Mekong River Commission

Basin Development Plan Programme, Phase 2

Regional Irrigation Sector Review for Joint Basin Planning Process

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EXECUTIVE SUMMARY

Introduction

The Basin Development Plan Phase 2 (BDP2) is designed to provide an integrated basin perspective through the participatory development of a rolling Integrated Water Resources Management (IWRM) based Basin Development Plan. The plan comprises:

- ***Basin-wide Development Scenarios***, which will provide the information that Governments and other stakeholders need to develop a common understanding of the most acceptable balance between resource development and resource protection in the various parts of the LMB. The results will guide the formulation of the IWRM-based Basin Strategy.

- ***An IWRM-based Basin Development Strategy***, which provides a shared vision and strategy of how the water and related resources in the LMB could be developed in a sustainable manner for economic growth and poverty reduction, and a coherent and consistent IWRM planning framework that brings basin perspectives into the national planning. The results will guide the formulation of the Project Portfolio.

- ***A Project Portfolio*** of significant water resources development projects and supporting non-structural projects that would require either promotion or strengthened governance, as envisioned in the 1995 Mekong Agreement.

The preparation of the Plan will bring all existing, planned and potential water and related resources development projects in a joint basin planning process, through a combination of sub-basin and sector activities, and a basin-wide integrated assessment framework. This offers an integrative platform for the Mekong River Commission (MRC) to engage in transboundary assessment and multi-stakeholder consultation to facilitate a broad and informed dialogue on sustainable water resources development and management.

As an input to the irrigation sector aspects of the IWRM-based Basin Development Plan, several activities were carried out by a team comprising staff of the Mekong River Commission Secretariat (MRCS), National Mekong Committees (NMCs), national sector specialists in Lao PDR, Cambodia, Vietnam and Thailand, and one international irrigation expert. The activities and key results are described in the report.

The irrigation sector forms the largest water user in the basin and effective planning and development of irrigation forms a fundamental part of the water management strategy for the basin. Irrigation development presently is of quite minimal effect on river flows, present dry season irrigation is estimated to be of the order of.1.2million ha about 30 % of the wet season irrigated area. The long term development trends of irrigation are not clearly defined and this irrigation review is directed at the assessment of the present irrigation and likely trends over the next 20 years as well as an assessment of the long term potentials. Under the BDP irrigation sector review it has been possible to develop:

- A well researched inventory of existing, planned and potential irrigation projects.
- Identification of the key opportunities, constraints and issues for sustainable irrigation development.
- A methodology based on simple assessment indicators to assess the (20years) and long term potential (indicatively 50 year) development scenarios of irrigation in the LMB.
- An outline institutional framework for irrigation development including support measures to ensure viability sustainability of investments.
- A portfolio of viable irrigation development projects as well as non structural support initiatives.

Irrigation Database

The large number of irrigation projects in the region requires the use of databases to effectively document and present the quite complex information on existing, planned and potential irrigation projects. The database includes key information on each irrigation project including the size, rice cropping, costs as well as information on future expansion planned and potential. The database includes around 10,800 inventoried existing projects and around 4000 new projects.

Grouping of Projects

The data in the database is too detailed for national or regional planning; disaggregated data is however important for district or provincial level planning. The data in the database will be maintained on a project by project basis, however for regional planning the projects have been grouped based on the key features, geographic areas and a strategy for development. The 15,000 individual projects have been grouped into 10 major groups and 40 sub groups.

The irrigation database consists of mainly numeric or short key information. To fully understand the project proposals a parallel descriptive data base has been developed. The descriptive data base includes summary information on the grouped project objectives, description, benefits, relation to national strategy, assessment and risks, duration etc.

Assessment

An approach using *assessment indicators* has been used. Economically viable and sustainable irrigation depend on a mix of parameters including water soils, whether gravity or pumped, if pumped pumping heads, farmer capacities and resources. If these parameters are all positive then the indication is that the development is sound and reasonably fast development is viable and might be expected. Most irrigation projects however suffer to some degree from constraints or issues; the *assessment indicators* have been identified and used to highlight issues and constraints and assess how these constraints might affect future development. The indicators have also been use to try and identify the likely support initiatives required to overcome the scheme shortcomings. For each of the grouped projects an assessment has been made on the likely opportunities, constraints and issues using the *assessment indicators.*

Development Scenarios

Development scenarios have been defined to assess the different levels of possible development of irrigation. The database includes information on the existing and planned projects as well as a long list of potential projects. The rate of implementation of the potential projects in the next 20 years and in the long term has been assessed subjectively, using the assessment indicators as a guideline. The long term has been assessed based on a long term high development scenario as well as a more likely long term development scenario which incorporates some assessment of the viability of the projects.

Summary of Irrigation

A summary of the present, 20year, long term, and long term high development scenarios for rice is shown in the table below.

Predicted Irrigation Areas (Hectare)

	Definite future (same as existing)				20-Year Development			
	Irrigation area	**Wet season area**	**Dry season area**	**3rd season area**	**Irrigation area**	**Wet season area**	**Dry season area**	**3rd season area**
Cambodia	504,675	273,767	260,815	16,713	778,838	452,291	378,012	21,077
Lao PDR	172,151	172,161	99,319	0	458,820	457,090	332,646	0
Thailand	1,425,015	1,372,631	171,768	0	1,829,510	1,765,016	279,831	0
Viet Nam	1,921,273	1,671,209	740,304	1,478,740	2,048,223	1,798,159	740,304	1,478,740
Total Basin	**4,023,114**	**3,489,768**	**1,272,206**	**1,495,453**	**5,115,391**	**4,472,556**	**1,730,793**	**1,499,817**

	Long Term Development				Long Term High Development			
	Irrigation area	**Wet season area**	**Dry season area**	**3rd season area**	**Irrigation area**	**Wet season area**	**Dry season area**	**3rd season area**
Cambodia	1,156,282	668,824	745,869	387,053	2,432,795	1,650,087	2,068,756	1,646,907
Lao PDR	729,646	727,218	512,139	0	1,935,138	1,931,357	1,274,152	0
Thailand	1,868,253	1,791,650	279,831	0	3,719,910	3,627,161	1,179,831	0
Viet Nam	2,066,359	1,816,295	1,106,277	1,547,019	2,102,630	1,852,566	1,106,277	1,576,285
Total Basin	**5,820,539**	**5,003,986**	**2,644,116**	**1,934,072**	**10,190,473**	**9,061,171**	**5,629,016**	**3,223,192**

1. Introduction

1.1 Introduction

The irrigation sector review is designed to form the basis of the irrigation sector inputs for the rolling IWRM Basin Development Plan. The report is based on an extensive database of existing, planned and potential irrigation projects; the database is described in detail in Appendix A. The irrigation review is based on the requirements described in the Terms of Reference, presented in Appendix B.

1.2 Overview

The natural resources of the Mekong Basin are extensively for their food security and livelihoods; water infrastructure development is limited compared with most other large river basins in the world. Irrigation forms the largest consumer of the Mekong waters, in comparison with the overall river resources irrigation abstractions remain however relatively small.

Currently, water resources development is being accelerated, in particular for the generation of hydro-electric power, driven by markets and the private sector. The riparian Governments have for a long period recognized the economic potential of the water resources in the Mekong Basin for hydropower, navigation and irrigation, also how flood management can contribute to increasing economic growth, alleviating poverty, improving livelihoods, and meeting the UN Millennium Development Goals.

Given the above described situation, there has been an increasing pressure from the basin countries and project developers for provision of an integrated basin perspective against which national plans and proposed projects can be assessed to ensure an optimal balance between economic, environmental, and social outcomes in the Lower Mekong Basin (LMB), and mutual benefits to the LMB countries.

The development of such a basin perspective is beyond the responsibility of any individual country or project developer. For example, a developer of a particular dam in the LMB cannot assess the impact of the dam on the basin's economic resources including capture fisheries.

MRC's Basin Development Plan Phase 2 (BDP2) is designed to provide such an integrated basin perspective through the participatory development of a rolling Integrated Water Resources Management (IWRM) based Basin Development Plan. The plan comprises:

Basin-wide Development Scenarios, which assess the potential and constraints for the further development of some of the water resources in the various parts of the LMB. The results will provide the information that Governments and other stakeholders need to develop a common understanding of the acceptable balance between resource development and resource protection. The selected scenario(s) will guide the preparation of the IWRM-based Basin Development Strategy.

An IWRM-based Basin Development Strategy, which provides a long-term view of how the LMB could be developed in a sustainable manner for economic growth and poverty reduction. The strategy will also provide a rolling planning, evaluation and reporting framework, which aims at bringing basin perspective into the national planning and vice versa, amongst others through the MRC sector programmes and BDP2's sector and sub-area activities.

A Project Portfolio of water resources development projects and supporting non-structural projects that would continue to develop some of the LMB's water and related resources, as envisioned in the 1995 Mekong Agreement, and minimizes harmful effects that might result from natural occurrences and man-made activities.

The IWRM-based Basin Development Plan will provide a framework for a more strategic implementation of the water utilization procedures, in particular the Procedures for Notification and Prior Consultation and Agreement (PNPCA). This would offer an opportunity for the MRC to demonstrate its wide range of experiences and skills, and add value to the identification, preparation, implementation of projects.

1.3 Irrigation and BDP Planning Objectives

The irrigation sector forms the largest water user in the basin and effective planning and development of irrigation forms a fundamental part of the water management strategy for the basin. Irrigation development is uncoordinated and largely project led. There is a lack of firm development strategies and rationales for investment. Although there has been a gradual expansion of irrigation schemes over the years the financial returns and production from irrigated agriculture has in many ways fallen below expectations.

From a basin perspective effective and well coordinated irrigation planning is critical element. Irrigation has the potential to provide significant increased crop production, rice is and will remain the main crop but increasingly opportunities are opening for diversified crops including fruit, beans, vegetables and fish. Long term sustainable irrigation require access to water, but require to be supported by good soils and access to finance, markets, agricultural inputs, adequate low cost labour. Frequently irrigation planning has focused on water with limited attention to the other key support parameters.

Irrigation development presently is of quite minimal effect on river flows, dry season irrigation is estimated to be of the order of.1.2million ha about 30 % of the wet season irrigated area. The long term development trends of irrigation are not clearly defined and this irrigation review is directed at the assessment of the present irrigation and likely trends over the next 20 years as well as an assessment of the long term potential.

Under the BDP irrigation sector review it has been possible to develop:

- A well researched inventory of existing, planned and potential irrigation projects.
- Identification of the key opportunities, constraints and issues for sustainable irrigation development.
- A methodology based on simple assessment indicators to assess the (20years) and long term potential (indicatively 50 year) development scenarios of irrigation in the LMB.
- An outline institutional framework for irrigation development including support measures to ensure viability sustainability of investments.
- A portfolio of viable irrigation development projects as well as non structural support initiatives.

1.4 Review Team

The Irrigation Sector review formed a contribution to the Mekong Basin Development Plan under the direction of BDP team at the MRC Secretariat:

Ms Pham Thanh Hang - BDP Programme Coordinator
Mr Ton Lennaerts - BDP Chief Advisor
Mr Thanapon Piman - BDP Supervisor
Mr Sengkham Inthiratvongsy GIS

The review was implemented by the following consultant team:

International Irrigation Consultant: Mr Adrian Young

National Consultant: Cambodia: Mr Sok Saing Im (BDP/FMMP-consultant), Mr Sok Heng Phai (consultant), Mr Virak Sou (consultant),Mr Dy Phana (consultant).

National Consultant Lao PDR: Mr. Somnuk Chanthaseth, Director of Planning Division, DOI;Mr. Phouthone Siriphanthong, Deputy Director of Operation and Maintenance Division, DOI

National Consultants Vietnam: Mr Luong Quang Xo(South Institute of Water Resources Planning), Ms Co Thi Be Nam (Integrated Resources Mapping Centre-Sub National Institute of Agricultural Planning and Projection.

National Consultants Thailand: Mr.Sawate Klainatorn Irrigation Planning Expert attached to National BDP Unit, Mr.Uten Ketkaew GIS Expert attached to National BDP Unit

National Database Consultant(MRC): Ms Penroong Bamrungrach

1.5 Approach Used for the Irrigation Review

The irrigation review has been developed based on extensive support from the line agencies and their consultants in each of the riparian countries. The irrigation line agencies with their consultants have prepared an extensive data base of the existing, planned and potential irrigation projects; the database is described in detail in Appendix A. The riparian experts have also prepared country irrigation sector review reports; both of these inputs have been used extensively in the preparation of this review and assessment.

Extensive reference has been made to a number of MRC reports and other assessments by the FAO and other agencies and consultants report.

The irrigation sector review sets out to assess the present and future trends of irrigation. A number of previous studies have made estimates and extensive reference has been made to these, including a recent study 'Future Trends in Agricultural Production'[1] . Irrigation assessments have previously based been based on trends and indicative growths that might be achieved. This review the approach has been somewhat different and has as far as possible examined existing and proposed irrigation projects and the key issues and opportunities of the different types of projects to help support the assessment of future development scenarios.

2. Irrigation Data Base

2.1 Introduction

The irrigation sector is complex and poorly understood. Irrigation development is largely ad hoc, uncoordinated; there is very limited information on the details of the existing irrigation schemes. Information on irrigation planning is not easily accessed with data dispersed without any coordinated information system or programming of investments. Significant investments have made to support irrigation with only very scant recording of the location and details of the investment and any type of assessment of the performance of the investments.

[1] MRC Technical Paper No12 February 2005 Future Trends in Agricultural Production

To address this situation, the BDP is addressing irrigation sector planning through the development of spatial databases. The databases will compile and store key information on existing irrigation investments as well as information on planned and potential irrigation projects.

The large number of irrigation projects in the region requires the use of databases to effectively document and present the quite complex information on existing, planned and potential irrigation projects. Databases if regularly maintained can provide a format for a continuous monitoring and evaluation of existing, planned and potential irrigation projects. The use of the irrigation database allows irrigation assessments to be based on individual projects with information from the riparian countries. The database includes key information on each irrigation project including the size, rice cropping, costs as well as information on future expansion planned and potential. The database manual includes the background and the details of the databases are described in detail in Appendix A. A summary of the irrigation database is shown in Table 1 below.

Table 1 Summary of the Irrigation Database

	Aspect	Description	Fields
1	Scheme names and references	Unique names and referencing for linkages etc	Ref MRC ID Country Code Project Name Project ID Scheme ID
2	Spatial information	To provide linkages to the GIS	Latitude Longitude
3	Main Descriptive Information	Description of the Irrigation Project	Construction Year Implementing Agency Headwork Type Irrigation Type Irrigation Status Non rice crop information
5	Existing Irrigation Area Data	Actual Irrigable Areas	Actual irrigable area Area of wet season rice Area of dry season rice Area of 3rd Season rice
6	Planned Irrigation Area Data	Planned Irrigable Areas (incremental area from existing area)	Planned irrigable area Planned Area of wet season rice Planned Area of dry season rice Planned Area of 3rd Season rice
7	Potential Irrigation Area Data	Potential Irrigable Areas (incremental from existing plus planned area)	Potential irrigable area Potential Area of wet season rice Potential Area of dry season rice Potential Area of 3rd Season rice
8	Cropping Patterns	Assessment of cropping patterns-links cropping patterns to irrigation projects	Existing, Planned and Potential Cropping Patterns

9	Supporting Information	Supporting Information on the Projects	Water source type Project Function Planning Status Funding Status
10	Proposed works	Information on the proposed works	Work proposed for headworks Work proposed for Irrigation Canal system
11	Assessment/ verifications	Criteria to support the assessment or verification of the proposed work	Verification of hydrology Verification of the soils Verification of the Land Availability Verification of the requirements for Land Development Verification of the Requirements for Resettlement Information on Project Costs Information on the operation costs(pumping requirements) Information on the Social Priority Information on the Likely Environmental Impacts Information on level of national priority

The database includes around 10,800 inventoried existing projects, around 4,000 new projects. To meaningfully examine such a wide number and type range of irrigation projects requires a logical framework of assessment and categorisation based on simple ranking criteria and development indicators.

2.2 Grouping of Irrigation Projects

The irrigation database has been derived from an extensive inventory of large, medium and small irrigation projects. This data is too detailed for national or regional planning; disaggregated data is however important for district or provincial level planning. To address these two requirements the database has been designed to incorporate:

- Data in the database will be maintained on a project by project basis. Data tables would held disaggregated by individual projects to enable detailed information to be presented by individual project as required.
- Projects have been grouped for national or regional planning. Grouping of projects has been based on development strategies, geographic area, size and type of projects.

Project grouping is done in the GIS by entering the 'Group ID Code' for each individual project.

The irrigation database consists of mainly numeric or short key information. To fully understand the project proposals a parallel descriptive data base has been developed. The descriptive data base includes summary information on the grouped project objectives, description, benefits, relation to national strategy, assessment and risks, duration etc. The 15,000 individual projects have been grouped into 10 major groups and 40 sub-grouped projects.

2.3 Assessment

The data base has been developed with provision for 14 assessment criteria[2]. These assessment criteria are described in detail in the database manual. The assessment criteria provide some useful supporting information for each of the projects that can be used support the project planning. The quantity and quality of the information provided from the riparian countries is quite varied and is insufficient to provide an absolute ranking of projects on a basin wide level.

To bridge the gaps in the assessment criteria, an approach using *assessment indicators* has been used. Economically viable and sustainable irrigation depend on a mix of parameters including water soils, whether gravity or pumped, if pumped pumping heads, farmer capacities and resources. If these parameters are all positive then the indication is that the development is sound and reasonably fast development is viable and might be expected. Most irrigation projects however suffer to some degree from constraints or issues; the *assessment indicators* have been used to highlight these issues and constraints and assess how these might affect future development; as well as identifying the likely support initiatives required to overcome the scheme shortcomings.

