DEVELOPING A BASIN FRAMEWORK FOR PRIORITIZING INVESTMENTS IN WATER RESOURCES INFRASTRUCTURE IN VIETNAM'S RED RIVER BASIN[1]

N. Bakker, Chu Tuan Dat, P. Smidt and C. Steley [2]

SYNOPSIS:

This paper presents lessons learned in implementing two integrated water resources management (IWRM) projects with particular emphasis on drainage. The first section describes the water resources sector. The second presents the main features of the first Red River Delta Water Resources Sector Project. The Project Completion Report, economic reevaluation, found drainage subprojects did not perform as well as expected at appraisal. This resulted in the hypothesis that drainage collection and delivery systems constrain the performance of pumped drainage outfalls requiring a more integrated approach to improve drainage. The third section presents the main features of the current Second Red River Basin Sector Project (SRRBSP) The fourth describes the preparation of the Water Sector Action Plan to provide a framework for selecting subprojects under SRRBSP. Irrigation diversion and drainage outfall capacities were found to explain 55% of the variation in irrigated agricultural production at the 0.015% significance level. The exponential production function provides a simple method of economic evaluation and subproject selection. It also supports the above hypothesis, indicating drainage system capacities may be a generic performance constraint, as the optimum drainage outfall capacity is only 3.2lps/ha compared with present design standard of 5 to 6 liter per second per hectare adopted by the Ministry of Agriculture and Rural Development. The final section presents the proposed design of a drainage research study to assesses the performance of drainage subprojects, identify constraints and develop a participatory approach to prepare integrated drainage subprojects.

1 THE WATER RESOURCES SECTOR

Vietnam has a long history of water management developed in response to water shortages during the dry season, a monsoon climate that regularly causes extensive flood damage, and a need to intensify agricultural production. Irrigation, drainage, and flood control have traditionally been the main focus of water sector development. At present, more than 2.6 million ha of agricultural land is irrigated through 75 large and medium-scales schemes and thousands of small-scale systems. These systems are managed by 173 state-owned irrigation management companies (IMCs) and thousands of agricultural cooperatives and water user groups. The Government recognizes that the country's irrigation systems suffer from a number of constraints that limit performance. These include (i) degraded or inadequate irrigation infrastructure, (ii) weak institutional capacity to manage the systems, and (iii) inadequate integration of agricultural extension with developing cropping systems. This low performance contributes to rural poverty.

The Red River basin is the main river basin in the north of Vietnam (see map). It is home to about 25 million people or about one third of the country's total population. Its total area is 169,000 square kilometres of which the upper half is in the Peoples' Republic of China. The Red River basin has 25 provinces: 9 are in the delta, and the remaining 16 are in the uplands. Hanoi and Hai Phong, the second and third largest cities of Vietnam, are located in the basin's delta. The rural delta is one of the most densely populated areas of the world supporting about 1,000 persons/km^2. Urbanization in the basin is about 15 percent, and the urban population is increasing by about 10 percent annually. The Red River delta has irrigation systems that were among the first to be developed in the country, several centuries ago. In the low-lying areas, drainage rather than irrigation is often the key factor affecting the stability and productivity of agricultural crops, and an extensive centuries-old system of river and sea dikes reduces vulnerability to flooding. Of the total hydropower potential of 8,600 megawatts (MW) in Vietnam, 8,480 MW or 45 percent is in the Red River basin.

Agriculture accounts for about 35 percent of the gross domestic product in the Red River delta, compared with 24 percent for industry and 41 percent for services. Land-holdings in the basin are small and scattered, particularly in the delta, where the average farm size is only 0.6 hectare (ha). Irrigated agriculture in the basin uses 78 percent of total water abstracted, followed by industry with 18 percent, and water supply for municipal and domestic use with 4 percent. The existing irrigation and drainage facilities in the basin are 30 large and medium-scale schemes in the delta, including 27 pumping stations, serving about 760,000 ha, and many small schemes in the uplands serving about 210,000 ha. About 20 percent of Vietnam's annual rice production is produced in the Red River basin. Reliable and timely availability of water is essential throughout the basin to ensure double- or triple-cropping seasons, and to allow cultivation of high-yielding varieties, which are the only possible response to the scarcity of arable land.

