Marshalling Water Resources:
A Chronology of Irrigation Development in the Chi-Mun River Basin, Northeast Thailand

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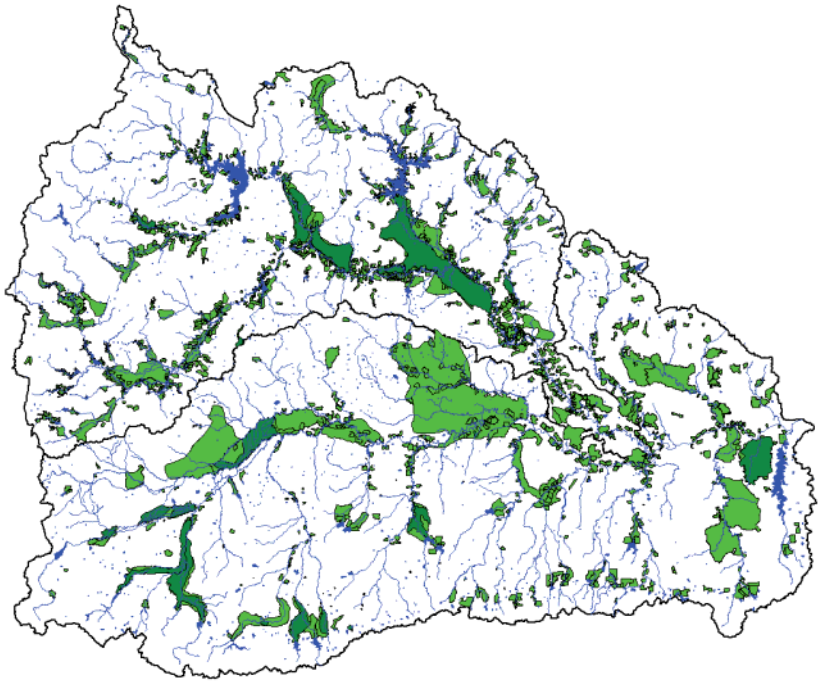

Working Paper

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Abbreviations and Conversion Factors

DEDP	…	Department of Energy Development and Promotion
DLD	…	Department of Land Development
EGAT	…	Electricity Generating Authority of Thailand
NEA	…	National Energy Authority
NEDB	…	National Economic and Development Board
NESDB	…	National Economic and Social Development Board
RID	…	Royal Irrigation Department

Area

1 rai	=	0.16 ha
1 ha	=	6.25 rai
1 ha	=	10,000 m^2

Volume

1 Mm3	=	1,000,000 m^3
1 Bm3	=	1,000,000,000 m^3

Abstract

Irrigation development in northeast Thailand has witnessed an eventful last century. The 'dry' and 'marginal' lands of northeast Thailand have been continuously reshaped, in an attempt to both balance the seasonality of rainfall and to counter the in-season variations that constrains rainfed cultivation. Apart from that, the Thai government's support for irrigation development has served many additional goals: food security and self-sufficiency, the creation of rural employment opportunities along with the support of agribusiness development, a counter-strategy against migration to the rural and national economic centers, and the fight against insurgency and the spread of communism.

Throughout this period, attempts to render nature fit for human use has been both a state and a local process. Years before the height of the hydraulic mission in Thailand, farmers and communities have diverted surface waters with earthen bunds, constructed water wheels, and scooped water from channels and ponds to supplement water for agricultural production. While mostly local in the early years of the 20th century, it was only in the 1950s, both with the advent of the states increasing attempts to draw the peripheries of Thailand closer to the central state of (then) Siam, and with international aid flowing in for water resources development, that state sponsored irrigation development started to shape the waterscape of the region. First small in scale, these developments soon turned to large and multipurpose projects, and to a regionalization of water planning and development, which (at least on paper) interconnected the river basins of northeast Thailand. Interbasin-diversion (mostly from the Mekong main stem and more recently from Laos) to supplement the regions low run-off and limited available storage sites have rationalized the expansion of irrigated areas and have triggered dreams of a "Green Northeast", an area where most agricultural land would be served by irrigation infrastructure.

We will here, revisit irrigation developments in Northeast Thailand in an attempt to periodize changes in the major schools of thought and the dominant ideologies pushing for changing water resources development options, the major impacts of these developments which in turn influenced the considered options, and the economics of irrigation development at large. Furthermore, we will propose a trajectory of irrigation development in the Chi-Mun river basin, which, linking with the proposed storyline, will quantify the developments in the last century. Through this exercise we will highlight changes in land and water use, and trace major paradigms of water resources development back to their roots.

1 Introduction

Irrigation development in northeast Thailand (Isaan), as in many other countries, has served many goals and objectives. The justifications put forward for irrigation development thus stem from a mixture of technical, socio-economical and political reasons (Molle and Floch 2007b). In a technical sense, irrigation allowed the stabilization of crop production during the wet season through supplementary irrigation during dry-spells, as well as dry-season cultivation, which would be impossible without irrigation. Socio-economically, it has been advocated as a mechanism to fight rural poverty, to ensure food sufficiency during times of rapid population growth, and to uplift (or 'modernize') the rural population through the proposed development of agribusiness which would rely on the produce from irrigated farms. Additionally, irrigation development has, over the years, served many other political (governmental) goals such as the fight against communist insurgency (as in the 1960s and 1970s), and was seen as a means to win the hearts and minds of the rural population in an effort to turn "battlefields into market places" (as in the 1980s), and to gain electoral support in rural areas (as in the early 2000s but also in all earlier periods). In retrospect, it seems, at first glance, little surprising that irrigation development has continuously ranked high on the Thai governments' policy agenda, as frequently pointed out (e.g. Sneddon 1999, 2002).

Among the four conventional geographical regions of Thailand, the Northeast has the largest share of agricultural land and the highest numbers of farms. However, farmers of the region are known to have the lowest farm income, although the average farm size is higher. Poor natural resource endowment, low fertility of soils, and the lack of storage and water resources infrastructure are regularly named as the dominant constraint to the region's development. As a result, northeastern farmers have increasingly relied on off-farm and non-farm revenues for their livelihoods, with migration to urban areas (both within the northeast and to Bangkok) being a large-scale phenomenon. This, in turn, has altered the profile of rural households in the region, including feminization and ageing of the agricultural labour force, while younger generations are increasingly employed in non-farm sectors.

While large scale state initiated irrigation in Thailand dates back to the late 19th century in the central region, it was only developed in Isaan 50 years later. The first pilot projects were constructed in 1939, but the bulk of irrigation was implemented after World War II. Today, public irrigation schemes in Thailand cover around 30 million rai (4.8 million ha) (Sacha et al., 2001), with about 7.5 million rai (1.2 million ha) in Northeast Thailand (Boonlue, 2005),

Problems associated with the implementation of irrigation projects are numerous, ranging from technical issues such as undulating topography, sandy soils with low water holding capacity, and high evaporation rates (KKU-Ford, 1982; Limpinuntana, 2001) and soil salinity (Srisuk, 1997), to more economic constraints linked to low commodity prices and labour shortage (Prapertchob 2001), and to social shocks such as forced resettlement (Lightfoot 1981). We are concerned here with the chronology of water resource development, the factors that influenced decision-making, and the various development options that have been pursued at different periods in time.

While billions of dollars were spent on irrigation development, there are however numerous accounts that irrigation has not performed as intended. Parnwell and Rigg (1995) argued that the politically motivated development concerns had delivered little in reality and that the region has largely missed the country's economic boom. This question will be addressed in subsequent working papers.

2 The Chi-Mun River Basin at a Glance

Unlike the central and southern regions of Thailand, the northeast Thailand drains towards a large international river basin: the Mekong. Thailand's contribution to this larger basin (the Thai Mekong Basin), stems mostly from the Northeast and partly from the north of Thailand, totalling some 188,645 km^2 (Koontanakulvong 2006)[1].

In 1994, the National Economic and Social Development Board (NESDB) commissioned a study on water availability in all of Thailand's river basins. The studies were based on the Royal Irrigation Department's (RID) classification of river basins in Thailand, which divides the country into 25 river basins. This classification, however, is based on both hydrological and administrative boundaries and, as Alford (1994) pointed out, on the eight natural basins which are totally within Thailand[2]. With the Chi River emptying into the Mun River near Ubon Ratchathani, some 100 km upstream of the confluence with the Mekong River, the two river systems are split by RIDs classification, though the river system that lies within Thai territory would actually be the Mun basin with its largest tributary as the Chi river. As the largest tributary to the Mekong River and the very core of regional planning efforts we will consider the Mun Basin (in Alford's sense), denoted here as the Chi-Mun River Basin[3].

2.1 Water Resources, Land Use and Population in the Chi-Mun River Basin

Hydrologically, the Mun and Chi rivers drain a good two-thirds of northeast Thailand, before emptying into the Mekong River. The drainage area of the Mun River comprises 69,700 km^2 and the drainage area of the Chi covers 49,477 km2 (THAICID 2005). Average annual runoff of these basins is 193.7 mm and 160.5 mm respectively (Srisuk et al. 2001), or 21 Bm3 in the Mun Basin and 11.2 Bm3 in the Chi-Basin (KU 2005).

The population of the Thai Mekong Basin totals more than 20 million, more than one-third of Thailand's population, but the Chi-Mun River basin population count in 2000 was reported to be 15.8 million (In addition to the dramatic population growth of the last 50 years, which peaked in the 1960s and 1970s, the structure of the population base has also changed profoundly. In the 1960s the population base of the Chi-Mun Basin was still very much a rural society, but urbanization has become increasingly important. The 2000 Population and Housing Census (NSO 2000) indicates percentages of population residing in municipal areas from as low as 7.9 percent in Surin province to as high as 21.7 percent in Khon Kaen province. In addition, a study projected that in 2015 urban population would reach 33.4 percent in the Mun Basin, and 29.5 percent in the Chi Basin (PCD 1997). Complemented by increasing off-farm employment and migration to regional and national economic centres, this dynamic has altered the structure of the rural labour force profoundly. This transition is reflected in water resources development studies (e.g. Binnie and Partners 1995) which found that "greater attention should be given to the role of women in agriculture, particularly in view of the increasing feminization of the region's rural population", and increasing accounts that farm labour in rural Northeast Thailand is getting dramatically old.

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[1] Apart from the Mun, Chi and Khong basins in Northeast Thailand, the catchment of the Kok river in the north of Thailand (15,647 km^2), and small parts of the Tonle Sap basin (4,150 km^2), also drain into the Mekong

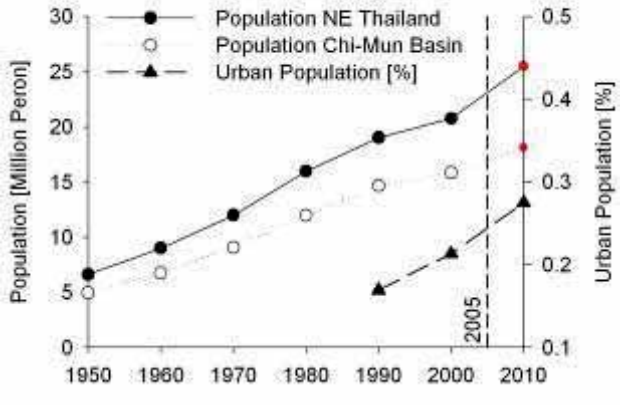
[2] (1) the Chao Phyra, (2) the Mun, (3) the Bang Pakong, (4)Mae Klong, (5) the Petchaburi, (6) the Tapi, (7) the Thale Sap, and (8) the Pattani.

[3] Other authors (e.g. Srisuk 2001) have denoted the Chi-Mun River Basin, south of the Phu Phan range (which splits Northeast Thailand into two dominant watersheds) as the Korat Basin, while naming what we will call here the Khong Basin (i.e. the set of other smaller rivers that drain directly to the Mekong river), as the Sakon Nakhon Basin.

Figure 1).

In addition to the dramatic population growth of the last 50 years, which peaked in the 1960s and 1970s, the structure of the population base has also changed profoundly. In the 1960s the population base of the Chi-Mun Basin was still very much a rural society, but urbanization has become increasingly important. The 2000 Population and Housing Census (NSO 2000) indicates percentages of population residing in municipal areas from as low as 7.9 percent in Surin province to as high as 21.7 percent in Khon Kaen province. In addition, a study projected that in 2015 urban population would reach 33.4 percent in the Mun Basin, and 29.5 percent in the Chi Basin (PCD 1997). Complemented by increasing off-farm employment and migration to regional and national economic centres, this dynamic has altered the structure of the rural labour force profoundly. This transition is reflected in water resources development studies (e.g. Binnie and Partners 1995) which found that "greater attention should be given to the role of women in agriculture, particularly in view of the increasing feminization of the region's rural population", and increasing accounts that farm labour in rural Northeast Thailand is getting dramatically old.

Figure 1: Population Growth in the Chi-Mun River Basin



Note: Projected Values and percentage of urban population: (PCD, 1997); Population Data from Population Census: Various Volumes[4]

Table 1: Main Features of the Chi-Mun River Basin and Northeast Thailand

	Mun Basin	Chi Basin	Chi-Mun Basin
Drainage Area [km^2] (a)	69,700	49,477	119,177
Population Density [person/km^2] (b)	120	112	-
Avg. Annual Precipitation [mm] (a)	1,275	1,181	-
Avg. Annual Runoff [Mm^3] (b)	21,092	11,187	32,280
Storage Capacity [Mm^3] (a)	4,255	4,246	8,501
Irrigation Area [Million Rai] (c)	2.983	2.619	5.602
Water Use [Mm^3] (a)	4,609	6,027	10,636
Irrigation	2,629	3,053	5,682
Domestic	338	195	533
Hydropower	591	2,156	2,747
Ecological Balance	957	573	1530

[4] Percentages are adopted from provincial data: The Mun River Basin is considered covering totally the provinces of Nakhon Ratchasima, Buri Ram, Surin, Sisaket, Ubon Ratchathani, Amnat Charoen, and the Chi Basin: Yasothon, Kalasin, Khon Kaen, Chaiyaphum, Maha Sarakham, Roi Et, Nong Bua Lam Phu. (While this obviously creates inaccuracies with regards to the actual basin populations, the values are assumed sufficiently accurate to give a preliminary trajectory of the increasing population in the Chi-Mun River Basin).

Tourism Industry	94	50	144

Sources: [a] (THAICID 2005), [b] (KU 2005), [c] (Boonlue, 2005)

The rainfall pattern in the Chi-Mun basin is bi-modal, with distinct wet and dry seasons, and varies from 1,000 mm on the west to 1,300 mm on the east. According to Koontanakulvong (2006), total groundwater use in the river basins that drain from Thailand into the Mekong, was estimated at 368 Mm^3, or about 1.4% of the total water resources used in 2003 (21,047 Mm^3). In the Chi-Mun River Basin, groundwater resources are predominantly developed for domestic consumption because of their low yield (average well yields are at about 2 m^3/h). In addition to low yield, underlying salt formations make groundwater unsuitable for groundwater development (Patamatamkul 2001). Srisuk (2001) reports that more than 75 percent of villages exploit groundwater for domestic and agricultural uses. Shallow wells are frequently used to complement on-farm water demand during dry-spells.

Physiographically, the landscape of Northeast Thailand consists of hilly areas, undulating land, non-flood plains, flood plains, and river levees (KKU-Ford 1982; Limpinuntana 2001). Most of the area consists in a plateau which varies from approximately 170 m to 300 m in altitude, overtopped by occasional mountain ranges whose height varies between 500 m and 1000 m. Each distinct physiographic area differs in terms of dominant landuse patterns, and both opportunities and constraints to people's livelihoods. The hilly areas of northeast Thailand are mostly found in the middle of the region, running from northwest to southeast and also along the western and southern borders. The shallow soils of the hilly areas, these days, are mostly used for tree and field crops, and are prone to soil erosion. Undulating lands accommodate both long-duration field-crops in the upland parts (mostly cassava and sugarcane), and wet season rice in the lowland; low soil fertility and drought are the main problems. The non-floodplains are mostly covered by sandy loam (and to a lesser degree by loamy clay); they are generally planted with rice in the rainy season and, if capillary soil water is available, with a second crop of peanut, soybean, water melon, etc. cultivated after the wet season. Problems associated with these areas are mostly related to flooding and soil salinity. And finally, the river levees, which are found in comparatively smaller areas, are dominated by loamy soils planted with a variety of crops, including rice, bamboo, fruit trees, vegetables and dry season crops that all benefit from receding water (Polthanee 2001).

Table 2: Land Use in Northeast Thailand and the Chi-Mun River Basin

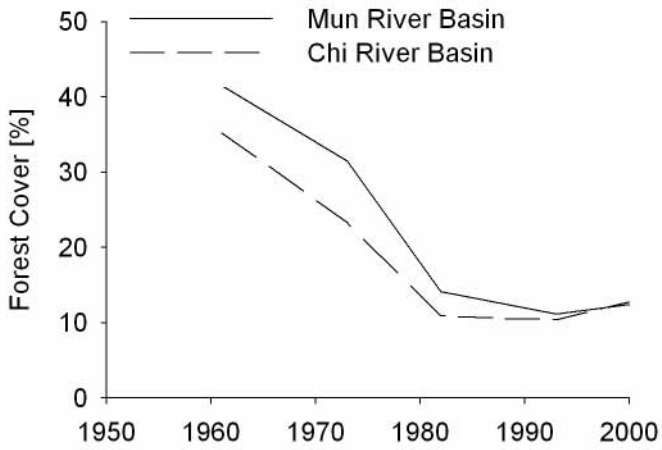
Type of Land Use	Chi-Mun River Basin [a]		Northeast Thailand [b]	
	Area [10^6 Rai]	% of Total Area	Area [10^6 Rai]	% of Total Area
Paddy Field	28.9	25.3	46.30	44
Field Crop	8.9	7.8	17.85	17
Fruit Trees and Tree crops	1.4	1.3	0.28	0.3
Idle Land	1.3	1.1	3.38	3
Grass Land	0.2	0.2	1.62	1.5
Flood Plain	n.a.	n.a.	0.49	0.5
Rivers and Reservoirs	n.a.	n.a.	1.85	1.8
Urban and Community	n.a.	n.a.	2.95	2.8
Forest	7.7	6.8	30.80	29
Total	114.2	100	105.52	100

Note: [a] Wongwiwatchai and Paisancharoen 2001, [b] Department of Land Development Land Use Study 2000 (cited in Boonlue, 2005)

The crop that –by far- dominates the agricultural landscape of Northeast Thailand is rainfed rice in the wet season. According to Polthanee (2001), some 80 percent of the agricultural land of Isaan is rainfed, with up to 75 percent of this area being devoted to rice cultivation. In 2000 the Department of Land Development (DLD) estimated land use in northeast Thailand as follows (Boonlue 2005):

Today's impressive agricultural area is the result of a rapid expansion during the 20th century. While a 1954 study on the region found that land in forest and grazing areas covered some 62 percent of the region, with only 18.4 percent being under cultivation (MOA, 1954), forest cover has been increasingly substituted by cultivation areas reaching ever further into the uplands (Figure 2).

Figure 2: Forest Cover in the Chi-Mun River Basin



Note: 1961 to 1993 Forest Cover are taken from Pednekar (1997); 2000 forest cover taken from Royal Forest Department (2001)[5]

2.2 Existing Storage, Irrigation, and Hydropower Infrastructure

During the last half century, numerous water resources development projects have been implemented in the Chi-Mun River Basin. In order to classify the different efforts of irrigation development, we will use RID's classification[6] which is based on technical and economic parameters; by storage capacity, construction costs, construction period, and water surface area (ESCAP 1991; Binnie et al. 1995; Khao-Uppatum 1992). In addition, the command area has been proposed as a classification criteria for large scale irrigation systems (Patamatamkul 2001; Sanguan 2001; Binnie et al. 1995) (Table 3).

Table 3: Classification Criteria for Large-, Medium-, and Small-Scale Irrigation Projects

Parameter	Large-Scale	Medium-Scale	Small-Scale
Storage Capacity	> 100 Mm^3	< 100 Mm^3	< 100 Mm^3
Construction Cost	> US$ 8 Mio	US$ 0.32 Mio - US$ 8	≤ US$ 0.32 Mio

[5] Percentages are adopted from provincial data: See footnote for Figure 1

[6] Additionally, medium and small–scale projects might be further disaggregated mainly based on storage capacity (see for example Patamatamkul 2001), while other accounts (e.g. Mekong Secretariat 1991b, Boonlue 2005) classified the existing irrigation projects with regards to the quality (and completion) of the installed irrigation facilities.

		Mio	
Construction Period	> 4 Years	-	≤1 year
Water Surface Area	> 15 km^2	< 15 km^2	-
Command Area	> 12,800 ha	< 12,800 ha	-

This classification has a number of implications of which two should be briefly mentioned here. First, whether a project is considered 'small', 'medium' or 'large' heavily depends on the scale of planning and the underlying visions for water resources development. The 1962 report on 'Economic and Social Aspects of Lower Mekong Development' (White et al. 1962) stressed that "those engaged in development should not engage in large-scale projects on the [Mekong] main stream, but concentrate on small-scale projects on the tributaries". From a Thai perspective, however, these 'small-scale projects' (in the early years they referred to the Lam Pra Plerng, the Lam Takhong, the Lam Pao and the Nam Pong projects), were explicitly described as 'medium' to 'large-scale' projects (Kambhu 1956). Hence the context of the source has an impact on the classification. This, in turn, has to be seen within the discourse of small(er) is (more) beautiful, advocating small- and medium scale irrigation developments. Pednakar (1997), for example, posited that the "medium-scale projects probably benefit local people more than large-scale projects, from the observation that local opposition has not been a major issue in the construction of these projects". At the same time, however, medium scale projects might experience just the same issues as larger projects. Construction of canals served by the Lam Se Bai Weir in Amnat Charoen province, for example, is currently on halt due to disagreement regarding land compensation schemes (RID Amnat Charoen 2007 Personal Communication), and in Ubon Ratchathani province, a small-scale tank project was decommissioned after 30 years of local opposition (Ubon Ratchathani University 2006 Personal Communication). Secondly, the classification of projects serves the Thai administration to assign legal prerequisites to planned projects. While large-scale projects, for example, necessitate a full-scale Environmental Impact Assessment (EIA), medium scale projects only require an Initial Environmental Examination (IEE), which bypasses the Office of Environmental Policy and Planning[7].

Apart from the more classical gravity irrigation systems which are to be classified according to the above criteria, pump irrigation has (as will be seen later) become an important feature of irrigation development in the Chi-Mun Basin. These pump irrigation projects have been mainly implemented by the Department of Energy Development and Promotion (DEDP). The Royal Irrigation Department (RID) also operates mobile pumps but these are only used in time of drought, wherever possible and needed.[8]

With more than 50 years of resource development by different agencies mostly concerned with individual project implementation, the concern with river basin management has been a challenge, starting with the mere summing up of water resources development projects that have been implemented in the respective 'administrative' basins (e.g. the Mun, the Chi, and the Khong) of Northeast Thailand. Different authors have, during the last years, presented different accounts on the number of irrigation projects and their actual irrigation areas. For

[7] Unlike the Environmental Impact Assessment, an Initial Environmental Examination need not be submitted to the Office of Environmental Policy and Planning (OEPP) for approval. The requirements for an EIA in Thailand are stated in the National Environmental Quality Act 1992, Section 46-47. This legislation lists projects or activities that need to prepare EIA Reports, including dams or reservoirs with a storage volume of 100 Mm^3, or storage area of 15 km^2 or more (OEPP 1998).