For each of the grouped projects an assessment has been made on the likely opportunities, constraints and issues using the *assessment indicators*.

2.4 Sub Basin Water Assessments

Irrigation projects in the database will include information on the existing, planned and potential rice areas as well as rice cropping schedules. Assessments of the irrigation water demand for the different development scenarios will be made by inputting the rice crop area and cropping schedules into the MRC's DSF IQQM software.[3] Sub Catchment water assessments will be used to assess the overall impacts on the basin water use as well as identification of water short sub basins. Where sub basin shortages appear likely then some review of the development planning will be required.

2.5 Project Identification Note (PIN)

Project Identification Notes (PIN) are a key part of the BDP programme. Under BDP1 initial PIN were developed and standard for all sectors and much of the information was fairly general. For the irrigation sector an irrigation specific PIN has been developed. The irrigation information would include key data to describe and support the proposed projects. The quantity and quality of the supporting information in the database is variable and the scope and level of the information in the PIN has been reduced accordingly. The PIN has been prepared in 'Microsoft Access' and would directly combine information from the irrigation data base and the supporting information. The PIN has been designed as a one page description for each grouped project. A summary PIN has been developed that is 4 lines per grouped project.

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[2] The criteria are data availability, planning status, funding status, hydrology, soils, land availability, land development requirements, resettlement requirements, project costs, operation costs(pumping requirements), national and social priority, supporting information..

[3] The IQQM programme is an irrigation water assessment model used in the Murray Darling Basin; the model has been adapted to meet some of the requirements of the LMB including multiple cropping.

2.6 Summary of the Status of the Database (March 2009)

A summary of the status of the irrigation database is given in Table 2

Table 2 Status of the Irrigation Databases

	Cambodia	**Lao PDR**	**Thailand**	**Vietnam**
Present projects	Assessment based on compilation of various project data bases together with the MRC(2004) data bases. Duplicate projects and errors have been removed as far as possible.	Extensive consultations with province and district officials to update the 2004 information on the existing schemes. Data considered realistic-dry season rice areas seem somewhat high.	Reference has been made to the 2003 master plan for irrigation development for the whole country. The plan gives information on existing and proposed projects. Data on the command areas but with limited information on actual achieved cropped areas.	Updated inventory for Delta and Highlands. Information on highland schemes is limited, dry season rice areas presented too high have been adjusted down to better reflect the likely situation.
Planned projects	Only a limited number of projects at planning stage. At present there are 21 projects in progress of preparation to feasibility level under the NWISP-however it is likely that only a small number of these will likely be taken up for development.	50,000ha of planned expansion of existing schemes. 280,000ha of new planned projects.	Level of planning appears to be mainly less than feasibility study-so only limited number of planned projects.	Present irrigation plan for the delta is for the period 2000-2010. It was updated by Sub Niap in 2003. Changes in the socio-economic conditions have resulted in quite significant deviations from the plan. The new production plan 2011 to 2020 will be prepared by the Sub Niap in 2009. No development plan presently exists. Information for the highland has been presented but requires some verification.

	Cambodia	Lao PDR	Thailand	Vietnam
Potential Projects	Major development of flood control and irrigated agriculture in the flood plains has been proposed as a potential irrigation development projects. These include 2 integrated flood control and irrigation schemes(FCDI) schemes based on desk studies by the FMMP programme.[4] In addition six projects have been identified with only concept level planning. 315 Irrigation schemes identified for development by the JICA master plan The Eastern Irrigation Development Project in the eastern part of the country. Schemes have been identified but with only very limited supporting information. Data includes information on existing, planned and potential projects. An indicative area of 30,000ha of potential irrigation from the proposed Prek Smao Tanou border canal has been identified. Potential	1.4million ha has been presented as the potential irrigation area. This is more than twice the total area of rainfed rice. The assessment is based on information from DoI and JICA desk studies.	Proposals in the national master plan –mainly small scale schemes but also some large medium schemes. Based on the master plan a prefeasibility study has been completed the Loei- Khong -Chi-Minh project. This is a very large project diverting water from the River Mekong at the mouth of the Loei river.	There is no existing information source for the potential development for the Mekong Delta. Potential for intensification remains. The potential cropping has been assessed based two scenarios a) development of increased flood control in the plain or reeds and Long Xuyen quadrangle and b) possible increases to dry season rice and shrimp crops if additional dry season water were to be made available . There appears to be limited scope for potential irrigation from the Prek Smao border canal on Vietnam the Vietnam side. Most areas adjoining this canal already have high levels of dry season rice.

[4] FCDI-multifunction flood control drainage and irrigation schemes

	Cambodia	Lao PDR	Thailand	Vietnam
	irrigation in the flood zone already considered under the FCDI schemes.			

3. Basin Overview

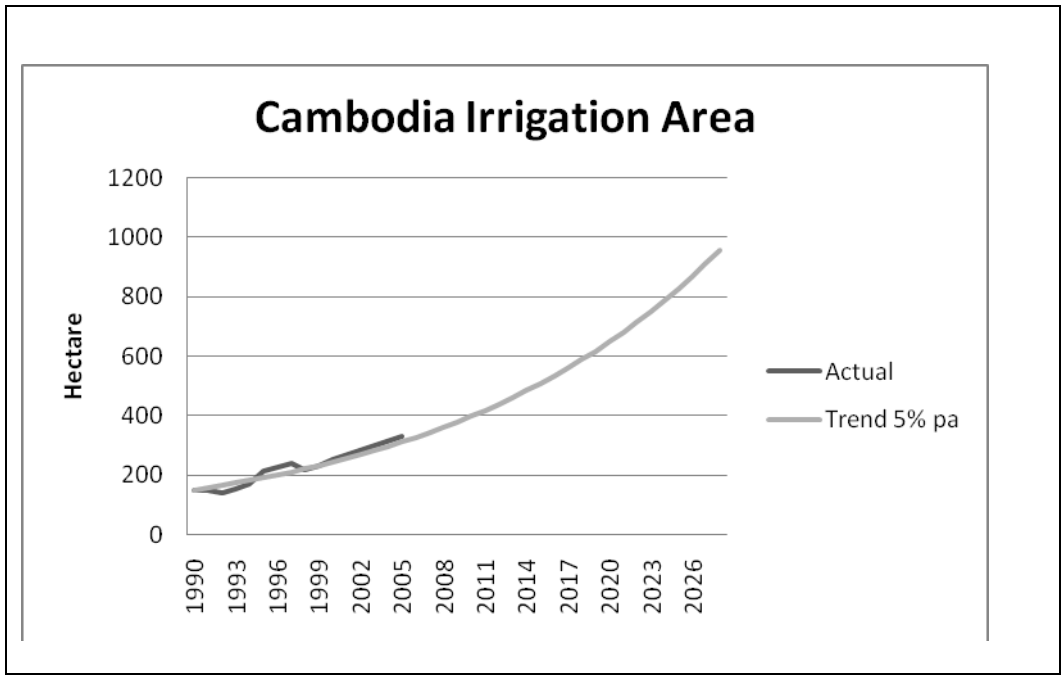
3.1 General

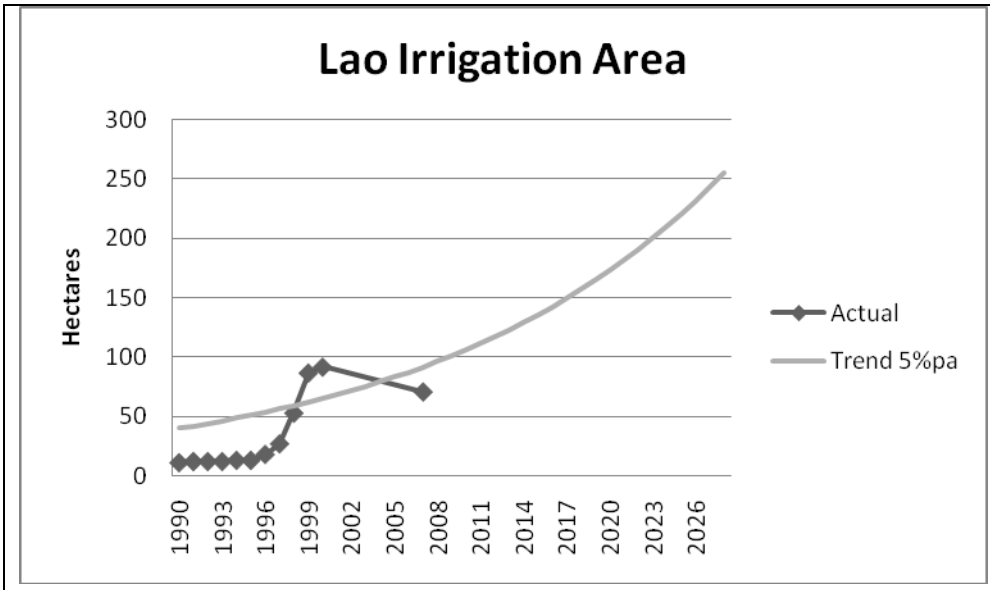
This section presents an overview of the status of irrigation sector in the basin including trends, opportunities, constraints, water demands, comparison of countries, previous studies.

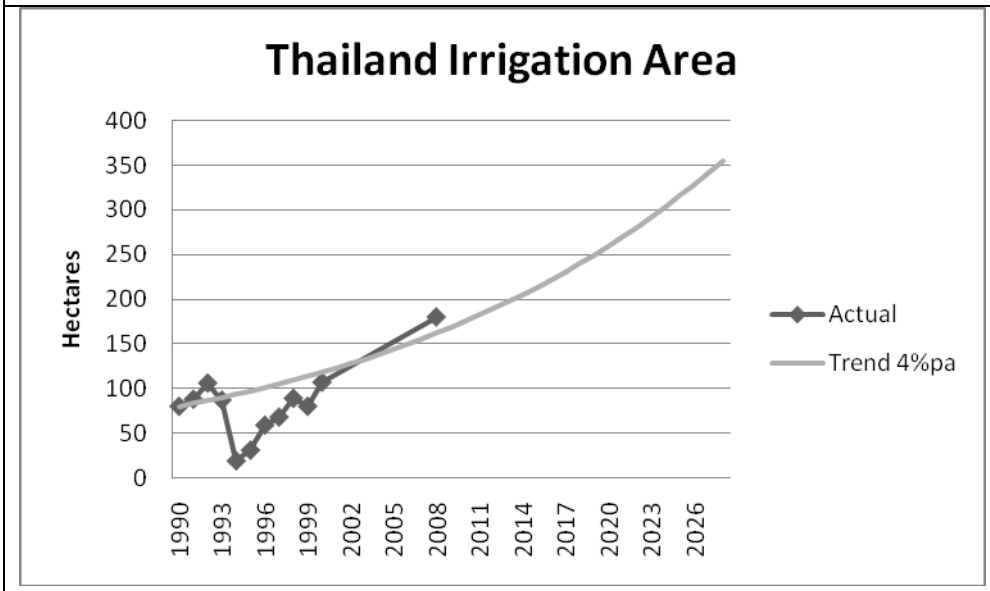
3.2 Irrigation Area Historical Development

Since 1990 the irrigation area has gradually expanded in the four riparian countries. Graphs of actual expansion and the indicative trends are shown in the Figure 1 below. There are some differences in some of the data sources but the indication is that the irrigation area has expanded by about 4-5% per annum in Cambodia, Lao and Thailand. The Vietnam Delta expansion of appears to be around 1%; increases of crop production have been significantly higher. It is estimated that expansion of the irrigation will slow over the next period as many of the best sites have already been taken up for development. There is also a high need to consolidate the existing irrigation to increase efficiencies and productivity.

Figure 1 Historic Trends in Irrigation Areas




Lao Irrigation Area
Hectares
300
250
200
150
100
50
0
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
2023
2026
Actual
Trend 5%pa


Thailand Irrigation Area
Hectares
400
350
300
250
200
150
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1990
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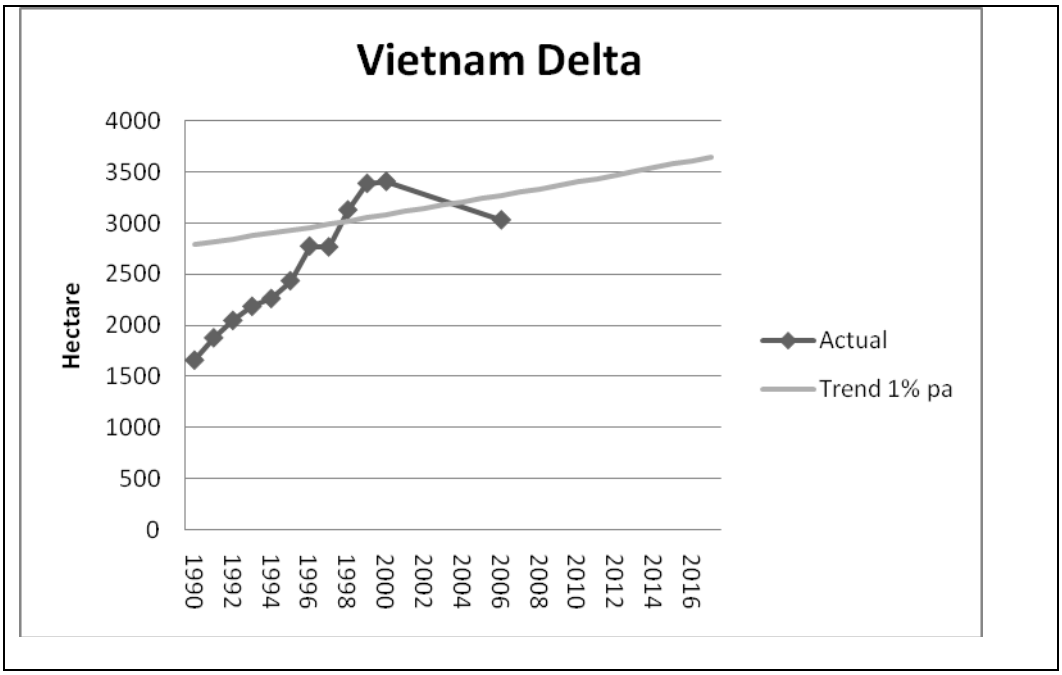
Trend 4%pa



3.3 Irrigation Classes of Irrigation

Irrigation can be defined as the artificial application of water to the soil for assisting in growing crops. Irrigation is mainly used in dry periods as well as periods of rainfall shortfalls . In the context of the Mekong basin it is not so easy to classify crops as irrigated or non irrigated, and irrigation is more a series regimes, moving from a 100% rainfed situation to full irrigation where the full water deficits in the wet and dry seasons is met by irrigation. Six water use regimes have been identified as shown in Table 3. It is estimated that the irrigation database primarily includes coverage of the irrigation in regime categories 4-6. Some schemes due to physical and water constraints however fall into categories 3 and 2. As can be seen from the figure there is a grey area of overlap between irrigated and rainfed.

The irrigation database includes key information on all the inventoried irrigation projects in each of the riparian countries. It is recognised that there are also a wide number of small informal irrigation schemes where no information exists., Most informal irrigation is restricted to the wet season and consumptive use is quite low (mainly in category 2 type schemes). It is estimated that the lack of these schemes in the database would not have major impacts on the basin wide estimates of consumptive use, or the overall development strategy.

Areas of rainfed rice, where potential to develop irrigation has been identified have been incorporated into the database and classed as planned or potential irrigation areas. Areas of rainfed rice with no potential for irrigation are not included in the database.

Table 3 Irrigation Classes

Water Use Regime	Class	Description	Examples	% of water deficit provided by irrigation	Rainfed Rice-not in data base	Irrigated Rice –in data base
1	Pure Rainfed	Shallow brief irregular ponding based on rainfall	Not included in data base	0%		
2	Rainfed + informal irrigation	Rainfall and higher water tables/ lower infiltration soils Plus occasional irrigation from 'informal irrigation' primarily during the wet season. Includes recession supported crops and small schemes from small streams, ponds	Many very small informal schemes supplied by small streams, ponds etc. Some schemes in the database in this category due to lack of water, poor physical condition etc.	10-20%		
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	60%		
4	Irrigation with some use of flood 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 or rivers	Schemes in Cambodia flood zone	60%		
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 gravity schemes with limited water management.	Pumped irrigation schemes. Gravity schemes with dry season yields of less than 3tons/ha.	80%		
6	Irrigated	Irrigation is regular and effective throughout the growing seasons.	Gravity irrigation schemes, schemes with yields greater than 3 tons/ha.	80-100%		

3.4 Present Area of Irrigation

The estimated present area of irrigation is summarised in Table 4 below.

Table 4 Present Rice Irrigation Area

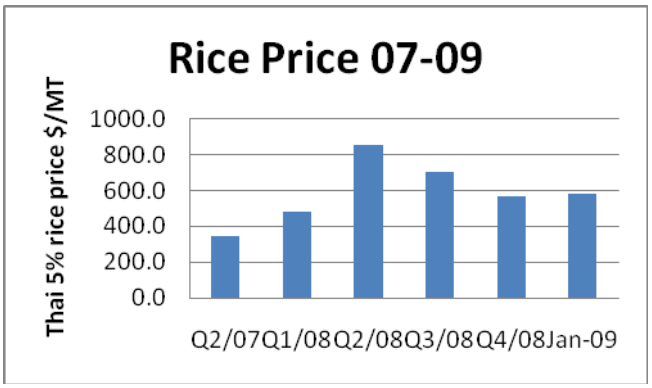
	Nr schemes	Irrigated Rice Area (ha)			
		Irrigation area	Wet (1)	Dry (2)	Third(3)
Cambodia	2,099	504,675	273,767	260,815	16,713
Laos	2,387	172,151	172,161	99,319	0
Thailand	5,710	1,425,015	1,372,631	171,768	0
Vietnam Delta	120	1,727,838	1,528,225	663,410	1,478,740
Vietnam Highlands	492	193,435	142,984	76,894	0
Total	**10,808**	**4,023,114**	**3,489,768**	**1,272,206**	**1,495,453**

3.5 Basin Wide Overview

Irrigation is presently at a cross roads, a number of very fast and changes are occurring that are and will continue to influence the development of irrigation. Key indicators relating to the irrigation sector are described in Table 5 below.