Table 1 indicates the total population of the RRB was about 25 million in 2000 of which 10 million (40%) were poor compared with the national average of 37%.[3] Poverty is most pronounced in rural areas which depend for their livelihood on agriculture, especially rice cultivation. Although the incidence of poverty is higher in the highlands (55% vs 37%), there are 25% more poor people in the densely populated rural delta (5.5 vs 4.4 million).

Table 1 Population and Poverty in the Red River Basin

Area	Population (million)	Poverty Incidence (%)	Poor Population
Ha Noi & Hai Phong Cities	2.0	5	0.1
Rural Delta	15.0	37	5.5
Highlands[4]	8.0	55	4.4
Red River Basin	25.0	40	10.0

Reducing poverty, sustaining economic development and improving management of natural resources remain challenges in the Red River basin. From an economic point of view, the most important challenge is to further increase agricultural productivity and reduce poverty in rural areas, despite the high population density and the consequently very small and scattered land-holdings. The scope for expanding the cultivated area has been nearly exhausted. To lift and keep poor households out of poverty, it is necessary to increase and maintain agricultural productivity. Labour absorption in other sectors is not likely to be sufficient to keep pace with the reduction in the agricultural labour force that would be necessary to reduce the pressure on land. For many people, rice self-sufficiency is still the immediate way out of hunger and poverty. Because the poorer farmers typically live at the end of the water distribution system and in low-lying areas with poor drainage, rehabilitating irrigation and drainage infrastructure and improving water management is therefore directly targeting poorer farmers.

The Government has recognized the need to shift away from the past largely supply-driven approach, with a heavy focus on investment targets determined at central level, to a more demand-driven decentralized approach. The Government has also made a start with adopting integrated water resources management in river basins. Most significant in this process was the adoption of the Water Resources Law (WRL) in 1998. The National Water Resources Council was established in 2000 under the WRL to advise on national water resource management issues. River basin organizations are being operationalized to improve and integrate water resources management in the large Mekong, Dong Nai and Red River Basins. In November 2002, the Government took another important step by transferring the important stewardship and regulatory functions of water resources management to the new Ministry of Environment and Natural Resources (MNRE). The Ministry of Agriculture and Rural Development (MARD) has retained operational water resource management and service delivery functions in the key flood control, irrigated agriculture and rural water supply and sanitation subsectors.

The need to rehabilitate and upgrade the water resources infrastructure in the Red River Delta (the Delta) prompted the Government of Viet Nam to seek Asian Development Bank (ADB) assistance in the late 1980s. In response, ADB provided a $75 million loan in 1993 for the Irrigation and Flood Protection Project and a $60 million loan in 1994 for the Red River Delta Water Resources Sector Project (RRDSP). The main component of the first project was to rehabilitate the dyke providing flood protection for Hanoi. The objectives of the RRDSP were to upgrading and rehabilitate irrigation and drainage systems in the Red River delta. In 2002, ADB provided a loan of $70 million in 2001 for the Second Red River Basin Sector Project (SRRBSP), a follow-on project to the RRDWRSP. The SRRBSP is co-financed by AFD through a $30 million loan and by the Government of the Netherlands through a $10.6 million grant.

2 THE RED RIVER DELTA WATER RESOURCES SECTOR PROJECT (RRDSP)

Implementation of the project commenced in 1995 and ended in 2001. RRDSP included three components: (i) upgrading and rehabilitating water resources infrastructure, (ii) strengthening operational management of the Bac Hung Hai irrigation and drainage system—the largest in the basin—and (iii) enhancing environmental monitoring capacity. A $1.4 million advisory technical assistance (TA) complemented the RRDSP to strengthen the capacity of sector agencies in planning, design, construction, and the management of irrigation and drainage systems.

The RRDSP improved irrigation and drainage systems serving an area of about 530,000 ha benefiting around 2.3 million farm households. Works undertaken under the project included construction or rehabilitation of pumping stations, drainage outfalls, irrigation intake sluices and irrigation and drainage canals. ADB's Project Completion Report (PCR) of 2002 concluded that the investments have indeed addressed important irrigation and drainage constraints.

However, the PCR concludes that the economic returns to project investments are lower than originally estimated. Irrigation performed better than drainage subprojects. The lower returns to investments in drainage subprojects were attributed to: (i) drainage generally benefits the summer wet season rice crop but not the spring dry season crop; (ii) the relatively high cost per area drained;[5] (iii) the virtual absence of flood-inducing major storms since 1994; and (iv) project investments were limited to the main drainage system (or part of it) without addressing constraints in the secondary and tertiary drainage systems.[6] Despite the low apparent returns, farmers interviewed during the Project Completion Mission generally reported favourably on the drainage subproject facilities. Overall, the PCR rates the RRDSP as successful.

