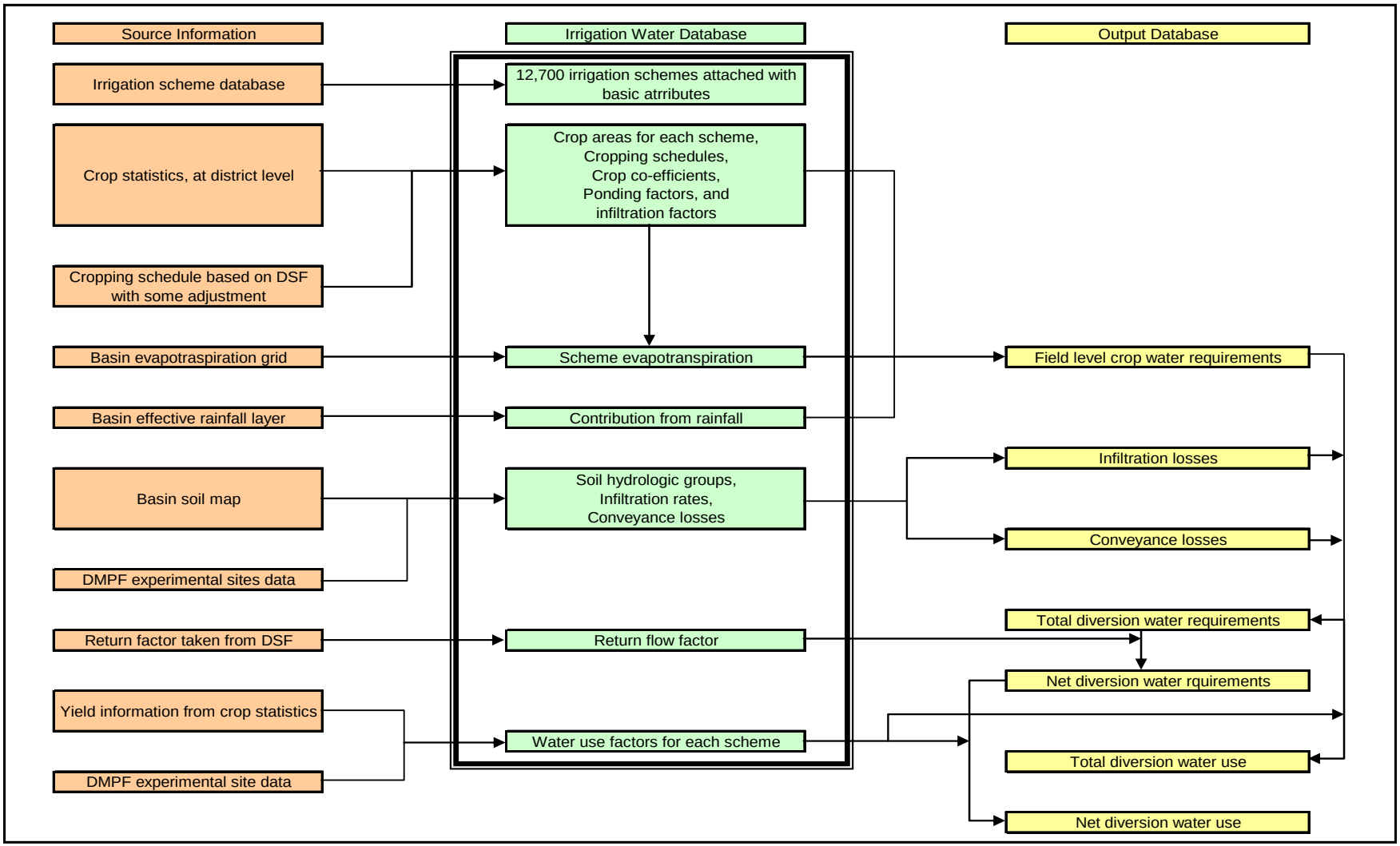
Table 10: Water Use Factors for Fish Ponds

Category	Description	Fish Pond Water Use Factor
1.	Coastal Brackish-water Fish Ponds	0.9
2.	Irrigation pump schemes-except for category 1 coastal Ponds.	0
3.	Gravity schemes in Cambodia	0.3
4.	Other gravity schemes	0.6

Analysis of data

The basic data has been compiled using Arc View Shape and Grid files. The main analysis of the different layers of the different layers has been carried out in 'Access'. The framework used to carry out the analysis is shown in Figure 2. The details of the analysis are given in Annex 4.