Table 5 Overview of Irrigation in the Basin

Markets After many years of static prices rice and other food prices soared in third quarter of 2008 as shown in the figure below. Prices in January dropped but remain 70% higher than prices in 2007.



It is estimated by the World Bank[5] that overall demand for food would slow over the next few decades, despite income gains. The Food and Agriculture Organization (FAO) estimates global food demand will increase by about 1.5 percent a year between now and 2030, with cereals, edible oils, and meats growing at 1.2, 2.3, and 1.7 percent, respectively—somewhat slower than they did between 1990 and 2006.

Response to market opportunities Low marker prices and costs of inputs have generally slowed the uptake of rice production especially in the dry season. The exception to this is the Vietnam delta where farmers have taken the opportunities to maximise the production wherever conditions permit; production is supported by good soils and easy access to water. In Lao a very intensive programme to develop pumped irrigation and subsidised power led to significant increases until 2000; since then the reduction in subsidies has resulted in a drop in dry season irrigation. The marked increase in food prices during 2008 provided a major shift of interest towards achieving food security and stability. Food security remains an issue and governments and donors are taking renewed interest in irrigated agriculture to support production.. The uptake by farmers to the higher prices has been quite muted, however there are some definite indicators of increased production in 2008.

Rice: Continues to be the main crop, all four of the riparian countries are net exporters. Low prices and high costs of inputs and increasing shortages of labour are suppressing the opportunities for intensification of rice production.

Crop Diversification: High production costs and low markets prices for rice promoted significant interest to grow other irrigated crops. Despite potentially higher net returns and the significantly lower water requirements the take up of non rice crops remains relatively low. Research in dry season non rice crops has been underway for many years but interest and uptake by farmers is limited. Access to markets, poor facilities for dry season irrigation, rapidly changing pricing and adversity to risk have all contributed to a slow development towards crop diversification, outside the Mekong Delta. In the Vietnam delta a policy for crop diversification over the last 10 years has resulted in some shifts away

[5] World Bank Global Perspectives 2009

from rice, however these have been less than targeted.

Aquaculture is diverse and includes the production and sale of fry and fingerlings and raising wild or artificially produced fingerlings in enclosed or semi enclosed ponds, rice fields and cages. Total production in the basin is estimated to be of the order of 260,000 tonnes per year with a farm gate value of about US$ 270,000M[6]. The development of aquaculture to date has been a narrow sectoral approach. Aquaculture like rice is rainfed (typically small household ponds) or an integral part of the irrigated areas; culture of rice and fish is gradually developing but from a small base. Brackishwater shrimp ponds have a very high economic value and ideally source sea and fresh water.

Irrigation Development: The best irrigation sites in the main have been largely developed, new sites tend to be more marginal with less attractive. Extensive developments of estate cash crops including oil palm and rubber have reduced the land available for new irrigation schemes; economic returns are comparable or maybe higher than irrigation. The irrigation investments have moved towards small scale irrigation development with more involvement of water user groups.

Participative Irrigation Management: Farmer involvement and the of water user groups has remained a key area of support over the last decade. Although a lot of progress has been made, the level of real participation and empowerment has not always been achieved. Farmers have taken on increased roles in the management of schemes; there however remains a significant capacity gap and continued lack of maintenance results in a rapid deterioration of schemes.

Government Support: Irrigation has been and remains a key area for Governments support. Irrigation is perceived a key requirement for poverty alleviation and food security. Significant support has been given to schemes that are not viable or marginally viable with very little resultant benefit.

Donor Support: Poor economic returns from irrigation and the complicated and long processes for development have affected the take up rate of donor support irrigation. For new schemes, less feasible sites, environmental issues and difficulties of achieving adequate return have reduced the expansion of new schemes. Donor support has largely been towards small scale schemes where quicker returns and improved sustainability are perceived to be achievable. The significant increase in food prices has recently increased the interest of donor support for irrigated agriculture.

Private sector The private sector is now gradually becoming involves in agriculture. Most private sector initiatives involve cash crops mainly rainfed. The role of the private sector in irrigation is quite new and not well developed. There appears to be interest fromprivate sector investors and also a potential role for the private sector.

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4. Develpment Objectives, Opportunities and Constraints

4.1 Objective

[6] **Water Management in the Mekong Delta: Changes, Conflicts and Opportunities Ian White** Centre for Resource and Environmental Studies, National Institute for the Environment, Institute of Advance Studies, The Australian National University Unesco 2002

A review has been made of the proposed, planned and potential project. For these projects an assessment of the objectives, opportunities and constraints has been made which have been applied to make a valued assessment of the likely future development of irrigation.

4.2 Technical Issues and Opportunities

Changes in the Wet and Dry Season Flow Regimes offer significant opportunities for irrigation. Definite and programmed include the the hydropower cascade presently being developed on the Lancang in the Upper Mekong Basin, including the large storage projects Xiaowan and the Nuozhadu, with 9,800 and 12,400 million m3 of active storage, respectively. These works are likely to cause the most significant seasonal redistribution of flow of any of the foreseeable water resources developments in the basin.

In addition the significant water resources developments on the LMB tributaries that have been constructed since 2000 or are being constructed (such as Nam Theun 2, Nam Ngum 2 hydropower projects) will have fixed and well defined impacts on the river flow regimes over the coming years will also have impacts on the wet and dry season flows.

These developments will offer a reduction in the peaks of flood flow, resulting in reduced risk to plant in parts of the flood zone. Dry season water availability in the main stream and selected tributaries will increase opening the potential to expand the area of dry season irrigation. Increased dry season water levels will reduce to an extent the dry season pumping lifts.

Risks from Artificial Controlled Flows Hydro electric dams are worldwide operated entirely to maximise the returns from generation as well as some requirements to maintain releases for environmental considerations. Operation procedures are based on normal situations and unforeseen rainfalls floods or droughts may result in changes to the operation regimes. During extreme flood events hydro dams will frequently allow emergency releases of water (if gates are fitted), similarly during extreme drought the dam operators may restrict releases. Both of these conditions could seriously change the downstream flow regimes during abnormal rainfall conditions. Impacts on crops could be significant; the old flood plains would gradually become cropped and would be very exposed to emergency releases, unplanned retentions in the dams during the dry season would affect dry season irrigation supplies.

Integrated Hydro and Irrigation Dams Development of multipurpose dams for irrigation and hydroelectricity offer many advantages; combined benefits can be applied to improve the benefits of investment and potentially open opportunities where a standalone irrigation dam would never be financially viable. Irrigation abstractions from above the dam are effectively a loss of power and some compromise must be made. Hydro dams are frequently sited in the higher parts of the catchments and irrigation may require long high cost canals. The alternative is to use the power generated to supply electric pumps-the costs and losses from high tension electricity line being significantly lower than canals.

Integrated Flood Control and Irrigation can open opportunities for development, irrigation in flood risk zones is rarely cost effective. The loss of benefit from wet season crop and the uncertainties of planning of crops in most cases results in low and unsustainable benefits. The significantly higher investment costs of combined flood control and irrigation can only be justified if the irrigation moves into a mode of semi intensive level of modern agriculture with crop intensities of 2 or more crops per year.

Expansion of Dry Season Irrigation Expansion of dry season irrigation is restricted by low flows in the tributary rivers and a general reluctance to use pumps in the dry season. Opportunities to expand dry season irrigation is primarily through abstractions of the main stream flows of the Mekong and Bassac rivers. With the exception of the Vietnam delta (with very low heads) this can only be achieved by pumping with medium heads of around 4 -12metres.

Pumping As a generality pumped irrigation tends not to be very successful and in from experience is frequently not sustainable. Pumped irrigation for dry season rice is especially difficult unless the heads are very low. Centralised pumping to medium or large schemes is especially problematic due to the high water losses and the high requirements for water management. Pumped irrigation can work if the if the heads are very low, soil conditions are good and individual farmers can use their own individual portable pumps.

Offsetting the costs of pumping can be achieved by improved water management, reduction in water losses (including piped distribution) diversification away from rice to lower demand higher value cash crops. Access to power to allow the use of electric pumps improves the opportunities and reduces the maintenance management requirements. Experience has shown that traditional farmers and subsistence farming methods rarely provide adequate returns to support the costs of pumping. Farmers are reluctant to plant in the dry season due to the high risks of crop losses due to pump breakdowns or non operation.

Irrigation Efficiencies Irrigation technologies and efficiencies have been very slow to develop. The significant growths in rice production have been largely been through expansion of non irrigated agriculture, introduction of high yielding crops. Irrigation has made contributions to production primarily in the wet season where schemes have easy access to high volumes of water(normally gravity) and the resilience of rice during the wet season to inefficiencies of water management.

Dry season irrigation is very limited; risks in the dry season are higher and with the low level of margin the farmers prefer to leave the land fallow. Farmers and the water user committees have inadequate access to resources to improve the effectiveness and financial returns of dry season irrigation.

Soils in the basin are mixed with many areas of poor soils. Many soils with low nutrient status, and extensive areas are saline or acidic when not water logged. These soils impose limits to crop cultivation and suitability. There is a very poor level of consideration of soil conditions during the irrigation planning processes, as a result the potential of many irrigation schemes is severely constrained..

Government Policies National Governments have placed a high priority on the development of irrigation and very significant funding has been directed to development. Irrigation is in line with national objectives including food security, poverty, economic development. Irrigation involves a high level of capital expenditure and significant levels of bilateral and multilateral financial support has been provided. Irrigation is seen as key and fundamental component of agricultural development.

Institutions and Governance Irrigation is led through the Water Resource Agencies in the different countries. Most of the irrigation agencies are very compartmentalised and there is very limited integration of the objectives of the sectors. In Cambodia and Thailand irrigation agencies are separate from the Agriculture Agencies. The focus of the irrigation line agencies is very much directed at the development of infrastructure with a low priority being given to agriculture outputs. Resources and capacities in irrigation management are now being developed, and gradually farmer institutions are improving and gradually capacity is being established to take on more management responsibilities.

Development Gap Irrigation development to date has largely been led by water and land. In the wet season land is the main constraint, in the dry season water. Most of the best irrigation sites have already taken up for development and irrigation is now moving towards the less attractive sites involving, less suitable soils, pumping and pumping. The key requirement for the future is to develop satisfactory production models that will enable a good uptake of cropping in the wet and dry seasons to justify the investments and to support the higher operational costs.

Private Sector Food security interests are driving alternative “private sector” investment in contract farming and both corporate and foreign direct investment into agriculture development, with strong interest in both Lao PDR and Cambodia. Private sector is in different forms ranging from small investor farmers leasing land in the south of Cambodia, to medium sized foreign investors. Whilst not offering a

solution to all the problems of irrigation the need for external support is very high. Most of the irrigation presently being considered for development in the basin involves medium to high investments and a high reliance on pumped irrigation. Typically the farmer uses the irrigation for wet season rice to meet his subsistence needs and some small surplus for sale. Development of modern irrigated agriculture requires access to finance, labour, marketing and mechanisation. The small scale of the traditional farm is appropriate for wet season rice, but less appropriate for cost effective dry season irrigation of mixed crops. Labour is increasingly an issue and economies of scale open opportunities for allow more economic use of agricultural inputs including mechanisation, as well as marketing of products.

Climate change There is considerable interest in how adaptation in agricultural management as well as the role of irrigation can be applied to reduce impacts of climate change. For example although it is clear that sea level rise in the Mekong delta would significantly impact rice production it is not clear how irrigation could easily address any resulting short fall in rice production.

In the other riparian countries the irrigated agriculture is presently only a small part of the total production from agriculture and as such has relatively limited scope to provide any significant buffer against climate changes. Adaptation in rainfed agriculture would likely offer more impacts on reduction of risk. There are however some possibilities to evolving a balance between rainfed and irrigated agricultural development if and only if the prime issues of sustainable irrigation can be addressed.

5. Irrigation Development Assessments

5.1 Introduction

Irrigation development assessments have been made using a critical analysis of the technical aspects of the projects together with assessment of the key constraints and opportunities and identification of support requirements The rate of uptake of the irrigation will depend on the physical characteristics of the projects (that can largely be derived from the database) as well the less clearly defined areas of markets, socio economics as well as the logistical and management resources available to build up and develop irrigated agriculture.

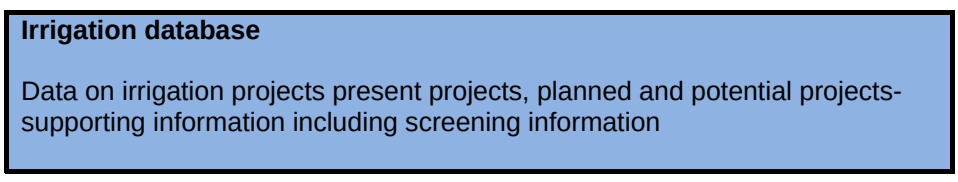
5.2 Assessment based on Irrigation Projects

The Irrigation development assessments have been based on actual irrigation projects in the database. The irrigation projects are a complex mix of agriculture, soils, farmers, hydrology, infrastructure, government and community institutions. The success or lack of success of irrigation and the likely rate of development is related to mix of the various parameters. This review aimed at consideration of the various parameters and making a value judgement of the likely development scenario.

5.3 Assessment Steps

The database provides the basic information on the existing, proposed and potential projects. To build this information into a development scenario requires a process of screening and assessment to identify the likely development scenarios. This concept is shown in Figure 2 below.

Figure 2 Assessment Steps



Grouping of Projects

Grouping based on development objectives, geographic locations, project similarities; including physical characteristics, objective issues, opportunities and support requirements

Assessment Indicators

National, regional assessments, technical, social, economic issues, constraints and opportunities

Identification of essential Support Requirements-physical requirements as well as non physical requirements

Development Scenarios

Assessment on the likely development of the grouped projects including expansion, new projects, intensification.

Assessments based on provision of the identified support requirements and the implications on the rate of irrigation development

5.4 Irrigation Development Scenarios

Three Irrigation development scenarios have been considered. Each scenarios describes to estimated development of irrigation including the expansion of schemes, development of new schemes and also intensification of cropping. The development scenarios cover.

1. The Definite Future Situation-this has been taken as the existing irrigation area
2. Likely development over the next 20 years
3. Long term feasible development
4. A long term high development scenario.

6. Cambodia Assessment

6.1 Present Irrigation

Irrigation in Cambodia stretches back many centuries, with a gradual development of small scale recession type irrigation with additional larger scale developments during the colonial, early independence, and under the Pol Pot regime. Many planned schemes were never built or built but never functioned , or were built and have subsequently fell into disrepair.

Since 1999 the Government with grant and loan support have invested heavily in irrigation. Since the 1990's the emphasis has shifted from large to small scale investments with considerable emphasis on

decentralisation, higher levels of local participation in the planning and management of the water resource projects and efforts to move towards an integrated Water Resource Management Approach (IWRM).

In 1995, Cambodia produced a surplus of rice and continued to remain in surplus from 1995 though to 2000; the country is estimated to have potential to produce a 150,000-200,000 ton surplus of milled rice in a good year using current farming practices. At the current rate of population growth, Cambodia will need to increase paddy rice production by 1.57 million tons if it is to feed its population in 2020.

In Cambodia, irrigation is mainly used for dry season rice farming. Wet season farming, which produces approximately 80 percent of the total crop, relies on rainwater. According to the Ministry of Agriculture, Forestry and Fisheries (MAFF), in 2006 total rice yield was estimated at 6.3 million tonnes, an increase of five percent from the previous year. The reason for this increase, according to MAFF was partly the expansion of irrigation, Despite its potentially important role, however, irrigation still receives relatively little investment from either the state or the private sector. The World Bank's 2006 *Cambodia Poverty Assessment* emphasises the need for improved irrigation infrastructure in increasing paddy yield and argues that more public investment is needed to strengthen irrigation management.

Irrigation development in Cambodia technically faces many challenges; flooding is a key issue and wet season production in many parts is seriously constrained by flooding. Dry season irrigation is very constrained by the very limited water availability in the tributary rivers. Efforts to address these frequently involve the construction of small flood protection works and shallow storage reservoirs which significantly affect the investment and O&M costs. Rapid deterioration of schemes results in low productivity and frequent rehabilitation of schemes is a heavy burden on the Government. Dry season water levels in the main rivers and immediate tributaries drops to about 3-8m below the adjoining land levels which can be accessed only by pumping.

Many irrigation schemes have been unable to meet their full potential because reservoirs have been deteriorated and leaking, limiting water for farming. Irrigation issues often go beyond limited water to water governance and conflicts. Thun and Chem (2007) argue that answers to the existing problems generally depend on a package of governance, technical design and popular participation.

Institutional Framework Irrigation is managed through the Ministry of Water Resources and Meteorology (MOWRAM), a new ministry established in 1999. The ministry has received a very high level of funding through loans and grants. MOWRAM is seriously overloaded both at the central as well as the provincial levels. Despite training and capacity building for the staff the operational capacity remains a serious constraint; Government salaries remain very low. MOWRAM remains very focused on construction of schemes with limited capacities to address scheme management and sustainability.

Over recent years the government with external assistance has focused on the development of the irrigation water user groups and the handover of small schemes to farmer and water user group management. This is giving farmers significantly more responsibility in the planning and management. The newly formed farmer water user committees (FWUC) and capacities for irrigation scheme management capacity is still new and weak. To help develop the gap in irrigation management of schemes a programme of Participatory Irrigation Management (PIMD) is being supported, designed to support the creation and empowerment of the FWUC. Participation is a loose term and studies indicate that participation is a new concept for Cambodians and there is a reluctance to become involved in development planning[7]; Cambodians often interpret participation as 'to be there and listen'

[7] Rusten et al (2004) The Challenges of Decentralisation Design for Cambodia

and are more used to be led than participate; contact with state representatives is often perceived as threatening[8].