Several important lessons, learned through implementation of the first RRDSP, were considered during the design of the follow-on SRRBDP. Getting the design of system rehabilitation and improvement right is the key to subproject performance and impact. The RRDSP employed a traditional engineering approach, focusing almost entirely on primary infrastructure. Because of inadequate investments in the secondary and tertiary canal systems, system performance has remained below expectations resulting in the inability to fully capitalize on project investments.

Therefore future projects need to: (i) ensure parallel downstream investments are made in a timely manner, (ii) deploy a more holistic and participatory subproject preparation approach involving primary stakeholders and (iii) base project planning on a river basin development approach within an overall system context addressing key constraints in an integrated manner.

3 THE SECOND RED RIVER BASIN SECTOR PROJECT (SRRBSP)

The objective of this project is essentially the same as the RRDSP, i.e. improving agricultural performance through improvements in irrigation, better drainage, watershed protection, and flood protection. In addition, the SRRBSP promotes integrated water resource management within the entire Red River basin. Furthermore, the SRRBSP has a sharper poverty focus and promotes stakeholder participation in water management at local and basin levels.

Part A addresses aspects related to integrated water resource management and associated institution building. Part B provides infrastructure improvements and associated rural development support investments at the community level to optimize the benefits from the water services. A sector approach is employed for the implementation of Part B, i.e. investments are screened and appraised against a set of agreed selection criteria.

Part A has five components: (i) support for capacity building for the recently established Red River Basin Organization (RRBO); (ii) public awareness and education programs for water resource management; (iii) a pilot water licensing and wastewater discharge permit systems; (iv) a water quality monitoring network; and (v) project management support.

Part B comprises investments ("subprojects") to improve: irrigation systems and watershed protection in the uplands, (ii) delta irrigation and drainage systems, (iii) flood protection systems in the delta, (iv) complementary project implementation support, and (v) research studies.
Components (i) and (ii) above will comprise two complementary subcomponents: (i) improving water resources infrastructure through civil works and provision of equipment (pumps, gates, etc.); and (ii) rural development support (RDS) through agricultural support services and small-scale water-related infrastructure at community level through a decentralized and participatory approach. Flood protection subprojects may also include RDS subcomponents as needed. The rationale for the RDS activities is that the diverse needs of poor farmers for agricultural improvements and poverty reduction are best met through a participatory process approach.
The SRRBSP is to be implemented over six years beginning in 2002. As of mid-2003, the project is still in its start-up phase with several preparatory works ongoing.

4 THE SRRBSP WATER SECTOR ACTION PLAN

The Water Sector Action Plan (WSAP) is required to provide a framework for selecting Part B investment subprojects. Agreement was reached in December 2002 to develop the WSAP in two stages:

- Stage 1 (WSAP1): Selection of systems based on their present performance, poverty levels and the potential for improved performance and increased agricultural production;
- Stage 2 (WSAP2): Selection of subprojects and other interventions based on the results of participatory diagnostic surveys (PDS) of priority systems selected during Phase 1.

This paper presents WSAP1 results and recommends priority delta systems for conduct of PDS to select irrigation and drainage subprojects under WSAP2. Different criteria may now be used to select upland subprojects. The inventory of the dyke system undertaken in 1999 will be used as a basis for further WASP2 development and flood protection subproject selection. The main findings of the analysis and interpretation are:

- Existing and optimum capacities are 1.9 and 3.5 lps/ha (irrigation) and 2.8 and 3.2lps/ha (drainage) indicating both irrigation and drainage capacities are generic constraints;
- However average rice intensity (total/summer area) was 197% and rice yields were 5.4 T/ha and 4.8 T/ha in spring and

summer respectively. High cropping intensities and spring rice yields indicate irrigation is not the limiting production constraint.

- The first RRDSP PCR found drainage subprojects were not as effective as irrigation.
- MARDs design capacities are about 1.8 and 5-6 lps/ha for irrigation and drainage. Thus the optimum capacities, estimated herein, are more than 1.5 times the MARD design standard for irrigation and only half the MARD design standards for drainage.
- The first RRDSP improved only outfalls (pumping stations and sluice gates). The PCR hypothesized that unimproved collection and delivery systems constrained drainage subproject performance and a drainage research study is now under preparation;
- The CPO proposed 16 irrigation and drainage subprojects in 11 polder systems. Twelve subprojects (75%), in 7 systems, and a further five systems are now recommended for priority consideration to develop the Stage 2 WSAP and select the non-core subprojects.