[8] With DEDP dissolved in 2002, the Royal Irrigation Department gained responsibility for these projects for a 3 months period only. After that, the responsibility for these types of pumping stations was transferred to the Tambon Administration Organization (TAO) (see below).

example, a 1998 study by Khon Kaen University (KKU 1998) found that the distribution of storage among the three dominant project classifications in Northeast Thailand was 3.4 Bm^3 for large projects, 1.2 Bm^3 for medium, and 0.65 Bm^3 for small-scale projects. In 2001 Siripong (Hungspreug 2001) estimated storage capacities in the Chi and Mun river basins to be 4.25 Bm^3 and 4.26 Mm^3, respectively. Boonlue (2005), on the other hand, found that there are currently 4.95 Bm3 of potential storage in the Chi Basin, and 4.05 Bm^3 in the Mun Basin (Table 4)[9].

Although data on overall storage is not fully consistent, design command areas of large-scale irrigation projects controlled by the Royal Irrigation Department are less controversial. Up to 2005, there were 11 large-scale irrigation projects in the basin (Table 5). Of those, 9 are gravity storage projects, while the Tung Sang Badan and the Tung Samrit projects are run-off-river diversion completed in early times (between 1939 and 1955). Storage project include single-purpose irrigation projects, while the Ubol Ratana Project (with the Nong Wei diversion serving as the irrigation diversion) and the Sirindhorn (Lam Dom Noi) Project are multipurpose, in a sense that they have attached hydropower facilities[10]. In addition, the Lam Takhong Pumped-Storage project, which has been completed in 2002, draws its water supply from the Lam Takhong project. In total, these projects have a total storage of 6.6 Bm3 and are design for a total irrigable area of 1,449,103 rai (231,856 ha).

Table 4: Irrigation Development in Northeast Thailand

Project	Chi Basin			Mun Basin			Northeast Thailand		
	No	Mm^3	Rai	No	Mm^3	Rai	No	Mm^3	Rai
Existing Water Resources Developments									
Large and Medium Scale Irrigation Projects	72	4,636.29	1.122	107	3,642.32	1.330	270	9,195.83	3.140
Small Scale Irrigation Projects	1349	227.44	0.637	1,903	337.97	1.059	4,224	815.48	2.304
Electric Pump Irrigation Projects	445	-	0.688	243	-	0.327	992	-	1.437
WRD by the Office of Accelerated Rural Development	445	90.54	0.172	90.54	73.94	0.267	610	321	0.602
Total Current Projects with distribution systems	517	4,636.29	1.810	350	3,642	1.657	1262	9,195.83	4.577
Total Current Projects without distribution systems	1,794	317.98	0.809	2,134	412	1.326	4,834	1,136.92	2.906
Grand Total	2,311	4,954.27	2.619	2,484	4,054	2.983	6,096	10,332.76	7.483

Source: (Boonlue 2005)

The construction of hydropower dams in Northeast Thailand started in 1962 with the establishment of the North-East Electricity Authority (NEA), who developed the Ubol Ratana dam from 1964 to 1966, the region's first hydropower dam (EGAT, 2005). At present there

[9] The same, 'of course', holds true for potential irrigation contemplated in different reports. We will sum up the different potentials in Chapter 4.

[10] Other project benefits, such as flood control, fisheries and domestic/municipal water supply are also been part of the project, and thus all projects might be labelled multi-purpose. We are here, however, only concerned with the major project purposes.

are six conventional hydroelectric dams and one pumped-storage hydropower plant in operation in Northeast Thailand (Table 6)[11].

Table 5: Large-Scale Storage/Irrigation Projects in the Chi-Mun River Basin

Project	Basin	Agency in charge of the dam	In service since	Storage [Mm3]	Irrigable Area [Rai]
Tung Sang Badan	Chi	RID	1955	-	180,000
Tung Samrit	Mun	RID	1958	-	153,000
Ubol Ratana	Chi	EGAT	1966	2,263	264,020
Lam Pao Reservoir	Chi	RID	1968	1,340	315,098
Lam Takhong	Mun	RID	1969	310	123,485
Lam Pra Plerng	Mun	RID	1970	149	63,100
Sirindhorn Reservoir	Mun	EGAT	1971	1,966	150,000
Lam Nang Rong	Mun	RID	1991	150	68,400
Upper Mun Reservoir	Mun	RID	1996	141	47,725
Lam Chae Dam	Mun	RID	1998	275	84,275
Total		-	-	6,594	1,449,103

Table 6: Hydropower Dams in Northeast Thailand

Project	Basin	In service since	No. of Units x Capacity [MW]	Total Capacity [MW]	Annual Production [Mio kWh]
Nam Pung	Khong	1965	2 x 3	6	17
Ubol Ratana	Chi	1966	3 x 8.4	25.2	56
Sirindhorn	Mun	1971	3 x 12	36	90
Chulabhorn	Chi	1972	2 x 20	40	59
Huai Kum	Khong	1980	1	1.06	-
Pak Mun	Mun	1994	4 x 34	136	280
Lam Takhong Pumped Storage	Mun	2002	2 x 250	500	400
Total		-	17	744.26	902

Source: (EGAT 2005)

[11] For a comprehensive overview of hydropower development in Northeast Thailand see Foran (2006)

3 A Short History of Irrigation Development in the Chi-Mun River Basin

In describing the evolution of publicly managed irrigation in South and Southeast Asia, Barker and Molle (2004) have distinguished three major eras, namely: (i) the Colonial Era (1850-1940), (ii) the Cold War Era (1950-1990), and (iii) the Era of Globalization (1990), along with defining features of each era with regards to primary goals of national and international agencies, defining events, resources availability, system management, etc. On a river basin scale, Courcier et al. (2005), in periodizing changes in water use in the Lower Jordan River Basin, have distinguished a pre-exploitation phase from an exploitation phase.

We will here adopt a similar attempt to periodize changes in irrigation development in Northeast Thailand, with some adjustment for the political circumstances and water resources development policies of Thailand. These adjustments, most notably, concern (i) the continuing independence of the country from colonial rule, and (ii) the status of river basin development and the dominant constraints for water resources developments. We will start, therefore, with a brief introduction of the status of the basin before the initiation of state sponsored irrigation projects in northeast Thailand: The Pre-Exploitation Period. With the Royal Irrigation Department starting to experiment with tank and diversion projects from 1939 onwards, we will turn our attention to 'The Early Years', which arguably lasted until the first major large-scale projects were implemented. From around 1960 to 1978, several large- and multipurpose schemes were implemented in Northeast Thailand, mostly pushed by geo-political goals associated with Cold War concerns. Finally we will conclude our historical introduction to the basin, by looking at the period from 1978 onwards, which was introduced by the publication of the two-pronged water policy (AIT 1978).

3.1 The Pre-Exploitation Period (up to 1939): A Brief Introduction

The Lower Mekong Basin, and hence the northeast of Thailand, is commonly reported to have a long tradition of water use for agriculture. There are reports of impressive hydraulic infrastructure and drainage systems scattered all over the Lower Mekong Basin (Van Liere 1980), and signs of ancient settlements are to be found all over the northeastern region of Thailand (Boyd and McGrath 2001; O'Reilly 2001), with remnants of ancient water resources infrastructure being scattered around Isaan. In fact, Van Liere (1980) found that early farmers of the region have left astonishing feats in re-sculpturing the landscape.

The first of the indianized kingdoms of which there is record was Funan in the Lower Mekong Valley (Croizat 1967). The kingdom was reported to have spread over large areas of the Southeast Asian peninsular and to have engaged in extensive drainage and irrigation works (principally in the Mekong delta). With the decline of the Funan kingdom, the Khmer empire absorbed its predecessor and seized power in the mid-sixth century, while also absorbing Funan's material culture (among others techniques of agriculture and hydraulics).

Although the reality of the Khmer 'Hydraulic Society' has increasingly been questioned[12] (Barker and Molle 2004), farmers were undoubtedly experts at trapping and storing rainfall in lakes and ponds to support a dense population. Since the decline of the Khmer empire[13],

[12] Van Liere (1980) for example argued that agricultural water use may not have been the prevailing interest of the Khmer, and that "the service of the Gods had much higher priority than the service of man"

[13] While the Mun river valley had, under the influence of the Khmer empire, several hundred settlements before the thirteen century, it seems to have been virtually depopulated for the following 400 years (Baker and Phongpaichit 2005).

irrigation works in Northeast Thailand were predominantly small in scale, with little state control (Bruns 1991).

These small scale and local irrigation developments, called "invisible" by Bruns (1991) for their blending into the landscape, have long been a 'forgotten' feature of irrigation water use in Northeast Thailand. With typical accounts of irrigation schemes building on traditional knowledge in Thailand centred on the *muang fay* systems of Northern Thailand (Uraivan 1995), the techniques used in the particular agro-climatic environment of Isaan have only been studied in more detail recently.

According to official administration reports, rice lands in the early 20th century were frequently equipped with earthen cross-stream bunds called *thamnop* (Neawchampa 1999). These local irrigation schemes have been created by farmers and constructed on the basis of informal mobilization of labour (Bruns 1991).

Fukui and Hoshikawa (2003) report that in 1920 as many as 503 earthen bunds were in place in Nakhon Ratchasima Province (Upper Mun Basin), another 101 of these systems to divert unregulated flows were to be found in Buri Ram (also in the Mun Basin), and 103 in Chaiyaphum province (which lies mostly in the Upper Chi Basin). Based on an extensive literature review and field surveys, the authors concluded that the majority of earthen bunds for irrigation were concentrated in the floodplains of tributaries to the main rivers of northeast Thailand and that, contrary to common knowledge, irrigation of paddy fields around the Mun Basin was the norm rather than the exception, with only the rapid expansion of rice areas in the later half of the 20th century transforming Northeast Thailand into the predominantly rain-fed area it today is.

While recent research increasingly point to the importance of traditional weir structures, especially in the first half of the 20th century, other accounts considered earthen weirs as insignificant. Palanisami and Apinantara (1984), for example, noted that "traditional diversion weirs constructed by farmers themselves (out of wood and mud) in the region to provide supplementary wet season irrigation for rice. However, these weirs are short lived due to poor construction techniques". In view of this, they argued, traditional weirs were unimportant and superseded by the growing popularity of modern weirs constructed "with appropriate engineering design in the region".

3.2 The Early Years (1939-1960): Experimenting with Irrigation

In order to encourage land reclamation, especially for rice production in the Central region, the government started issuing land titles from around 1905. In the northeast of Thailand, however, the new land tenure system began to be implemented only in the 1920s and 1930s. In addition, in an effort to draw the periphery closer to the central state of then Siam, the government extended government services to the provinces; amongst others water resources and irrigation development.

In 1939, the Royal Irrigation Department commenced its construction efforts in northeast Thailand with the construction of pilot irrigation tank projects and run-off-river diversions (see below): a major change with regards to water resources developments in the region. We have, therefore, adopted this year as a benchmark in the history of irrigation development in Isaan.

3.2.1 Run-Off-River Diversions and Flood Protection

The first activity of the Royal Irrigation Department in Northeast Thailand focused on the construction of run-off-river irrigation schemes, and flood-protection projects, with the main objective to create schemes that would supply additional water for wet season agriculture. Adapted from RIDs' experience in the North and Central Regions, this type of irrigation

infrastructure was first experimented with in the Chi-Mun Basin. A total of nine projects were initiated in 1939 and completed between 1955 and 1959.

Within the Chi-Mun River Basin, a total of five projects were constructed (THAICID 2004): three irrigation projects and two flood mitigation projects (Table 7).

Table 7: The early run-off-river and flood-mitigation projects in the Chi-Mun Basin

Project	Basin	Province	Area [Rai]
Lam Takhong Irrigation Project	Mun Basin	Nakhon Ratchasima	100,000
Tung Samrit Irrigation Project	Mun Basin	Nakhon Ratchasima	153,000
Huai Saneng Irrigation Project	Mun Basin	Surin	46,000
Thung Saeng Badan Flood Mitigation Project	Chi Basin	Roi Et	180,000
Ban Tum Dan Tiu Flood Mitigation Project	Chi Basin	Maha Sarakham	29,000

Sources: Agricultural Statistical Yearbook, (THAICID 2004), (MOA 1954)

The construction of diversion works for irrigation on unregulated rivers, however, was soon found to make limited sense. After 15 years of observation, Kambhu (1956) concluded that "diversion works without supplemental storage, as built in the North and Central Region, cannot be adopted in Northeast Thailand, as there is not enough regular runoff to divert continuously throughout the cultivation season". A theme that would later recur through the first feasibility studies for large-scale storage projects in the Chi-Mun River Basin.

3.2.2 The Tank Irrigation Program

"As a measure of endeavouring to give satisfaction to the people of the Northeast Region, the Royal Irrigation Department (RID) in 1939 had to expand its activities into the Northeastern Region, with 8 State Irrigation Projects constructed in seven of the [note: by then] 15 province" (Kambhu, 1956). The objective of the Northeast Thailand Tank Programme was no less than reaching the maximum number of people in the shortest possible time; a policy theme that would prove to be recurring.

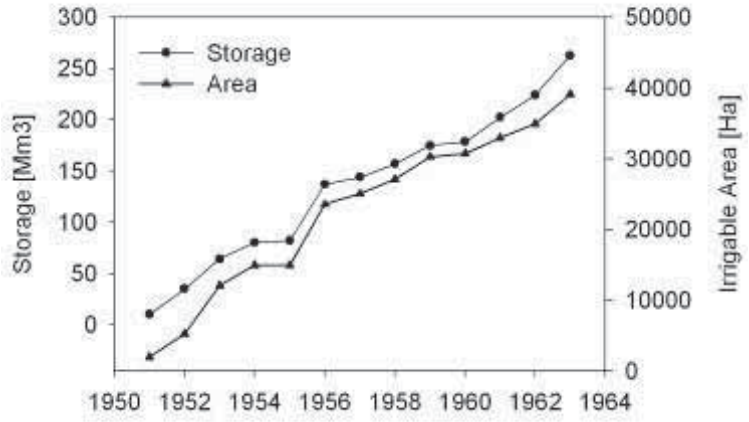
In 1942, RID started with three pilot tank projects to study their economic return and Kambhu (1956) stated that "the people were well receptive" of the idea of tank irrigation. Interrupted by the advent of World War II, the development of irrigation tanks later resumed. Already by that time, there was reservation within the Royal Irrigation Department, with Kambhu stating that "although hydrological data did not encourage the resumption of the construction, the political viewpoint indicated its necessity". Subsequently, the RID requested the FAO Mission to Thailand "to find the best solution for water problems in the region" (Kambhu 1956). The FAO report recommended Tank Irrigation in 1948[14], and the government of Thailand concurred in 1949, giving way to the Northeast Thailand Tank Programme, which was ultimately started in 1951. At completion the program would provide some 5 Bm^3 of storage (USBR 1965).

In engaging in the construction of tank projects, the Royal Irrigation Department first focused on small-scale tanks, as the lack of run-off data and the limited quality of available military reconnaissance maps made it difficult to delineate catchment areas and plan larger reservoirs. Kambhu, in re-examining RID's policy in 1956, stated that it was considered that "small projects would render less faux-pas". However, with the expansion of United States interest in Thailand, along with larger amounts of funds and construction materials becoming available from 1953 onwards, the storage volume of the tanks was increased. Whereas the early tank

[14] The Griffin Mission to Thailand also backed the rationale for the Northeast Thailand Tank Program.

projects ranged in storage between 0.32 and 9 Mm3, storage of individual projects would reach up to 20 Mm^3 in 1960, and to 30 Mm^3 in the 1970s (Tubpun et al. 1982).

Figure 3: Progression of the Northeast Thailand Tank Project (1951-1963)



Note: Adopted from RID data listed in the USBR Mun-Chi Basin Development plan (USBR 1965)

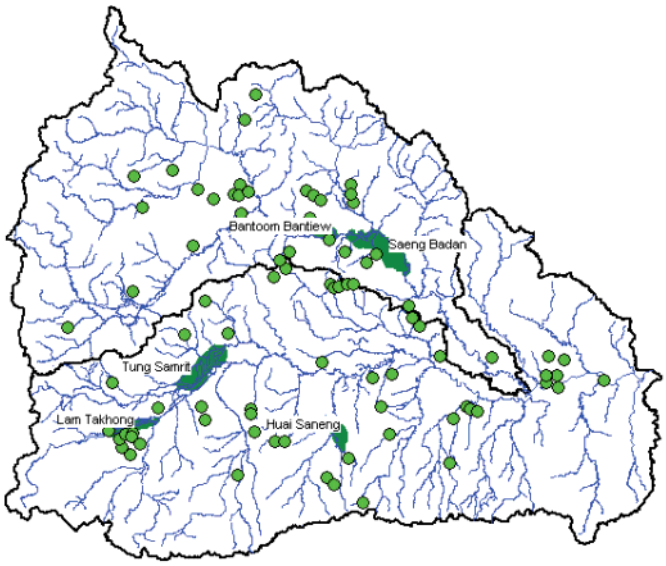
Due to the nature of the terrain and the topography, and partly due to the political necessity of having projects widely scattered throughout the basin and close to communities, the sites chosen seem not to have always been the most desirable from an engineering point of view. The tanks were often shallow and resulted in comparatively large evaporation losses but, so argued the then head of the Royal Irrigation Department, they "served their purpose exceptionally well" (Kambhu 1956).

Despite some rather positive reviews of the achievements of RID's Northeast Thailand Tank Program (e.g. Kambhu 1956), the success of the program was not undisputed. Hans Platanius, advisor to the Committee of the Development of the Northeast, reported that "the results [of the Tank project] have been somewhat disappointing" and that "many tanks were built before the necessary hydrological studies have been completed". Moreover, he concluded, that due to faulty design, the flooded areas of the tanks regularly exceeded the beneficial areas to be served (Platanius 1963).

By 1959, according to official statistics, irrigable areas had reached approximately 900,000 rai (144,000 ha) in Northeast Thailand, more than 600,000 rai (102,032 ha) potentially served by the diversion schemes, and another 250,000 rai (40,000 ha) served by the tanks (NEDB 1961)[15]. Within the Chi-Mun River Basin, the total irrigable area exceeded 550,000 rai (88,000 ha) (Figure 4).

[15] The remaining fraction was served by projects labelled "community projects" (see e.g. MOA 1954). The listed "community projects" are, however, not to be mistaken with the local *thamnop* systems which had not been mentioned in MOA (1954)

Figure 4: Existing RID Irrigation Projects in 1963



Note: Adapted from USBR (1965)

3.3 The Rise of Storage (1960 – 1978): Cold-War Engineering

With increasing pessimism about the possibility of diverting unregulated flows from the main rivers of northeast Thailand, and with the implementation of the Tank program being a comparatively slow and tedious process, in the late 1950s and early 1960s the Royal Irrigation Department increasingly looked into possibilities of large-scale storage projects.

With the communist takeover in China in 1949, the United States had already extended their military and economic assistance to Thailand (Chomchai 1994). In what was seen as vital to both Thai and American security (Steinberg 1986), the Allan Griffin Mission was dispatched to Asia in 1950 and made recommendations for economic assistance to Thailand under the Point Four program. The same year, US President Truman authorized US$10 million in military assistance to Thailand under the unexpended China Aid Act of 1948 and on September 1950, the Thai-American Accord was signed, which was the basis on which future economic support was provided (Steinberg 1986)[16].

3.3.1 The Mekong as a Source of Water for Northeast Thailand

Already by the late 1950s, the Mekong Program, with dams cascading the lower Mekong Basin and large-scale water transfer into Northeast Thailand started to shape a water vision for Northeast Thailand which, although revised and amended, would persist until today. Kambhu (1956) noted that the northeast would not benefit from large-scale irrigation development unless the Mekong is harnessed. The same year, a reconnaissance report undertaken by the USBR and commissioned by the United Nations Economic Committee for Asia and the Far East (ECAFE)[17] concluded that "of all the four countries in the lower basin of the Mekong, Thailand is the one that has the most urgent need for the development of irrigation in its northeastern region" and further postulated that "if large scale cultivation for

[16] In the two decades between 1950 and 1970, Thailand received US$615.7 million in foreign loans, of which the World Bank (56.3 percent) was the largest donor and the Unite States, with US$97.6 million the largest bilateral supporter. On the other hand, technical assistance (grants) from the United States for the same two decades totalled US$403.6 million, or 78.2% of all grants (Steinberg 1986)

[17] As a prelude to the formation of the intergovernmental Mekong Committee in 1957.

crops requiring a significant quantity of water is contemplated … the only way of assuring such supply will be to tap the flows of the Mekong" (USBR 1956; Sneddon 2003).

As a result of the 1956 report, a resolution was adopted at the thirteenth session of ECAFE to promote the development of water resources in the Mekong basin, regarding such development as indispensable for the economy of the four riparian countries of Cambodia, Laos, Thailand and Vietnam. The United Nations Technical Assistance Administration, headed by General R.A. Wheeler[18], was entrusted with carrying out further investigations, in answer to a special request made by the Committee in December 1957. Wheeler proposed fundamental investigations to be conducted: reconnaissance of major tributaries, hydrological observations, surveying and mapping, related and special studies, and preliminary planning.

Following up on the Wheeler Report, the Japanese government proposed to the Mekong Committee to undertake the "Reconnaissance of Major Tributaries", one of the items mentioned by Wheeler, which was accepted in December 1958. In surveying 34 tributaries of the Lower Mekong Basin, the study team found that though "the [northeast] region is not fertile … if the water resources within the region are collectively developed by drawing water from the Mekong, the arable land will be enlarged with greater yield, resulting in the remarkable development of agriculture" (EPDC 1960). Within the Lower Mekong Basin, the study team identified 16 sites[19] and found that the most suitable for large-scale river engineering in Northeast Thailand would be the "Nam Pong", the "Nam Gam", "Lam Dom Noi", and "Chaiya Phum"; with the Nam Pong in Thailand (with the dam later named Ubol Ratana) selected by the team as the project that appeared most favourable for development, and which consequently would undergo investigations under the United Nations Special Fund.

When, in 1970, the Mekong Secretariat detailed its Indicative Basin Plan[20], the importance of the Mekong waters ranked high on the agenda of officials concerned with developing irrigation infrastructure in Northeast Thailand; in 1973 the Thai National Mekong Committee posited that it is "truly the Mekong River itself that holds the key for the prosperity of the northeastern part of Thailand, as well as to the national power supply in the coming decades" and that "support to the Mekong Committee is firmly rooted in that promise" (Mekong Committee 1973). In addition, the 4th National Development Plan noted, that "water projects have to be implemented on a region-wide basis and more water from the Mekong River must be pumped and channelled into the irrigation canals" (NESDB 1976).