Extending commercial agriculture is a key recommendation of the technical group on Agriculture and Water[9]. Commercialised agriculture provides the means for rural households and communities to generate cash income, as well as providing a basis for agri-businesses. The irrigated areas urgently require commercial agriculture to build up production to levels that can provide sustainable returns to support the costs of management of the scheme; including pumping and maintenance.

6.2 Irrigation Database

The irrigation database for Cambodia is summarised in Table 6 below.

Table 6 Irrigation Database Cambodia

Existing Irrigation	The 2004 MRC-MOWRAM database has been checked and updated. Many projects have been identified under other programmes and to avoid duplication these have been removed. The database is quite old but has reasonably valid information on the existing schemes. The data on potential areas is considered unreliable and has been removed. There are no planned projects identified in the database.
Planned Irrigation and Potential Irrigation	
North West Irrigation Project	This ADB supported project covers the Mongkol Borey, Dantri, Baribo basins. A total of 47 projects were identified. 21 projects have been selected for feasibility studies and these have been grouped as planned projects. The list of the final projects to be implemented is likely to be significantly less. 26 projects were dropped from the project-some of these are not feasible or environmentally unsuitable and have not been considered. A second group have been identified as possible as rejection by NWISP was based on non technical criteria. These have been classed as potential projects.
Irrigation Sector Project	ADB has supported this project. 27 schemes have been identified though desk studies, with 3 of these schemes assessed to feasibility level. These projects have been presented as planned (3 projects) and the remaining as potential projects.
JICA Master Plan	The JICA master plan study was carried out in 4 catchments- Battembang, Sangker, Dauntri, Pursat, Baribo and part of Theknot. These projects (except for some duplicates with NWISP) have been proposed as potential projects in two classes (<100ha and >100ha)

[8] Hughes C.(2003) the political economy of Cambodia's Transition

[9] MAFF and MOWRAM Cambodia 2007.

Korean Master Plan	The Korean master plan has identified a number of projects; however there is limited information available.
FMMP Flood Studies and subsequent studies by BDP	Two Flood control and irrigation projects have been identified to desk study level by the FMMP project. Based on this model a further six schemes have been identified to concept level. One project is a multipurpose project with the proposed hydropower Sambor dam. To total estimated irrigable area of the 8 FCDI schemes is estimated to be around 1.6million ha
FWUC Studies	An inventory of 292 schemes with formally established farmer water user committees. Good information existing scheme information. Does not include planned schemes.
Eastern Region Irrigation Development Project	A large number of projects in provinces Kampong Cham, Kratie, Ratanak Kiri, Prey Veng, Mondul Kiri, Svay Rieng, Stung Treng. Data has processed into the database as existing as well as potential projects.
Other schemes	A number of other schemes have been identified including Prek Thnot, Steng Slakou,Steng Chinit,30 Septemeber, Mkak and Trapeang Thmor.
Provincial Irrigation Information	Non spatial data from the PDRAM identifies around 2400 irrigation projects, with a reported dry season irrigation area of around 0.4 million hectares. The data is poor without any location information; many of the schemes are recession with limited external water requirement. The irrigation areas are in general considered over estimated and would in many cases duplicate the other project information. Without any source of verification it has been agreed not to include the PDRAM data.

6.3 Development Opportunities and Issues

General Many of the present irrigation schemes are technically and economically marginal; the problems of flood and drought present farmers with quite limited opportunities; heavy maintenance requirements are putting a heavy load on the capacities and finances of the farmers and Government organisations. Continued use of traditional low risk, yielding and long duration rice varieties limits opportunities to make use of the 'narrow windows of opportunity' for planting. The high risk of crop loss results in reluctance to invest in inputs including any significant payments for pumped water. Identification of technically and economically viable schemes is difficult. The logistics to prepare design and implementation of projects is a major difficulty. The ADB supported NWISP initially identified over 50 schemes but the actual number of schemes to be implemented under the six year programme is likely to be about a quarter or less of the original list.

Dry season water availability in the tributary catchments is a major constraint. The smaller catchments require expensive reservoirs; often shallow and subject to siltation. Most catchments under the NWISP are close to full development capacity. A number of small hydro projects are proposed in the catchments of Stung Sen(1 scheme), Battembang(2 schemes) and Pursat (2 schemes); in addition extensive hydropower in the 3S catchments(Sekong, Sesan and Srepok) will provide increased dry season flows.

The main potential to expand dry season irrigation is through direct abstractions from the main Mekong, Bassac or close tributary rivers. Access to the river or tributaries fed by the main rivers[10] pumping heads are key constraints. Water is presently abstracted directly from the river, or by pumping from tributaries or creeks connecting into the main stream-many of these are shallow and dry up during the dry season. Investigations are required to assess the viability of expansion of the network of creeks and rivers to widen the access to pumped irrigation.

Flood Protection Flooding is a serious constraint and many irrigation projects have had to invest in flood protection to secure the wet season crop. Flood protection for individual schemes is expensive and only viable on the fringes of the flood area. Development of large scale or sub regional partial flood protection in the Mekong flood plain is presently being considered as a part of the Flood Management and Mitigation Programme Component 2 (FMMP-C2) .The concept is to open up agriculture opportunities through:

Partial Flood Protection in the Deep Flood Zone

- Provision of early flood protection to allow a short crop to be planted prior to the flood (May to July) and.
- To retain flood water in the protected area to support a post flood recession crop (November to April).

Full Flood Protection in the Shallow flood zone

- In the higher land with shallow flooding of the flood area flood protection and drainage facilities could be provided with full flood protection

Irrigation is a key requirement to maximise the agriculture potential from these investments. Irrigation would provide supplementary irrigation for the early crop and also use stored water for the post flood recession crop.

These integrated schemes combining flood control, drainage and irrigation (FCDI) represent a new direction for Cambodian irrigation. Over recent years the trend has been for the development of small scale irrigation; these have been considered appropriate development models with the focus of community management and requiring minimal requirement for government participation. Flood protection on a larger scale can offer some economies of scale. Although the flood protection is large scale there would appear to scope to maintain the irrigation based on small scale units within the larger flood schemes.

Farming Systems in Cambodia remain very basic and are farmers are not equipped to exploit the potential benefits of irrigation investments. Farming is almost entirely subsistence and major efforts are required to support the development of modern irrigated farming systems. Intensive programmes of Participatory Irrigation Management and Development (PIMD) programmes are a key requirement. Consideration should be given to raise awareness of the possible role of the private sector to provide supplementary support inputs and initiatives. The (PIMD) programme should address continued intensification of existing schemes as well as support for rapid build up of benefits of new schemes. There is limited paid alternative work, however in parts labour maybe an issue and some degree of mechanisation maybe required to reduce costs.

Pumping is a critical factor for Cambodian irrigation. The wide spread use of traditional farming and irrigation methods are difficult to reconcile with the costs and logistics of pumping. Irrigation

[10] In the dry season the tributaries act as creeks and water from the main Bassac or Mekong rivers can be used to abstracted out the tributaries.

development to date has favoured gravity systems, however the lack of appropriate sites and limited water resources often results in high investments and maintenance costs.

The small portable pump is the most appropriate for the Cambodian farmer, this works well with low heads (<3m) and pumps can be portable and stored when not in use. A number of contractors now provide a pump hire service; which illustrates an example of the potential for private sector involvement in irrigation Pumping in many cases is complex with farmers initially accessing water by gravity and later providing supplementary pumping from ponds, creeks and rivers depending on availability, accessibility and the requirement to minimise the pumping heads.

The perennial dry season water in the Mekong, Bassac or immediate tributaries offers opportunities for dry season irrigation-pumping heads are more significant (dry season 4-9m) and a strategy to identify sustainable methods for cost effective pumping and access this water is a necessary requirement. Centralised pumping has some technical advantages but requires a well managed and effective irrigation management and complex charging structure.

Decentralised individual farmer pumping can provide a more farmer friendly approach but would require direct river access or access to deep creeks or connecting canals. Expansion of rural electrification offers opportunities for lower cost and simpler pumping. Smaller more dispersed pumping is more appropriate for farmer management and cuts the costs of distribution. Lower tariffs for pumping may be an appropriate method to support irrigation expansion. Smaller single phase pumps can be supplied by lower cost electricity lines. Private sector presently provides hire of small pumps and allows access to pumped water without requirements of capital, maintenance and transport.

Hydropower expansion is planned for Cambodia and can offer irrigation opportunities though increased dry season flows as well as access to water direct from the hydro dams. There are a number of hydro power dams proposed in Cambodia-some of these may offer opportunities to open up gravity irrigation though transfer canals from the reservoirs. The Sembor dam a main stream dam under consideration potentially with very long transfer canals irrigate by gravity of the order of 1.2 million ha in the lower parts of Cambodia; the capital costs however would be extremely high. An alternative strategy would be to distribute the power to a network of electric pumps; thus avoiding the high costs of canalisation and water losses in the canals.

Support Infrastructure Transport is a key requirement to access markets, upgrading of transport facilities including road and river will be of benefit to irrigation. Scheme planning should assess access as one criteria for selection. Upgrading and expansion of rural electrification has significant potential to support irrigated pumping.

Management Capacities Ongoing programs for capacity building and institutional strengthening of government staff and also the water users is making progress. There remains a very severe skills and management capacity gap which is and will continue to constrain the development of irrigated agriculture. Management constrains are complex and include a lack of knowledge but also financial resources (low paid Government staff, lack of capital of farmers), organisations etc.

Capacities and resources of the Farmer Water User Communities (FWUC) are likely to be inadequate to effectively manage medium to large schemes. Government resources are very limited and the system is inappropriate to meet day to day management requirements Without a change in strategy production of existing medium large schemes will remain static and production may decline.

Pumping offers access to major water sources. Pumping costs except very low lift pumping in general cannot be supported without a change from subsistence agriculture. Any medium or large scale project with pumping requires a major change in the management models including private sector development. Appropriate and sustainable approaches to filling this management gap is probably the key area facing the Cambodian irrigation sector.

Private Sector is increasingly more involved in the irrigated agriculture sector; the role includes supply of inputs, ploughing, pumping and milling of rice. The private sector acts in primarily a support role with the farmer maintaining the lead including financing. There appears to be scope to further develop the role of the privates sector though support mechanisms. PIMD activities could potentially encompass the possible role of the private sector and act as a catalyst for development of farmer-private sector partnerships.

Private sector in a service role can support irrigated agriculture in a wide number of ways; contract farming is beginning to develop and expand, presently this is mainly for estate crops but the similar approaches may be appropriate for the irrigated agriculture. Various rice milling enterprises are being established which can reduce farmers costs; there are examples where rice mills can form a nucleus of support for farmers. Small contractors frequently hire pumps to meet the needs of additional irrigation during water shortage.

Encouraging the private sector to invest in irrigation is more complicated and requires an attractive and low risk investment opportunities.. Access to Government gap funding or incentives to attract investment maybe required. The investment climate in Cambodia is improving, risk however the irrigation sector remains quite high risk including flood, drought pests etc.

Since the mid 1990's a wide number of support programmes have been active including the Government (at Central, Provincial, District and Commune levels) as well as consultants and NGO. Growth in rice production has been maintained however the management and capacity gap remains very high. The private sector is now developing and there appears to be good opportunities for the private sector to further participate in the development of irrigation. The private sector should work in close coordination with the communities and the FWUC, and the role of private sector requires to be supported and guided with active participation of the PIMD programmes.

Models of private sector participation; Three models are considered to be of possible application in Cambodia.

Model A Public Sector (PIMD model modified) Irrigation development remains dominantly public sector planned and implemented with focus on providing the irrigation facilities. Agriculture and irrigation management support would remain under the public sector, with FWUC taking on the role for management of the schemes. FWUC would work with the private sector to access support to improve access to inputs and access to improved markets. This model would remain appropriate for the smaller more remote low intensity irrigation areas using gravity systems and some supplementary pumping.

Model B Improved: Public Sector with Private Sector Support: Irrigation development would still be dominantly public sector planned and implemented. For medium sized schemes it is likely that full management may be beyond the capacities of the FWUC alone. Under this model, some constraints will be difficult to address, namely i) public financing of O&M support, and (iii) resources for effective O&M support. Gaps in the management would be identified and support programmes developed including a medium level of private sector participation; these could be simple service contracts or profit share. Appropriate for the medium sized irrigation schemes with larger structures, canals and pumps.

Model C Advanced: Private Sector Lead This model would be similar to Model B, but, instead of development planning and implementation being public sector dominated, it would be strongly private sector-driven (and lead), through establishment of public-private partnerships or long term concessions. A strong role of the private sector may offer opportunities to help to overcome the constraints that Model B would find difficult to address. For large new schemes it is envisaged under this model the private sector investor could take on a major part of the investment and management of the scheme.. Appropriate for the large schemes including the proposed major FCDI schemes.

Improved Planning Development of irrigation has been hampered by poor planning. Schemes selected for development must focus on development of sustainable economically viable projects. Projects should demonstrate minimum levels of utilisation and production to ensure sustainability and adequate returns to the investments. Experience from NWISP indicate that only 30% of long list projects are viable. Improved capacity for planning and development is a key requirement. Development of Cambodian irrigation is complex and high quality master planning is important to identify best schemes. Planning must integrate requirements for flood protection and possible expansion of hydropower, careful assessment of soil conditions is required. There is potential for planning and design for large schemes to be implemented under the direction of the private sector investors.

6.4 Grouping of Projects

Projects have been grouped based on similarities of hydrological conditions and development opportunities. For Cambodia three major groups have been identified; i) Irrigation from the tributary rivers around the Tonle Sap,ii) Mekong Area Irrigation Projects and iii) Integrated Flood Control, Drainage and Irrigation Schemes. Within the three major groups 16 sub groups have been identified.

6.5 Assessment Indicators

Irrigation in Cambodia has good potential for expansion. The practicalities and logistics to plan, design and implement effective and sustainable irrigation schemes is however a major constraint. Many irrigation schemes have been built or rehabilitated over recent years but the uptake of modern agriculture is slow and the rate of physical deterioration is of serious concern. The key factors and issues affecting irrigation in Cambodia are described in Table 7 below.

Table 7 Cambodia Assessment Indicators

1. Irrigation from Tributary Rivers around Tonle Sap Small and medium schemes, some wet season flooding, and likely water shortages in dry season. Although not large the projects are quite complex involving reservoirs, drainage and some flood protection. Further planning-is required to assess viability to incorporate large scale flood protection in schemes. There maybe possible benefits of hydropower schemes. Experience from the NWISP projects indicate that only about 30% of identified projects are technically and economically viable.		
1.1	NWISP and Sector Projects (ADB supported)	ADB funding likely of selected projects. All the NWISP and sector projects have been screened-100% take up of planned and potential projects over the next 20 years should be possible. Medium sized schemes would benefit from model B management(private sector support)
1.2	JICA master plan projects – small (<100ha)	The level of investigations for these projects is desk study. Significant further planning required and likely that many projects may not be viable. Problems of flooding and water shortage affects the scheme viabilities. Smaller projects would be easier to construct and managed. Model A management(PIMD modified)
1.3	JICA master plan project medium (>100ha)	Planning similar to small JICA schemes. Larger projects will require more planning. Estimated that viability of some schemes will be an issue and viable potential will be less than in the master plan. Model B(private sector support)
1.4	Mowram (MRC inventoried schemes)	These schemes were inventoried in late 1990,s data is limited and very limited planning. Potential areas are not fully supported and many schemes will not be viable. Full master planning to update inventory and planning required. Model A or Model B management depending on size of scheme.

1.5	KOICA Korean Planning	Limited information-level of planning to be reviewed. It has been assumed that the information is similar to the JICA schemes.
2. Mekong Area Irrigation Projects A mixture of small and medium irrigation projects on the West and East Sides of the Mekong. Some of the projects are supplied from the Mekong River direct, others from the tributary rivers. Some these schemes are in the flood plain and would be incorporated into the integrated flood control and irrigation schemes (FCDI schemes).		
2.1	West Mekong MOWRAM-MRC inventoried points	Existing and potential areas-data quite old and not complete. No planning data, the data on potential area is considered indicative. Potential areas likely to be less than indicated in the database. Project area requires integrated master planning to include the scope for integrated flood control and irrigation. Larger schemes would require model B or C management support.
2.2	West Mekong Prek Smao Tanou Border Canal	This canal is being considered for expansion-potentially about 30,000.ha of irrigation could be developed pumping on the Cambodian side Soils conditions are Acrisols and viability has to be assessed. Irrigation could be developed from the existing canal-development would be appropriate for a Model C Private Sector Lead Development; proximity to border opens opportunities for private sector investors.
2.3	East Mekong Schemes	Project inventory and planning under the Eastern Region Irrigation Development Project(ERIDP). Mixture of small and medium projects-some but incomplete information on planned and potential area. A few projects under MRC. Data is very limited. A number of projects maybe developed as a part of the FCDI schemes. Viability of these schemes is uncertain and integrated planning is required.
3. Integrated Flood Control, Drainage and Irrigation Schemes Very large schemes requiring major investments. Long period of planning and development-schemes involve a wide range of social and environmental issues. Planning, development and management requirements are high with significant levels of investment. Adequate financial returns from these investments can only be recovered through modern agriculture of rice and cash crops. Private sector lead partnerships (Model C) would likely be required to achieve the requirements for financing as well as support for the development logistics. The schemes involve medium head pumping (3-12m) head; pumping is likely to not sustainable unless farmers move to cash crops. Electrification can reduce the logistics of managing pumps. Small individual pumps are more appropriate. Any major pumps would require private sector management Due to the very long development period it there would be advantages to phase the development, gradually building up the irrigated agriculture in parallel with the development of flood control infrastructure. There are reports from the provincial agriculture authorities that flood control is not considered a priority. These schemes have been classed as new schemes-there is exiting irrigation inside the schemes(inventoried separately as existing schemes) Potential area of crops under the FCDI schemes is the incremental area(potential area of the FCDI-present inventoried area of the small schemes). The economics of these schemes has to be established. Dry season irrigation has high dependence on pumping. Environmental impacts of these schemes would be significant; including changes on flood levels, impacts on fish, reduction in flood nutrients etc. Major environmental assessments would be required.		