The present analysis is based on system data (Table 2) derived from the following sources:

- 97 – 01 agricultural production estimated from district data by polder system provided by the General Statistics Office (GSO);
- Similar estimates of the incidence of poverty in each system explained below and;
- Latest MARD data (March 2003) on irrigation delivery and drainage evacuation capacities for 27 systems. The small Yen Lap, Uong Bi and Dong Trieu schemes were excluded.

Both the Chi Linh and North Ninh Binh (including the Hoang Long flood retention area) systems exhibit relatively low productivity of land despite high pump capacities. They were both found to be outliers as the significance of the land productivity and capacity association was improved by their exclusion despite the loss of 2 degrees of freedom. The North Ninh Binh and upland Chi Linh systems were excluded from further analysis.

There is widespread belief that Vietnamese irrigated agriculture is not achieving its potential.[7] Of 4 million hectares (mha) of cultivated rice land, 3 mha was found to be equipped with some kind of irrigation but only 2 mha was irrigated. Poor performance was attributed to incomplete systems, design deficiencies, deterioration of infrastructure and poor operation (but not water shortage). National rice yields were reported to be 70% of those achieved in China.

The 25 delta systems analysed grew 566,561ha of dry season rice in spring and 585,658ha in the summer wet season. Thus the average cropping intensity (CI = total rice area/summer area) was 197%. Soc Son is much lower (168%) but North Nam Ha Song Cau and Ba Vi are the only other systems with CIs below 190% indicating irrigation capacity constrains agricultural production. South Yen Dung is the only system with a large CI (223%) indicating a drainage constraint. Average rice yields were 5.4T/ha, in the spring dry season, and 4.8T/ha in the summer wet season. While this may be due to seasonal weather differences, especially during ripening, it may also indicate a generic drainage constraint. Table 3 summarizes the impact of irrigation service on rice production. IDMCs do not keep similar data on drainage services.

Table 3 indicates the downstream end of Dan Hoai system received a lower level of irrigation service in 2002. Both spring and summer rice yields were slightly lower at the downstream end of the system indicating irrigation and drainage were mild constraints. However the spring area was slightly higher than summer area indicating drainage, rather than irrigation, was the limiting constraint at the downstream end of the system (despite 2002 being about a one-in-three dry year[8]). Irrigation is essential in the dry season which implies downstream farmers compensate for poor official service by re-pumping return flows. Thus MARD may well be justified in using an irrigation design standard of only 2.3 lps/ha as system efficiency will be relatively high. This discussion indicates land, and not water, may be limiting in the RRD and drainage capacity, rather than irrigation, is the more likely generic constraint limiting system performance.

Table 2   Irrigation Service and Rice Production; Dan Hoai System 2002

Irrigation Service	Downstream Commune	Spring Rice Crop		Summer Rice Crop		Cropping Intensity (%)
		Area (ha)	Yield (T/ha)	Area (ha)	Yield (T/ha)	
Full	56%	4,749	6.1	4,762	5.7	200
Partial	85%	1,810	6.1	1,892	5.4	196
None	100%	297	5.8	281	5.2	206

Table 2 indicates average irrigation delivery and drainage evacuation capacities are only 1.9 & 2.8 lps/ha respectively. While the systems can supply 83% of the irrigation design standard (2.3 lps/ha) they have only about half the preferred drainage capacity (5 to 6 lps/ha). There are also large variations between systems. Irrigation delivery capacities range from 0.3 (Soc Son) to 5.8 lps/ha (Nghia Hung). Drainage evacuation capacities range from only 0.2 (North Duong) to 7.6 lps/ha (Song Nhue). Thus there is an apparent need to invest in increasing both irrigation and drainage capacities (apart from rehabilitating existing infrastructure).