The most prominent project associated with the development of land and water resources in northeast Thailand was the Pa Mong Project (Figure 5), a Mekong mainstream dam, upstream of Vientiane (Laos PDR) and Nong Khai (Thailand), that has never gone beyond feasibility

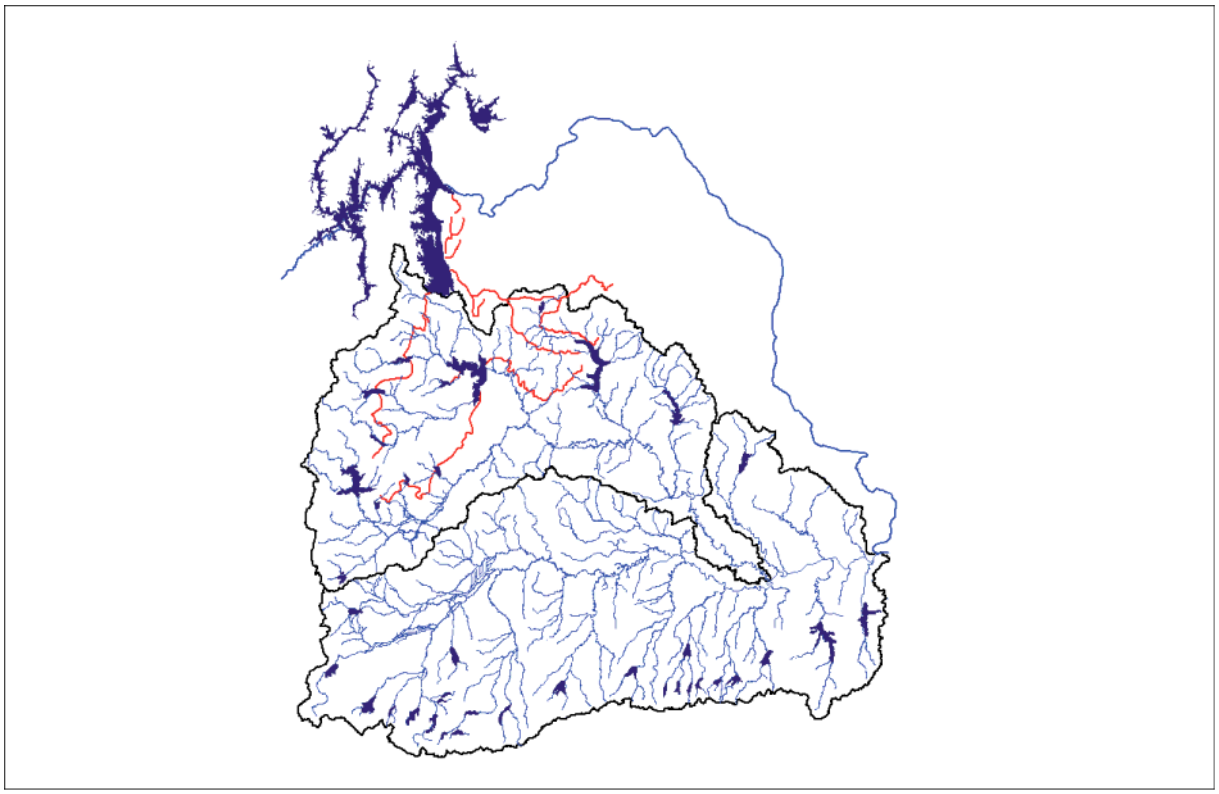
[18] The so called Wheeler Report.

[19] In Cambodia the team favored: Stung, Battambang, Prek Thnot, Stung Sen and Stung Pursat; in Laos: Nam Ngum, Se Done, Nam Lik, Nam Theun, Se Bang Fai, and Se Bang Hieng; and in Vietnam: the Upper Se San and the Upper Srepok projects (EPDC, 1960)

[20] The riparian countries attitude towards the plans drawn up in the Indicative Basin Plan was, at best, a mixed bag. It was generally thought that it would be good if the plan matured, but there was no harm if it did not because it was not realistic anyway. The projects prepared by the Mekong Secretariat were too grand and too inconsistent with the current and foreseeable needs of the countries, the considerable external resources developed to planning and investigations did not benefit the riparian countries (the assistance of donor countries was mostly utilized to finance their own experts), and at last the water resources of the Lower Mekong Basin were so vast that there was no conflict over their use. In addition, in reviewing the Indicative Basin Plan, the World Bank was highly critical of the secretaries approach to planning and recommended that any meaningful development for a great majority of the people of these countries should, in the first instance, be centred on improvements in agricultural productivity through small-scale irrigation projects, rural development and related hydropower development (Chomchai 1994).

studies but influenced generations of planners. From early descriptions as 'Prima Donna' and 'Would be giant', the Pa Mong Project would later be considered 'problematic' and 'dubious' (Muscat 1990).

Figure 5: The Pa Mong and Transfer Routes to NE Thailand



Sources: Pa Mong dam and Transfer Routes (Mekong Secretariat 1970); Proposed Dams: (USBR 1965)

First feasibility studies proposed a mainstream dam with a storage of 77 BMm³, inundating over 3,700 km^2 (exceeding even the size of Cambodia's Great Lake, the Tonle Sap!), and serving, in its initial stage of development, approximately 29,370 ha of irrigable land in Northeast Thailand and 10,620 ha in Laos (SMEC 1981). Embedded into the development of northeast Thailand's tributary projects, the project would transfer water across the Khong basin (supplying water to this area along the transfer routes, with additional irrigation schemes envisioned), and empty into the three then proposed large-scale reservoirs: the Upper Chi, the Nam Pong (Ubol Ratana), and the Lam Pao (Figure 5). "In the long run, Thailand's well-being will depend in no small measure on the Mekong. One single dam, such as the Pa Mong, could provide a massive block of power to meet essential needs" and "in the future, only Mekong water, stored behind a mainstream dam, could sustain the irrigation development needed for the region to produce enough food, rather than becoming a liability to the rest of the country" (Mekong Secretariat 1977).

Soon it was recognized by planners and decision makers, that resettlement from that large reservoir area was not feasible, and later proposals of the Pa Mong were smaller in height and capacity, though still massive with respect to other projects in the region[21].

[21] For an overview of the Pa Mong irrigation vision, along with other direct Mekong mainstream diversions for irrigation in northeast Thailand see Floch and Molle 2007b (forthcoming).

3.3.2 Thailand's Irrigation Planning

Apart from the Royal Irrigation Department's concern with the existing irrigation infrastructure, towards the end of the 1950s a number of senior officials began to contemplate the country's long-range economic prospects and international organizations continued to exert increasing pressure on the Thai government to formulate overall development policies and programs in order to mobilize maximum foreign assistance in support of public development efforts (Pakkasem 1972). In particular, the World Bank fielded a mission to Thailand between July 1957 and June 1958, which was to become the first overall assessment of the Thai economy. The mission recommended, among other things, "the establishment of a central national machinery entrusted with long-term development planning", which was in turn to do away with the lack of guiding objectives for past public development efforts, which had turned out to be unbalanced, uncoordinated and excessively diffused (Chomchai 1994). Sarit Dhanarat's 'revolutionary government', which came to power in 1958, readily accepted the mission's recommendations and proceeded to set up the National Economic Development Board (NEDB) to perform central planning functions at the national level (Chomchai 1994).

In its first planning document for Northeast Thailand, 'The Northeast Development Plan 1962-1966', NEDB proposed "two irrigation and five multipurpose projects to be submitted to lending agencies after thorough feasibility study". They would be related to the larger Mekong Development Project but would not include the Mekong project itself, as this was considered a long term vision (NEDB 1961). Furthermore, the report detailed a total of 16 potential large-scale storage projects[22] in Northeast Thailand, that would potentially store 9.2 Bm3, serving an irrigable area of 1,742,000 rai (278,720 ha).

As already indicated, the Royal Irrigation Department was not convinced by the performance of run-off-river projects from unregulated rivers. For example, in the upper Mun River Basin (on the Lam Takhong river), the Phimai Barrage and the Tung Samrit Project were considered not to be suitably supplied and a 1962 RID study specified that "the areas near to the two diversion works are increasingly opened up for cultivation and that hundreds of temporary dams, along with the construction of pumping units along the upper tributaries are causing considerable low flow in the water-deficient Lam Takhong Area" (RID 1962). In addition, the report argued that the Tung Samrit project was "fully cultivated at present, but the existing run-off-river-scheme alone is not adequate, due to its irregularity of river supply; at times it is flooded, while at others little water is available". Moreover, in 1963 another study stated that "from these works [the run-off-river projects], irrigation can only be provided during and immediately after periods of heavy rain and no water whatsoever during the dry season. Thus the increase in production is so limited and no benefits accrued from use of water from domestic, fish breeding and livestock during the dry season" (RID 1963). This, in turn, was the main argument for the construction of an upstream storage: the Lam Takhong Reservoir.

Some observations can be made here: (i) the shift from single-purpose to multi-purpose projects can be observed in project justification with domestic water use, fish breeding and flood control being put forward (e.g. RID 1962, 1963), (ii) based on its experience in river basin planning (Kambhu 1963 and planning documents by the Mekong Committee), the Royal Irrigation Department formally recognized the unity of the river basin for planning and management, (iii) the local dynamics of irrigation water use through the construction of earthen weirs and pumping stations in the upper tributaries posed questions for the further downstream state irrigation projects (e.g. RID 1962), (for example the Lam Takhong basin was arguably already early into its development experiencing competition of basin water

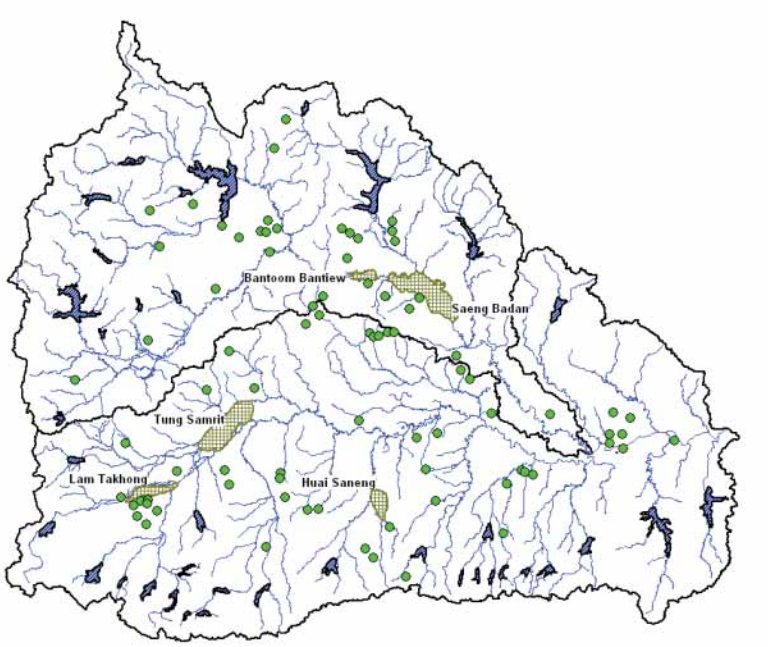
[22] Defined by today's classification as projects larger 100 Mm^3.

resources[23]), and (iv) that local water use, though constantly omitted in planning documents, was still an important feature in (at least parts) of the Chi-Mun River Basin in the 1960s.

Based on the new paradigm of River Basin Planning, the "Government of Thailand proposed, in 1964, a more detailed survey to be made for the Chi-Mun River Basin" (Mekong Committee 1978). Following the USBR Reconnaissance of the Lower Mekong Basin, conducted from 1955 to 1956 (see above), the study of the Chi-Mun Basin was, again, entrusted to the United States Bureau of Reclamation (USBR).

With the principle objective of recommending "a program for the orderly economic development of the Chi-Mun Basin, and to establish an order of priority for undertaking feasibility grade surveys on the potential projects in the basin" (USBR 1965), a study team was deployed to Northeast Thailand in 1964. Little surprisingly, the study concluded that "multipurpose water resources development was needed for orderly economic growth", and identified six priority projects; with the Lam Mun, the Lam Chi, and the Nam Yang projects being classified as first priority projects, and the Huai Khayoung, the Lam Dom Yai and the Lam Dom Noi as part of a second priority group[24]. The plan for the comprehensive development of the Chi-Mun Basin (Figure 6) thus foresaw a garland of large- and medium-scale storage on the perimeter of the basin, with corresponding downstream developments for irrigation use.

Figure 6: The Chi-Mun Development Vision of USBR (1965)



Note: Adapted from USBR (1965)

Shortly after USBR had laid out its plans for developing the Chi-Mun basin, a study of the Nam Yang Project was initiated in 1966, but it was found that the project would not be feasible. In addition, feasibility investigations were conducted on the Nam Mun and Nam Chi projects (Mekong Committee 1978). The feasibility study of the 35,580 ha Nam Chi Irrigation

[23] Indeed, Fukui et al., report that the in 1921 the Royal Thai Government had already forbidden the construction of earthen weirs on the Lam Takhong River.

[24] Apart from the six projects recommended for further direct investigation the USBR recommended that reconnaissance-grade investigations be continued of other water resources development and irrigation potentials, to identify projects worthy of consideration for the ultimate comprehensive development of these basins, a theme that would later occupy an army of both national government staff and international consultants (both at the Mekong Basin Authorities and in contract with the Thai government) in search of potentialities in the basin.

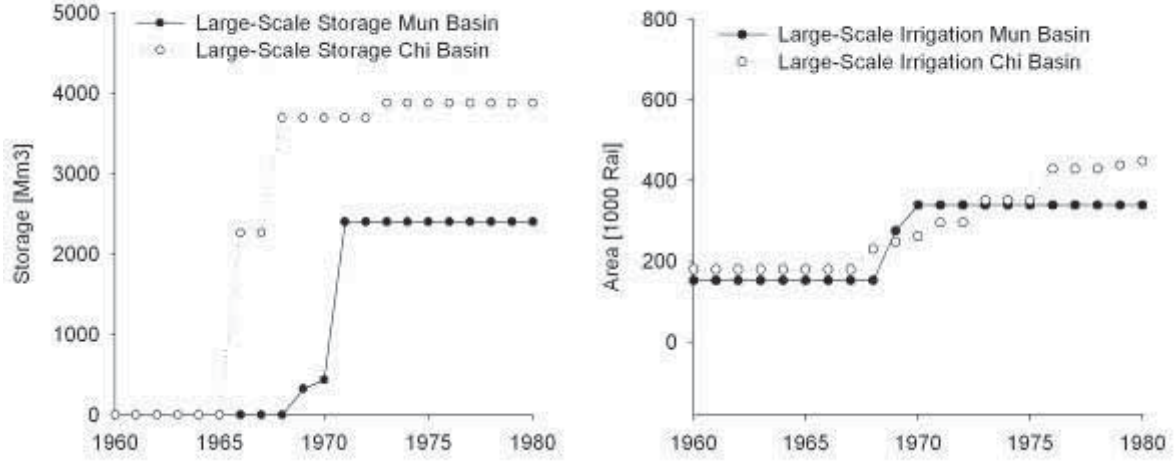
Project was completed in 1971 (USBR 1971a) and proposed the construction of a storage dam with a height of 42 m and a crest length of 650 across the Chi river. The reservoir would have a gross storage close to 2 Bm3, with a second dam (Chi Long dam), further downstream, being incorporated in the irrigation area. The feasibility study of the 19,520 ha Nam Mun Project was also completed in 1971 (USBR 1971b). Even though found justifiable in economic terms, both of these early projects were not implemented as the resettlement of farm families constituted too much of a problem[25].

3.3.3 Implementing Irrigation Projects: 1960-1978

While the large-scale visions of water resources development in northeast Thailand, as outlined by planning documents for the Lower Mekong and the Chi-Mun Basin, were far from being implemented, Thai agencies concerned with water resources development, backed with support from donor countries, embarked on the construction of several irrigation and multipurpose projects (see Table 5).

The construction of large-scale storage in the Chi-Mun basin, however, was not paralleled by an equal (or linear) expansion of the irrigation service areas. While total large-scale storage skyrocketed during the 1960 to 1978 period, totalling some 6.28 Bm^3, areas under large-scale irrigation only rose from approximately 333,000 rai (the area served by the initial projects constructed in the early years of engagement) to about 788,000 rai (Figure 7).

Figure 7: The Rise of Large-Scale Storage (1960 - 1980)



The implementation of irrigation systems had proven to be a considerably more intricate task than envisioned in earlier proposals. For example, with the exception of the initial construction of the Ubol Ratana dam and its 1984-1986 modification, the implementation of all other (sub-) projects required much more time than originally estimated (NEDECO 1988; see also Annex: Figure 23), with initial construction (1965-1974) and subsequent rehabilitation, improvement, and in the Case of Nong Wai, on-farm development (1974 – 1986) having required just over two decades.

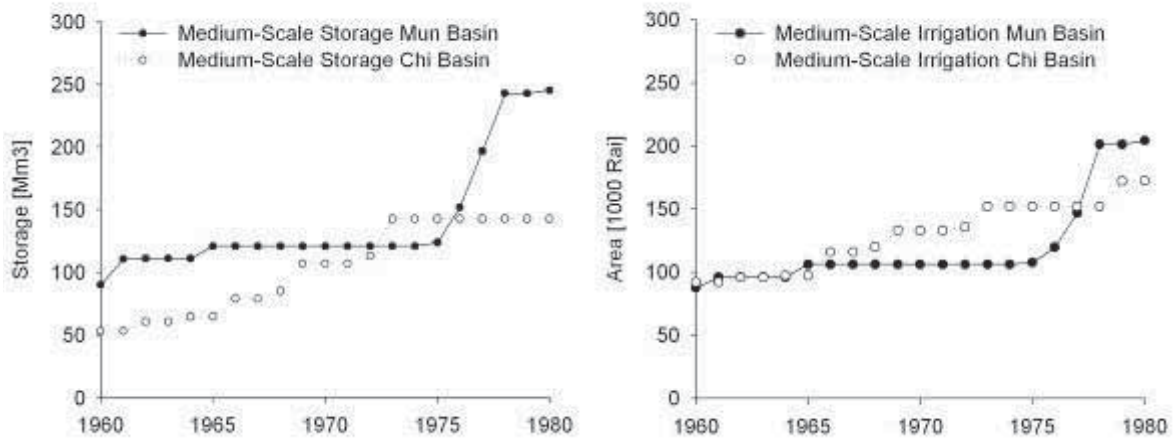
[25] The farm families residing in the Nam Chi reservoir area, were estimated to be 3,530 in 1971, and close to 5,000 by 1984 (when WATCO Consultant reassessed the project). Likewise, the number of families to be ousted by the construction of the Nam Mun project was estimated to be 760 in 1971 (WATCO 1984).

In comparing irrigation development from the 1960s to the 1970s, it was found that irrigation area in northeast Thailand increased from 174,400 ha in 1960 to 377,900 ha in the mid-1970 (Van Liere and Kawai 1973).

In fact, by 1974, the International Bank for Reconstruction and Development (IBRD) prepared an appraisal report on the Northeast Thailand Irrigation Improvement Project, comprising of three sub-project: The Lam Pao, the Lam Phra Phlerng and the Nam Pong Projects, aiming at the improvement and completion of irrigation systems covering an area of 42,000 ha served by existing large-scale reservoirs[26] (NEDECO 1988).

Moreover, medium scale projects were still being implemented and complemented the large-scale water resources developments. By 1978, total areas under small- and medium-scale irrigation, under the administration of the Royal Irrigation Department totalled approximately 385 Mm^3, serving an irrigation extent of 353,000 rai (Figure 8). And the continuation of the Tank program was carried out. However, "many of the small projects", it was argued, "such as tanks, have no distribution systems and the irrigated areas account only for 16 to 43 percent of the irrigable areas" (IBRD 1973).

Figure 8: Medium-Scale Irrigation Development: 1960 - 1980



A new form of irrigation projects was soon to develop in the Chi-Mun Basin in northeast Thailand during this period: pump irrigation (see 3.4.3). In 1965, the Mekong Committee and the National Energy Authority[27] (NEA) of Thailand, which at that time acted as the Secretariat of the Mekong Committee in Thailand, completed the 6.3 MW Nam Pung hydropower project in Sakhon Nakhon province (Northeast Thailand). Originally designed as a multipurpose project supplying 18 million kWh of electricity, re-using the released water for the irrigation of 80,000 acres in the vicinity of Sakhon Nakhon city, providing flood-control benefits for an additional 40,000 acres as well as fishing grounds for an annual catch of 200,000 kg (Julichan 1966), the project soon came under severe criticism from Thai academics who argued that it was uneconomical as the total electricity demand of Northeast

[26] In addition, the Northeast Thailand Irrigation Improvement Project had a second component; the Rainfed Rice Pioneer Project, which was designed to develop and promote techniques for attaining higher yields under rainfed conditions.

[27] Later this agency would transform into the Department of Energy Development and Promotion (DEDP), and the pumping stations would be labelled DEDP Pumping Stations.

Thailand was far below the dam's generating capacity (Kamkongsak and Law 2001)[28]. Arguably, in an attempt to minimize these critics, NEA proposed an electric water pumping project to utilize excess electricity and installed a 100 HP electric pump adjutant to the Mekong River in Nakhon Phanom province for the purpose of experimenting and demonstrating electrical energy utilization for agricultural activities (Tangaya 1994).

While the National Energy Authority was still experimenting with pilot pumping units, the Royal Irrigation Department had already resorted to diesel pumps to salvage irrigated crops in times of shortage. Between 1960 and 1972, the areas reached by those mobile pumping units ranged between 3,000 rai (1963) and 191,000 rai (1967) (Agricultural Statistics Yearbook, Various Volumes).

3.4 Diversifying Irrigation Development (1978 – 2005)

In the 1980s, ideas of comprehensive development of irrigation would explore all types of solutions in the face of the constraint of lack of storage. Localized solutions such as small tanks and pumping stations along main rivers will develop but the "dream" of a total control of the river system embodied in the USBR plans of the 1960s will reincarnate in three successive plans, only achieved in part and leaving several contradictions gaping.

3.4.1 The Two-Pronged Water Policy

In 1977, at the request of the Water Resources Planning Subcommittee of the National Economic and Social Development Board, the Asian Institute of Technology conducted a study on Northeast Thailand water resources with the objective to formulate policies, programs and projects for the government accelerated efforts to supply reliable water resources to the farmers of northeast Thailand (AIT 1978). The study, which was titled "Water for the Northeast: A Strategy for the development of small-scale water resources", received direct endorsement from Prime Minister Kriangsak Chomanand (1977-1980), and was originally entitled "Zoning and implementation strategies for small water resources development schemes in northeast Thailand". The strategy, dubbed the "two-pronged water policy", proposed (AIT 1978)[29]: (i) the rapid development of distribution systems from reservoirs and rivers, in order to deliver water to the maximum number of farm families, and (ii) the rapid development of small scale resource projects in every village as a means of meeting the basic subsistence requirements for domestic water needs, for minimal supplementary irrigation and for minimal dry season irrigation of garden plots.