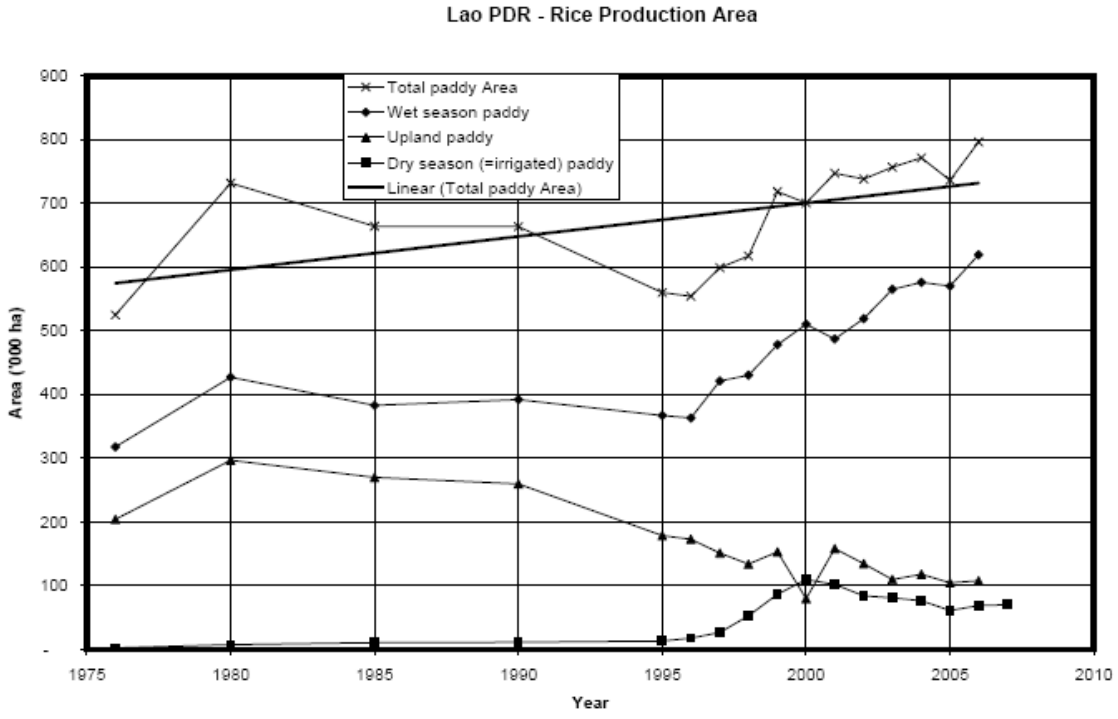
3.1	Three FCDI schemes near the Vietnam border	Three schemes adjoining the Vietnam border offer quite good potential for more rapid development. Vietnamese and other farmers are beginning to lease land and operate a semi private sector operation. The present focus is primarily on post flood rice and does not require protection. The three schemes are East Mekong Neuk Leung and the West Bassac-presently being studies by FMMP to prefeasibility level Trans Mekong Bassac.
3.2	FCDI-other	Remaining 4 FCDI schemes-more limited information exists on the feasibility of these schemes.. These are major schemes and they have been proposed as long term high development project.
4 West Mekong Prek Samao Border Canal. This canal is being considered for expansion/upgrading. There would appear indicatively to be about 30,000ha potential area that could be considered for pumped irrigation on the Cambodian side-requires technical and socio economic studies. Development would be appropriate for multiple small private sector investments or concessions.		

7. Lao PDR

7.1 Present Irrigation

The irrigation sub-sector is a part of the Agriculture and Forestry Sector. Historical rice production in Laos trends are shown in Figure 3.

Figure 3 Lao Rice Production



Until about 1995 the wet season rice crop area remained more or less stable between 350 and 400,000 ha. However, since 1996, the area has been on a steady increase; by 2006, the area had become 620,000 ha, producing 2.2 million tons. Average yields increased modestly from roughly 3 tons to 3.5 tons per hectare. The clear increase after 1996 may reflect the effect of the expansion of irrigated command area under NPIMP and other projects. Irrigation is not only important for the dry season, but also for the wet season crop, namely to speed up soil preparation and to help the crop through dry spells, the estimated irrigated wet season area is 170,000ha,about 27% of the total area.

Upland Paddy Production - In the past, the upland paddy crop contributed 40% of the national paddy production and thus took the second place as contributor. It reached a peak in 1990 with nearly 0.4 million tons. After 1990, it decreased steadily to reach in 2006 0.2 million tons (about 50% of the peak). The decline reflects government efforts to control shifting cultivation.

Dry Season Paddy Production is fully irrigation dependent on irrigation. Until 1995, dry season paddy production was negligible. The irrigation sector was transformed in the 1990's with the installation of over 7000 diesel and electric pumps. Production increased until, in 2000, it peaked at 465,000 tons, harvested from 110,000 ha. In that year, it contributed 21% to annual total production. After 2000, a steady decline took place in dry season paddy area, while yield remained stagnant at about 4.4-4.5 tons/ha. By 2006, dry season rice area had shrunk by more than 1/3 to 69,000 ha, producing 310,000 tons, equalising just 12% of total annual paddy production. The general clarification for this decline is that farmers regard the cost of irrigation in pump-lift schemes as too high, relative to the value of the crop they can produce. In those schemes, the cost includes not only the finance/effort required to keep the irrigation infrastructure in good condition, but in addition the considerable expense for electrical power (or diesel fuel) to drive the pumps. Another reason would be that after 2000, government stopped or reduced the subsidies on inputs including subsidies on electricity tariffs. According to the national statistics, the achievement in 2006 of the self-sufficiency target was mainly due to the increase in wet season crop production; the wet season crop has always been and likely to remain the largest contributor to the total annual paddy production.

The reduction of the levels of subsidies and the resultant drop in irrigation utilisation illustrates the very low capacities of the farmers to fully finance and manage irrigation schemes. Development of a national irrigation strategy is a now on going and key priority of the Lao Government.

7.2 Irrigation Database

The Lao irrigation data base is described in Table 8 below.

Table 8 Lao Irrigation Database

Existing Irrigation	2,417 projects have been identified based on extensive provincial consultations. The wet and dry season irrigable areas are estimated to be 172,000ha and 99,000ha respectively. Rice cropping information from the statistics the dry season irrigation is estimated to be about 70,000-80,000ha. There is evidence in some recent decline in dry season rice due to the withdrawals of subsidies and high pumping costs
Planned Projects	About 44,000ha of planned expansion of existing irrigation schemes have been identified.-this data appears inconsistent and it is not clear that this is based on feasibility level studies. 280,000ha of new projects are classed as planned projects and are reported to have designs. The planned dry season area of 279,000ha represents a threefold increase in relation to the present dry season irrigable area. Land and water availability require to be confirmed. Although classed as planned, it is considered that in reality many of these projects

	might be considered as potential project.
Potential Projects	The potential irrigation area has been estimated to be 1.4 million ha; irrigable area; 300,000ha of this have been identified by the Government and 1.1million by JICA. The data is reported to based on desk studies of maps and aerial photographs. For comparison the total rainfed rice area in Lao is presently only 630,000ha. These potential projects consist of 496 diesel pumps,589 electric pumps and 1085 gravity schemes. The heavy dependence of pumped irrigation in Lao is of concern. Data on the estimated pumping lifts for each project is an important factor in assessing the viability. Recently, the Department of Irrigation (DoI) has re-assessed the national potential for new irrigated area development at 913,000 ha of wet season area, including 850,000 ha of dry season area.11 This area includes ongoing development projects (68,000 ha), designed schemes (107,000 ha), feasibility studies (124,000 ha), and reconnaissance studies (614,000 ha). The data presented in the database including existing and new schemes would be.1.75million ha, significantly higher than the DoI estimates.

7.3 Development Opportunities and Issues

Lao presents potentially quite high opportunities for irrigation development. The availability of irrigable land, good access to water, combined with access to potentially low cost electric power for pumping. There are however constraints, including the soil suitability, farmers capacities to adopt new technologies, access finance and markets for crops, remote locations. In assessing the long term development of irrigation it is necessary to consider three key areas..

Hydropower development is a high government priority in Lao and opens opportunities for irrigation through increased the dry season flow availabilities in the tributary rivers and main stream, as well as a possible net surplus of electrical power in the country. The hydropower dams could also be used for irrigation abstractions points; in most cases, however the use of the distribution of power to appropriate locations and using electric pumps may be more cost effective than long transfer canals.

Lao irrigation has a high dependency on medium head pumping(7-12m). The provincial governments are presently providing an element of subsidised power and it is clear this subsidy is of significant benefit to the farmers using the electric pumps. The price of electricity that the hydropower providers can charge is typically between 3 and 7 cents per kWh[12]. Electricity tariffs for irrigation are presently of the order of 3 cents per kWh. Although there are some questions over the subsidy; as mentioned above it maybe more cost effective to use hydro-schemes and electric pumps rather than expensive gravity schemes and long transfer canals. Low crop prices and limitations of the farmer capacities indicate that full commercial tariffs for pumping at the present might result in a some drop off in

[11] Department of Irrigation, 30/05/08, Letter 0751 “Report of conclusions on the potential for irrigated area development in the whole country”.

[12] MRC Hydropower Sector Review 2009

utilisation of some of the irrigation schemes. Raising of production outputs and increasing of irrigation efficiencies should be implemented to help enable the farmers to absorb the pumping costs.

The local governments presently provide financial support for electricity for pumping; this tends to be on an ad hoc, usually seasonal, basis. Under the Irrigation Management Transfer programme (IMT) the principle of full IMT (Prime Minister Decree 26 of 1998) means that their responsibilities and mandate to provide support for electricity tariffs for are disputable. While Government support for pumping costs does and can potentially lift production levels, there is a lack of long-term certainty which reduces its effectiveness; sometimes the tariff may change during the growing season. Pump-lift schemes therefore raise some questions of sustainability under the current circumstances. A clear and long term strategy of electricity tariffs for irrigation is required to help support irrigation planning and development.

Management Capacities Farmer capacities to develop high value irrigated agriculture remains a serious constraint. Cropping intensities are low and consequently the returns to investments of are limited. Constraints include labour, access to markets and low crop prices. The lack of distribution systems result in high water losses and low uptake of dry season irrigation.

The present strategy is based on irrigation Management Transfer (IMT)". This means that farmers are required to pay the full cost of O&M plus a fee that is serves for return of a part of the investment cost. For pump schemes, the cost of investment is relatively low but the cost of O&M is very high, as it includes the cost of electricity and of the maintenance and repair of the pump installations.

Management Models To bridge the gap in management capacities three production models are considered:

Model A Public Sector (current model): Irrigation development is dominantly public sector planned and implemented with focus on providing the water facility (weir and pump), and full IMT for O&M. Agriculture and irrigation management support would remain under the public sector. Under this situation there remain many constraints of the present farming systems including the availability of investment resources from the public services and the farmers. This model would remain appropriate for the upland low intensity irrigation areas largely using gravity weirs

Model B Improved: Public Sector with Private Sector Support: Irrigation development would still be dominantly public sector planned and implemented, but much more holistically managed, namely by promoting irrigation as 'irrigated agriculture", based on the full range of MTIC factors. Under this model, some constraints will be difficult to address, namely (i) public sector financing of investment, (ii) public financing of O&M support, and (iii) establishment of human resources capacity (numbers and quality of government staff) for O&M support. Gaps in the management would be identified and support programmes developed including appropriate levels of private sector participation.

Model C Advanced Private Sector Lead This model would be similarly holistic as Model B, but, instead of development planning and implementation being public sector dominated, it would be strongly private sector-driven (and lead), through establishment of public-private partnerships. A strong role of the private sector may offer opportunities to help to overcome the constraints that Model B would find difficult to address. Private sector involvement in agriculture is gradually developing in Lao, different management arrangements exist including contract farming.

Development Areas There are two principal types of production area for irrigated agriculture, each with its own typical mix of opportunities for and constraints to development of irrigated agriculture:

Lowland Major Plains-In Lao there are seven major development plains, these adjoin the Mekong River and access a high proportion of their water directly from the Mekong River or the tributaries. Water availability is very high throughout the year. Soils in the plains are varied and development should focus on the best soils. Market access another consideration and is influenced on the proximity to the urban centres; the Vientiane plain has a major advantage in this respect. The water in the major

plains is primarily sourced from pump schemes (with pumping heads of the order of 7-12m) pumping directly from the Mekong or connected rivers; most pumps are now electrical pumps.

Upland Irrigation Schemes –the upland irrigation schemes outside the major plains are located in valley floors and are supplied primarily by gravity. Irrigation is promoted for local food security, poverty alleviation and to reduce the area of slash and burn agriculture. Demand for products for sale is low due to the distance to major markets and difficulties of access; therefore agricultural production is likely to remain directed primarily to local subsistence. The geography of the area, topography and hydrology offers good opportunities for development of small 'run-of-the-river" irrigation schemes. In parts of the Northern uplands, the local climate results in rather low temperatures during the cool dry season which limits the possibilities

Development Opportunities in the Lowland Major Plains. The major plains offer reasonably good opportunities for semi intensive irrigated agriculture based on small scale schemes.. Development will likely be highest in the plains with have better access to the urban markets, better soils and higher density farming communities; economic returns in these areas are also likely to be higher.

Irrigation in the major plains is primarily associated with pump-lift irrigation. Most of these schemes were constructed under the national "crash programme" for raising paddy production (1996-2000), or shortly afterwards, when this was still seen as the way forward. New innovative development strategies are required for all types of irrigation but especially the pump schemes.

Reservoirs are the best performers but their application is limited. Their development is very costly and has so far the nominal area under such schemes has remained small. Gravity schemes are limited but suffer dry season water shortages. Pump-lift schemes are the poorest performers. There are important reasons for their low performance. The first is that many of their canal systems have remained incomplete: (i) they were constructed under the premise that farmer communities would construct the minor infrastructure systems, which they never did; and (ii) construction contractors had to pre-finance the cost, in some cases not completing the works. The other key reason is the cost of scheme O&M mainly the pump operation costs and the high distribution losses due to the lack of distribution canals.

Identification and implementation of effective management strategies for the pump schemes is the major requirement in the lowland plains. The role of the private sector is seen to be a key way forward for irrigation development in the major plains. Management Models B and C could potentially provide the necessary management support for intensification of the irrigated agriculture in the major plains.

Development Opportunities in the Upland Irrigation Schemes Poor access and difficulties to develop improved technologies limit the scope for intensification of these schemes. The schemes are largely by gravity and therefore are more robust and less dependent on cash returns to support sustainability. The potential role of the private sector in these dispersed quite areas is probably limited and management Model A would likely be the most appropriate management model.

7.4 Grouping of Projects

The wide number of projects in Lao have been grouped based on the 7 major plains and 3 categories of upland projects.

- **Major Plains**: 7 major plains- Attapeu; Borikhamxai; Champasack Khammoune; Savannahket Vientiane and Xedon
- **Upland Schemes**: Three zones North Lao; Central Lao and Southern Lao

7.5 Assessment Indicators

Irrigation development in Lao has reasonably good potential; there is good scope to intensify the irrigation of existing schemes as well as continued expansion of new schemes. The full potential areas

have been assessed based on desk studies and appear to be difficult to achieve in practice however if some of the key management issues can be addressed then a reasonably high level of development might be viable over the next 20 years. The future development of irrigation has been based on the assessment indicators shown in Table 9 below.

Table 9 Lao PDR Assessment Indicators

1. **Development of Irrigation in the Major Plains** The major plains have very good access to dry season water from the Mekong River. The soils are fair but some plains have high percentage of less fertile acrisols. Irrigation is highly dependent on pumped irrigation (5-12m heads) and a move to modern irrigated agriculture including expansion of cash crops is essential. There is however a key requirement to identify and develop a management model that will allow the full potential production of existing schemes prior to be achieved prior to embarking on large scale development of new schemes. Development has been based on the following support assumptions. • Some level of continued access to subsidised electricity tariffs-this will be important, at least in the interim stage until issues of losses and the introduction of higher return cropping can be established. • A gradual entry of the private sector-requires government and community support and an attractive financial model with appropriate Government incentives. • In parallel with private sector involvement farmers would gradually directly develop initiatives to achieve higher production levels. Government and/or private sector support for upgrading of distribution systems including pipe systems(gated pipes) to improve dry season irrigation efficiencies. The viability of this approach requires to be assessed and fairly slow expansion of the irrigation areas in the major plains is quite likely, in the short term. Most of the best locations have already been developed and it considered the development of the full potential area will not be viable. Many planned projects appear to be based on very limited planning and a phased development of planned and potential projects has been used for the estimation of the development scenarios. Dry season pumped irrigation for rice is expensive and a gradual move to lower consumptive non rice crops will be required.
2. Development of Irrigation in the Upland Areas Irrigation in the upland areas is designed to support food security, community development and the establishment of permanent agriculture. The schemes are gravity and have reasonably low requirements for management. Cropping is primarily an irrigated wet season rice crop with limited opportunities for dry season crops as the water availability becomes less. Management can follow the present methods through the public sector and community water user groups. Many of the best sites have been developed and further expansion will likely be gradually be less feasible and require higher investment costs per hectare. A gradual expansion rate of about 5% per annum over the next 20years is considered feasible.