Figure 2: Schematic Framework for the water use analysis



5. Final Output of Water Use Assessment Databases

Irrigation Scheme Database

The irrigation water use database is linked and designed to complement the irrigation scheme database. The irrigation scheme database was developed in 2000/01 and has been updated with some updated information for 2004 under the current programme. The components of the irrigation scheme database are shown in Table 11.Table 11: Components of the Irrigation Scheme Database

	dataset name	**Irrigation Scheme Data Base**
1.	b_irrproj04	Irrigation project-point locations and key data for all irrigation schemes
2.	b_irrhw04	Irrigation headworks-point locations and key data for all irrigation headworks
3.	b_irrres04	Irrigation reservoirs-spatial area showing irrigation and other reservoirs
4.	b_irrarea04	Irrigation area-spatial area showing the irrigation command areas
5.	b_irr_data04	Irrigation data: data table on the irrigation schemes can be linked to the irrigation projects by unique codes

Irrigation Water Use Key Database

The Irrigation Water Use Database is a spatial model in GIS format that can be easily applied to a wide number of applications depending on the requirements of the user. It is designed to complement the irrigation scheme database and has a compatible referencing system that allows the two databases to be easily linked.

Table 12: Irrigation Water Use Key Databases

	Dataset name	**Irrigation Water Use Key Database**
1	irrsch04	Irrigation scheme key base showing key data used for the analysis.
2.	DWU	All irrigation schemes showing Total Diversion Monthly Water Use as well as Net Diversion Monthly Water Use in ‘000m3/month. *The Total Monthly Water use is the total water abstracted at the head works, the Net Monthly Water Use is the Total use minus the portion of the water abstracted that is returned to the river as return flow.*

Irrigation Water Use Supporting Databases

To estimate the irrigation water use it was necessary to develop and number of supporting databases from which the key water use data has been derived. The irrigation support databases can be linked to the main database and can be used as required to meet specific needs. Table 13 shows the list of supporting datasets.

Table 13: Irrigation Water Use Supporting Databases

	Code	**Irrigation Water Use Database**
A1	cropschd	Crop schedule database-crop area factors, crop coefficients, factors for ponding, infiltration, ponding depths and return flows for each of the different crop schedules.
A2	fschw	Monthly Irrigation schedule for the wet season rice showing crop area factors, infiltration and ponding factors.
A3	fschd	Monthly Irrigation schedule for the dry season rice showing crop area factors, infiltration and ponding factors.
A4	fsch3	Monthly Irrigation schedule for the 3rd season rice showing crop area factors, infiltration and ponding factors.
A5	et_ef	Effective rainfall and evapotranspiration
	rice_evap	Evapotranspiration requirements for rice
A6	rice_ef	Water requirements for rice evapotranspiration
A7	rice_inf	Water requirements for rice infiltration
A8	rice_pond	Water requirement for rice land preparation and ponding
A9	rice_field	Total rice water requirements at the field level
A10	rice_d_req	diversion water requirements for rice crops
	rice_req_ret	diversion water requirements for rice crops minus the water returned to the river as irrigation returns
	fish factors	factors used to derive fish pond field requirements
	fish_dreq	fish pond diversion requirements
	fish_dreq_net	diversion water requirements for fish ponds minus the water returned to the river as irrigation returns
A11	nrice_fdeq	non rice field and diversion requirement
A12	nrice_dreq_ret	diversion water requirements for rice crops minus the water returned to the river as irrigation returns
B. Data covering the whole basin		
B1	b_et	Evapotranspiration map for LMB (grid map)

B2	b_avgrain	Average Rainfall for LMP (grid map)
B3	b_effrain	Effective Rainfall for LMB (grid map)
B4	b_soil_hp	Soil Map for LMB including soil hydrologic properties

Summary of Outputs

Some summary maps of the analysis are given in Annex 4. The total estimated net water use is shown in Table 14 below.