Hence, the project backed the observation that little benefits had accrued from the existing projects, with large-scale irrigation infrastructure not having been completed, and found that

[28] It is worth noting here that the performance of the Nam Pung Project, later assessed by NEDECO in 1988, was found disappointing at best. With a net present worth (NPW) at 6% (apparently the cut-off rate considered in 1962 during the original studies) expressed in 1987 US$ of -15.1 million and ditto at 10% of US$ -14.7 million the project, it was found, "has clearly not produced the benefits expected at the time the decision to implement was taken". This was found even more disappointing considering the fact that the project was constructed on time and within budget. Considering that the irrigation development initially proposed in the early development plans never materialized, NEDECO allocated 45% of the common cost to this never implemented Stage 1 irrigation component, and found that the project's NPW was still negative: 1987 US$ -10.5 million at 6% and 1987 US$ -10.7 million at 10%. This, in retrospect, led the consultant to state that the project had likely been a stimulant for pump irrigation development in Northeast Thailand, and as one of the first dam projects implemented in the Northeast, had been "a valuable step on the learning curve" (NEDECO 1988).

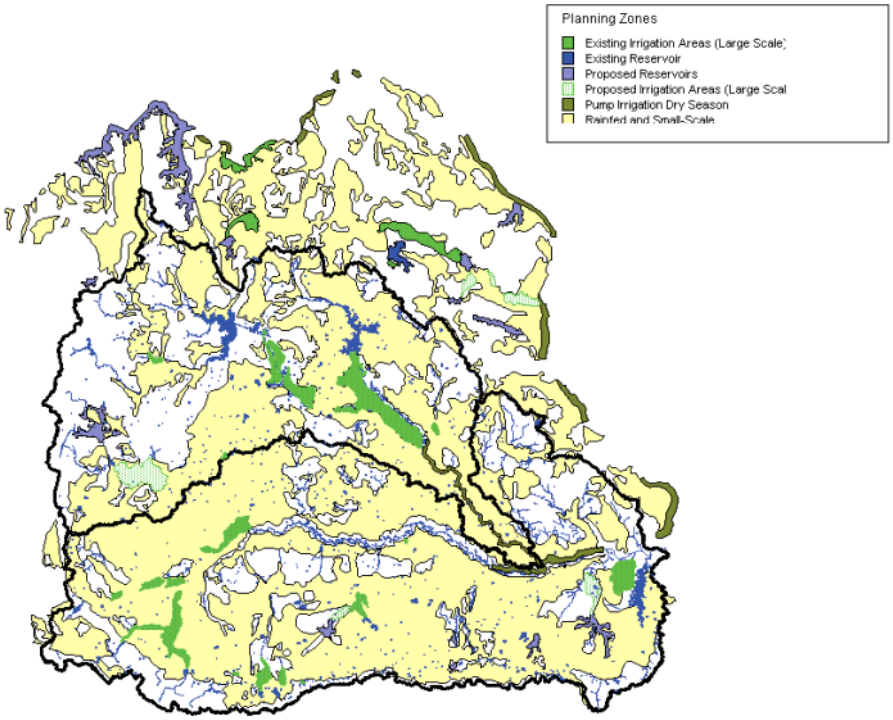
[29] For Palanisami and Apinantara (1984), investing on economically sound projects, and improving the existing schemes for better performance was the two-pronged strategy for water resources development in the region; linking the scale of intervention to the economic soundness of implemented projects.

in order to serve the maximum possible number of people in the shortest possible time, the agencies concerned with water resources development should engage in the construction of small-scale projects; particularly tanks and weirs.

For implementation, the planning document divided the northeast into three major zones (Figure 9):

- Zone I: Areas irrigable by large reservoirs, which can provide water for a total irrigable area of 2.1 million rai, and benefit 8 – 9% of farm families[30].
- Zone II: Areas irrigable by pump irrigation from reliable rivers which can provide water for a total irrigable area of 1.9 million rai in the wet season and benefit a maximum 10 % of farm families.
- Zone III: Areas inaccessible from large reservoirs and reliable rivers, which contain 80% of the rural population and where small water projects at the village level, as well as larger tanks in selected locations are required to supply basic village water requirements.

Figure 9: Development Zoning for the Two-Pronged Water Policy



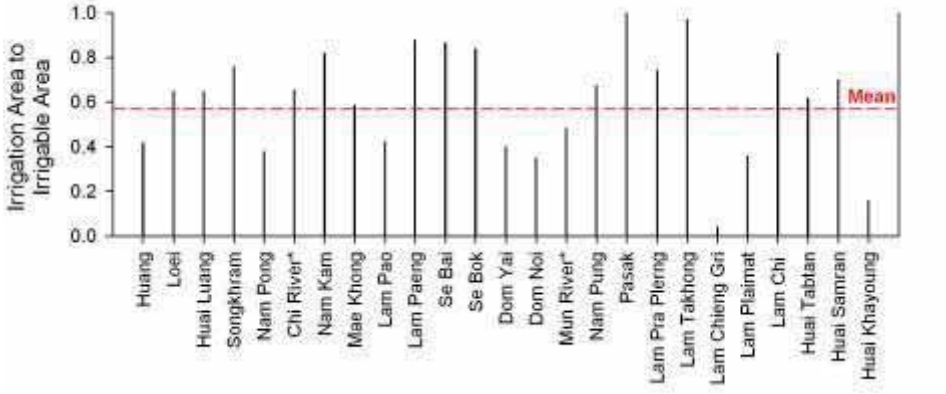
Source: (AIT 1978)

It was further concluded that, in general, supply in Zone III projects will not be sufficient for year-round irrigation as a basis for economic development. Adding the various requirements, the basic needs of a typical village were estimated to involve storage of the order of 100,000 m^3, or alternatively 1,000 m^3 per family.

Due to a number of difficulties in the completion of reservoir projects, the area actually irrigated by reservoirs remained considerably smaller than the total command area (estimated at 4.2 million rai in 1978 in the whole of Isaan; AIT 1978; Figure 10)[31].

[30] The emphasis on distribution of water resources in the region takes two major forms. Support, both political and financial, is essential to the completion and maximum extension of distribution systems from the large reservoirs and reliable rivers. In the future, as more and more distribution systems come into operation, limited water supplies will have to be shared among water users in the various provinces. A Mun-Chi River Basin Authority may be needed to monitor and ration water supplies.

Figure 10: Actual irrigated area as percentage of design command area in northeast Thailand (1978)



Note: RID projects completed in 1978 and under construction in 1979 (cited in Suchart et al. 1981)

In addition to apparent deficiencies in large-scale irrigation systems, the study team found that "none of the [small-scale] projects had a completed distribution system, and a large percentage had no distribution system at all". Since "operation and maintenance procedures", the report specified, "had been left to the local people, with little explanation or assistance from the agencies, many of the systems were incomplete, non-existent or in serious disrepair[32].

While the report found that in many cases rehabilitation of existing systems could meet a considerable portion of this basic requirement, it found that "it must be accepted that in many cases villages will continue to rely on further development of rainfed agriculture, and cannot expect the benefits of fully irrigated agriculture". In addition, it was stated that "natural conditions, land capability and rainfall constraints make it impossible, within present knowledge and resources, to provide for irrigated agriculture throughout northeast Thailand" and that "large areas remain inaccessible to reliable water resources, but that, at the same time, development cannot be restricted to areas suitable for irrigated agriculture" (AIT 1978).

However, it was noted that "realizing that the water resources of the Northeast are still grossly inadequate to meet irrigation needs for the region, long term development will require substantial additional investment in large and medium scale dam construction" (AIT 1978). Hence, although the two-pronged water policy might at first appear as a step away from large-scale irrigation development, it appeared that it merely reshuffled and reordered preferences towards completion of existing infrastructure and implementation of small-scale developments in the short-run, while retaining the long-term vision of the needs for irrigation development. This, however, does not mean that the overall rhetoric of water resources development appear to have been more sensitive towards environmental impacts[33].

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[31] AIT (1978) cited different studies ranging, for wet season irrigation, from as low as 187,000 rai to as high as 1,211,250 rai, and for dry season irrigation between 50,000 and 55,000 rai. Additionally, AIT cited a study on three small reservoirs (tanks) with irrigated areas only ranging between 18% and 43% in 1973.

[32] On the same wavelength, Wang (1973) remarked that "farmers have no equipment, techniques or financial resources to do such work [on-farm development] even if they were interested" and that "farmers in the project area have no enthusiastic and responsible attitude to maintain the distribution system already constructed". Instead, the study found that "60 percent of the constructed system was damaged by farmers during the first five years of the project" and concluded that "the real useful life of all the irrigation structures is probable half or one-third of their expected survival life. Therefore, the farmer's organization, educational program and group action to make good use of the irrigation system become the determining factors for the establishment of a successful water development project" (Wang 1973).

[33] For example, a study on the development of the Tung Kula Ronghai Area by Chulalongkorn Univesity, commented on a proposal of water import through a Mekong-Mun Cascade, a scheme that would pump water through a cascade of reservoirs along the Mun river (with structures at Satuk, Tha Tum and Rasi Salai), that

Table 8: Arable Land, Water Resources and Irrigable Land in Northeast Thailand: 1978

	Storage in [Mm³]	Areas in [Rai]
Arable Land Suitable for Paddy Suitable for Upland Crops		62,560,000 22,640,000 39,920,000
Land Use Paddy Upland Crops		43,125,000 35,000,000 8,125,000
Existing Storage In existing large scale reservoirs In existing tanks Planned Storage In planned reservoirs (excl. Pa Mong) In planned tanks Total Potential Storage	5,611 4,833 778 8,782 7,867 915 14,393	
Irrigable Area from Existing Resources Large Scale Reservoirs Tanks Pumping Irrigable Area from Planned Resources Large Scale Reservoirs (excl. Pa Mong) Tanks Pumping Total Potential Irrigable Area		4,205,495 1,193,300 1,112,195 147,000 2,973,195 2,218,650 754,545 1,900,000 7,178,690

Source: (AIT, 1978)

3.4.2 Small-Scale Irrigation Development

Since the mid-1970s, the Thai government had greatly increased its funding of small-scale water resources development. Up to the late 1980s, the Royal Irrigation Department had built over two thousand small scale weirs and reservoirs in northeast Thailand, and even more small weirs were funded by the Job creation Program (Bruns 1991). In 1975, in an attempt to decentralize water resources development, Kukrit Pramoj's government initiated the Tambon Fund, seen by Bruns as a radical innovation in how rural development was to be carried out[34]. The concept of the Tambon Fund was institutionalized in the Job Creation Program that was started in 1980 and continued on the following years by successive governments headed by Prime Minister Prem Tinsulanonda. Among the priority projects for rural development were water resources developments, and weirs and ponds constructed under this program would later be labeled "Kukrit weir" or "Kukrit pond". Equally, for the first time, large amounts of money flowed through the hands of local leaders. And according to Bruns, the hurry with which the program was implemented triggered problems with regards to the quality of construction, poor choice of projects, and corruption. The program, however, "was very popular at the local level" (Bruns 1991).

Another program for small-scale irrigation development, that would receive some attention later on, was the construction of weirs under the Khon Kaen University– New Zealand Weir Program (KKU-NZ). With an average of 3 to 5 villages benefiting from one constructed weir and initial investments of 100,000 baht (at 1986 prices) for a crest length of 10 – 15 m, the

careful considerations should be given with regards to the intrusion into the floodplains of the Mun basin, along with its impacts (CUSRI 1981; Volume II, Chapter 8).

[34] In addition, the creation of the Tambon fund represented an important innovation in Thai politics, and was tied to the "Democracy Period", the growth of electoral agitation by rural people who had previously been excluded from the political process (Bruns 1991).

projects have reportedly been successful with regard to the "income earned from growing vegetables and summer crops"; in Ubon Ratchathani Province it was found that "within one year, growers can expect to get the return of capital plus profit" (KKU-NZ-UBON Weir Program 1986).

At the same time, the earthen weirs (*thamnop*), which had long been in use for supplementary irrigation in the tributaries of the Chi-Mun river basin, were increasingly replaced by concrete structures that would, arguably, better suit the farming population of the region[35].

3.4.3 Pump Irrigation

With the two-pronged water policy (AIT 1978; see above) designating 10 percent of northeast Thailand to be supplied through means of pumps, this option became the defining feature of the following 20 years in Northeast Thailand.

In the wake of criticism with regard to the investments in the Nam Pung project (see above), in 1965, the Department of Energy Development and Promotion (DEDP; by then NEA) installed a 100 HP electric pump with a 6-inch transmission line, covering an area of 1,000 rai (160 ha) adjacent to the Mekong River (Nakhon Phanom province) for the purpose of experimenting and demonstrating electrical energy utilization for agricultural activities (Tangaya 1994)[36]. According to Tangaya (1994) the Local Administration Department "came to realize the efficiency and the comfort of using electrical pumps and, therefore, in 1968 the Demonstration Pump Project was carried out". A total of eight pumps were installed in the northeastern provinces of Nong Khai and Nakhon Phanom.

First operated by the Local Administration Department, with the Department of Energy Development and Promotion as technical advisors only, the operation of the pumps was soon fully transferred to DEDP (in 1971)[37].

Originally, DEDP justified the implementation of pumping schemes by pointing to the limitations of the existing gravity irrigation schemes, built and operated by the Royal Irrigation Department, explaining that such (gravity) projects were unsuited to the high plateau of the northeast region with its undulating landscape (Kamkongsak and Law 2001).

In 1978, the Government, "recognizing the significance and success of the project in solving drought problems in northeast Thailand", requested DEDP to speed up the work, and the consecutive Fifth National and Social Development Plan (1982 – 1986) emphasized this through setting a target for the implementation of pump irrigation at a rate of 200,000 rai or 80 stations per year all over the country (Tangaya 1994). The two-pronged water policy found that "pumping irrigation for dry season cropping is effective and has considerable potential,

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[35] For a more detailed account on the history and nature of the *thamnop* irrigation system, see Fukui and Hosikawa (2003), Hoshikawa (2004).

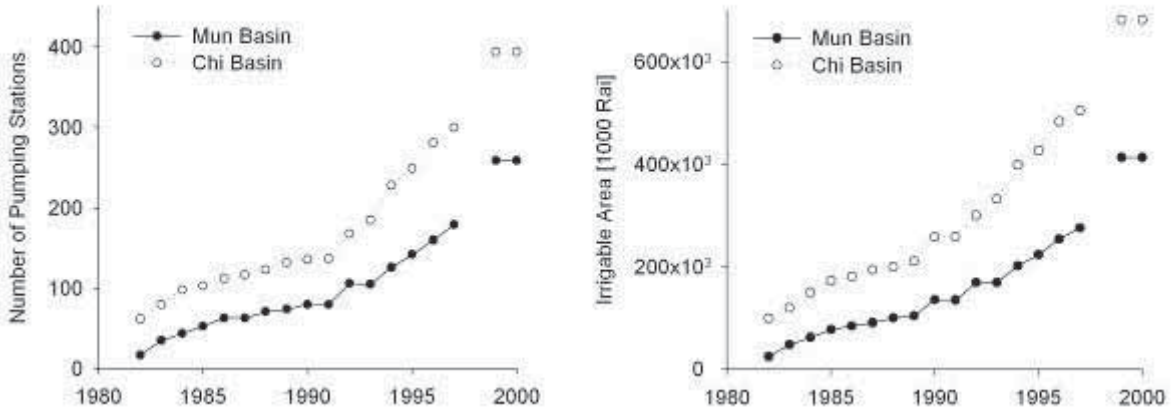
[36] The written accounts of the objectives of pump irrigation schemes, as with other accounts, vary from source to source. In pursuit of the Mekong Irrigation Programme, the Mekong Secretariat stated in 1983 that the objective of the DEDP (NEA) Pump Programme was to: (i) increase agricultural development in northeast Thailand, and to stabilize crop yields and production through the implementation of electrical projects in suitable areas, (ii) to form farmer irrigation associations for future operation and maintenance as well as servicing of the projects, (iii) to foster the social and economical development of the northeast through the implementation of (i) and (ii), and (iv) the improvement of the political status of the northeast region through the above mentioned social and economic development (Mekong Secretariat 1983). On the other hand, Tangaya (1994) listed: (i) The promotion of electricity utilization for agricultural activities, (ii) the promotion of rural development, especially the areas adjacent to water sources where electricity is available. With irrigation systems, farmers will be able to develop year round cultivation and increase agricultural produces as well as income, and (iii) to promote electrical utilization in rural areas for the well-being of the people.

[37] The transfer of responsibility for pump irrigation to DEDP was justified on the grounds of "unsuccessful maintenance" of the then 11 installed pumping stations (Tangaya 1994).

with the most attractive features mentioned the need not to construct storage facilities, the possible rapid speed of implementation, and the few technical problems that were expected to be faced" (AIT 1978). Early into the phase of accelerated implementation, the Mekong Secretariat (1983) commented that "pump irrigation projects have been developed with some success, and are of interest to the Thai Government and the farmers in the region, as these projects can be implemented within a short period of time and with low initial investments." This was backed by the observation that an estimated 40 percent of the total northeast population were living within nine kilometers from the three major rivers and could be conveniently served by the pumping stations.

From 1980 to 2000, pumping stations sprouted throughout the Chi-Mun river basin and northeast Thailand. While the total number of stations in the Chi-Mun basin rose from 79 in 1982 (155 for Northeast Thailand) to some 653 in 2000, the potential irrigable areas supported by these stations grew from 124,000 rai to over 1,000,000 rai[38]. In 2000, the government claimed, that out of the total irrigated area of about 5-6 million rai in Northeast Thailand, some 40 percent were being irrigated by electric pumps.

Figure 11: Development of Pump Irrigation: 1980-2000



Note: The presented figures are adopted from various volumes of the Agricultural Statistics Yearbook, with number of projects aggregated from provincial data, as indicated above[39].

Although it was argued in 1991 that the pumping stations were (and are) "selected at locations where there is enough water throughout the year, and the amount of water and the amount of water pumping designed in such a way that it does not cause shortage downstream" (ESCAP 1991), this had already been questioned by several observers. Palanisami and Apinantara (1984) citing AIT (1978) and Sriswasdilek (1983) concluded that "pumping schemes have limited success due to the problems of inadequate dry season river flows, which lead some pumping schemes failing to perform better in achieving the target benefits"[40]. In 1988, a water

[38] It might be noted here that pump irrigation, in the early years, was predominantly a Northeast Thailand phenomenon with over 80 percent of all implemented stations in that region. By 2000, however, out of the total 1973 pumping stations in Thailand, only 51% where located in northeast Thailand.

[39] The apparent hike in projects from 1997 to 2000 can, so far, not be confirmed nor ruled out, and is therefore presented as in the original data. The presented data, however, is confirmed by Sanguan (2001) who states that there are more than 600 pumping stations in the Chi-Mun basin, with a total irrigated area of some 500,000 rai. Considering the low cropping intensity observed in the basin, Sanguan's number is probably an overstatement, while confirming the major trend of pump irrigation.

[40] The study also pointed to the competition for implementing pumping schemes between the Royal Irrigation Department (RID) and the National Energy Authority (NEA): "The current problem is the increasing number of

use study on the Chi Basin, found that, as the river flow is reduced during the dry season, with those stations located downstream beginning to suffer from shortage (RID 1988). In addition, the Interim Mekong Committee, as part of their Mekong Irrigation Programme[41], conducted an economic analysis of pumping projects in northeast Thailand and found that "agronomic potentials of the irrigation systems were underutilized and that the actual irrigated area, compared to the pumping capacity, as well as crop productivity, were low" (Mekong Secretariat 1991). More recently, Komkongsak and Law (2001) argued that on average only 210 rai (33.6 ha) are devoted to dry season agriculture "because farmers cannot meet the costs of electricity and fertilizer that are required for a second crop"[42].

While DEDP pumping projects spread along the Mun and Chi rivers and its major tributaries, the Royal Irrigation Department expanded the stock of mobile pumping units it had run since 1964. These moveable pumps were reported to serve some 290,000 rai in the wet season and about 330,000 rai in the dry season (Palanisami and Apinantara 1984). Mobile pumps are, nowadays requested by farmers via the Tambon Administration Organization (TAO) for minimum areas of 300 rai (Personal Communication RID Amnat Charoen, 2007).

With the dissolution of the DEDP in 2002, the Royal Irrigation Department was granted responsibility for the (former) DEDP pumping stations for a brief 3 month period, before they were, again, transferred. This time the TAO sought responsibility and is now handling all related activities, with the Royal Irrigation Department's being consulted from time to time (Personal Communication RID Amnat Charoen, 2007).

3.4.4 Medium-Scale Irrigation Development

While DEDP was rapidly implementing pumping stations along the rivers of northeast Thailand, the Royal Irrigation Department increasingly embarked on the construction of medium-scale irrigation projects. This change in emphasis, away from the large-scale construction in the 1960s and 1970s, resulted from several factors: (i) the exhaustion of suitable areas for large-scale engineering, (ii) the large-number of resettled people during earlier phases of basin development, (iii) the up to the 1980s poor performance of large-scale irrigation projects, and (iv) medium-scale projects (as indicated above), did (and still do) not require a full-scale Environmental Impact Assessment. In addition, NESDB was increasingly skeptical towards the Irrigation Department large-scale irrigation projects and demanded more stringent proof of economic viability before allocating funds to this type of investment.

From mid-1980s onwards, various studies proposed the construction of medium-scale irrigation projects. DHV Consultants et al. (1991) proposed some 76 medium scale projects in

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pumps being initiated both by the NEA and the RID. The number of pumps upstream of the rivers is increasing, resulting in low river flows for the downstream pumps, particularly in the later part of the dry season. This causes water uncertainty and reduced crop acreage. Hence an appropriate strategy with a good mix of the NEA and RID is increasingly needed for efficient use of the pump projects. This will help to avoid the mushroom growth of pump, and will help provide full season water supply to exploit the dry cropping to the full extent. If this strategy is practically feasible, then it will further help eliminate the problem of improper site selection for future pump projects, as currently to achieve more target on pump projects many pump projects are started in locations unsuitable for steady pumping" (Palanisami and Apinantara 1984).