8. Thailand

8.1 Existing Irrigation

NE Thailand is a major exporter of rice, with one third of Thailand's exports originating from NE Thailand. Farms in NE Thailand produce all the country's high quality jasmine rice and its cultivation earns farmers a small premium. Due to the relative poverty of the region and low rainfall significant

injection of Government funding has gone into the NE to support irrigation projects as well as the promotion of the increasing the value of agricultural products. Major investments in irrigation were supported by the World bank in the early 1980's

Although NE Thailand is a major rice exporter, the income it generates is relatively small compared with what farmers can earn in the increasingly prevalent local industry. Labour is an issue, there are now significant off farm employment opportunities in the NE area and also in Bangkok offering higher salaries. As a result labour is expensive and many farmers especially the young seek off-farm jobs to better support their families.

Total harvested rice areas in NE Thailand increased by approximately 4% over the seven-year period between 1990/91 (4,795,870 ha) and 1997/98 (4,971,432 ha) (TIF, 2002) and now little land remains to be cleared for agriculture. Although grain yields have increased at a rate of 3% nationally, yields in the northeast of the country have grown at a slower pace, if at all, in both the irrigated and rain-fed areas. WUP-MRC data indicate that the area of crop receiving supplemental irrigation in the wet season increased steadily at a rate of 4.5% annually between 1990 and 2000. The present area of irrigation schemes from the 2008 database and other sources is estimated to be about 1.3million hectares and appears largely unchanged since 2000.

Although supplemental irrigation should take the risk out of crop production with a result that yields should gradually increase over time. This however has not happened in NE Thailand, this may be an indication of poor soils and possibly the lack of priority farmers have paid to their crops in recent years due to the increasingly available cash income available from the industrialised centres. Irrigated dry season rice areas did not increase during the decade from 1990 – 2000 (Table 3) and little increase is projected for the future unless it is possible to improve returns from irrigation. As the GDP per capita in Thailand has increased there is evidence that the consumption of rice has and is likely to continue to decrease as dietary preferences change.

The Northeast part, however, remains the poorest region in the country. It is suffers from relatively poor soils and has a period of 6 months with scant rainfall. Although it accounts for 45% of agricultural land, it has received only 18% of irrigation expenditure. Irrigation is constrained mainly due to the lack of attractive sites for dams and to environmental constraints, which are reflected in an average per hectare cost higher than in other regions . Although the percentage of the population living below the poverty line has fallen dramatically since World War II, poverty remains higher in rural areas in general (16%) and in the northeast in particular (26%).

Irrigation development was previously under the management of a number of agencies; this has now been rationalized to two main agencies the Royal Irrigation Department (RID) and the Department of Water Resources(DWR). Irrigation development in the North East has primarily focused on supplementary irrigation for wet season rice with very low percentages for dry season crops; estimated to be around 25% for medium and large schemes and less than 5% for small scale schemes

8.2 Irrigation Database

The irrigation data base for Thailand is described in Table 10 below.

Table 10 Irrigation Database for Thailand

Existing Irrigation	A total of 5700 projects have been identified by the Thai National Consultants, consisting of 251 Medium and Large Schemes, 4449 small gravity schemes and 974 pump schemes. The total wet and dry season irrigable areas are estimated to be 1.37 million ha and 171,000ha respectively.
Planned Projects	A total of 447 planned projects have been identified. These projects would

	irrigate a total area of wet season 134,000ha and dry season 79,000ha
Potential Projects	A total of 254 projects irrigating an incremental potential area of 1.9 million ha. The main potential project is the proposed Khong Loei-Chi-Mun Diversion Project which is planned to irrigate at total of 3.5 million ha –the incremental area would be 1.8million ha.

8.3 Development Opportunities and Issues

Water Grid In 2003, the Thai administration launched the idea of a national ‘‘water grid’’ that would triple the area of irrigated land in the country. Although covering the whole country the focus of the project is the North East. The water grid has been considered for many years, the concept is to

- Rehabilitate the existing irrigation including increasing the storages on the existing dams Develop an integrated system of gravity and pumped irrigation by optimizing the water in the reservoirs and rivers. Improved water management to increase efficiencies..
- Implement a major water transfer scheme from the Mekong River to supplement the existing limited water available in the basins.

The water grid is the key component of the long term irrigation planning. The water grid has been recently been given official Government Approval, even though the water transfer element is still an uncertain factor. The water grid without the transfer element will allow some development and expansions through increased reservoir storage, scheme rehabilitation, and improving irrigation efficiencies. Significant expansion will however require the implementation of the Mekong water transfer.

The water transfer is complex due to the enormous financing requirements, agreements on release of water from the Mekong river and opposition on environmental, social and economic grounds. There are questions raised on the problems of soil salinities, the impacts of increased irrigation water, the level of demand for increased irrigation and lack and high costs of labour

Two proposals for the water transfer have been presented:

Ngam Ngum Water Transfer: The initial concept of the water transfer was to transfer water from the Ngam Ngum reservoir in Lao and through a culvert under the Mekong provide pumped water to the headworks of the Chi and mun rivers. The estimated irrigation area is 800,000ha. This proposal was prepared by the Department of Water Resources. It is assumed(but not confirmed) that this proposal has been superseded by the later Khong-Loei-Chi-Mun transfer.

Khong-Loei-Chi-Mun transfer: This second proposal presented to pre-feasibility study in May 2008 by the RID involves abstracting water from the Mekong River by gravity at the Loei river to irrigate a total of 2.86million Ha in the Chi and Mun basins and 0.64 million in the Khong basin.

Planned Projects Without any firm agreement on the water transfer the present priority is to upgrading of the existing irrigation within the existing water resources.

The total area of irrigation at present is estimated to be 1.4 million ha with about 170,000ha under irrigation in the dry season.

Normal Planning**:** The normal planning process includes provision of additional area through rehabilitation of existing schemes(94,000ha) and new planned schemes(372,000ha).

Special Planning: Work is proceeding to develop the water grid under an initial stage (without additional transfer water. These include small schemes(75,000ha), improvement of irrigation efficiencies(175,000ha) and development of the water grid (237,000ha)

Total Normal and Special Planning would provide 953,000ha incremental area

The lack of water resources is a major problems, the topographic conditions are not appropriate for the development of new projects or storage. Five major schemes are presently under feasibility studies to increase the storage levels and capacities of existing reservoirs. The present total storage in the Chi Mun basin 8500MCM, this incremental storage will provide of the order of 10% additional storage.

- Lam Pao Increase storage by 550.MCM (38% increase) to the dry season irrigation areas at Lam Pao and downstream.
- Lam Takong increase supply level by 3metres-increased irrigation area of 1824ha
- Lam Phra increase storage capacity by 50MCM
- Lam Sam increase storage capacity by 1.4MCM
- Chi Bon Irrigation under study

8.4 Assessment Indicators

Irrigated agriculture in North East Thailand has been fairly static over the last 10 years. Despite the high investments in irrigation water usages remain very low outside the wet season. There are now significant opportunities for employment outside agriculture and the availability and costs of labour in NE Thailand are serious constraint.

Much of the irrigation requires pumping, even where dams and reservoirs have been constructed the topography is such gravity supplies are not feasible.. There is fierce opposition to irrigation charging, the Government does subsidise the pumping or in cases provides power free of charge; initiatives to levy charges for maintenance on the farmers have not been well received. The Government has developed very ambitious targets for irrigation development through the proposed water grid. This project is a potential project, there are however major technical, social and economic factors that may affect the viability of the project.

The assessment indicators for Thailand are summarised in Table 11 below.

Table 11 Assessment Indicators Thailand

1. **Medium and Large Scale Schemes** Expansion of existing L&M schemes is proposed in the general plan, this would be achieved through increasing the storage and improved water management, no specific information has been provided. Despite many years of attempts to expand the dry season irrigation area the take up by farmers has remained low. The water resources and potential for new or increased storage are quite limited.
2. Small pump and gravity schemes The best locations for schemes have been developed. Small scale pump schemes are heavily subsidised and the long term sustainability is of concern. Attempts to charge for water have not been successful. A slow take up of potential schemes has been incorporated into the assessments.
3. Khong-Loei-Chi-Mun Transfer Project This is a major water diversion project from the Mekong river via the Loei river. The project studied to prefeasibility level by the RID will transfer water by gravity to the Chi and Mun basins. The proposal is for a gravity scheme via the Loei river though a 12 long tunnels to feed supplies into the Chi and Mun basins. The project would provide irrigation to over 3.5 million ha (2.85million in the Chi and Mun basins and 0.65million ha) in the Khong basins. The incremental area of wet season irrigation (above the present irrigation) would be of the order of 1.8 million hectares. No information on the dry season area is available but it is indicatively estimated to be about 50% of the wet season area.

The averaged diversion would be 38,662millionm3/year (1225m3/sec). The diversion is by gravity but would require construction of 12 number -10m diameter 80km long tunnels; involving rock excavation of around 75 million m3. The estimated capital costs of the project are around 800,000 million Bhat (US$ 22.4 billion). The Khong-Loei-Chi-Mun Transfer project has been classed as a long term high development project.

9. Vietnam Delta

9.1 Present Irrigation

All of Viet Nam's rice exports originate from the Mekong Delta after supplementing shortfalls in other parts of the country. Agriculture in the Mekong Delta has undergone extremely major and rapid developments since 1976. Agricultural development has been supported by major infrastructure works to manage the complex water regimes to meet the needs of crops including rice, annual crops, aquaculture (fresh and brackishwater). The increase of the rice growing area to the year 2000 was 5% per year. Since 2000 Government policy has been to shift to other diversified crops, however the area of rice and rice intensities have continued to increase. Table 12 Land Use in the Mekong Delta 1990 to 2006 shows the changes in land use in the Delta since 1990. The table indicates the harvested area increased by 2% per year from 2000 to 2006. There are reports of increased planting of rice during 2008 at the peak of the rice price.

Outside rice the major shift has been to aquaculture where the expansion of the area of aquaculture has been at a rate of 11% per year, some of this has been conversion of rice land. The irrigation system in the Mekong Delta is shown in Figure 4

Figure 4 Existing Irrigation Systems in Mekong Delta

EXISTING IRRIGATION SYSTEM IN THE MEKONG RIVER DELTA - VIETNAM

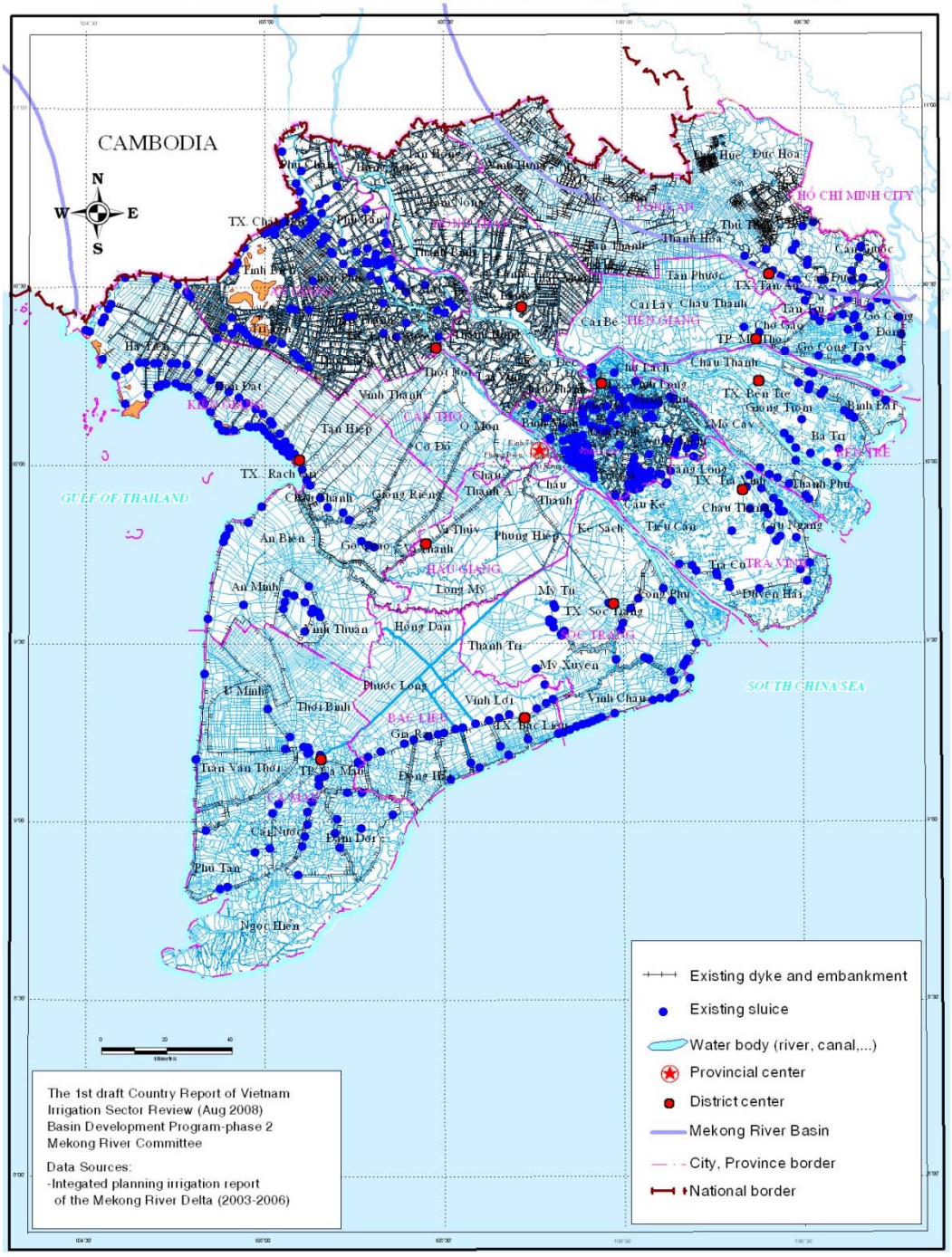


Table 12 Land Use in the Mekong Delta 1990 to 2006

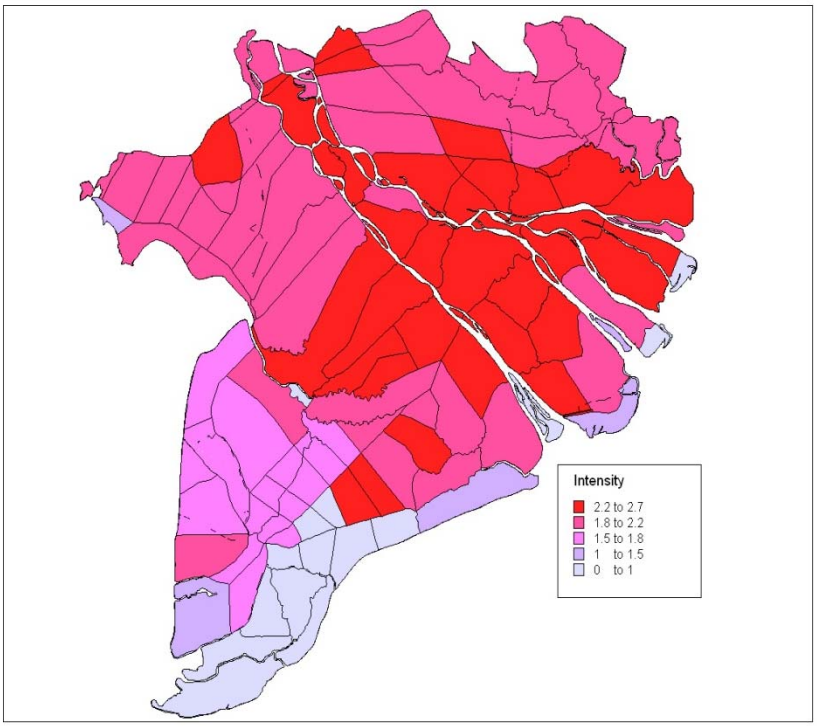
Land use	1990		2000		2006	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Mekong Delta gross area*	3971232	100.0	3971232	100.0	3971232	100.0
I. Agricultural lands	2465601	62.1	2853017	71.9	2986893	75.2
1. Annual crops	1972412	49.7	2216725	55.8	2141264	53.9
1.1. Rice, upland crops	1813641	45.7	2082605	52.4	1963212	49.4
- 3 crops of rice, /upland crops			183088	4.6	662084	16.7
- 2 crops of rice, /upland crops			1367164	34.4	1041492	26.2
- 1 crop of rice			532353	13.4	140796	3.5
- 1 crop of rice + Shrimp/fish					118840	3.0
1.2. Other annual crops	158771	4.0	134120	3.4	178052	4.5
2. Perennial crops	347793	8.8	406940	10.2	425268	10.7
3. Aquacultural land	145396	3.7	229352	5.8	420361	10.6
III. Forestry land	348673	8.8	337688	8.5	320451	8.1
III. Urban land	15518	0.4	22351	0.6	27837	0.7
IV. Settlement , garden	203709	5.1	218630	5.5	257947	6.5
V. Other land (unused, rivers,)	937731	23.6	338381	8.5	378104	9.5

*Total area without islands area

(Sources: Ministry of Natural Resources & Environments, 2000-2005 and validated by land use map in 2006 prepared by Sub-National Institute of Agricultural Planning and Projection

The Vietnam delta Irrigation is based on 120 blocks, served by a network of canals, around and within the blocks. Rice areas by block have been based on the 2006 data statistics by district and adjusted to rice areas by irrigation block The delta has a significant non rice water demand from upland crops/ fruit trees as well as significant areas of brackishwater shrimp. Present rice intensities in the Delta can be seen in Figure 5..