Table 3 Capital Cost of RRDSP Pump Subprojects

RRDSP Subproject	Cost ($million)	Service Area (ha) Irrigation	Service Area (ha) Drainage	Capacity (cu m/hr)	Duty (lps/ha)	Unit Cost ($/lps)
Khai Thai	3,085		4,200	75,600	5.00	147
Yen Lenh	2,789		4,472	78,000	4.85	129
South Ninh Binh	1,849		14,010	188,000	3.73	35
Co Do Van Thang	1,884		6,035	96,000	4.42	71
Huu Bi 2	2,147		11,250	86,400	2.13	89
Vinh Tri 2	2,324		20,006	90,180	1.25	93
Do Neo	2,553		3,910	72,000	5.11	128
Van Thai	2,186		4,329	75,600	4.85	104
Kim Doi - Trinh Xa	2,775		18,000	50,400	0.78	198
Soc Son	1,875		2,789	38,880	3.87	174
Trieu Duong	1,331		3,958	31,200	2.19	154
Phan Dong	1,748		2,267	12,600	1.54	499
Thanh Diem	3,727	7,574		36,000	1.32	373
Phu Sa	1,195	10,150		40,320	1.10	107
Dai Dinh	2,241	9,012		48,000	1.48	168
Total	33,709			1,019,180		119
Legend:		Indicates core subprojects				

Source: ADB (2002) *Project Completion Report on the Red River Delta Water Resources Sector Project*

4.1 Agricultural Productivity and System Capacities:

Statistical associations between system irrigation diversion and drainage outfall capacities and the agricultural productivity of land were explored using simple linear, quadratic, semi-log and exponential (log-log) productivity functions. Exponential productivity functions proved the most significant for all applications. Surprisingly there was no significant difference between pumped and gravity capacity for either irrigation or drainage. Thus the analyses were based on total capacities. Regression analysis was used to estimate the following productivity functions:

$P = 8.5052D^{0.157569}$, $R^2 = 0.426$ and significance = 0.04%

$P = 8.4380I^{0.188945}$, $R^2 = 0.0.395$ and significance = 0.08% and

$P = 8.1712I^{0.122754}D^{0.109789}$, $R^2 = 0.553$ & significance = 0.015% (Eq 1) where:

P = productivity of land (T/ha) = annual production/crop area

I = irrigation delivery capacity (lps/ha) = total irrigation capacity/crop area

D = drainage delivery capacity (lps/ha) = total drainage capacity/gross area

Equation 1 is illustrated in Figure 1. It explains more than 55% of the variation in agricultural productivity, over the period 1997 to 2001, and is statistically significant at the 0.015% level. This is a slight improvement over the previous 2001 function ($R^2 = 0.552$ vs 0.546). The significance of the drainage function is, however, increased considerably ($R^2 = 0.462$ vs 0.362) while that of the irrigation function diminished commensurately ($R^2 = 0.395$ vs 0.464). These results are perplexing as 2001 and 1997 were particularly wet and dry respectively. Thus the original 2001 production function might have been expected to overestimate the effectiveness of drainage capacity rather than irrigation. Nevertheless the above production functions indicate irrigation capacity remains a more significant determinant of agricultural productivity than drainage capacity (exponent = 0.122754 vs 0.109789). Limited drainage collection and delivery capacity may be restricting the effectiveness of drainage outfall capacity.