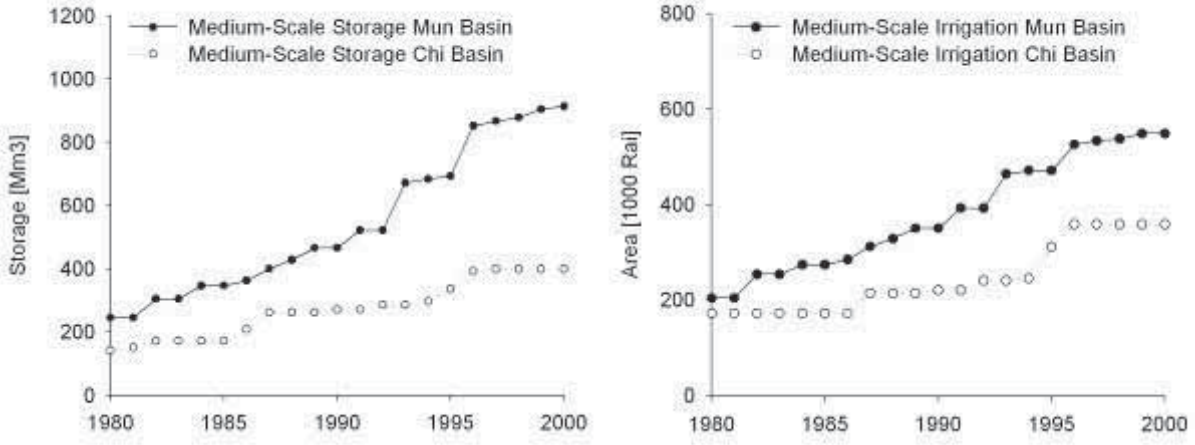
[41] The Mekong Irrigation Programme (MIP), hosted by the Mekong Committee and sponsored by the Government of the Netherlands, lasted from November 1988 until May 1991. Its overall objective was to increase agricultural production in pump irrigation schemes in Thailand and Lao PDR through improved water management and other support services (Mekong Secretariat 1991).

[42] This observation is supported by actual dry season cropping on the Lam Se Bai, stated by RID officials to average 10% of the irrigable area (RID Personal Communication 2007). On the other hand, field visits to pumping stations around the city of Ubon Ratchathani confirmed that there are extreme variations with regards to water use in the pumping schemes, with some farmers reporting to be able to cultivate three crops of rice per year, while another station, some 2 km further upstream, was largely idle during the 2007 dry season.

the Chi-Mun basin; A&R consultants (1994) proposed the construction of 55 medium-scale projects from 1995 to 2000.

During the 1987-1991 period, some 13 medium-scale projects were completed with a live total storage of 11 Mm3 and an irrigable area of 11,462 ha (Pednekar 1997).

Figure 12: Medium-Scale Irrigation Development: 1980-2000



By 2005, the total storage in medium-scale projects in the Chi-Mun basin had accumulated to some 1.3 Bm3 serving a potential irrigable area of approximately 985,000 rai (157,600 ha).

3.4.5 Large-Scale Gravity Irrigation Development

While feasible during earlier days, large-scale irrigation engineering was found to be no longer possible. Yet, in 1978, a desk study of the Interim Mekong Committee found 14 projects sites in northeast Thailand to be worth further study (Mekong Committee 1978)[43]. This was ruled out just six years later by WATCO, a consultant appointed by the Committee to study project options in the Lower Mekong Basin, as part of the Lower Mekong Information System (WATCO 1984). According to the consultant, most of the projects considered in the 1978 desk study would either create large resettlement problems or were economically unfeasible. The only projects that appeared attractive to the consultant were the Lam Saphung and Huai Pa Thao power projects, and the Lam Dom Yai irrigation project with an irrigable area of 36,000 ha. From a gross storage of 664 Mm^3 water would have to be pumped from the reservoir to two pumping stations, one on each bank, to supply the irrigation area. However, with a 1984 cost estimated at US$191 million (US$ 5,310 per hectare), the consultant posited that this "is probably too high compared with the benefits that can be derived from irrigation" (WATCO 1984)[44].

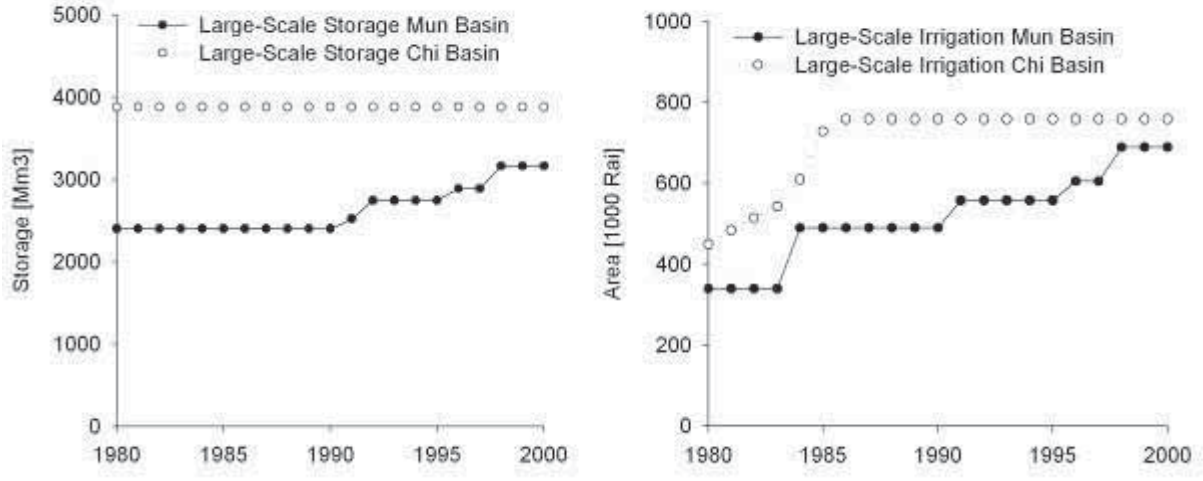
Other large-scale projects, which had already been introduced by USBR in 1971, were re-studied by various consultants and consecutive studies in the 1980s looked into the possibilities of developing the area south of the town of Chaiyaphum for irrigation. Scaled

[43] The study found that a total of 122,350 ha could further be irrigated by large-scale projects in the Chi-Mun basin (34,110 ha in the Chi basin and 88,240 ha in the Mun Basin) with a total gross storage of 3.0 Bm3 (793 Mm3 in the Chi basin and 2.2 Bm3 in the Mun basin). Most notably, the Lam Dom Yai project was proposed with a gross storage of 664 Mm3, the Lam Se Bai (Alternative II) with 445 Mm3 and the Huai Khayoung with 504 Mm3.

[44] The Lam Dom Yai Sub-basin was later studied by various consultants in search for possible irrigation developments, e.g. (JICA 1992), (Binnie and Partners 1995). While deemed unattractive by the EU-Funded Binnie and Partners study, the project was later bundled into the overall water resources development scheme for northeast Thailand labelled Khong-Chi-Mun (see below).

down in size, studies of the dams at Yang Na Di (92 Mm^3), Nam Chi (136 Mm^3) and Prong Khun Phet (108 Mm^3) were studied and later reassessed by BIWATER as part of the Green-Isaan Study (BIWATER 1987). The development of this area was later studied by Sir Alexander Gibb & Partners and TEAM consultant as part of the Chi Basin Water Use Study (RID 1988). Prefeasibility study, however, suggested that "up to 1,000 families could be resettled in an area adjacent to the reservoir area, but that it would be difficult to resettle larger numbers" (BIWATER 1987). Up to now, the development of the Upper Chi has not materialized.

Figure 13: Large-Scale Gravity Irrigation Development: 1980-2000



The only large-scale irrigation developments that the Royal Irrigation Department could finalize were the relatively smaller Upper Mun Project (1996) with a total storage of 141 Mm^3 serving some 47,725 rai and the Lam Sae Reservoir (1998) with a storage of 275 Mm3 designed to supply 84,275 rai, both in Nakhon Ratchasima province. In the Chi river basin the Royal Irrigation Department was not able to secure funding for additional storage projects but embarked on the completion of the irrigation service areas that were not completed from initial project implementation.

3.4.6 Channel / Floodplain Storage

With the above mentioned (at least perceived) problems associated with pump irrigation from unregulated (or natural) rivers (see 3.4.3), planners were already early in the 1980s contemplating ways to harness the rivers of the Chi-Mun Basin in order to ensure maximum benefits from the rise of pump irrigation. In addition, by the late 1980s it became increasingly clear that the traditional storage reservoirs would neither be economically feasible (with most, if not all, of the favorable sites already been exploited), and that resettlement, resulting from inundating larger areas for storage construction would make the implementation of large-scale storage projects problematic.

These factors served as the two single most important justifications for the construction of storage in the floodplains of the Chi-Mun River Basin. By 1989, the (Interim) Mekong Committee argued that "it had introduced a new concept in the design of flood-control and storage projects, by constructing reservoirs in the areas affected by annual flooding" (Mekong Secretariat 1989). With this new concept, altogether four projects capable of irrigating another 160,000 ha (or 1 million rai) were identified, including the Huai Mong flood-control and irrigation project (Khong Basin) which was completed in 1985. Two other projects, namely the Nam Suai and the Lower Mun Project had been found economically and technically

feasible, and a feasibility study for the Nam Songkram Project (Khong Basin) had been proposed and was later conducted.

The first feasibility study considering the use of the floodplains of the Chi-Mun basin for storage was conducted in 1982 by Dutch consultant NEDECO on behalf of the Interim Mekong Committee (NEDECO 1982a). It proposed to construct a reservoir in the floodplains of the Mun river, 35 km downstream of Rasi Salai. Recognizing the problems affecting pump irrigation in the Chi-Mun Basin, the consultant stated that "a large number of pump irrigation projects are under construction or planned along the Mun river", and that, "these projects will fully utilize the irrigation potential of the unregulated flow of the river" (NEDECO 1982b), highlighting the major advantage of the floodplain storage being that "resettlement problems will not arise since all the villages lie well above the normal flood levels.

The idea of channel storage (intruding into the floodplains, at least in the Lower Chi-Mun basin), was further developed during the Chi Water Use Study in 1988, which looked at the possibility of development "a cascade of regulated reaches with dams located at an average interval of about 80 km, each providing an active storage of about 15 Mm^3 (RID 1988). With the length of the Chi river taken as 800 km from near Chaiyaphum to the confluence with the Mun River above Ubon Ratchathani, the study found the theoretical possibility of ten channel storage reaches and approximately 6,000 ha[45].

3.4.7 Completing and Upgrading Existing Irrigation Infrastructure

Apart from the focus on establishing small-scale irrigation tanks and weirs in the "two-pronged" water policy, the upgrading of existing irrigation infrastructure was the second main strategy postulated. By 1978, the concerned agencies within the Thai administration had already started to implement projects related to the completion and upgrading of distribution systems with the Northeast Irrigation Improvement Project (Phase I and Phase II). Initiated in 1974, the project aimed at completing the downstream areas of four large-scale irrigation projects in northeast Thailand: Lam Phra Plerng, Lam Pao, Nam Pong and Lam Takhong projects. In addition to the projects focused on large-scale irrigation infrastructure, the "Northeast Small-Scale Irrigation Project" (NESSI) looked, from 1982 to 1989, into improving the operation of the existing tank projects which where considered to have fallen into a "state of despair filling with silt" with "the farmers in the project areas planting less and less during the dry season" (RID 1985). The NESSI project aimed at rehabilitating seven irrigation tanks in the Northeast, improving the existing main canal and laterals, together (in places) with an expansion of the command areas. It was hoped that a "replicable approach and institutional capabilities for increasing agricultural incomes for small farmers" would be established (RID 1985), and that "an appropriate model for tank irrigation" would be found (Patamatamkul 2000). From 1990 to 1997, a second stage of rehabilitation was initiated, including the NEWMASIP project which adopted the NESSI model to further tank projects along with the RID Ditch and Dyke program (Patamatamkul 2000).

Along with the rehabilitation of infrastructure, both the NESSI and the NEWMASIP projects attempted to implement new water management modes to the targeted irrigation systems through the introduction of Water User Groups. Standard format Water User Organisation rules and regulations were proposed and farmers were expected to take part in water management (Molle et al. 2002). However, for the NESSI project it was later observed that the WUAs which had been inactive before and activated for the project implementation

[45] In addition to the financial implication of these cascades, the study found that "such a development would provide a challenging task to the operating agency, in view of both the risks associated with failure to open gates during times of flood and the difficulty of allocation of supplies in times of shortage", and, in view of this, concluded that "the creation of Chi river operating agency would be a prerequisite of any such development (RID 1988).

(Johnston et al. 1989), have “stopped functioning soon after the completion of the project (Havorongkura 1995). The comparatively larger NEWMASIP project showed varied results, with only one of the ten implemented sub-projects known to have still a WUA with some degree of activity (Molle et al. 2002).

3.4.8 The "Green Isaan" Project

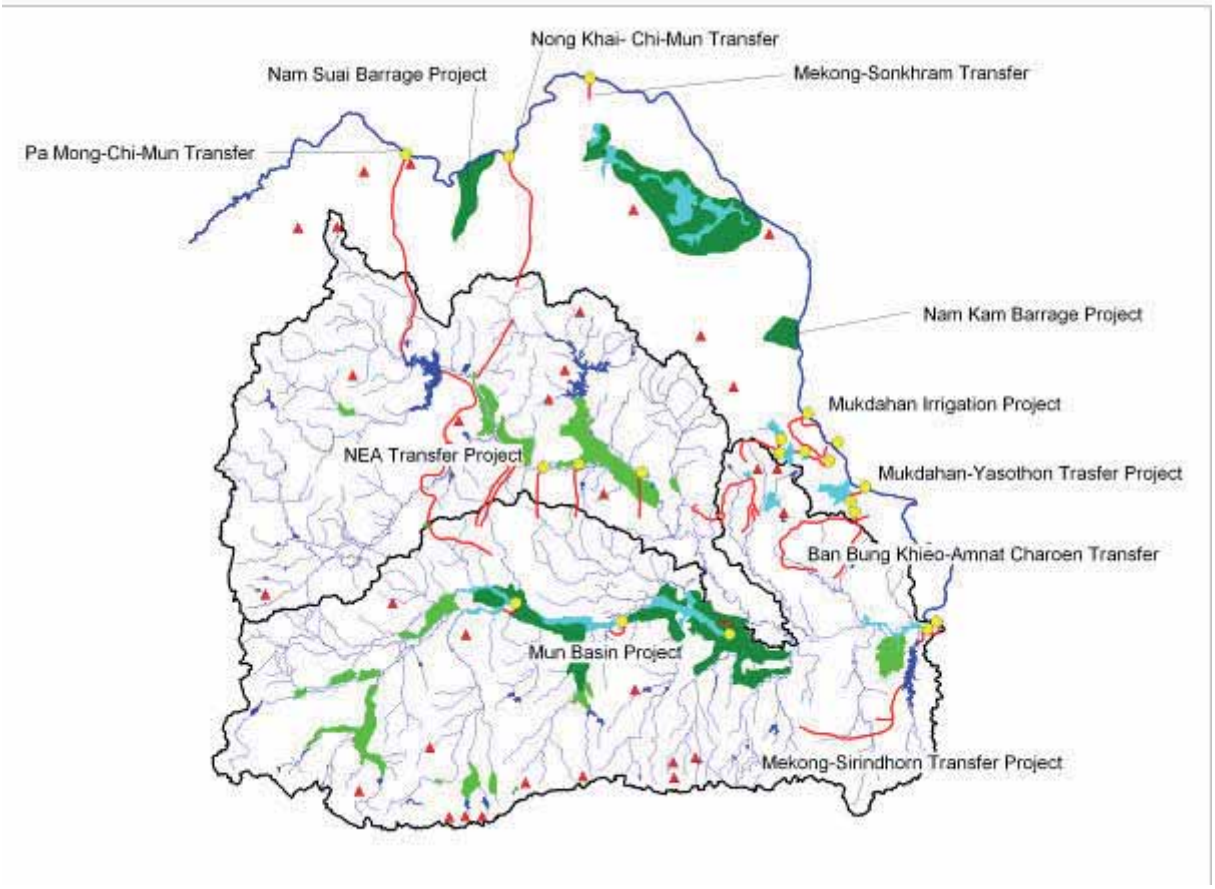
In 1987, General Chavalit Yongchaiyudh presented His Majesty the King with a masterplan for the development of the Northeast called "Green Isaan" (*Isaan Kiew*). A severe drought had just hit Khon Kaen and several other provinces in 1987, and the project was opportunely presented as a response to this problem (Bruns 1991). The report, prepared by British Biwater company, was geared towards accelerated development of water resources, ensuring water supply, increasing reafforestation, and improving rural incomes (Biwater 1987). “Irrigation development in northeast Thailand”, the study detailed “will allow a move away from subsistence agriculture towards forestry, livestock production and industry. The establishment of agro-industry was the focal point of development and would "produce the processed goods for regional export, create employment opportunity in the urban areas and create the demand for agricultural products… irrigation, required to produce raw materials for the agro-processing industry, will create wealth and job opportunities in the rural areas" (Biwater 1987).

With irrigation seen as an essential input for regional development, the study continued to detail a strategy for water resources development. Biwater identified numerous projects for irrigation development in northeast Thailand. Possible large-scale developments would possibly store some additional 4.95 Bm^3, irrigating 1.8 million rai (288,000 ha); medium-scale irrigation projects would store some 200 Mm^3 for a service area of 183,380 rai (29340 ha). Among the large-scale project, the Lower Hua Luang[46] was proposed with a storage of 511 Mm^3, the Lower Mun was designed to store 490 Mm3, the Lam Dom Yai was listed with 578 Mm^3 storage, the Huai Khayoung with some 471 Mm3 and a barrage at the Lam Se Bai river (a Mun tributary) with 383 Mm3.In addition various possibilities for projects with water supplemented from the Mekong and transferred throughout northeast Thailand, which had been studied previously by various consultants, were detailed (Figure 14): The Pa Mong-Chi-Mun project (up to 460,000 rai), the Nong Khai-Chi-Mun project (1,400,000 rai), the Mekong-Sirindhorn project (up to 400.000 rai), the Mekong-Songkhram project (440,000 rai), and the Ban Bung Khies-Amnat Charoen project (100,000 rai).

Initially planning for the Green Isaan project was dominated by the Thai Military, but greater attempts were subsequently made to involve the National Economic and Social Development Board and other agencies. However, it was unclear to what extent plans drew on the extensive experience which existed in dealing with the problems of the Northeast (Bruns 1991). Eventually, even though General Chavalit tried to negotiate a loan with the World Bank (Hewison 1994), the project did not materialize.

[46] The Huai Luang dam would later become a backbone of the Khong-Chi-Mun transfer scheme; see below

Figure 14: Interbasin diversion projects



Source: Biwater (1987)

3.4.9 The Khong-Chi-Mun Irrigation Project

Realizing the increasing uncertainty of the Pa Mong dam, The Thai government began to place greater emphasis on the seemingly simpler task of withdrawing water directly from the Mekong through pumps located almost precisely where the Pa Mong dam had been planned 2003). While the idea of constructing floodplain storage was seen by planners as a means to mitigate the problems associated with resettlement, the low run-off of the Chi-Mun basin was still posing considerable limitations to the expansion of irrigated areas. While in the early 1980s, the Thai government's focus was onto possibilities to augment supply from small-scale irrigation developments, it was acknowledged by the AIT (1978) study that transfer of water from the Mekong would be the only reasonable solution for substantially raising irrigated areas in the area. According to Sneddon (2003), although the idea of water import was "relatively dormant for a significant period in the late 1970s and early 1980s" it reappeared prominently by the later half of the 1980s, with a series of reports commissioned by the Office of the Prime Minister and "carried out by consulting firms reaffirming the necessity of watering the northeast".

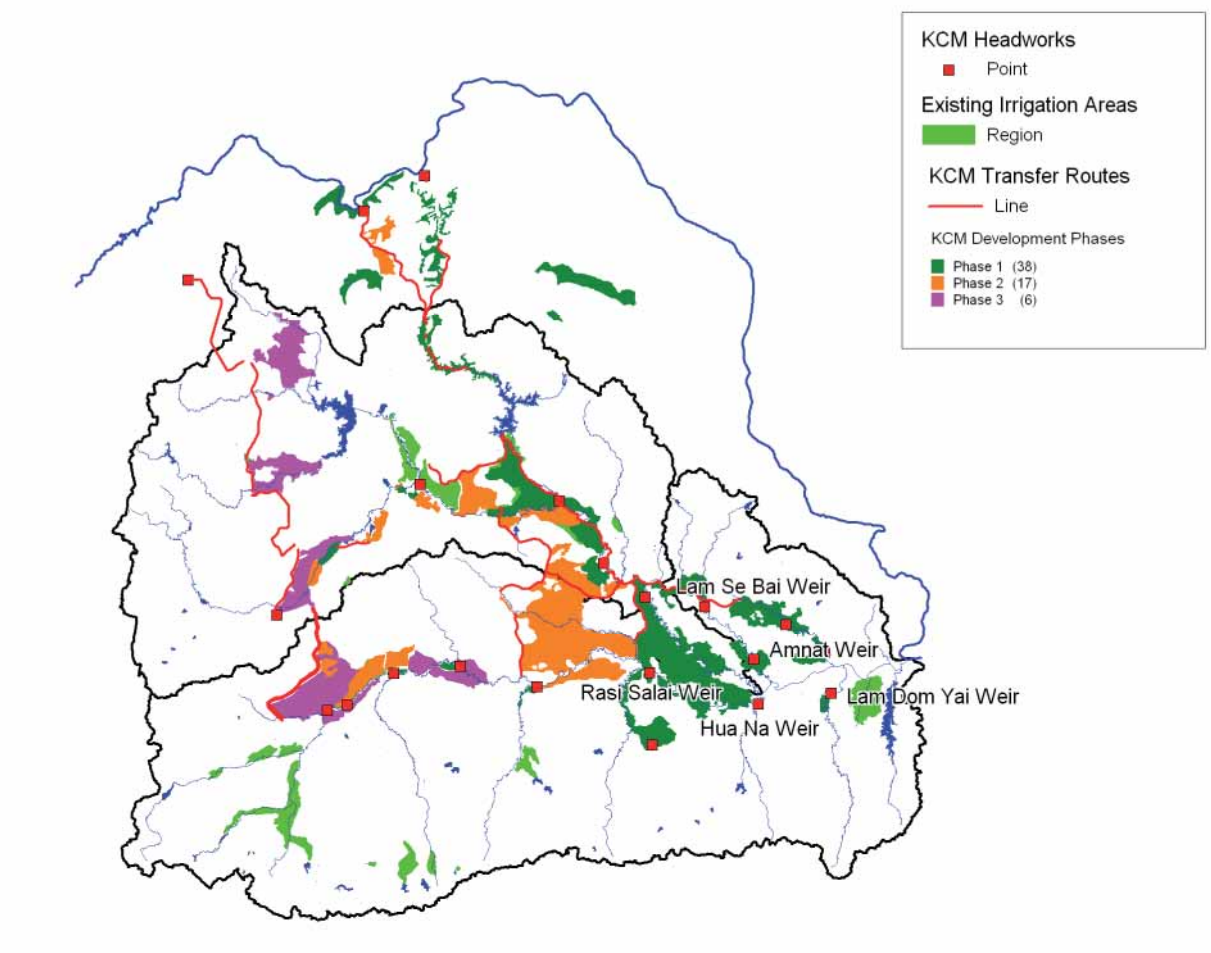
Based on earlier ideas of water import, a new grand vision was elaborated in the late 1980s under the banner of the Khong-Chi-Mun project (KCM). Borrowing from earlier studies on both floodplain storage and water transfers into the Chi-Mun basin, a consolidated strategy[47] for developing northeast Thailand was proposed and approved in 1989 by the Thai Government. The Council of Ministers of the Chatichai government passed a resolution

[47] In 1989 the intergovernmental Interim Mekong Committee proposed to the Thai Government that it should adopt this concept of floodplain storage in a consolidated way (Mekong Secretariat 1989).

approving the construction of the project and asked the National Energy Administration, under the Ministry of Science and Technology, to complete feasibility studies by 1992 (Molle and Floch 2007b).