Figure 5 2006 Rice Intensities in the Mekong Delta



9.2 Development Opportunities and Issues

The Present 10 year Development Plan runs 2000-2010, the plan was updated in 2003 and following Government policy was directed at crop diversification and reductions of stabilisation of the rice intensities. Whilst on the ground the interest and intensity of rice production has gradually increased over recent years. Other irrigated crops remain an important feature but no significant reduction in rice area or intensity has been observed. It is agreed with the Sub Niap that the 2003 plan was not appropriate for future planning.

The Sub NIAP[13] institute will prepare the new 2011 to 2020 plan in 2009. Therefore at this point no specific development plan for the delta exists.

General trends: Rice will remain the major crop in the medium to long term. The general trends for rice production include:

- Further expansion of the rice growing area: Increasing the area for domestic consumption and export
- Raising the effectiveness of rice production to raise yields, reduce costs and post harvesting losses.
- Further crop diversification of crops and land by rotation with upland crops, integrated farming including rice and aquaculture (rice shrimp and rice fish systems).

[13] Sub National Institute for Agricultural Planning

Farming Systems Even though there is a very large surplus of rice production in the Mekong Delta, farmers remain poor compared with many of those in metropolitan areas. While rice consumption will not diminish for some time, farmers, when possible, will convert to growing crops where the greatest cash returns. For this reason, the area under fruit trees and fish farms is increasing rapidly (Nesbitt, Johnston and Solieng, 2003). Although fish farms have continued to grow the major change from rice has not occurred. The Vietnam farmer is very tuned to the market opportunities. Increasing the crop area has now limited potential however options remain to lift yields, reduce costs and increase the product value through crop selection. More recently the improved prices of rice have continued the trend to increase rice production.

The total area under rice production increased significantly in the decade between 1990 and 2000; since 2000 the growth has slowed. Yields remained reasonably static; therefore, most of the productivity gains were due to an increase in cropping intensity. Rice in the Mekong Delta has a potential yield of 8-9 t/ha per hectare with current plant types and many farmers are reaching this target (if their farms are producing an overall yield of 5.3 t/ha). However, unless there is a scientific breakthrough producing a more prolific rice variety, farmers will achieve only slightly higher overall rice yields[14].

Costs continue to rise, especially for fuel, fertiliser and other agricultural inputs. If farmers are to boost their incomes, they must increase the value of their grain, grow alternative crops or convert their rice farms into fishponds or other more profitable farming practices. An increasing number of farmers are growing fruit trees, but, in the Mekong Delta, only a limited area will support such cultivation and market forces remain quite weak for perishable goods.

In conclusion, farmers in the Mekong Delta will continue to identify opportunities to maximize their return, presently these appear to be in the direction of further rice intensification and fish and shrimp cultivation. The Government policy to date has been that over intensification in these areas run risks of and opportunities are issues for serious consideration in the proposed development plan 2010-2015.

Increased Dry Season Flows open major opportunities for farming in the delta; dry season rice yields are 75% higher than wet season yields (Nesbit). Large parts of the delta remain with low intensities and increased freshwater supplied to this area through the hydropower developments could make significant impacts.

Shrimp culture as well rice and shrimp culture[15] offer high returns and as a result continue to expand in the coastal areas. To date irrigation planning has been largely towards rice production. Improved and more integrated planning to meet the needs of rice and shrimp farmers is important; increased fresh water for shrimp farming can increase yields and improve the environmental conditions. Water demand for shrimp is important in the south of Ca Mau peninsula. Up to now, unfortunately there is no full research on water demand for shrimp in this area. Most of the south of Ca Mau peninsula is outside of salinity control system, fresh water shortages seriously affect the salinity levels, flushing of shrimp waste and production levels in the shrimp ponds in the dry season (from January to July). Government policy is to reduce the area shrimp farming due to the environment and disease risks. Improved water management, with increased fresh water can potentially help reduce the risks and support sustainable and increased production systems.

Water and Soil Quality are issues; the Mekong Delta has one of the major accumulations of acid sulphate soils in the world. Oxidation of acid sulphate soils on drying results in problems through

[14] Nesbit MRC Technical Paper 2005

[15] This is a wet season rice followed by a dry season shrimp crop

oxidation of the pyrite. Salinity intrusion a long term issue in the delta is tackled through major salinity control gates. Improved water management together with increased fresh water can potentially provide significant benefits through increased flushing.

Estimation of the Potential No detailed studies exist on the irrigation potential for the Delta. Sub Niap carried out a an assessment of the potential to increase rice intensities based on an assessment of the existing intensities. and assessing the potential intensities by applying (FAO land suitabilities for flood acid sulphate, and salinity conditions. The assessment indicated a potential increase of potential to increase the rice land area by 11%.

Changing the Hydrological Conditions of the Delta Despite the very intensive level of production in the Delta there remains potential to further increase the production levels of irrigated agriculture including fish and shrimp culture.

These changes would require to be supported by changes in the hydrological conditions including increased dry season supply in the Mekong and Bassac rivers as might be become available as the hydroelectric dams are completed in the upper Mekong catchments. Four possible scenarios have been considered that could potentially further increase the Mekong Delta production.

1. Further flood control works to increase rice intensities in flood zones presently with only partial flood control facilities-Plain of Reeds and Long Xuyen Quadrangle
2. Water management to reduce impacts of acid sulphate soils-requires additional fresh water-in acid sulphate zones
3. Provision of increased fresh water to the low intensity rice production areas in the west towards the South Ca Mau Peninsula. This could be achieved if additional fresh water resources were available from the main stream Mekong and Bassac rivers.
4. Increased water supplies to the coastal shrimp farms to improve salinity levels during the dry months and support flushing of contaminants. Improved water management of the shrimp and rice areas, to remove conflicts and optimise production (subject to increased fresh water availability).

Grouping of Projects The Vietnam Delta has been delineated into 120 blocks. The Southern Institute for Water Resources Planning the Vietnam Delta has been divided the Delta into 33 development zones. For this review the irrigation blocks have grouped based on the 4 development areas.

1. Plain of reeds flood protection
2. Long Xuyen Quadrangle Flood Protection
3. Increased Dry Season Irrigation
4. Additional Freshwater for Brackishwater Aquaculture

9.3 Mekong Delta Assessment Indicators

The assessment indicators for the Mekong Delta are shown in Table 13Table 13 Assessment Indicators for the Vietnam Mekong Delta.

Table 13 Assessment Indicators for the Vietnam Mekong Delta.

1. Expansion of irrigation area Government policy is to maintain diversified cropping and no change in the present area of rice has been considered for the development planning.

<table>
<tr><td colspan="3">2. Increased Flood Protection
Based on proposals for flood protection by the FMMP_C2 component by some upgrading of the flood protection works it would be able to provide full protection for parts of the Plain of Reeds and Long Xuyen Quadrangle. There are no planning for these initiatives but they are potential developments and therefore have been classed under the Long Term Development scenario.</td></tr>
<tr><td>2.1</td><td>Plain of Reeds Flood Protection</td><td rowspan="2">Upgrading of flood dykes and sluices to provide flood protection for the Autumn Winter Crop . It is estimated that 70% of the benefit rice area would be able to plant an Autumn Winter Crop. Vietnamese farmers have capacities to expand their production without requirements for addition institutional support. Environmental impacts would be quite significant and would require detailed assessments.</td></tr>
<tr><td>2.2</td><td>Long Xuyen Quadrangle Flood Protection</td></tr>
<tr><td colspan="3">3. Increased Dry Season Irrigation
Future increased fresh water flows in the Mekong and Bassac rivers open opportunities for increasing area and intensities of dry season irrigation. Distribution of freshwater would enable Increased dry season irrigation (winter-spring crop) to about 24 blocks which presently have less than 10% rice(winter-spring crop). With increased fresh water it is estimated these blocks would be able to achieve 70% rice area.</td></tr>
<tr><td colspan="3">4. Increased freshwater for brackishwater aquaculture
Additional fresh water could be allocated to brackishwater ponds during dry season. Integrated management and planning to balance water demands for dry season rice and shrimp would be required. No change in the shrimp area has been considered but the benefits would be to increases the production and improve the environmental conditions through flushing. About 40 blocks covering 460,000ha where high areas of shrimp or rice and shrimp would benefit. The indicative water requirement is of the order of 1m3/sec per 1000ha. The work may require some adjustments to salinity control structures, improved canalisation and possibly pumping.</td></tr>
</table>

10. Vietnam Highlands

10.1 Existing Irrigation

The highland area suffers from long dry seasons when the river levels drop 6-7m, and up to 10m in some parts below the level of the fields. In the wet season the water rise significantly and flooding of 1.5 to 2.5m depth of water occurs in many parts. Production levels are quite low due to the lack of new technologies of the ethnic farming communities.

10.2 Irrigation Database

The irrigation database for the Vietnam highlands is summarised in Table 14.

Table 14 Vietnam Highland Database

Existing Projects	492 schemes with irrigable area of 193,000ha, wet season area 143,000ha and estimated dry season irrigated area of 77,000ha(dry season area has been adjusted down from the original data, from an analysis of the district crop statistics). Irrigated coffee is a major feature.
Planned Projects	Data was presented as planned projects but re-classified as potential projects(due to lack of data)

Potential Projects	447 schemes with a potential area of 204,000ha. No supporting information was presented.

10.3 Development Opportunities and Issues

Irrigation in the Vietnam highlands is directed at rice as well as irrigated coffee. The main areas of development include:

Development of Modern Agriculture and Irrigation through extension and water management. The mix of rice and cash crops (mainly coffee) provides a good foundation for the long term expansion of irrigation.

Investment in large irrigation structures including the Krong Buc Ha,Upper Krong Pach, EaMoa, Ea-Thul and Ea_Mla Tap. Construction of new irrigation schemes would concentrate in the high production areas, especially the resettlement areas, remote areas and borderlands. The irrigation projects are designed to transform the production patterns to ensure the winter spring crops, expansion of the dry season irrigation, with especial attention for industrial crops (coffee, pepper etc) . There are ongoing programmes to apply and develop modern irrigation technologies including sprinkler, drip systems etc for long term industrial crops.

Integrated Development-there are ongoing programmes to develop multipurpose projects incorporating irrigation, flood control and power generation on the main streams of the Sesan and Srepok rivers. This work is being coordinated with the Ministry of Industry.

Flood protection: Flooding is a major problem in the highlands. Programmes planned to address the flood issues include flood dykes and the construction of reservoirs.

Groundwater: Groundwater plays an important role in irrigation and integrated planning of ground and surface water resources is important for the area.

10.4 Assessment Indicators

The assessment indicators for the Vietnam highlands are described in Table 15.

Table 15 Assessment Indicators for the Vietnam Highlands

1 Existing Schemes No information has been provided on the expansion or intensification of the existing schemes. Grouping of the projects would be based on the two catchments Sesan and Srepok.
2 New schemes 448 new irrigation projects proposed there is no supporting information. Irrigation in the highlands is a high government priority and a fairly rapid build up of the irrigation area is likely. Flooding is a key issue and flood protection maybe required for many schemes.

11. Overall Basin Development Scenarios

11.1 Data Base

The irrigation database provides information on the present, planned and potential irrigation areas for each irrigation scheme. Planned projects are projects which have been planned to feasibility level or higher. Potential projects are projects with a concept level of planning. It is unlikely that all potential projects would be developed-in many cases the projects may not be technically, economically feasible or socially or environmentally appropriate.

11.2 Development Scenarios

Development scenarios have been defined to assess different levels of possible development of irrigation. At the extreme the Long Term High Development Scenario is based on a fairly unlikely development situation where all the potential projects are developed. The long term development presents a more realistic situation and considers that only viable projects would be developed. The 20year development is an assessment of the development that would likely be achieved in 20 years- the concept is explained in Table 16.

Table 16 Definition of the Development Scenarios

Definite future	**20 year Development**	**Long Term Development**	**Long Term High Development Scenario**
Existing irrigation projects	Existing irrigation projects + planned projects +a **percentage** of the potential projects (viable priority projects)	Existing irrigation projects + planned projects **+ percentage** of potential projects (viable projects)	Existing irrigation projects + planned projects + (100%) of potential projects

The estimation of the percentage of the potential projects that would be developed in the 20year and long term is complicated and reference is made to the assessment indicators described in each of the country reviews described above. The estimated build up of the irrigation area for each scenario has been based on percentages of the planned and potential projects as described in Table 17 below.

Table 17 Development Scenario Factors

			Definite future(same as exisiting)				20 year development					Long Term					Long Term High Development				
	Grouping	Type (existing or new	Existing	Existing Planned	Existing Potential	New projects	Existing	Existing Planned	Existing Potential	New projects planned	New project potential	Existing	Existing Planned	Existing Potential	New projects planned	New project potential	Existing	Existing Planned	Existing Potential	New projects planned	New projects potential
	Cambodia																				
	1. Tonle Sap Tributaries																				
1.1	NWISP and Sector Projects	Exist&New	100%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1.2	JICA Master Plan Projects (small scale <100ha)	Exist&New	100%	0%	0%	0%	100%	100%	60%	100%	60%	100%	100%	70%	100%	70%	100%	100%	100%	100%	100%
1.3	JICA Master Plan Projects (medium scale >100ha)	Exist&New	100%	0%	0%	0%	100%	100%	40%	100%	40%	100%	100%	60%	100%	60%	100%	100%	100%	100%	100%
1.4	Mowram-MRC Inventory	Exist&New	100%	0%	0%	0%	100%	100%	20%	100%	20%	100%	100%	50%	100%	50%	100%	100%	100%	100%	100%
1.5	Korean Development (KOICA)	Exist&New	100%	0%	0%	0%	100%	100%	40%	100%	40%	100%	100%	60%	100%	60%	100%	100%	100%	100%	100%
	2. Mekong Irrigation Projects																				
2.1	West Mekong Schemes	Exist&New	100%	0%	0%	0%	100%	100%	20%	100%	20%	100%	100%	50%	100%	50%	100%	100%	100%	100%	100%
2.2	West Mekong Prek Smao Border Canal	New				0%					20%				0%	40%	100%	100%	100%	100%	100%
3.1	East Mekong Schemes	Exist&New	100%	0%	0%	0%	100%	100%	20%	100%	20%	100%	100%	50%	100%	20%	100%	100%	100%	100%	100%
4	Integrated Flood Control, Drainage and Irrigation (FCDI)																				
4.1	West Bassac FCDI	New				0%				0%	0%				100%	100%				100%	100%
4.2	Trans Mekong Bassac FCDI	New				0%				0%	0%				100%	100%				100%	100%
4.3	East Mekong Neuk Leung Vietnam border	New				0%				0%	0%				100%	100%				100%	100%
4.4	Tonle Sap Mekong FCD1	New				0%				0%	0%				0%	0%				100%	100%
4.5	Steung Sen FCDI	New				0%				0%	0%				0%	0%				100%	100%
4.6	Steun Sreng FCDI	New				0%				0%	0%				0%	0%				100%	100%
4.7	Kratie Kampong Cham FCDI	New				0%				0%	0%				0%	0%				100%	100%
4.8	Tonle Sap Mekong FCD1	New				0%				0%	0%				0%	0%				100%	100%
5	Lao PDR																				
5.1	Attapeu Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.2	Borikhamxai Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.3	Champasack Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.4	Khammoune Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.5	Savannahket Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.6	Vientiane Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.7	Xedon Major Flood Plain	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.8	North Lao Upland Schemes	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.9	Central Lao Upland Schemes	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
5.1	Southern Lao Upland Schemes	Exist&New	100%	0%	0%	0%	100%	100%	10%	60%	5%	100%	100%	20%	80%	20%	100%	100%	100%	100%	100%
	6 Thailand																				
6.1	Chi Basin Medium & Large	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	20%	100%	100%	40%	100%	60%	100%	100%	100%	100%	100%
6.2	Mun Basin Medium & Large	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	20%	100%	100%	40%	100%	60%	100%	100%	100%	100%	100%
6.3	Chi Basin Small(pumped,gravity)	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	30%	100%	100%	50%	100%	60%	100%	100%	100%	100%	100%
6.4	Mun Basin Small(pumped gravity)	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	30%	100%	100%	50%	100%	60%	100%	100%	100%	100%	100%
6.5	North East (medium and large)	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	20%	100%	100%	40%	100%	60%	100%	100%	100%	100%	100%
6.6	North East Small (pumped and gravity)	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	30%	100%	100%	40%	100%	60%	100%	100%	100%	100%	100%
6.7	Chiang rai--catchment	Exist&New	100%	0%	0%	0%	100%	100%	30%	100%	40%	100%	100%	40%	100%	60%	100%	100%	100%	100%	100%
6.8	Khong Loei-Chi-Mun Water Transfer	New				0%				0%	0%				0%	0%	100%	100%	100%	100%	100%
	7 Vietnam Delta																				
7.1	Plain of reeds flood control	Exist	100%	0%	0%	0%	100%	0%	0%			100%		100%			100%	100%	100%		
7.2	Long Xuyen quadrangle flood control	Exist	100%	0%	0%	0%	100%	0%	0%			100%		100%			100%	100%	100%		
7.3	Dry season irrigation	Exist	100%	0%	0%	0%	100%	0%	0%			100%		70%			100%	100%	100%		
7.4	Brackishwater Aquaculture	Exist	Not applicable														Full take up under the long term potential				
	Other blocks	No change																			
	8 Vietnam Highlands																				
8.1	Sesan Catchment	Exist&New	100%	0%	0%	0%	100%	100%	80%	100%	70%	100%	100%	90%	100%	80%	100%	100%	100%	100%	100%
8.2	Serepok Catchment	Exist&New	100%	0%	0%	0%	100%	100%	80%	100%	70%	100%	100%	90%	100%	80%	100%	100%	100%	100%	100%

11.3 Non Rice Crops

Apart for the Vietnam delta it was not possible to source any real information on irrigated non rice crops. Non rice crops have significantly lower water demand and a high accuracy in the estimates is

less critical. The present levels of non rice are quite low and do not significantly contribute to the water demand.