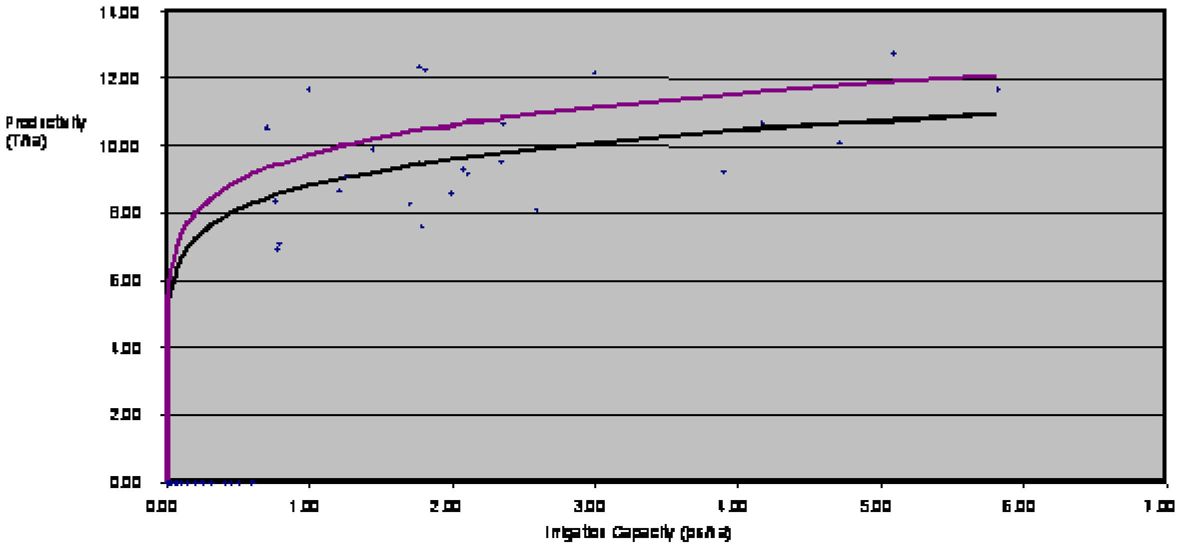

Figure 1 WSAP Production Function P=8.1712 I

4.2 Cost of Pumps:

Capital cost influences optimum pump capacity. Table 4 summarizes relevant Red River Delta Sector Project subproject data. While irrigation capacities were reasonably consistent the design drainage duty varied considerably from less than 1lps/ha to more than 5lps/ha. The rationale for these large variations is not immediately apparent and SRRBSP should consider adopting a uniform drainage capacity.

Table 4 also indicates the unit cost of pumps varied considerably from 35 $/lps to nearly 500 $/lps. This variation is not, however, due to expected economies of scale as there is no statistical association between capital cost and pump capacity (R^2 = 0.002). The three core subprojects ($307/ha) cost three times the non-core subprojects ($103/ha). In the absence of adequate explanations, for these large variations in cost, the present analysis was based on the average unit cost of RRDSP pumped subprojects ($119/lps). Sensitivity analysis was undertaken to estimate the impact of higher costs ($200/lps).

4.3 Optimum Capacities:

The methodology is summarized below:

- The PCR productivity of rice is $110/T and production costs are about 40% of GVP;
- The present value of investing 1 unit/annum @ 12% IRR over 25 years is 7.843;
- Typically electricity usage in the RRD is about 300 kWh/ha.[9] The subsidized cost of electricity (VND 660/kWh) is reported to be only a third of its economic cost. Thus the economic cost of operation is $39.6/ha or 7% of the capital cost of the average irrigation and drainage capacity (4.7 lps/ha @ $119/lps = $559/lps);
- The PCR for RRDSP allowed 10% of total capital cost every five years for major repair or equipment replacement. This is equivalent to 1% of direct capital costs per annum. Thus O&M costs are taken herein as 8% pa of direct capital costs of pumps;
- Capacities are optimum when marginal benefits equal incremental costs ie the slope of the production function = (1 + 7.843 x 0.08) x 119/ (7.843 x 66) = 0.3741 T/lps.

$dP/dI = 8.4380 \times 0.1889 I^{-0.811055} = 0.3741$, I_{opt} = 6.0 lps/ha and P_{opt} = 11.8T/ha and
$dP/dD = 8.5052 \times 0.1576 D^{-0.842431} = 0.3741$, D_{opt} = 4.5 lps/ha and P_{opt} = 10.8T/ha

Either irrigation capacity of 6.0lps/ha or drainage capacity of 4.5lps/ha optimized agricultural production in 1997 to 2001 (3.1 and 2.5lps/ha respectively for a unit pump cost of $200/lps). Similarly for the combined production function Eq 1: I_{opt} = 3.5lps/ha, D_{opt} = 3.2lps/ha and P_{opt} = 10.8T/ha. (I_{opt} = 1.8lps/ha, D_{opt} = 1.6lps/ha & P_{opt} = 9.2T/ha for a unit pump cost of $200/lps). The range 1.8 to 3.5lps/ha is a common irrigation capacity (corresponding to 40 to 80% efficiency) but the optimum drainage capacity of 1.6 to 3.2lps/ha is very low compared with MARDs design standard (5 to 6 lps/ha). The results confirm irrigation delivery capacity is presently more effective than the capacity of drainage outfalls in contributing to the productivity of land.

4.4 Interpretation of Results:

PCR economic reevaluation of RRDSP core subprojects also found drainage did not perform as well as irrigation (Table 4) because: (i) drainage benefited the wet season (summer) crop only; (ii) Phan Dong unit costs were high; (iii) the virtual absence of flood inducing major storms in the period 1995 to 2001 and (iv) investments were limited to main drainage systems without addressing lower level constraints. These explanations for poor drainage performance are considered below.