Table 14: Total Estimated Net Water Use

	Total Net Annual Irrigation Water Use (million m3)					
Month	Cambodia	Laos	Thailand	Vietnam Delta	Vietnam Highland	Total LMB
January	365	488	654	4,273	100	5,881
February	408	393	685	3,884	84	5,454
March	413	360	536	3,319	38	4,665
April	274	164	202	3,911	3	4,554
May	57	55	681	2,286	-	3,079
June	198	17	584	1,248	38	2,086
July	186	263	1,003	1,405	24	2,882
Aug	129	9	957	753	12	1,861
Sept	81	94	959	665	20	1,819
October	95	303	1,511	477	34	2,420
November	199	284	1,085	887	50	2,504
December	343	528	494	3,183	82	4,630
Total for Year	**2749**	**2,957**	**9,352**	**26,291**	**485**	**41,835**

Of the Total Net Water use it is estimated that 78% (32,000million m3) is water use for rice, 20% (8000 million m3) is for fish ponds 2% (800,000million m3) is for non rice crops. The data for fish and non rice is very limited and must be considered only indicative. It does however show the very high volume of water used by fish ponds.

6. Comparison with Other Water Use Analyses

DMPF Vietnam Delta

A water use analysis was carried out by the Vietnam National Mekong Committee as part of the DMPF project. The analysis was carried out in 2004 and analysed water use for delta region. The analysis looked at total water use including bare-land open water, crops, fish, livestock, potable water. The analysis was on a 10 day time series. It also included a water use factor based on the assumption that 50% of the crop yield reduction was due to water shortage and the other 50% due to other factors. The analysis used the same 120 block irrigation units as shown in this analysis. The total water use for the year came to 52,974 million m3. The analysis includes requirements for potable water, bareland, livestock and etc which were not included in the DMPF analysis. The estimate for the Delta from the DMPF analysis is 26,300 million m3 per year-adding 400 million for urban and industrial demand (data from the DSF) gives a total of 26,700 which is lower than the VNMC estimate. Limited details of the calculation were available so it not possible to assess the reason for the differences.

DSF Analysis

The DSF programme carried out a comprehensive analysis of irrigation water demands in the Lower Mekong basin in 2003 and 2004. Many of the parameters used in the DSF analysis were incorporated into this analysis-however there were some significant differences in parts both in the data used as well as the approach used which has clearly affected the final output. It has not been possible to carry out a detailed comparative assessment of the two approaches however a summary of the main differences are summarised below.

Table 15: Main Differences between the DSF and DSF Water Use/Demand Analyses

	Component	**DSF (2003)**	**DMPF**	**Significance of the different approaches**
1	Basic unit	Sub Basin	Irrigation scheme	
2	Areas of rice	Provincial rice crop statistics assigned to sub basins.	Combination of the irrigation scheme database with district level crop statistics where scheme database was lacking.	Cropping data for both analyses is considered weak
3	Areas of non rice crops	Provincial statistics	Used data from DSF	
4	Areas of fish ponds	Fish ponds not included in analysis	Statistics plus information on pond areas per scheme in delta	Fish ponds are a very significant water use
5	Crop coefficients and crop	Researched by DSF	Followed DSF but with some adjustments	Small not very significant

	scheduling			differences.
6	Land preparation and ponding	Fixed amount for land preparation and gradual increase in ponding depth of crop period	Land preparation requirements depending on situation. No gradual increase in ponding depth	Small differences
7	Evapotranspiration and effective rainfall	From rainfall and evapotranspiration data.	Same data sources. Some with slight modifications in the approach to the analysis	Very small differences
8	Infiltration	Fixed rate for whole basin	Infiltration rate variable depending on soil hydrological groups for each scheme	Quite significant difference
9	Conveyance efficiencies	Empirical information-standard for the whole basin	Variable conveyance efficiencies depending on the soil hydrologic group as well as scheme size. Reduced losses proposed for schemes with high water tables.	Significant differences
10	Analysis	Daily soil moisture analysis	Basically the same but a monthly analysis.	Fairly insignificant
11	Irrigation return flows	Irrigation return flows based on empirical return flow factors	Net water use based on the same return factors as proposed by the DSF	Used same values – accuracy of the factors should be further researched.
12	Water use	Irrigation demand which is the irrigation requirement minus the return flows.	Irrigation Water Use based on the water requirement but includes a reduction to reflect actual water use by the farmers. Two parameters calculated:- 1/ Total Water Use and 2/ the Net Water Use (which includes a further reduction from irrigation return flows).	Fairly significant reduction in the estimated volume .

A comparison of the outputs shows despite fairly large differences in the approach there appears not to be very large differences in the final output of the two analyses as shown in Table 16.