The area dry non rice has been estimated based on the percentage of the land available during the dry season outside the area cultivated with rice; the concept is described in Appendix A: section 3.4. The non rice factors are shown in .Table 18.

The category 'Non rice' includes a wide range of crops including soya, groundnuts, vegetables, fruit trees, etc, it could also include aquaculture (a high water demand). Development of non rice cropping is well established in the Vietnam Delta but presently very limited in other areas. The advantages of dry season non rice cropping are significant, (especially for pumped irrigation); with potentially higher returns, lower water requirements, lower labour requirements etc. Development of effective non rice cropping does however represent a move from subsistence to modern medium/high input farming; a change that requires development of new management and financing initiatives.

11.4 Summary of Development Scenarios

The areas of existing planned and potential projects have been analysed to assess the development scenarios for each irrigation project and also each of the grouped projects. The output of the analysis of the grouped projects is presented as a PIN (Project Identification Note). Two types of PIN have been developed i) a full PIN with one page for each project and ii) a summary PIN with 4 lines per project.

A summary of the present, 20year, long term, and long term high development scenarios for rice is presented in Table 19 and Table 20. The estimated areas of non rice and also the shrimp in the delta is shown in Table 21.

.Table 18 Non Rice Factors

Group Code	Grouped Projects		% Non rice factors				
			Definite Future	20 year development	Long Term	Long Tem High	
	Tonle Sap Tributory Schemes						
111	NWISP and Sector Projects		5	5	5	5	limited scope for
112	JICA Master Plan Projects (small scale <100ha)		5	5	5	5	non rice due
113	JICA Master Plan Projects (medium scale >100ha)		5	5	5	5	limited water
114	Mowram-MRC Inventory		5	5	5	5	availability
115	Korean Development (KOICA)		5	5	5	5	
	Mekong irrigation projects		5	5	5	5	
121	West Mekong Schemes		5	5	5	5	
122	West Mekong Prek Smao Border Canal		5	5	5	5	
131	East Mekong Schemes		5	5	5	5	
	Integrated Flood Control, Drainage and Irrigation (FCDI)						
141	West Bassac FCDI		0	0	0	0	All planned
142	Trans Mekong Bassac FCDI		0	0	0	0	cropping based
143	East Mekong Neuk Leung		0	0	0	0	on rice
144	Tonle Sap Mekong FCD1		0	0	0	0	
145	Steung Sen FCDI		0	0	0	0	
146	Steun Sreng FCDI		0	0	0	0	
147	Kratie Kampong Cham FCDI		0	0	0	0	
148	Tonle Sap Mekong FCD1		0	0	0	0	
	LAO PDR						
201	Attapeu Major Flood Plain		10	30	50	80	major move to
202	Borikhamxai Major Flood Plain		10	30	50	80	dry season non
203	Champasack Major Flood Plain		10	30	50	80	rice crops
204	Khammoune Major Flood Plain		10	30	50	80	
205	Savannahket Major Flood Plain		10	30	50	80	
206	Vientiane Major Flood Plain		10	30	50	80	
207	Xedon Major Flood Plain		10	30	50	80	
208	North Lao Upland Schemes		10	30	50	80	
209	Central Lao Upland Schemes		10	30	50	80	
210	Southern Lao Upland Schemes		10	30	50	80	
	THAILAND						
301	Chi Basin Medium & Large						
302	Mun Basin Medium & Large		20	25	30	40	some in increase
303	Chi Basin Small(pumped,gravity)		20	25	30	40	in non rice -
304	Mun Basin Small(pumped gravity)		20	25	30	40	problems of
305	North East (medium and large)		20	25	30	40	water availabiliy
306	North East Small (pumped and gravity)		20	25	30	40	
307	Chiang rai--catchment		20	25	30	40	
308	Khong Loei-Chi-Mun Water Transfer				50	90	major development of non rice
	VIET NAM Delta						
411	Plain of reeds flood control		Areas based on actual date				No increase foreseen as area fully developed without scope for expansion
412	Long Xuyen quadrangle flood control						
413	Fresh water distribution						
415	Others						
	VIET NAM Highlands						High due to
421	Sesan Catchment		30	40	50	80	importance of
422	Serepok Catchment		30	40	50	80	irrigated coffee

Table 19 Prediction in Increases in Rice Area-Definite Future and 20 year Development

(Unit: Hectare)

		Definite future (same as existing)				20-Year Development			
Group ID	Group Description	Irrigation area	Wet season area	Dry season area	3rd season area	Irrigation area	Wet season area	Dry season area	3rd season area
	Cambodia								
111	NWISP and Sector Projects	22,085	18,256	7,019	137	89,264	85,014	11,599	167
112	JICA Master Plan Projects (small scale <100ha)	2,114	5	2,114	2,589	4,210	2	4,186	2,942
113	JICA Master Plan Projects (medium scale >100ha)	99,939	12,836	90,009	10,285	141,884	24,297	121,960	13,559
114	Mowram-MRC Inventory	107,126	78,396	36,162	0	167,663	125,627	53,713	6
115	Korean Development (KOICA)	2,350	0	2,350	0	10,166	7,816	2,350	0
121	West Mekong Schemes	188,981	109,622	90,218	3,702	214,713	129,226	99,969	4,402
122	West Mekong Prek Smao Border Canal	0	0	0	0	6,000	6,000	4,000	0
131	East Mekong Schemes	82,080	54,652	32,943	0	144,938	74,309	80,235	0
141	West Bassac FCDI	0	0	0	0	0	0	0	0
142	Trans Mekong Bassac FCDI	0	0	0	0	0	0	0	0
143	East Mekong Neuk Leung	0	0	0	0	0	0	0	0
144	Tonle Sap Mekong FCD1	0	0	0	0	0	0	0	0
145	Steung Sen FCDI	0	0	0	0	0	0	0	0
146	Steun Sreng FCDI	0	0	0	0	0	0	0	0
147	Kratie Kampong Cham FCDI	0	0	0	0	0	0	0	0
148	Tonle Sap Mekong FCD1	0	0	0	0	0	0	0	0
	Total Cambodia	504,675	273,767	260,815	16,713	778,838	452,291	378,012	21,077
	Lao PDR								
201	Attapeu Major Flood Plain	2,245	2,245	1,605	0	19,919	19,919	15,483	0
202	Borikhamxai Major Flood Plain	6,456	6,456	5,559	0	16,881	16,881	22,178	0
203	Champasack Major Flood Plain	6,180	6,180	4,490	0	32,082	32,062	26,127	0
204	Khammoune Major Flood Plain	12,470	12,470	6,885	0	42,910	42,910	35,592	0
205	Savannahket Major Flood Plain	21,595	21,595	14,429	0	63,540	62,301	40,278	0
206	Vientiane Major Flood Plain	46,080	46,080	29,555	0	55,927	55,927	44,233	0
207	Xedon Major Flood Plain	15,611	15,611	11,551	0	35,360	35,360	27,762	0
208	North Lao Upland Schemes	32,837	32,837	15,497	0	66,973	66,973	38,156	0
209	Central Lao Upland Schemes	26,642	26,652	8,420	0	69,106	68,637	39,795	0
210	Southern Lao Upland Schemes	2,035	2,035	1,328	0	56,123	56,121	43,041	0
	Total Lao PDR	172,151	172,161	99,319	0	458,820	457,090	332,646	0
	Thailand								
301	Chi Basin Medium & Large	203,753	203,753	50,938		294,137	294,137	106,663	0
302	Mun Basin Medium & Large	242,792	242,792	60,697		321,680	321,680	74,084	0
303	Chi Basin Small(pumped,gravity)	187,500	187,500			187,500	187,500	0	
304	Mun Basin Small(pumped gravity)	295,738	287,664	8,078		413,378	393,194	8,078	0
305	North East (medium and large)	129,557	129,557	32,389		247,140	247,140	71,340	0
306	gravity)	205,919	161,609			205,919	161,609	0	
307	Chiang rai--catchment	159,756	159,756	19,666		159,756	159,756	19,666	0
308	Transfer					0	0	0	0
	Total Thailand	1,425,015	1,372,631	171,768	0	1,829,510	1,765,016	279,831	0
	Viet Nam								
411	Plain of reeds flood control	288,454	247,657	24,642	288,454	288,454	247,657	24,642	288,454
412	control	310,820	265,718	28,966	310,820	310,820	265,718	28,966	310,820
413	Fresh water distribution	178,295	167,657	146,331	3,247	178,295	167,657	146,331	3,247
415	Others	950,269	847,193	463,471	876,219	950,269	847,193	463,471	876,219
421	Sesan Catchment	2,678	937	455		7,281	5,540	455	0
422	Serepok Catchment	190,757	142,047	76,439		313,104	264,394	76,439	0
	Total Viet Nam	1,921,273	1,671,209	740,304	1,478,740	2,048,223	1,798,159	740,304	1,478,740
	Total Basin	**4,023,114**	**3,489,768**	**1,272,206**	**1,495,453**	**5,115,391**	**4,472,556**	**1,730,793**	**1,499,817**

Table 20 Prediction of Increases of Rice Long Term Development Scenario

		Long Term Development				Long Term High Development			
Group ID	Group Description	Irrigation area	Wet season area	Dry season area	3rd season area	Irrigation area	Wet season area	Dry season area	3rd season area
	Cambodia								
111	NWISP and Sector Projects	89,264	85,014	11,599	167	89,264	85,014	11,599	167
112	JICA Master Plan Projects (small scale <100ha)	4,560	2	4,532	3,001	5,608	0	5,568	3,178
113	JICA Master Plan Projects (medium scale >100ha)	156,790	23,962	137,765	15,197	186,604	23,292	169,373	18,471
114	Mowram-MRC Inventory	192,441	130,445	76,796	15	233,736	138,474	115,267	30
115	Korean Development (KOICA)	10,166	7,816	2,350	0	10,166	7,816	2,350	0
121	West Mekong Schemes	229,467	138,979	107,080	5,452	254,056	155,233	118,931	7,202
122	West Mekong Prek Smao Border Canal	12,000	12,000	8,000	0	30,000	30,000	20,000	0
131	East Mekong Schemes	155,112	82,741	85,270	0	172,067	96,793	93,660	0
141	West Bassac FCDI	139,110	63,170	144,321	174,211	139,110	63,170	144,321	174,211
142	Trans Mekong Bassac FCDI	72,686	68,001	72,911	90,955	72,686	68,001	72,911	90,955
143	East Mekong Neuk Leung	94,687	56,696	95,247	98,055	94,687	56,696	95,247	98,055
144	Tonle Sap Mekong FCD1	0	0	0	0	561,821	427,198	585,791	612,838
145	Steung Sen FCDI	0	0	0	0	144,199	144,222	153,350	154,769
146	Steun Sreng FCDI	0	0	0	0	84,738	15,338	92,360	92,610
147	Kratie Kampong Cham FCDI	0	0	0	0	284,328	284,587	306,659	306,943
148	Tonle Sap Mekong FCD1	0	0	0	0	69,725	54,253	81,369	87,478
	Total Cambodia	1,156,282	668,824	745,869	387,053	2,432,795	1,650,087	2,068,756	1,646,907
	Lao PDR								
201	Attapeu Major Flood Plain	41,537	41,537	29,465	0	140,871	140,871	90,588	0
202	Borikhamxai Major Flood Plain	22,508	22,508	27,876	0	43,975	43,975	52,630	0
203	Champasack Major Flood Plain	52,647	52,607	40,634	0	144,018	143,818	99,226	0
204	Khammoune Major Flood Plain	75,397	75,397	63,269	0	218,754	218,754	180,937	0
205	Savannahket Major Flood Plain	82,736	81,084	50,515	0	166,344	164,279	92,978	0
206	Vientiane Major Flood Plain	78,703	78,703	65,434	0	197,189	197,189	176,021	0
207	Xedon Major Flood Plain	54,656	54,656	41,115	0	135,956	135,956	93,223	0
208	North Lao Upland Schemes	90,396	90,396	48,681	0	187,814	187,814	89,748	0
209	Central Lao Upland Schemes	129,108	128,378	73,754	0	416,849	415,363	228,606	0
210	Southern Lao Upland Schemes	101,958	101,952	71,396	0	283,368	283,338	170,195	0
	Total Lao PDR	729,646	727,218	512,139	0	1,935,138	1,931,357	1,274,152	0
	Thailand								
301	Chi Basin Medium & Large	294,137	294,137	106,663	0	294,137	294,137	106,663	0
302	Mun Basin Medium & Large	321,680	321,680	74,084	0	321,680	321,680	74,084	0
303	Chi Basin Small(pumped,gravity)	187,500	187,500	0		187,500	187,500	0	
304	Mun Basin Small(pumped gravity)	452,121	419,828	8,078	0	503,778	455,339	8,078	0
305	North East (medium and large)	247,140	247,140	71,340	0	247,140	247,140	71,340	0
306	North East Small (pumped and gravity)	205,919	161,609	0		205,919	161,609	0	
307	Chiang rai--catchment	159,756	159,756	19,666	0	159,756	159,756	19,666	0
308	Khong Loei-Chi-Mun Water Transfer	0	0	0	0	1,800,000	1,800,000	900,000	0
	Total Thailand	1,868,253	1,791,650	279,831	0	3,719,910	3,627,161	1,179,831	0
	Viet Nam								
411	Plain of reeds flood control	288,454	247,657	202,005	288,454	288,454	247,657	202,005	288,454
412	Long Xuyen quadrangle flood control	310,820	265,718	217,576	310,820	310,820	265,718	217,576	310,820
413	Fresh water distribution	178,295	167,657	146,331	71,526	178,295	167,657	146,331	100,792
415	Others	950,269	847,193	463,471	876,219	950,269	847,193	463,471	876,219
421	Sesan Catchment	7,938	6,197	455	0	9,253	7,512	455	0
422	Serepok Catchment	330,583	281,873	76,439	0	365,539	316,829	76,439	0
	Total Viet Nam	2,066,359	1,816,295	1,106,277	1,547,019	2,102,630	1,852,566	1,106,277	1,576,285
	Total Basin	**5,820,539**	**5,003,986**	**2,644,116**	**1,934,072**	**10,190,473**	**9,061,171**	**5,629,016**	**3,223,192**

Table 21 Non Rice Development Scenarios

Group I	Group Description	Type	Non-rice area (ha) Existing	20 YR Devp	Long Term	L.Term High Devp'ment
	Cambodia					
	Tonle Sap Tributaries					
111	NWISP and Sector Projects	Existing & New	753	3,883	3,883	3,883
112	JICA Master Plan Projects (small scale <10	Existing & New	-			
113	JICA Master Plan Projects (medium scale >	Existing & New	497	996	951	862
114	Mowram-MRC Inventory	Existing & New	3,548	5,698	5,782	5,923
115	Korean Development (KOICA)	Existing & New	-	391	391	391
	Mekong Irrigation Projects					
121	West Mekong Schemes	Existing & New	4,938	5,737	6,120	6,756
131	East Mekong Schemes	Existing & New	2,457	3,235	3,492	3,920
	Total Cambodia		**12,193**	**19,940**	**20,620**	**21,736**
	Lao PDR					
201	Attapeu Major Flood Plain	Existing & New	64	1,447	6,250	40,870
202	Borikhamxai Major Flood Plain	Existing & New	90	640	1,368	4,285
203	Champasack Major Flood Plain	Existing & New	169	1,790	6,027	35,998
204	Khammoune Major Flood Plain	Existing & New	583	2,267	6,184	30,446
205	Savannahket Major Flood Plain	Existing & New	745	7,272	16,587	59,308
206	Vientiane Major Flood Plain	Existing & New	1,653	3,627	6,832	17,250
207	Xedon Major Flood Plain	Existing & New	406	2,279	6,770	34,186
208	North Lao Upland Schemes	Existing & New	1,734	8,934	21,339	79,444
209	Central Lao Upland Schemes	Existing & New	1,822	9,299	28,654	153,685
210	Southern Lao Upland Schemes	Existing & New	71	3,950	15,451	91,902
	Total Lao PDR		**7,335**	**41,504**	**115,462**	**547,375**
	Thailand					
301	Chi Basin Medium & Large	Existing & New	30,563	54,069	64,882	86,510
302	Mun Basin Medium & Large	Existing & New	36,419	62,312	74,774	99,698
303	Chi Basin Small(pumped,gravity)	Existing & New	37,500	46,875	56,250	75,000
304	Mun Basin Small(pumped gravity)	Existing & New	57,532	101,325	133,213	198,280
305	North East (medium and large)	Existing & New	19,434	43,950	52,740	70,320
306	North East Small (pumped and gravity)	Existing & New	41,184	51,480	61,776	82,368
307	Chiang rai--catchment	Existing & New	28,018	35,023	42,027	56,036
308	Khong Loei-Chi-Mun Water Transfer	New	-	-	-	810,000
	Total Thailand		**250,649**	**395,032**	**485,662**	**1,478,212**
	Viet Nam					
	Delta					
411	Plain of reeds flood control	Existing	37,326	37,326	37,326	37,326
412	Long Xuyen quadrangle flood control	Existing	21,147	21,147	21,147	21,147
413	Fresh water distribution	Existing	42,827	42,827	42,827	42,827
415	Others	Existing	193,599	193,599	193,599	193,599
	Highlands					
421	Sesan Catchment	Existing & New	748	2,839	3,877	7,255
422	Serepok Catchment	Existing & New	34,295	94,666	127,072	231,280
	Total Viet Nam		**329,943**	**392,404**	**425,848**	**533,434**

	Dry Season Shrimp (Mekong Delta)	
Group I	**Group Description**	**Dry Season Shrimp Area (ha)**
411	Plain of reeds flood control	-
412	Long Xuyen quadrangle flood control	21,598
413	Fresh water distribution blocks	232,770
415	Others Blocks	256,665
	Total	**511,033**