First limited irrigation delivery capacity might explain why farmers were unable to take full advantage of improved drainage to increase dry season (spring) rice production. This implies all drainage subprojects should assess current irrigation service levels and provide increased delivery capacity and other improved services where required.

Second Table 5 confirms Phan Dong unit costs were high at $771/ha or $501/lps. Table 4 also presents hypothetical pump subproject EIRRs adjusted to reflect: (i) average unit cost of only $119/lps and (ii) the full economic cost of operation and maintenance.

Table 4 Economic Reevaluation of RRDSP Pumped Core Subprojects

PCR Economic Reevaluation					WSAP Revision		
Core Subproject		Area (ha)	Cost ($/ha)	EIRR (%)	Duty (lps/ha)	Benefit ($/ha/yr)	EIRR (%)
Name	Type						
Thanh Diem	Irrigation	7,574	492	17.1	1.32	95.6	52.6
Phan Dong	Drainage	2,267	771	4.3	1.54	66.4	28.1
Trieu Duong	Drainage	3,958	336	6.1	2.19	33.3	1.4
Weighted Average		47,799	361	12.1	NA	53.6	15.9

Table 5 indicates accounting for the average unit cost improves economic performance of both the four core subprojects (and RRDSP) in general and Phan Dong in particular. However accounting for the full economic cost of O&M further reduces the Trieu Duong EIRR because of the relatively small benefit of increased agricultural production. Table 4 also confirms the poor performance of drainage relative to the irrigation subproject.

Third, from 1995 to 2001, the mean annual rainfall at Hanoi is reported to have been about the same as the long term average for 1890-1990 (1,690 mm) favouring the effectiveness of neither irrigation delivery nor drainage evacuation capacity.

Finally the lack of sufficient drainage collection and delivery capacity remains the most likely explanation of poor main drainage performance together with a possible lack of irrigation delivery capacity to benefit by increasing dry season (spring) rice production.

4.5 System Ranking and Selection:

The ranking methodology is described below:

Eq 1 was used to estimate: (i) the incremental irrigation and drainage capacities required to increase present agricultural productivity to the optimum of 10.8T/ha and (ii) the incremental agricultural productivity resulting from increasing present irrigation and drainage capacities to the optimums of 3.5 and 3.2lps/ha respectively;

This then allowed estimation of economic costs (C) and benefits (B) and calculation of two alternative benefit cost ratios from BCR = 7.843 (66B -0.08 x 119C)/119C);

The average BCR was then multiplied by system poverty incidence (p) to give the average poverty impact ratio PIR = p x BCR which was used to rank the systems.

Table 6 indicates Soc Son has the highest PIR. However, in view of its low agricultural productivity, the GOV is reported to have designated Soc Son as an industrial zone and the crop area has contracted from nearly 10,000 ha in 2001 to only 1,160 ha at present. MARD have now confirmed Soc Son should be excluded from further consideration. The following systems are now proposed for further consideration during preparation of Phase 2 of the WSAP.

Box 1: Systems Proposed for PDS during WSAP Stage 2

RRD System	BCR	PIR	CPO Subprojects
South Yen Dung	2.11	1.07	1
Song Cau	2.11	1.07	1
Ba Vi	1.80	0.83	0
North Duong	2.04	0.78	1
Phu Sa	1.85	0.78	2
Lien Son	1.72	0.71	2

Thuy Nguyen	1.75	0.64	0
Bac Hung Hai	1.53	0.57	3
Kinh Mon	1.51	0.47	0
An Thuy	1.17	0.43	0
An Kim Hai	1.33	0.42	0
North Nam Ha	1.38	0.42	2
Total			12

Box 1 shows use of the 1997 to 2001 production function has improved the potential for agricultural production increases through provision of increased system irrigation and/or drainage capacity. Nearly half the systems considered (12 of 25) now offer attractive economic returns (average BCR > 1). Systems may be divided into three groups:

- CPO proposed 12 (75%) subprojects in 7 ranked systems (BCR > 1): South Yen Dung, Song Cau, North Duong, Phu Sa, Lien Son, Bac Hung Hai & North Nam Ha;
- CPO did not propose subprojects in the other 5 ranked systems (BCR > 1): notably Ba Vi but also including Thuy Nguyen, Kinh Mon, An Thuy and An Kim Ha and;
- CPO proposed four (25%) subprojects in 4 unranked systems (BCR < 1): Tien Lang, Hai Hua, Bac Ninh Binh and South Thai Binh. The only change from the previous ranking is that Tien Lang has now joined this group of less promising systems.