The study that was later presented (ASEAN et al. 1992) suggested that it was technically feasible to irrigate 4.98 million rai (796,800 ha) in 15 provinces of Northeast Thailand, with construction being envisioned in three successive stages over a period of 42 years (Figure 15).

Figure 15: The Khong-Chi-Mun Project: Phased Development



Source: (ASEAN et al. 1992)

Although the earlier proposed interbasin transfer schemes only remained on paper, the construction of the initial structures commenced in the Chi-Mun basin in 1992. The Rasi Salai weir on the Lower Mun River (upstream of the confluence with the Chi River) was completed in 1994; Huana Weir was constructed from 1992-2000 (also on the Mun River); on the Lam Se Bai, a tributary of the lower Mun river (after the Chi confluence), in Amnat Charoen, another two weirs were finalized, and, finally, a project on the long studied Lam Dom Yai river was constructed. These projects, however, are just a fraction of the total headworks installed under the Khong-Chi-Mun project (see headworks, transfer routes and planned irrigation areas on Figure 15).

What the individual components of the Khong-Chi-Mun project had in common (though with different intensities), is the set of problems that the implementing agencies (first DEDP, and later RID) have faced up to now. The notion postulated earlier that the storage of water in the floodplains would not interfere with the settlement patterns of the Chi-Mun population and would be a way to mitigate earlier experiences with resettlement problems related to water resources development turned out, in retrospect, to be wishful thinking. While it was argued at

times that this was a not-to-be-expected byproduct of the floodplain storage, a 1981 study on the Thung Kula Ronghai area (in the middle and lower parts of the Mun River) indicated that an intrusion into the floodplains would pose a considerable threat to the floodplain ecosystem[48] (CUSRI 1981). The studies cautious approach eventually proved right insofar as an outcry by local population and civil society groups accompanied the construction and inauguration of the projects, and sustained up to present times. The Rasi Salai and Huana weirs are therefore (along with the Pak Mun, which was to become an icon of destructive development), highly visible emblems of the struggle of the rural population for a bigger say in water resources development and for financial compensation[49]. Moreover, even the medium scale projects are facing problems associated with the completion of the projects. The Lam Se Bai weir, for example, is these days witnessing disagreement between the Royal Irrigation Department and local farmers about the land on which to construct the distribution system, and the associated compensation scheme (Personal Communication 2007).

Apart from the construction and livelihood related problems, the project itself has yet to prove that farmers would be willing to use (and pay) for irrigation water. A visit to the two implemented pumping station of Rasi Salai indicated that no water was used for irrigation drawing from the generated reservoir[50]. The distribution system of the Lam Dom Yai Weir, a KCM component constructed on the lower Lam Dom Yai river, is not completed up till now (2007), and water for dry season agriculture is only conveyed to a maximum of 50 farmers through the main canal (Personal Communication)[51].

4 Trajectory of Irrigation Development and Major Impacts of Irrigation Development

In retrospective, planners and decision-makers concerned with irrigation development, and more generally the development of water resources, have resorted to a host of different development options over the last half century. The early focus on run-off river diversions was soon considered unsuitable for the conditions of the Chi-Mun basin and upstream storage was constructed to regulate the flow. While the earlier projects, however, have been planned mostly for supplementary wet season irrigation supply, the following upstream storage projects were justified on the basis of the benefits expected from double cropping (e.g. RID 1963, RID 1964). At the same time, the early construction of irrigation tanks were supposed to bring supplemental irrigation water in the wet-season, which later triggered criticism as most small-scale projects constructed during that time (and later) came without distribution systems.

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[48] In 1981, the use of the floodplains was discussed as part of a scheme that was envisioned to pump Mekong water through a cascade of 3 reservoirs (located at Satuk, Tha Thum and Rasi Salai) on the Mun River: The Mun-Cascade.

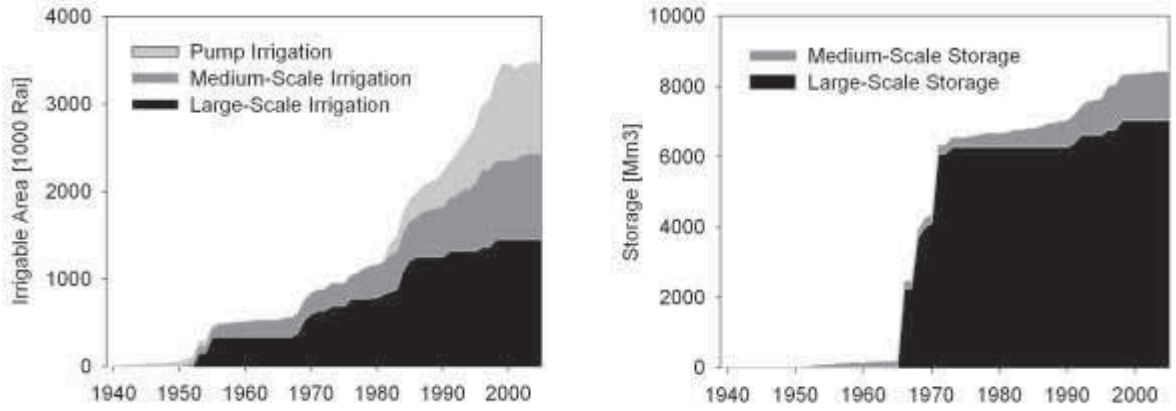
[49] At least off-record, RID Officials would comment on the difficult legacy they received from the DEDP constructed projects; with one official contemplating the decommissioning of the still never closed Huana Weir.

[50] Rasi Salai pumping stations where visited in August 2006. It is acknowledged here, that the existing pumping stations might have benefited from the construction of the storage, which however can neither be confirmed nor ruled out by the authors. On the Lam Se Bai, farmers using water DEDP pumping stations stated, that the Amnat Charoen Weir is now balancing dry season flows to a certain extent, and that farmers can request water from the weir via the Tambon Administration (Personal Communication). What is clear however is the fact, that the newly created pumping stations of Rasi Salai are not functional on the scale proposed in the project proposal.

[51] The cost incurred by the operation of the main pumps, however, is currently covered by the Tambon Administration, and it remains, again, to be proven that farmers are willing to pay for water once the distribution system is completed.

With the creation of the intergovernmental Mekong Committee, and with increases in foreign aid to Thailand, large-scale and multipurpose projects became the principle pattern of irrigation development. Total storage in large-scale projects in the Chi-Mun river basin skyrocketed during the period of 1965 to 1971 with the impoundment of the Lam Pao, the Nam Pong and the Lam Dom Noi rivers (Figure 16).

Figure 16: Cummulative Irrigable Areas and Storage of Large, Medium and Pump Irrigation Projects in the Chi-Mun Basin



The development of irrigation in the Chi-Mun Basin has introduced a host of new challenges to the Thai administration. The massive scale of involuntary resettlement which accompanied the construction of the large-scale storage (Table 9) would not remain without an impact for latter water resources development proposals. From the construction of the Ubol Ratana reservoir in 1965 to the completion of the Huai Luang project, total evacuees in northeast Thailand have been estimated at 86,898 or 14,463 households (Lightfoot 1981).

Later attempts to implement large-scale storage projects for irrigation proved unsuccessful, as viable resettlement sites where simply unavailable. Proposals by the Royal Irrigation Department for large-scale storage on the Lam Dom Yai river (Lower Mun basin) and for the development of the Upper Chi near the town of Chaiyaphum could not secure funding, and planners increasingly stressed that resettlement problems would prohibit the construction of such projects. Consequently, RID embarked on the construction of small- and medium-scale projects during the years to come. In addition to the implementation of the two-pronged water policy (AIT 1978, see Chapter 3.4.1), the Royal Irrigation Department also tried to improve existing irrigation projects. The implementation of pumping projects, another recommendation of the 1978 planning document, was to be implemented mostly by another player in the water sector: the Department of Energy Development and Promotion. Pumping projects proved interesting for decision-makers for a number of reasons; most notably the short time for implementation and the lack of need for storage. While marginal in the early 1980s, the potential irrigable area from electrical pumping stations makes up today a substantial share of the total irrigable area (Figure 16).

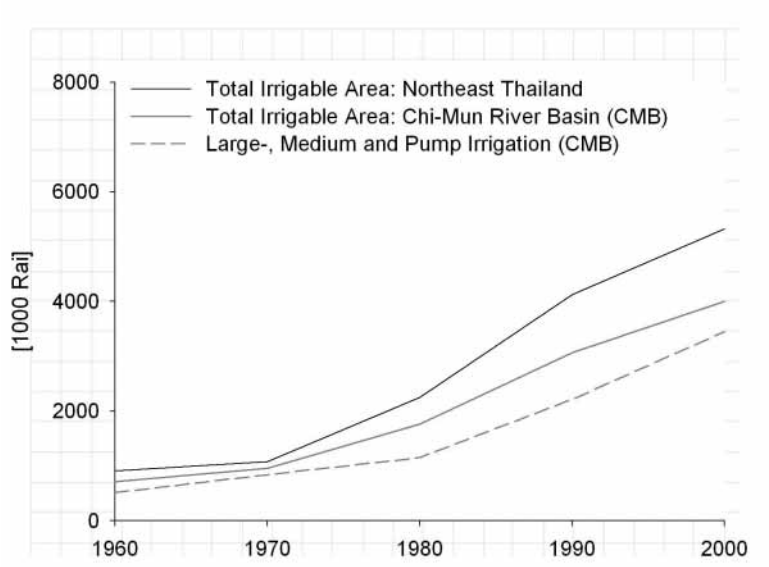
Table 9: Number of evacuees and compensation for large-scale water projects in Northeast Thailand up to 1980

Project	Evacuees		Compensation Rates [Baht/rai]		
	Households	People (estimated)	Paddy	Upland	Houselot
Nam Pong (Ubol Ratana)	5,012	30,072	231-826	693-826	693-826
Lam Pao	5,459	32,754	n.a.	n.a.	n.a.
Lam Takhong	444	2,664	2,600	1,700-1,800	8,000
Lam Dom Noi (Sirindhorn)	1,317	7,902	300-500	300-500	300-500
Lam Nam Oon [(a)]	1,639	9,834	800	800	2,000
Huai Luang [(a)]	612	3,672	2,000	2,000	4,000
Total	14,463	86,898	-	-	-

Source: (Lightfoot 1981); [(a)] outside Chi-Mun River Basin

While large-, medium- and pump irrigation project, today represent the bulk of the potentially irrigable area in the Chi-Mun Basin, those projects do not, by any means, comprise the total irrigation areas that have accumulated over time. Small-scale irrigation projects introduced through the Job Creation program in the wake of decentralization, the Royal Irrigation Department's own small-scale development program, and other agencies (most notably the Department of Accelerated Rural Development) have contributed to the expansion of irrigation areas in the Chi-Mun Basin (Figure 17).

Figure 17: Irrigation Development in Northeast Thailand, the Chi-Mun Basin in comparison with RID Large- and Medium-Scale Projects and DEDP Pump Irrigation



The difference between irrigable areas in the Chi-Mun basin and the potential in large-, medium-scale and pump irrigation projects in the basin, derived from data collected from the Agricultural Statistics Yearbook (Various Volumes), corresponds by and large to the area served by additional small-scale projects. However, it must be stressed here that these overall figures refer to wet season potential, which is hardly realized. Even more, in the dry season, the actual irrigated areas in the Chi-Mun basin is only a small portion of that figure.

4.1 Potentials of the Chi-Mun Basin for Storage and Agricultural Production

Even though potential irrigation areas in northeast Thailand have more recently been equated with the total cultivated area (e.g. in the "Water Grid" project calling for irrigation of over 100 million rai all over Thailand; see Molle and Floch 2007a), there are limits to irrigation development, to storage within the basin, and to suitable lands for cultivation. The determinants that we will highlight here are potential water resources along with suitable sites for storage, along with potential irrigable areas which are suitable for agricultural production in the Chi-Mun River Basin.

The recent account on potentials for land and water resources development in the Chi-Mun Basin presented by Boonlue (2005), is considered here as a point of departure (Table 10).

Table 10: Potential Water Resources Development in Northeast Thailand

Project	Chi Basin			Mun Basin			Northeast Thailand		
	No	Mm^3	Rai	No	Mm^3	Rai	No	Mm^3	Rai
Potential Water Resources Developments									
Large and Medium Scale Irrigation Projects	44	416.30	0.400	5	816.65	0.448	113	1,885.09	1.708
Pipe Irrigation Project	40	-	0.149	43	-	0.297	147	-	0.704
Irrigation efficiency improvement project									
Case of Water Resources Development	53	120.48	0.393	126	70.01	0.498	330	340.01	1.397
Case of Diversion between branches	6	-	0.017	10	-	0.115	27	-	0.143
Case of Diversion between branches in Khong River Basin	-	-	0.043	-	-	0.082	-	-	0.164
Khong Chi Mun Project	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4.98
Projects in the Development Plan	143	536.78	1.002	184	886.66	1.440	617	2225.10	9.096
Total Potential	660	5,173.07	2.812	534	4,528.98	3.097	1,879	11,420.93	13.673

Source: (Boonlue 2005)

The topography of the Chi-Mun river basin has long been recognized as a challenging environment for large-scale irrigation engineering. The undulating landscape and the lack of viable sites for storage construction were early recognized to limit the potential of water resources development within the area, and the increase in storage was accompanied with an equal decline in potential new storage sites that could be additionally exploited (Figure 17).

Before the first large-scale storage project was constructed, the National Economic Development Board (NEDB 1961) identified large-scale projects[52] for a combined total storage of 7.4 Bm^3. Four years later, the United States Bureau of Reclamation's study on Mun-Chi Water Resources (USBR 1965) identified Large- and Medium Scale Storage in the

[52] Projects with storage capacity greater than 100 Mm^3

Chi-Mun basin to be potentially exploited to be ranging between 8.6 BM3 and 10.4 Bm3[53]. With the start of construction of large-scale storage, the total volume of storage in large- and medium scale projects had reached some 6.6 Bm^3 by the late 1980s and additional storage sites were increasingly getting less attractive. However, in reviewing potential additional projects in the Chi-Mun Basin, the Mekong Committees desk-study on potential projects in the basin identified sites for 3 Bm^3 of new large- and medium-scale storage (Mekong Committee, 1978). The same year the Asian Institute of Technology's study "Water for the Northeast", while emphasising the need for completion of the incomplete distribution system of existing large-scale irrigation projects, and the focus on small-scale and pump irrigation, posited that there is a total of 5.1 Bm3 of potential additional large- and medium-scale storage[54] in the Chi-Mun Basin (AIT, 1978 (a) in Figure 19) and estimated potential total additional storage at 8.8 Bm3 (AIT, 1978 (b) in Figure 19), totalling a potential storage of 14.4 Bm^3 (AIT 1978). Ten years later, potential additional storage was estimated by Biwater (1987) at around 3.6 Bm3, and more recently Boonlue (2005) listed potential large- and medium scale projects with a total storage of 1.2 Bm^3. Accordingly, large- and medium-scale dam sites for storage in the basin are almost completely depleted, with only marginal additional storage of high quantity of resources being technically left for exploitation (not including financial, societal and environmental costs that the final exploitation of possible storage would arguably bring with it)[55].

In addition to the large- and medium scale projects, potentials for smaller storage projects have regularly been estimated. USBR (1965) commented on the RID Tank Irrigation Program of the early development years, stating that after finishing the tank[56] program in northeast Thailand, the total storage in these projects would reach 5 Bm^3. This would indicate a total storage envisioned by USBR of 15.4 Bm^3 in the Chi-Mun basin. A more conservative estimate by AIT found that 14.4 Bm^3 could be stored in surface storage (AIT1978), while more lately Boonlue (2005) found that the total surface storage could be as high as 17.9 Bm^3.

The amount of land that can potentially be irrigated in the Chi-Mun river basin is also not straightforward. Accounts for potential irrigation areas range from 12% of the total agricultural land (Limpinuntana 2001) to some 20% (Boonjung 2000) for northeast Thailand. As the extent of potential irrigable areas is, more than storage, determined by the sources of supply (Chi-Mun basin resources only, Mekong water import, etc…), the chosen irrigation option (gravity or pump irrigation), and sometimes soil suitability, the total potential irrigable areas presented in various reports differ considerably (Figure 19).

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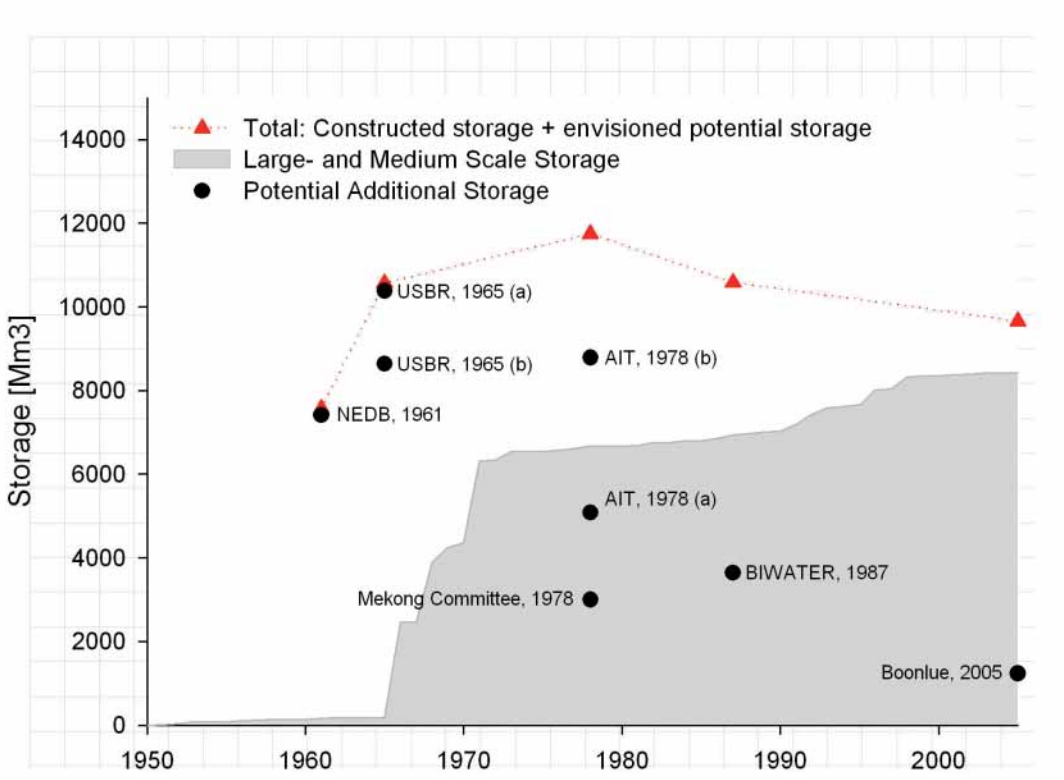
[53] The difference of 1.8 Bm^3 stems from the Lam Chi project which was considered with a total storage of 2.3 Bm^3 and, alternatively, with a smaller storage of 550 Mm^3; the figures are indicated in Figure 19 by USBR, 1965 (a) and USBR 1965 (b).

[54] In 1984, WATCO, a Netherland consultant appointed by the Interim Mekong Committee to study project possibilities in the Lower Mekong Basin, as part of the Lower Mekong Information System, concluded that most of the projects proposed by the 1978 Mekong Committee desk-study would either create large resettlement problems or be economically unfeasible. According to the consultant, only three projects, the Lam Saphung, the Huai Pa Thai power projects, and the 26,000 ha incarnation of the Lam Dom Yai irrigation project would appear as realistic options.

[55] One option to increase storage that is currently contemplated is to increase storage in the Lam Pao reservoir by some 500 Mm^3. This is linked to the envisioned transfer of water from Mekong into the Chi-Mun basin.

[56] Using the above mentioned classification, the early tank projects would contribute to both small- and medium-scale developments.

Figure 18: Large- and Medium Irrigation Storage and Potential New Storage (1950-2005)



Accounting for internal water resources of the Chi-Mun Basin, NEDB (1961) found that some 1.3 million rai of farmland could be irrigated with large-scale storage[57]. Together with the infrastructure implemented in 1961, the total served area would total approximately 1.8 million rai. The more comprehensive AIT (1978) study found that the total potential irrigable area in northeast Thailand to be 7.2 million rai, with some 2.2 million rai from large-scale reservoir projects (excluding the Pa Mong), 1.9 million rai from pump irrigation projects and another 0.7 million rai from small-scale development; approximately 12% of the arable land which was estimated at 62.6 million rai by the study team[58]. Biwater (1987) found that new large- and medium scale projects inside the Chi-Mun basin would be capable of serving 1.4 million rai, which together with the already installed infrastructure, would total just over 3.1 million rai. However, the reviewed interbasin diversion projects could increase this figure considerably (Table 11; Figure 14).

If we consider that either the Pa Mong transfer or, alternatively, the Nong Khai-Chi-Mun transfer (see Figure 14) was to be realized[59], the total irrigable area in the Chi-Mun Basin would increase to a maximum of 5 million rai, not including small-scale developments and pump irrigation (Biwater 1987).

[57] Note that the total potential large-scale storage in Northeast Thailand was estimated at 9.2 Bm³, and some 7.4 Bm³ in the Chi-Mun river basin

[58] Many studies in the 1980s and early 1990s adopted this 12% of arable land, as an upper limit of potential irrigable land in northeast Thailand (see below).