Table 16: Comparison of the Outputs of the DSF and the DMPF water use analyses

Area	**DSF Average Annual Irrigation Water Demand**	**DMPF Net Annual Water Use**
	(million m3 per month)	
Vietnam Delta	23,358	26,291
Great Lake	7,362	2,867
Upstream of Kratie	13,063	12,676
Total	43,783	41,834

7. Possible Applications of the Water Use Assessment

The database can be applied to assess a wide number of issues relating to irrigation water use. There must however be some caution in the interpretation of the results due to the many limitations in the original data.

The main general applications of irrigation water use data would include:

- A key input to maintaining an up to date and constant understanding of the dry season water balance in the basin.
- To provide key information to evaluate efficiencies of water use which can be used to support effective water management planning within the basins, as well as over the whole LMB.
- To provide a tool to effectively assess impacts of additional abstractions from the rivers.
- Development and implementation of effective irrigation water management activities.

Although the objectives of the studies are primarily focused on water use, the rice cropping information can be applied to assess rice production including the following:

- Spatially linking rice areas with yields to obtain spatial estimates of production per irrigation scheme.
- Spatial information on rice areas provides a useful interface with the flood information. Overlays of crop production and the flood areas show a good correlation of low production in most flood prone districts during the flood season.
- Potentially providing spatial assessments on the food production and security. The irrigated rice areas being less prone to rainfall shortfalls.

Specific analysis that could be carried out could include:

- Analysis of irrigation scheme efficiencies-irrigation efficiencies could be analysed in terms of both water efficiency (i.e. the portion of water losses in the irrigation system) as well as water production efficiencies –the amount of water (m3) required to produce each ton of rice.

- Assessing the irrigation water use by hydrologic sub basin-calculated by aggregating the water use for schemes inside a sub basin it will be possible to assess the monthly irrigation water use for sub basins.

- Linking the irrigation water use to estimates of available water in each sub basin it is to identify the ratio of water availability to water use in each month. Sub catchments could then be classified depending on the water availability/ water use ratios. Rivers with low availability/use ratios could be considered as sensitive with possible issues of water use conflicts and water shortages.

All these analyses are reasonably straightforward using standard GIS data analyses procedures.

8. Proposals for the Future

Key Objectives for the Future

The key objective for the future is to refine and improve the quality of the data. Scope for basin wide data collection is clearly limited and methodologies have to be developed to develop effective and cost effective ways to improve the data quality.

Selecting sample schemes/areas

Some of the databases are required to be maintained and for the whole basin (ie the irrigation scheme database) it is recommended that some aspects should be based on sampling. From the irrigation water use analysis it was found that 78% of the water use was from 226 larger schemes(larger defined as having an annual net water use of greater than 20million m3- (21 schemes in Cambodia, 14 in Laos, 75 in Thailand, 113 in the Vietnam Delta and 3 in the Vietnam). More detailed monitoring of these or some of these schemes could provide a reasonable sample that could be then applied to the wider basin.

Improvements in the quality and availability of crop statistics

Presently the crop statistics provide the most comprehensive information on planted and harvested rice. There are however no basin wide standards as to how these are collected and how the data is made available. The statistics are aimed primarily at crop production and do not differentiate between irrigated and non-irrigated crops. The cropping data at district level obtained under the DMPF programme is extremely useful and should be compiled and made available on a regular basis to the MRCS. There would appear to be scope to review and improves the methodologies of collection and dissemination of crop statistics.

To Review and Further Assess the role of Remote Sensing to Measure Crop Areas.

Although the trial using remote sensing to assess cropping showed some limitations, it is considered that further investigation into remote sensing should be undertaken to assess it's potential to spatially measure dry season rice areas. In the initial stages remote sensing must be supported by adequate ground verification. For the longer-term ground truthing could be substituted by 'control areas' where cropping patterns are regular and guaranteed and could be used as permanent reference points. There are quite a number of studies into the application of remote sensing review to assess cropping and the programme should build on existing research as much as possible.

Upgrading of the Irrigation Scheme Database

The irrigation scheme database was established in 2000/01 using a fairly limited budget using mainly secondary data. Some updates have been received in 2004 these are however fairly minimal.

The longer-term objective will be a major upgrade involving field surveys in selected schemes using GPS of the scheme information and spatial locations. The work would involve properly defining the scheme areas as well as cropping within the schemes. Using GPS, survey teams could quickly survey quite large areas for minimal costs/hectare. The surveys could be supported by use of the topographic maps, aerial photographs and high resolution satellite imagery..