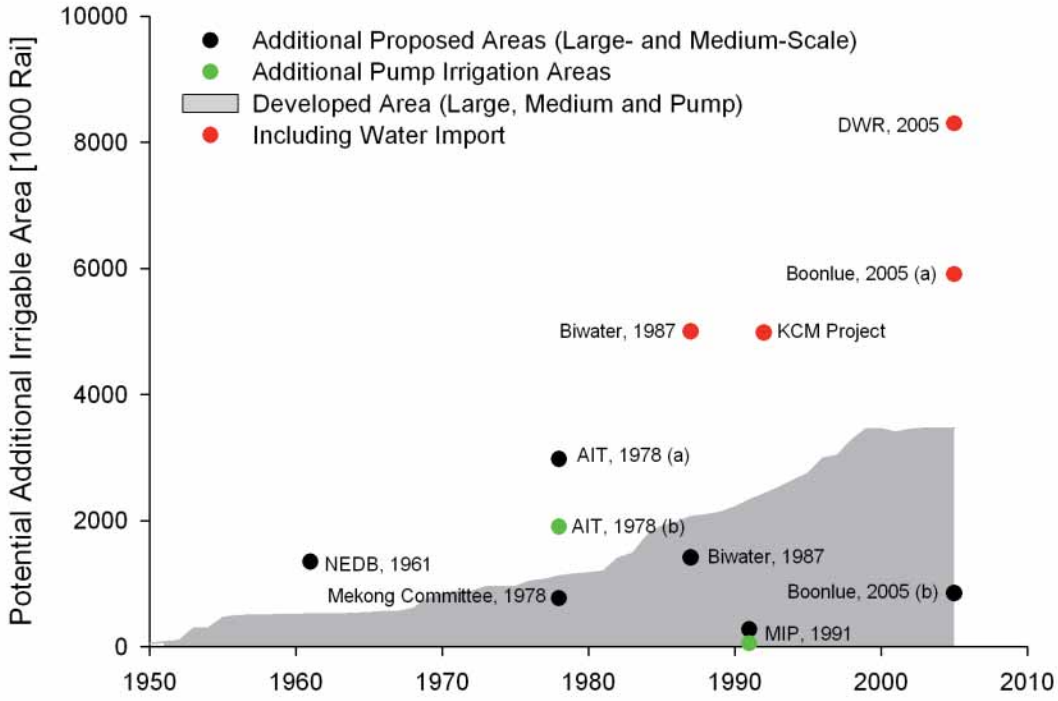
[59] With the Pa Mong increasingly being considered non-feasible by the late 1980s, the Nong Khai-Chi-Mun transfer became an alternative which was presented as a Mekong diversion possibility, in case the Pa Mong would not be built. In the summary of potential areas to be served by irrigation in northeast Thailand, presented in the Green Isaan study (Biwater 1987), we will therefore consider that only the Pa Mong or, alternatively, the Nong Khai-Chi-Mun diversion was considered for implementation.

Table 11: Transbasin Projects (Biwater, 1987)

Scheme Name	Benefiting Area [1000 Rai]
Pa Mong – Chi/Mun [(a)]	400 to 460
Nong Khai – Chi/Mun	1,400
Mekong – Sirindhorn	250 to 400
Mekong – Songkhram [(b)]	440
Ban Bung Khieo – Amnat Charoen	100

Notes: (a) depending on pumping capacity, [(b)] benefiting area outside Chi-Mun basin

Figure 19: Large-, Medium and Pump Irrigation Areas and Major Additional Targets



We have shown earlier that by the early 1990s, when the Khong-Chi-Mun irrigation project was started to be implemented, total irrigable areas in the Chi-Mun Basin had already reached 3.3 million rai (for the whole of northeast Thailand the respective figure was 4.5 million rai). The envisioned 4.98 million increase during the proposed 42 year development scheme would therefore more than double the irrigated area of the region and would total some 9.5 million rai, 15.2 percent of the arable land according to AIT (1978). More recently, the Thai "Water Grid" aimed at trebling the areas served by irrigation in Thailand[60]. The total additional irrigation area envisioned by the project for northeast Thailand was 14.8 million rai (2.4 million ha), distributed among 5 sub-project in the region (DWR 2005) Out of the total irrigable areas listed in the document for northeast Thailand at least some 8.3 million rai

[60] For a more comprehensive overview of the decision-making process and the underlying impacts of the Thai "Water Grid" see (Molle and Floch 2007a)

would be located within the Chi-Mun basin[61], a development vision that would triplicate the Khong-Chi-Mun Project targets. Finally, Boonlue (2005) listed the potential additional irrigable area in the Chi-Mun Basin at 5.9 million rai (Table 10) which, together with the existing irrigation infrastructure would increase the total irrigable area to 10.1 million rai. At the same time, potential additional irrigation service areas in northeast Thailand, where estimated at 13.7 million rai which together with the estimated total existing irrigable area of 5.6 million rai would total 19.3 million rai, or over 30% of the total arable area in northeast Thailand. It can thus be concluded at this stage that planners and decision-makers have recently considerably moved away from the earlier notion of a potential of 12% to be irrigated in Northeast Thailand, and have more than doubled this figure to exceed 30%.

4.2 Dry Season Irrigation Potential

Irrigation development is justified by the additional benefits that water supply generates for crop production and related activities and in climatic environments like northeast Thailand, the facilitation of dry season agriculture. From as early as the 1950s, the promotion of dry season agriculture was one of the main vehicles for the promotion and justification of public investment in irrigation..For decades, changes in cropping patterns and land-use practices have been proposed by planning documents and national policies. Reflecting on the early tank project in northeast Thailand, Ng (1970) found that "these structures are small in scale and limited in effectiveness and that the irrigation water provided is generally regarded only as supplementary source of water in years of drought, and the tanks have done little to initiate any fundamental changes in the land use pattern". "However, -he reasoned-, modern irrigation projects of larger scales can supply the vital needs in the dry season so that the cropping period can be extended". However, though it increased over time, the large-scale adoption of dry season agriculture never happened (Figure 20). Moreover, it has been shown that diversification in Thailand has been fostered by middleman in close connection with market demand (Rigg 1987), and that this market demand is often induced by deficits in the world market (e.g. kenaf in the 1960s, cassava in the 1980s and rubber at present), and cannot be induced artificially. Figure 21 shows the evolution of paddy and upland areas in Northeast Thailand, and evidences that most of the upland expansion did not occur to the detriment of paddy areas but, rather, through the conversion of forest areas.

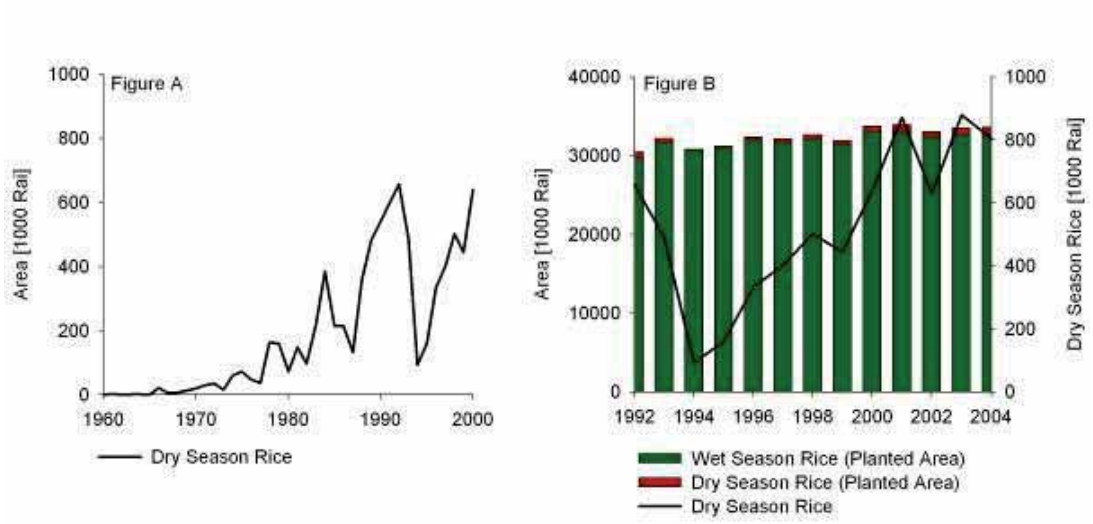
In addition, while planners and decision-makers have adopted varying potential irrigable areas (see above), the gap between irrigable areas and actual irrigation areas is reportedly considerable. In 1995, a study on the Mun river basin (Binnie and Partners 1995) concluded that "water shortage regularly occur in the majority of irrigation schemes during the wet season, even though many of the schemes are only used to 70 percent of their designed command areas, and that "after developing existing schemes to their full potential, and introducing a fully diversified cropping pattern away from the existing dominance of rice, the basin's water resources will be able to support an average of 11 percent dry season cropping". The study concluded that the potential for agricultural development had been "previously been overly optimistic, with an average of less than 5 percent dry-season cropping across the basin".

For pump irrigation in Northeast Thailand, areas effectively irrigated in the dry season constitute only some 13 percent of the planned areas (Kamkongsak and Law 2001). Limpinuntana (2001) reports that out of the total irrigable area by storage projects some 8

[61] Sub-projects that cross over the basin boundary have been fully discarded for this overview; the 8.3 million rai may thus be considered a conservative estimate.

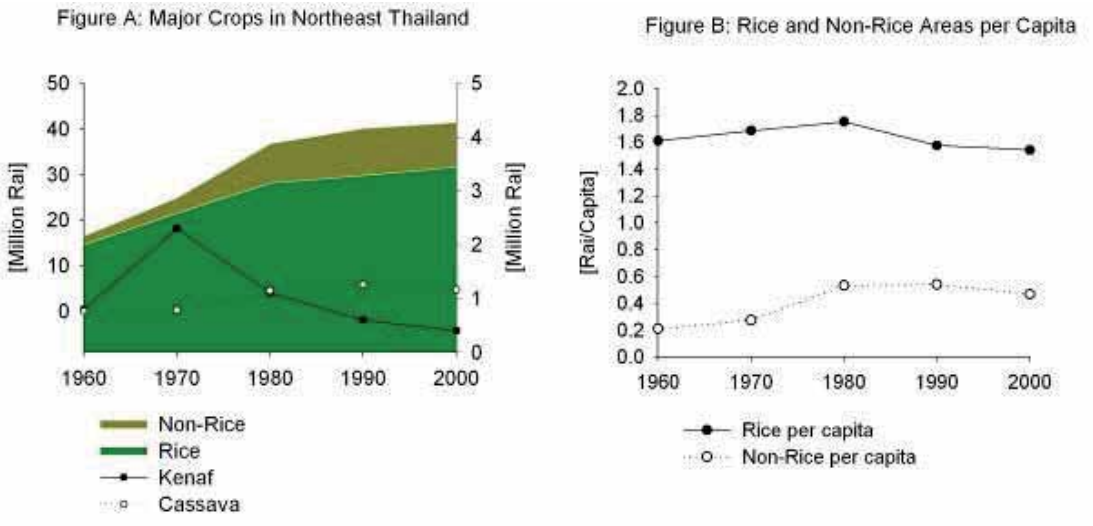
percent where cultivated in the dry season, and about 12 percent in pump irrigation projects[62]. Considering that most of the economic appraisals of at least the last 30 years assumed diversified and dry-season cropping as a prerequisite for economic justification, it appears hardly surprising that multiple reports on irrigation development in northeast Thailand have pointed to the low economic performance of these investments (e.g. NEDECO 1988, Palanisami and Apinantara, 1984).

Figure 20: Dry Season Rice Cultivation in Northeast Thailand



Notes: 1960-1988 values from (Mekong Secretariat 1991a), 1989-2004 values from Agricultural Statistics Yearbook (Various Volumes)

Figure 21: Major Crops and Agricultural Production in Northeast Thailand



4.3 Economic Aspects of Chi-Mun Basin Development

As favourable sites for irrigation development are generally exploited in early phases of river basin development (Molle 2003), the unit costs for mobilizing water resources for agricultural water use tend to increase over time. This unfavourable relationship increases the total costs

[62] The figures presented here serve the purpose of raising our awareness that there is a large gap between what is irrigable on paper (or planned), and what is actually been irrigated. A later working paper will provide a more detailed account of the water use status of irrigation systems in northeast Thailand.

of projects, and it becomes increasingly difficult to justify irrigation developments on cost/benefit ratios or other economic indicators[63].

In the case of the Chi-Mun river basin, already early into the development of water resources, it was apparent that costs of development were likely to exceed the direct benefits of these projects. As mentioned earlier, Kambhu (1956) noted that it was the political will to invest into the agricultural sector that justified the Royal Irrigation Department's endeavour in northeast Thailand, rather than technical or economic rationales. By then, however, the cost of direct run-off-river diversion was estimated by the author to be 300 baht/rai[64] or about 2,700 baht/rai (all costs are expressed here in 2000 prices). Equally, the early tank projects in the Chi-Mun basin, reportedly ranged between 2,700 baht/rai (ASY 1965) and 3,440 baht/rai (USBR 1965). By the time NEDB (1961) reported on the government planned engagement in large-scale engineering, cost estimates would average at 11,500 baht/rai. However, with over 15,000 baht/rai, the Nam Oon, Lam Takhong and Lam Pao projects would later be considerably more expensive than proposed (AIT 1978).

In comparing irrigation developments in the 1960s and 1970s, Van Liere and Kawai (1973) found that the total investment per paddy area had tripled, with the average unit area costs for irrigation development reported to be 504 baht/rai (1972 price level; 2,669 baht/rai 2000 price level), and unit storage costs to be 0.93 million baht/Mm^3 of stored water (4.92 million baht/Mm^3 in 2000 prices).

In 1988, RID commissioned a study of water use in the Chi-Basin (RID 1988). In looking into possible development scenarios of the Chi basin, the study team compared unit development costs for the various alternatives for dam sites in the Upper Chi river, and possible channel storage. The consultant concluded that “the unit cost of creating channel storage is between two and three times that for the Upper Chi sites, suggesting that channel storage is unlikely to be an economic alternative”. “However”, the study team continued, ”although not as attractive as the conventional alternatives in terms of the costs of creating storage volume, channel storage should not be ruled out as one of the smaller scale development options when account is taken of the greater reliability of the filling of the reservoir in view of its size in relation to the catchment area” (RID, 1988). The full development foreseen by the 1988 study comprised a cascade of regulated reaches of about 80 km; each individual channel storage with an active storage of about 15 Mm^3. The capital cost of the dams for this theoretical full development of channel storage in the main stem of the Chi river would be of the order of 1,000 million baht (RID, 1988).

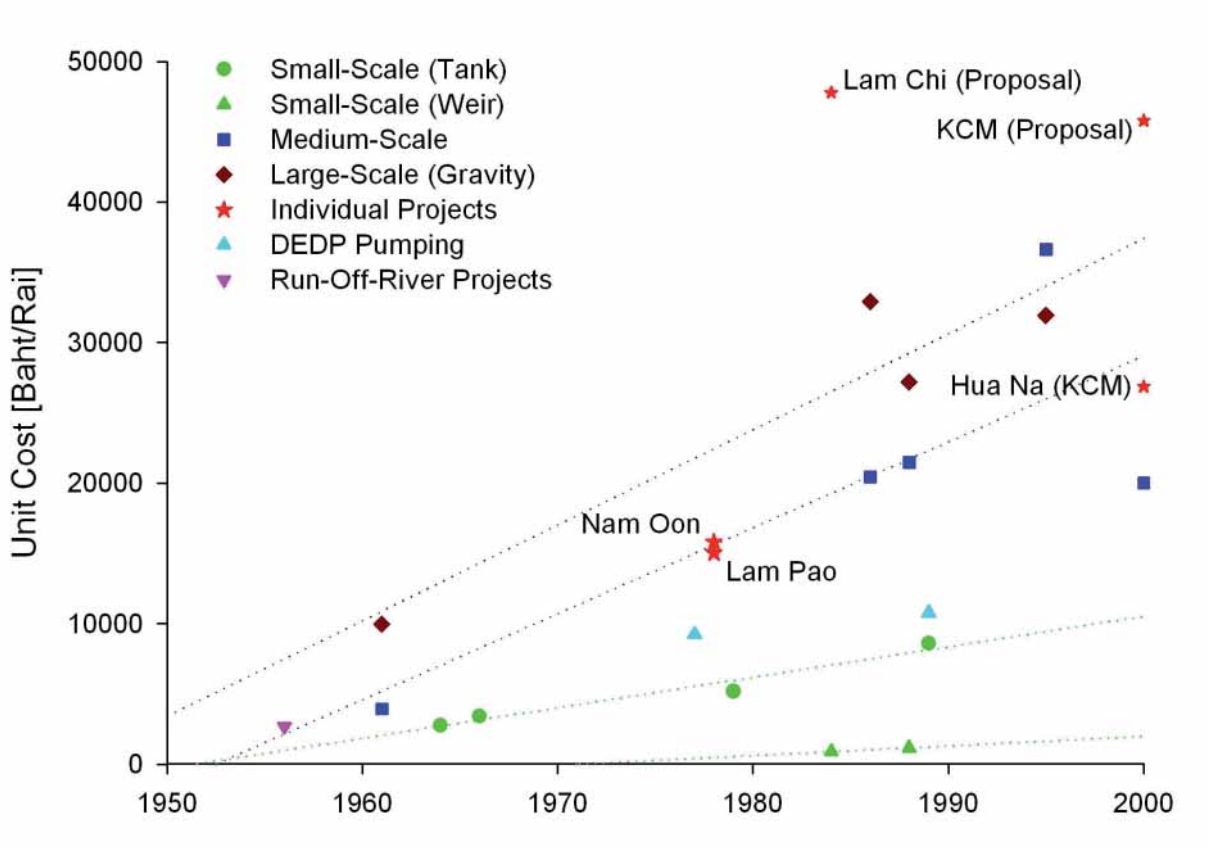
At the same time, WATCO's (1984) reassessment of earlier proposals found that projects like Lam Chi would generated costs as high as 47,700 baht/rai (2000 price level).

Figure 23 summarizes unit costs for developing irrigation in the Chi-Mun Basin and Northeast Thailand. This crude overview of the costs incurred by irrigation development in the Chi-Mun Basin reveals a sharp rise in the unit costs of irrigation development, a familiar feature of river basin development.

[63] For a more comprehensive account of irrigation economics in the Chi-Mun Basin see (Floch and Molle 2007c)

[64] Though not indicated in the original paper, this price level is assumed to present 1956 prices.

Figure 22: Evolution of Unit Costs for Irrigation Development in Northeast Thailand



Notes: all unit costs expressed in 2000 price level.

Components of the Thai "Water Grid" project proposed by the Department of Water Resources (DWR 2005), would dwarf the unit costs observed and proposed in earlier basin development plans. The interbasin transfer scheme included potential projects, such as the Sirinthorn – Yasothon component[65], that would generate costs up to 188,228 baht/rai (current prices). This helps explaining why the project was justified based on expected benefits (shrouded in a pro-poor rhetoric), rather than on cost-benefit ratios (Molle and Floch 2007a).

5 Conclusion

This chronology of irrigation development in the Northeast of Thailand has illustrated a number of points that –perhaps– reflect the worldwide history of water resource development. The rationale for developing water resources remained centred on the unquestioned desirability of "greening", or making wet a region depicted as dry. This was diversely justified by fighting poverty, raising incomes, smoothening regional disparities or combating the spread of communism.

All along the past 60 years this development drive took diverse forms, contemplating small scale (ponds, weirs, pumps), medium scales (dams, pumping stations), and large scale (dams,

[65] The Sirinthorn – Yasothon component of the Thai "Water Grid" was designed to serve a total of 244,385 rai through the pumping of some 500 Mm3 of water passed through the existing Sirinthorn reservoir in the lower Chi-Mun basin and fed into "underdeveloped" areas in the middle Mun basin. Proposed at a capital cost of 46,000 million baht (DWR 2005), the project would generate unit storage costs of 92 baht/m3 or unit area costs of 188.228 baht/rai in current prices.

irrigation schemes) investments. Large scale investments would successively be made possible by the development of dams on all rivers, the diversion from Mekong river (either from major reservoirs to be built or by pumping), or instream storage. The very nature of the topography of the Chi-Mun basin, however, has always made irrigation development a difficult and, especially more recently, costly task. Most importantly, the available storage in the basin is limited, and was largely exploited after the 1970s, with the completion of the major reservoirs in the basin. Apart from the technical potential, the construction of storage would later be constrained by attendant resettlements problems. As a way to bypass these constraints concerned agencies moved to the floodplains and introduced the idea of instream storage; a strategy that would later prove to be both costly and environmentally unsound as the floodplain ecosystem already served livelihood functions before the construction of irrigation systems.

Irrigation development, at the same time, was always defined as reaching potential targets or realizing the potential of the region. Firstly, the potential storable water resources in the basin, which was identified as 10.4 Bm3 (USBR 1965) and 14.4 Bm3 (AIT 1978) was mostly realized, with a total official storage in the basin as high as 10 Bm3 (Boonlue 2005). The additional potential storage sites, which have been contemplated over the last 20 years (mostly storage in the upper Chi basin near Chaiyaphum, and in the Lower Chi-Mun basin) have been discredited due to resettlement problems, environmental impacts, and marginal cost-benefit ratios. Secondly, the percentage of arable land in northeast Thailand, potentially served by irrigation, increased from some 12% (7.2 million rai; AIT 1978) to more recent targets of approximately 30% (Boonlue 2005). The sharp increase is associated to water import from the Mekong or neighbouring countries. However, even the “low target”, set in 1978 by the Asian Institute of Technologies (AIT 1978), is far from being realized at present, with some 9% of the arable land being irrigated. This, in turn, is by itself misleading, as most irrigation is concentrated on supplementary irrigation in the wet season, with dry season irrigation remaining a marginal phenomena in the region, leaving northeast Thailand as a predominantly rainfed area up to present times.

Water import from the Mekong was (and still is) the basis of ‘the’ vision for developing the Chi-Mun basin, and northeast Thailand. While technically possible, the soundness of water-import into the Chi-Mun Basin is faced with a host of open questions: dry season water use (on which project benefits are predicated) has never materialized on a large-scale in the northeast of Thailand; changes in the rural population structure and the increasing percentage of “farmers” now engaged in off- and non-farm employment impacting on the available labour force; the environmental impacts that are likely to built up or increase (salinity and destruction of wetlands); and, ultimately, the costs that the project would generate both for the general public (in terms of capital costs for project implementation) and the farmers which would have to shoulder higher fees (Molle and Floch 2007a).

We have shown that the increase in unit costs of developing irrigation areas has been continuous throughout the last 50 years, which limited the direct benefits that would be derived from additional irrigation projects. Already early into the development of the basin, Kambhu (1956) noted that it was the political will to invest into the agricultural sector that justified the Royal Irrigation Department's endeavour in northeast Thailand, rather than technical or economic rationales. This political will to invest in irrigated agriculture was demonstrated numerous times over the same period, and finally culminated in the “Water Grid” proposal, which had to be justified by expected benefits, shrouded into a pro-poor rhetoric, rather than benefit/cost ratios. Expected benefits from large-scale irrigation development, history shows us, have never materialized, mostly because of marginal dry-season cropping and crop diversification. Though constantly proposed by planners and decision-makers as a way out of “the problems of northeast Thailand” over the last 50 years,

the contemplated solutions were not adopted by farmers which have, for generations, adapted to the agro-climatic realities of the basin through diversified livelihood strategies.

While the investments realized should not be minimized, further development has been hindered by several constraints: physical (lack of water to be mobilized, topography of the terrain and lack of suitable soils for agricultural production), economic (high costs of certain options), political (opposition to resettlement or environmental degradation), and geopolitical (the regional wars which blocked main stream projects on the Mekong river). While the dream of a "Green Isaan" would seem to fade away it is recurrently resuscitated by politicians in search of political support (Molle and Floch 2007a). While rural development may have appeared as a natural option in the 1960s and 1970s, one may now wonder if such an agriculture-based vision of economic development is sound, when seen in the light of wider economic dynamics in Asia.

6 References

A&R Consultants, 1994. Integrated Basin Development Planning: Study on Development Needs and Related Policies in Thailand. Report prepared for the Mekong Secretariat. Bangkok, Thailand (cited in Pednakar, 1997)

Alford D. 1994. Water Budgets and Water Regions: Planning and Managing Water Resources Development in Thailand. TDRI Quarterly Review 9(4): 14-23. Thailand Development Research Institute. Bangkok, Thailand.

AIT 1978. Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources (Volume 1). Asian Institute of Technology. Bangkok, Thailand.

ASY (Agricultural Statistics Yearbook), Various volumes. Office of Agricultural Economics. Bangkok, Thailand

ASEAN, PALCON, SWHP, NIPPON KOEI 1992. Me Kong-Chi-Mun detailed feasibility report. Prepared for the Department of Energy Development and Promotion. Bangkok, Thailand.

Baker C. and P. Phongpaichit 2005. A History of Thailand. Cambridge University Press. Port Melbourne, Australia.

Barker R. and F. Molle 2004. Evolution of irrigation in South and Southeast Asia. Comprehensive Assessment Research Report 5. Comprehensive Assessment Secretariat. Colombo, Sri Lanka.

Binnie and Partners 1995. Mun river basin water resources development master plan. Final technical report. Prepared by Binnie and Partners in association with WS Atkins International Ltd., UK; ITC, Netherlands; ATT Consultants Co. Ltd. and TA&E Consultants. Royal Irrigation Department, Ministry of Agriculture. Bangkok, Thailand.

Biwater 1987. Investigation and preparation of a water resources development programme for northeast Thailand (Final Report: Water Resources). Bangkok

Boonjung H. 2000. Climatic Variability and Rice Production in Rainfed Rice Area in Northeast Thailand: Risk Analysis and Management Application. International Forum on Climatic Prediction, Agriculture and Development. 26.-28 April 2000. IRI, pp 202-205

Boonlue C. 2005. The present condition on water resources development in the northeastern region of Thailand. In: Proceedings of the International Symposium on Sustainable Development in the Mekong River Basin. Japan Science and Technology Agency.

Boyd W. and R. McGrath 2001. The geoarchaelogy of the prehistoric ditched sites of the Upper Mae Nam Mun Valley, Northeast Thailand, III: Late Holocene vegetation history. Palaeogeography, Palaeoclimatology, Palaeoecology 171: 307-328

Bruns B. 1991. The Stream the Tiger Leaped: A study of intervention and innovation in small scale irrigation development in Northeast Thailand. Ph.D Dissertation. Cornell University

Chomchai P. 1994. The United States, the Mekong Committee and Thailand: A Study of American Multilateral and Bilateral Assistance to Northeast Thailand since the 1950s. Asian Studies Monograph No. 051.

Courcier R., J.P. Venot, and F. Molle, 2005. Historical Transformation of the Lower Jordan River Basin (in Jordan): Changes in water use and projections (1950-2025). Comprehensive Assessment Research Report 9. Comprehensive Assessment Secretariat. Colombo, Sri Lanka.

Croizat V.J. 1967. The Mekong River Development Project: Some Geographical, Historical, and Political Considerations. The RAND Corporation. Santa Monica, United States

CUSRI, 1981. Kula Ronghai Project: Review for Implementation (Volume 1 and Volume 2). Chulalongkorn University Social Research Institute (CUSRI) for the National Economic and Social Development Board. Bangkok, Thailand.

DHV Consultants, A&R Consultants, TEAM Consultants and SMED, 1991. Mekong Irrigation Programme. Volume 5: Study of a Water Resources Development Plan for Northeast Thailand. Prepared for the Mekong Secretariat. Bangkok, Thailand.

DWR 2005. Water Grid Project: Executive Summery (in Thai). Department of Water Resources. Bangkok, Thailand.

EGAT 2005. Hydroelectric Dams in Northeastern Region. Electricity Generating Authority of Thailand. www.egat.co.th (last accessed: 26. November 2005)

EPDC (Electric Power Development Company Ltd.) 1960. Comprehensive Report on the Major Tributaries of the Lower Mekong Basin. The Mekong Reconnaissance Team organized by the Government of Japan. Tokyo, Japan

ESCAP 1991. Assessment of water resources and water demand by user sectors in Thailand. United Nations New York

Floch and Molle 2007b. Re-opening river basins: Interbasin transfer in Northeast Thailand. Working Paper. IWMI/IRD. (Forthcoming)

Floch and Molle 2007c. Irrigation Economics in Northeast Thailand: Costs, Benefits and Impacts of Irrigation Development. Working Paper. IWMI/IRD (Forthcoming)

Foran T. 2006. Rivers of Contention: Pak Mun Dam, Electricity Planning, and State-Society Relations in Thailand, 1932-2004. Ph.D. Thesis submitted to the Division of Geography, School of Geosciences, University of Sydney.

Fukui H. and K. Hoshikawa, 2003. Earthen Bund Irrigation in Northeast Thailand. In: Proceedings of the 1st International Conference on Hydrology and Water Resources in Asia Pacific Region. 13-15 March 2003, Vol 1: 179-184. Kyoto, Japan.

Havorongkura M. 1995. Irrigation management transfer in Thailand: Huay-Aeng Irrigation Project case study. In Irrigation Management Transfer in Asia, edited by Geiger, FAO/IWMI, pp. 127-134.

IBRD, 1973. Pioneer Project for Tank Irrigation in Northeast Thailand, Volume 1. Prepared by Sir William Halcrow and Partners, and Urwick Lugg and Gould Ltd., London. (cited in Palanisami K. and A. Apinantara, 1984)

Julichan 1966. The Nam Pong Project. Indian Journal of Power and River Valley Development. Mekong Project Number. Calcutta

Johnson, S. H. III; Patamamkul, S.; Apinantara, A.; Charoenwatana, T.; Issariyanukula, A.; Paranakian, K.; Reiss, P. 1989. Medium scale irrigation systems in Northeast Thailand: Future directions. ISPAN. Arlington, United States of America (cited in Molle 2002)

Havorongkura, Metha (1995) Irrigation management transfer in Thailand: Huay-Aeng Irrigation Project case study. In Irrigation Management Transfer in Asia, edited by Geiger, FAO/IWMI, pp. 127-134.

Hewison K. 1994. Greening of Isaan – More than just a pinch of salt. Australian Natioanl University Coombsarchives. Thai-Yunnan Project Newsletter Issue 24.

Hoshikawa K., 2004. History, Structure, Function and Topographical Control of Traditional Irrigation Systems in Northeast Thailand. National Research Council of Thailand. Bangkok, Thailand

Hungspreug S. 2001. Water Management in the Korat Basin, Northeast Thailand: Policy, institutional and management from farm/village to regional levels. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Kamkongsak L. and M. Law, 2001. Laying waste to the land. Thailand's Khong-Chi-Mun Irrigation Project. Watershed (People's Forum on Ecology), Vol-6(3): 25-35

Kambhu X., 1956. Memorandum on water condition, water requirement, and water control projects in the northeast region of Thailand. Royal Irrigation Department, Ministry of National Development. Bangkok, Thailand

Kambhu X., 1963. Water resources development in Thailand and its policy. Royal Irrigation Department, Ministry of National Development. Bangkok, Thailand

Khao-Uppatum V. 1992. Irrigation/Water Management for Sustainable Agriculture Development in Thailand In: Irrigation performance for sustainable agriculture development. Report of the Expert Consultation of the Asian Network on Irrigation/Water Management, 25-28 August 1992. RAPA Publication 1994/17: 151-160. Bangkok, Thailand

KKU, 1998. Preperation of Master Plan for National Water Resources Development Projects (19 Northeastern Provinces). Royal Irrigation Department. Bangkok, Thailand (cited in Srisuk et al., 2001)

KKU-NZ-UBON weir Program 1986.

KKU-Ford 1982. An Agroecosystem Analysis of Northeast Thailand. KKU-Ford Cropping Systems Project. Faculty of Agriculture, Khon Kaen University

Koontanakulvong S. 2006. Water Situation in Thailand in the year 2003. Faculty of Engineering, Chulalongkorn University. Presentation presented at the: http://www.watercu.eng.chula.ac.th/publications/Present_191006_1.pdf (last accessed 5 March 2007)

KU, 2005. River Basins of Thailand. Department of Irrigation Engineering, Kasetsart University. Bangkok, Thailand. http://www.eng.ku.ac.th (last accessed, December 2005)

Lightfoot R. P. 1981. Problems of Resettlement in the Development of River Basins in Thailand. In: River Basin Planning: Theory and Practice, ed. Saha S. K. and Barrow C. J., Wiley – Interscience Publications. Great Britain

Limpinuntana V. 2001. Physical Factors as related to agricultural potential and limitations in the northeast Thailand. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Mekong Committee, 1973. Report on the sixty-second session (special) of the Mekong Committee. Tokyo (cited in Sneddon, 2003)

Mekong Committee, 1978. Inventory of Promising Tributary Projects in the Thai Part of the Lower Mekong Basin: Projects in the Mun-Chi Basin. Working Paper. Committee for Coordination and Investigations of the Lower Mekong Basin.

Mekong Secretariat, 1970. Indicative Basin Plan. Committee for Coordination and Investigation of the Lower Mekong Basin. Bangkok, Thailand

Mekong Secretariat 1977. Thailand and the Mekong Project. (cited in Sneddon 2003)

Mekong Secretariat, 1983. Pump Irrigation on the Mun/Chi (Stage 1): Final Report. Note by the Secretariat. Interim Committee of Investigations of the Lower Mekong Basin.

Mekong Secretariat, 1989. The Mekong Programme and Irrigation Development of the North-East. A Briefing Paper. prepared by the Mekong Secretariat.

Mekong Secretariat 1991a. Mekong Irrigation Programme: Northeast Thailand Irrigation Data. Prepared by DHV Consultants in association with A&R Consultants, TEAM Consulting Engineers and SMED for the Mekong Secretariat

Mekong Secretariat 1991b. Mekong Irrigation Programme: Summery Report. Prepared f by DHV Consultants in association with A&R Consultants, TEAM Consulting Engineers and SMED for the Mekong Secretariat

MOA 1954. A Statistical Review of Thai Agriculture. Division of Agricultural Economics, Office of the Under-Secretariat of State, Ministry of Agriculture. Bangkok, Thailand.

Molle F. 2003. Development Trajectories of River Basins: A Conceptual Framework, Research Report No 72, Colombo: IWMI. http://www.iwmi.cgiar.org/pubs/pub072/Report72.pdf

Molle F., N. Ngernprasertsri and S. Sudsawasd 2002. Are water organisations crucial for water management? A post-mortem analysis of water user groups in Thailand the prospect for reincarnation. Paper presented at the 6th conference on Participatory Irrigation Management. 20-26 April 2002. Beijing

Molle F. and Floch, P. 2007a. Water Poverty and the Governance of Megaprojects: The Thai "Water Grid". Working Paper. Mekong Program on Water, Environment and Resilience, IRD/IWMI.

Molle F. and Floch P. 2007b. The "desert bloom" syndrome: irrigation development, politics, and ideology in the Northeast of Thailand. Working Paper. Mekong Program on Water, Environment and Resilience, IRD/IWMI.

Muscat R.J., 1990. Thailand and the United States Development, Security and Foreign Aid. Columbia University Press.

Neawchampa C., 1999. Socio-economic changes in the Mun River Basin, 1900-1970. In Fukui H. (Editor): The Dry Areas in Southeast Asia: Harsh or Benign Environment?. CSEAS, Kyoto University. 215-235. Kyoto, Japan

NEDB 1961. The Northeast Development Plan 1962-1966. National Economic Development Board, Office of the Prime Minister. Bangkok, Thailand.

NEDECO, 1982a. Development of the Lower Mun Basin: Feasibility Study (Volume i - Main Report). NEDECO Netherlands Engineering Consultants for the Interim Committee for Coordination and Investigations of the Lower Mekong Basin. Arnheim, The Netherlands.

NEDECO, 1982b. Development of the Lower Mun Basin: Feasibility Study (Executive Summery). NEDECO Netherlands Engineering Consultants for the Interim Committee for Coordination and Investigations of the Lower Mekong Basin. Arnheim, The Netherlands.

NEDECO 1988. Perspectives for Mekong development: Indicative plan for the development of land, water and related resources of the Lower Mekong Basin. Working Document: Volume 5: J. Review of Existing Projects. NEDECO, Electrowatt Engineering Services Ltd. and Asian Engineering Consultants Corp. Ltd. for the Interim Committee for Coordination of Investigations of the Lower Mekong Basin

NESDB, 1976. The Forth National Economic and Social Development Plan (1977-1981). National Economic Development Board. Bangkok, Thailand

Ng R.C.Y. 1970. Some Land-Use Problems of North-east Thailand. Modern Asian Studies 4(1): 23-42

NSO 2000. The 2000 Population and Housing Census, Thailand. National Statistics Office. Bangkok, Thailand.

OEPP, 1998. Environmental Impact Assessment in Thailand. Office of Environmental Planning, Ministry of Science, Technology and Environment. Bangkok, Thailand.

O'Reilly D., 2001. From the Bronze Age to the Iron Age in Thailand: Applying the Heterarchical Approach. Asian Perspectives 39(1-2)

Pakkasem P. 1972. Thailand's Northeast Economic Development Planning: A Case Study in Physical Planning. Ph.D Thesis. Unviersity of Pittsburgh. (cited in Chomchai 1994)

Palanisami K. and A. Apinantara, 1984. Performance Evaluation and Investment Priorities in Irrigation Systems of Northeast Thailand. Faculty of Agriculture, Khon Kaen University. Khon Kaen, Thailand.

Patamatamkul S., 2000. Tank Irrigation Systems in Northeast Thailand: Past, Present and Future Outlook. Khon Kaen University. Khon Kaen, Thailand

Patamatamkul S. 2001. Water Resources Development and Management in the Korat Basin, Northeast Thailand. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Parnwell M and J. Rigg 1995. The people of Isan: missing out on the Economic Boom. (cited in Pednekar 1997)

PCD 1997. Development of an action plan to improve the water quality in the northeastern basin, Thailand. Pollution Control Department, Ministry of Science, Technology and Environment. Bangkok, Thailand

Pednekar S.S. 1997. Resources Management in the Thai Mekong Basin. Mekong Working Papers, Working Paper No. 71. Department of Geography, University of Sydney

Plantanius H., 1963. The North-East of Thailand: Its Problems and Potentialities. National Economic Development Board. Bangkok, Thailand

Polthanee A. 2001. Rice-Based Farming Systems in the Korat Basin of Northeast Thailand. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Prapertchob P. 2001. Human Resources and the Economy of the Northeast Region of Thailand. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Royal Forest Department, 2001. Forestry Statistics of Thailand 2001. Royal Forestry Department. Bangkok, Thailand

RID, 1962. Hydrology and Water Studies of the Lam Takhong Project. Hydrological Section, Survey Division, Royal Irrigation Department. Bangkok, Thailand

RID, 1963. Feasibility Report on Lam Takhong Storage Dam Project, Korat Province, North-East Region, Thailand. Volume 1: Project Evaluation. Royal Irrigation Department, Ministry of Agriculture. Bangkok, Thailand

RID, 1985. "Final Report of Consultant Task Force for the Northeast Small Scale Irrigation Project " Royal Irrigation Department, Ministry of Agriculture and Cooperatives. Bangkok, Thailand.

RID, 1988. Chi Basin Water Use Study. Final Report: Appendices. Sir Alexander GIBB & Partners, TEAM Consulting Engineering Co, Ltd., MINSTER Agriculture Ltd., Institute of Hydrology. Royal Irrigation Department. Bangkok, Thailand

Rigg, J. 1987. Forces and influences behind the development of upland cash cropping in northeast-Thailand. The Geographical Journal 153(3): 370-382.

Sacha Sethaputra, Suwit Thanopanuwat, Ladawan Kumpa, Surapol Pattanee, 2001. Thailand's water vision: A case study. In: From Vision to Action: A synthesis of experiences in Southeast Asia, ed. Ti and Facon. Food and Agricultural Organization/Economic and Social Commission for Asia-Pacific

Sethaputhra Ch., S. Buatuan, C. Vadhanavikkit and N. Pluengnuch, 1985. Village Level Water Storage and Utilization Practices in Northeast Thailand: A Survey and Project Evaluation. Khon Kaen University. Thailand.

Snowy Mountains Engineering Corporation (SMEC) 1981. Pa Mong multipurpose project. Organization and financing for project implementation. Report submitted to the Interim Committee for co-ordination of investigations of the Lower Mekong Basin.

Sneddon C.S. 1999. Altered rivers: socio-ecological transformations, water conflicts and the state in Northeast Thailand. Ph.D. Thesis submitted to the Faculty of the Graduate School of the University of Minnesota

Sneddon C.S. 2002. Water conflicts and river basins: The contradiction of comanagement in northeast Thailand. Environment and Planning A, 35: 229-2250

Sneddon C., 2003. Reconfiguring scale and power: the Khong-Chi-Mun project in northeast Thailand. Environment and Planning 35: 2229-2250

Srisuk K. 1997. Conceptual groundwater model for saline water and saline soils in the Chi-Mun basin, northeast Thailand. Presented at the International Symposium on Hydrology and Water Resources for Research and Development in Southeast Asia and the Pacific. 16-19 December 1997. Nong Khai, Thailand

Srisuk K., V. Sriboonlue, C. Buaphan, C. Hovijitra 2001. The Potential of Water Resources in the Korat Basin. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

Sriswasdilek J., 1983. An Economic Analysis of Two Pump and Four Tank Irrigation Projects in Northeast Thailand. Paper presented at the Water Management and Policy Workshop, 13-15 September 1983, Khon Kaen, Thailand. (cited in Palanisami K. and A. Apinantara, 1984)

Steinberg, D.I., 1986. The Role of External Assistance in the Economic Development and Planning of Thailand: Torques and Tensions in the American Aid Program. Aid Evaluation Occasional Paper No. 6, U.S. Agency for International Development.

Suchart Prasith-rathsint, Manu Srikhajorn, Tawatchai Artuorn-thrurasook and Rungrote Pungpun 1981. The impact of agricultural irrigation projects on fertility in northeast Thailand. National Institute of Development Administration. Bangkok, Thailand

Tangaya K., 1994. The Electrical Pumping Project. In: Water lifting devices and groundwater management for irrigation: Report of the Export Consultation. United States Food and Agriculture Organization FAO. Bangkok, Thailand.

THAICID, 2004. History of Water Resources Development in Thailand. Thailand Commission on Irrigation and Drainage (THAICID). Bangkok, Thailand

THAICID, 2005. 25 River Basins of Thailand. Thai National Committee on Irrigation and Drainage. Bangkok, Thailand. http://www.rid.go.th/thaicid (last accessed, December 2005)

Tubpun Y., K.W. Easter and D. Welsch, 1982. Tank Irrigation in Northeast Thailand: The Returns and their Distribution. Institute of Agriculture, Forestry and Home Economics. University of Minnesota. United States of America.

USBR 1956. Reconnaissance Report: Lower Mekong Basin. Prepared for the International Cooperation Administration. United States Bureau of Reclamation (cited in Sneddon, 2003).

USBR 1965. Reconnaissance report of findings and recommendations on Mun-Chi River Basin Water Resources. United States Bureau of Reclamation, Department of Interior. United States.

USBR 1971a. Nam Chi Project Feasibility Report. Prepared for the Agency for International Development and the Royal Irrigation Department. United States Bureau of Reclamation, Department of Interior. Washington, United States

USBR 1971b. Nam Mun Project Feasibility Report. Prepared for the Agency for International Development and the Royal Irrigation Department. United States Bureau of Reclamation, Department of Interior. Washington, United States

Uraivan Tan-Kim-Yong, 1995. Muang-fai communities are for people: Institutional strength and potential. Bangkok: Chulalongkorn University Social Research Institute

VanLiere W.J. and T. Kawai, 1973. Topography, population and actual agricultural land use in the Northeast in relation to its present and future land capability. Discussion paper for the Agricultural Working Group of the Development Assistance Group Thailand. Khon Kaen 31 October – 5 November 1973. Committee for Coordination and Investigations of the Lower Mekong Basin.

VanLiere W.J., 1980. Traditional Water Management in the Lower Mekong Basin. World Archeology 11(3): 265-280

Wang J.C.W., 1973. Experimental and Demonstration Farm for Irrigation Agriculture in Kalasin, Thailand. Royal Irrigation Department and UNDP/FAO. Bangkok, Thailand (cited in AIT, 1978)

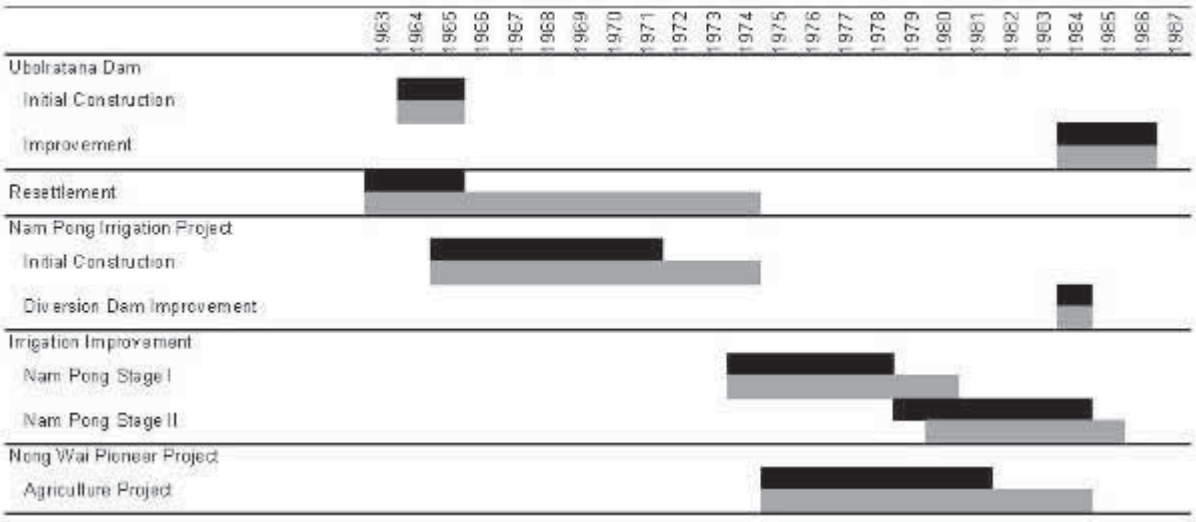
WATCO, 1984. Lower Mekong Water Resources Inventory: A component of the Lower Mekong Basin Information System (Summery of Project Possibilities). Interim Committee for Coordination and Investigations of the Lower Mekong Basin. WATCO, Gaanderen, Netherlands

White G., E. deVries, H.B. Dunkerley and J.V. Krutilla 1962. Economic and Social Aspects of Lower Mekong Development. Report to the Mekong Committee

Wongwiwatchai C. and K. Paisancharoen 2001. Soil and Nutrient Mangement of some major field crops in the Korat Basin, Northeast Thailand. In: Natural Resource Management Issues in the Korat Basin of Northeast Thailand, ed. Kam et al. International Rice Research Institute. Los Banos, Philippines

7 Annex

Figure 23: Nam Pong Project - Planning and Implementation Scheduling



Source: (NEDECO 1988)