Improving the Soil and Infiltration Database

The soil infiltration information is quite limited and the existing method to linking the soil classifications to FAO and USDA soil databases is clearly short-term solution. There would appear to be available information in the riparian countries on infiltration, often prepared during the feasibility studies for the various schemes. This data could usefully be compiled and incorporated into the existing soil mapping. Further infiltration tests could be commissioned as required to help fill the information gaps.

Improving the information on fish ponds

Fish ponds are a very major water user and an area where water use conflicts can easily occur. The main area of fish ponds is in the brackishwater delta area where freshwater availability is a key environmental issue during the dry season. There are indications that the area of fish ponds as well as intensities is increasing. At present there appears to be very limited information on the fish areas as well as the water use requirement for fish ponds. Sample ponds should be monitored to assess the water use whilst satellite imagery could help assess the areas of fish ponds,

Improved Integration of the MRC Irrigation Water Use Programmes

Improved integration of the irrigation water use activities within the MRC is proposed. The river modelling section has carried out a number of studies including irrigation assessments. The software presently used by this section however does not have a GIS interface, which constrains the possible exchange of input and output data. Further work is required to review the requirements of the various sections in the MRC involved in water use and see how their needs can be effectively incorporated into the programme. The AIFP role would appear to be to facilitate the upgrading and provision of improved irrigation and agricultural data.

Improving Information Availability on Actual Water Use

The analysis proposed for the DMPF programme described in Section 6 is based on a theoretical analysis to assess scheme irrigation water requirements and relating these to actual water use by applying water use factors depending on the field situations. Some initial work has been undertaken by the DMPF to try to assess these factors but it is clearly an area requiring significant further investigation. It is proposed that water use analysis should be based on selected schemes and should include information on water supplied, cropping and crop schedules and if possible some information on infiltration rates.

Effective Application of the Information to Identify and Implement Irrigation Management Strategies

In the initial stages the activities have focused and data collection and compilation, there however must be a transition to start applying the information to address issues. Up till now the availability of basin wide data has always been incomplete or too inaccurate to be usefully applied to water management.

The objectives of the irrigation water use assessments must be to gradually apply the information for water use planning and management activities. This change from a pure data collection and analysis function to an effective management role frequently requires support and improved understanding how the information can be effectively applied to address real situations.

Institutions and Sustainability

Activities relating to irrigation water use are long-term programme requiring a very active involvement of the water institutions in the riparian countries.

Experience has shown that the riparian water agencies have limited capacity and resources to undertake water use and management tasks. To ensure the long term sustainability of the work there is a key requirement to strengthen and upgrade the irrigation institutions.

It is proposed that in parallel with the technical work that institutional studies are carried out. These would be designed to provide strategic proposals for planners and senior management. The suggested scope of the studies would include a review of the various irrigation institutions, coordination requirements, legal aspects, financial requirements, involvement of stakeholders and the private sector and cost recovery. The output would be plans and recommendations for an effective strategy to implement and improve the efficiencies of irrigation institutions within the riparian countries.

The work would build on other ongoing or completed studies The MRC would have an important role to help coordinate the actions of the different countries and where appropriate develop a common theme between countries.

Proposed Approach

The time and resources to effectively evaluate water use should not be underestimated. To build up the information from the present level to an acceptable level of accuracy will require some fairly major upgrades in the quality of the data and upgrading of the institutions. The main problem for the LMB is the scale of the work. Prior to embarking on a basin wide programme it is proposed that the approach and methodologies and costs involved are tried and tested in a few selected schemes.

For the future it is therefore proposed that future activities are divided into three parts:

- Trying and testing new concepts in selected schemes.
- Accessing other existing data and research from specific programmes that could be incorporated into the database or knowledge information system.
- Introducing tried and proven upgrades over the whole basin as and when they are identified and considered appropriate for basin wide implementation.

Staged Programme

An indicative staged programme is presented in Table 17.

Table 17: Proposed Phased Development of Irrigation Water Use Activities

	Phase 1_LRIAD 1997-2001	Phase 2_DMPF 2002-2005-completed		Phase 2_DMPF possible activities for 2006	Long Term 2007-
	Basin wide	Selected Areas	Basin Wide	Selected Areas	Basin Wide
Irrigation GIS Data	Format developed and initial GIS data base established	Upgrading of irrigation GIS in selected areas-defining requirements and resources required to implement a major upgrade.		It is proposed to focus on one zone. Investigations would include-acquisition of satellite imagery, remote sensing analysis to assess cropping, sample monitoring of scheme water abstractions and ground truthing of cropping. Sample infiltration tests.	Major upgrade of Irrigation Scheme GIS database based on experience in selected areas. Annual updating of irrigation scheme data.
Cropping Information	Basic cropping information included in the GIS	Preliminary assessment of remote sensing to assess cropping in Takeo province Cambodia	Compilation of available data from statistics and schemes. Preparing cropping patterns, spatial information on irrigated and non-irrigated rice areas.	Detailed surveys of cropping in selected basins. Review of crop data collection procedures. Development of a strategy to upgrade crop monitoring and crop statistics. Investigations into the use of remote sensing to assess cropping. Trials and verification of different remote sensing imagery in selected areas. .	Development of an integrated strategy to monitor cropping. Implement a basin wide crop study involving various methods as defined by the strategy Routine crop monitoring based on agreed strategy.
	Mapping of flood risk areas		Preparation of cropping patterns by applying rainfall and flood information to cropping data	Field surveys of rice cropping areas-development of 'control areas' to support remote sensing	
Irrigation Water requirements		Evaluation of on farm monitoring at 8 sites	Compilation of monthly rainfall maps. Assessments of effective rainfall.	.	
			Development of reference evapo-transpiration mapping	Assessment of water use in selected schemes based on monitoring and survey information	Expanding water use monitoring to selected schemes basin wide.
Soils and Infiltration	Comprehensive soil mapping	Infiltration studies in 8 farm sites	Compiling indicative permeability/infiltration map based on soil information and	Collection and compilation of existing infiltration information. Conducting infiltration tests in selected schemes	Expanding studies on infiltration basin wide.
Irrigation Efficiencies		Assessing irrigation efficiencies from farm monitoring sites.	Preparing indicative parameters to assess irrigation efficiencies.	Studies in selected schemes to review irrigation methods and efficiencies. .	
Rice Regime Factors				Monitoring of water use on selected schemes Developing information on actual irrigation water use in relation to the theoretical requirements	
River Recharge			.	Dry season flow measurements to assess river recharge-assessment of contribution of irrigation to river recharge.	Development of basin wide river recharge assessments.
Compiled water use mapping			Preliminary compilation of water use estimates based on existing data.		

Possible Activities for Final Period of DMPF

For the final period of the DMPF it is proposed that programme should focus on further improving the quality of the irrigation data. In the time and with the limited resources available it is proposed to focus activities only in one selected area. The objective of the studies would be to investigate and identify cost effective methodologies of compiling high quality data that could be later applied to the whole basin. The final selection of the area to be studied can be reviewed however for logistical reasons it is proposed to concentrate in an area near Vientiane and including a small part of Northern Thailand. The work would focus on the irrigation schemes lying inside the Landsat image number 12848. The image covers an area of about 160x160km and includes a total of 947 schemes. Of these 18 schemes would be classed as large (>20 million m3 per year net water use). The analysis would provide a reasonable sample that could be applied to much of Laos and Thailand.

The proposed period would be the dry season starting in November up to May. And if time permits this could start in November 2005.

9. Conclusions

The analysis has estimated the total net quantity of water of water abstracted from the LMB as 41,834 million m3.

The use of GIS to do the analysis has been very successful and considerable use of the GIS facilities for selecting and linking the various data sources has been made. It has the great advantage of flexibility that is not always available by using commercial water use software packages. The calculations have been carried out in ‘Access’ which is more appropriate for the many linkages and calculations that have been required.. The flexibility of the database however does allow a reasonably skilled GIS Operator to access the various files and prepare summaries of irrigation water use as required by the user.

The preparation of the water use analysis was complicated by the quite large gaps in the data requiring extensive use of empirical estimates. The analysis is based on standard procedures for estimation of crop water use by the FAO and other organisations. For the LMB the large number of schemes and the very differing conditions found in the basin do make the analysis more complex. A lot of effort has gone into developing a logical approach that can be built on and refined in the future.

For the future it is recommended that the routines and methods of introducing new data and other changes made more user-friendly. This could be done by developing a user interface for data input.

In many parts the data is quite weak and as the final output is based on applying data from each layer in turn creates increased inaccuracies. For the future the emphasis must be to improve data quality; in particular the data on cropping, infiltration rates, and conveyance losses are the three main areas where inadequate data can significantly affect the final estimate of water use.

To upgrade basin wide data is a major undertaking and it is proposed to develop the methodologies in selected areas before considering a basin wide applications.