4.6 Direct Economic Analysis:

The WSAP production function and GSO production data facilitate economic analysis of subprojects. There is still a risk the predicted benefits fail to eventuate but the analysis provides a transparent consistent method of ranking subprojects and identifying those that are unlikely to generate enough benefits to justify the investment. PDS may still be required to reformulate subprojects where preliminary analysis indicates a marginal BCR. The following example uses District data to illustrate the method. The benefit cost ratio (BCR) is estimated for the minimum discount rate (IRR) of 12%pa. Availability of Commune data would improve confidence in the results.

4.7 Example: Kinh Thanh 2 Drainage Subproject – North Nam Ha System

- From the economic reevaluation of RRDSP in the PCR the price of rice is $110/T, production costs are about 40% of GVP and the gross margin or NVP is $66/T;
- The Ha Nam Province Yearbook provides 97-01 agricultural production data in Binh Luc & Thanh Liem Districts which encompasses Kinh Thanh area in NNH system:
  - Thanh Liem average spring rice yield was 5.26T/ha & cropped area 7,426ha. Summer rice yield was 4.55T/ha and cropped area 6,970ha (CI = 207%);
  - Binh Luc average spring rice yield was 5.32T/ha and cropped area 9,106ha. Summer rice yield was 4.65T/ha and cropped area 9,246ha (CI = 198%);
  - Regression analysis investigated rice area trends. For Thanh Liem the most significant quadratic functions indicate summer and total (spring + summer) areas will stabilize in 2006 at 7,154ha and 14,626ha respectively indicating a potential to increase summer area by 318ha. Binh Luc summer area already exceeds its spring area indicating irrigation, rather than drainage, constrains;
  - Regression indicates Thanh Liem summer yield will be 5.1T/ha in 2005;
  - Total rice productivity averaged 9.82T/ha (vs 5.30 + 4.61 = 9.91T/ha);
- Existing Co Dam (37cumec), Kinh Thanh (19cumec) & Vinh Trang (64.5cumec) PS currently drain 35,045ha @ 3.44lps/ha. The Nam Dinh Consulting Company report five irrigation PS (total capacity 34.55cumec) serve 9,071ha of which only 6,671ha is cropped. Thus irrigation capacity is 5.2lps/ha (vs 2.2lps/ha in the WSAP). The two Kinh Thanh PS will drain 11,814ha of which 8,437ha (71%) is cropped. Unit cost of Kin Thanh 2 (34cumec) is only $4.8million/35,045 = $137/ha. The future situation is:
  - Kin Thanh: 53cumec draining 11,814ha @ 4.49lps/ha
  - Co Dam: 37cumec draining 8,500ha @ 4.35lps/ha
  - Vinh Trang: 64.5 cumec draining 14,731ha @ 4.38lps/ha
  - Total: 154.5cumec draining 35,045ha @ 4.41lps/ha

- The WSAP production function provides the following estimates of rice production:
    - $P = 8.1712 \times 5.2^{0.122754} \times 3.44^{0.109789} = 11.46$T/ha
    - $P = 8.1712 \times 5.2^{0.122754} \times 4.41^{0.109789} = 11.77$T/ha
- Thus alternative estimates of incremental rice production are: 1st method = 11.77 – 9.82 = 1.9T/ha, 2nd method = 11.77–11.46 = 0.3T/ha and the average = 1.1T/ha;
    - The estimated incremental O&M costs are $149,500/annum with the subproject;
    - Average BCR = 7.843{66(35,045x1.1 + 318x5.1) – 149,500}/4,800,000 = 4.1
    - Lowest BCR = 7.843{66(35,045x0.3 + 318x5.1) – 149,500}/4,800,000 = 1.1
    - $\{(1+i)^{25}-1\}/i(1+i)^{25} = 4,800,000\{66(35,045x1.1 + 318x5.1) -149,500\} = 1.9186$
    - $\{(1+i)^{25}-1\}/i(1+i)^{25} = 4,800,000\{66(35,045x0.3 + 318x5.1) -149,500\} = 7.3684$

Therefore by iterative solution i = average IRR = 52% and lowest IRR = 13 %

5 THE PROPOSED DRAINAGE RESEARCH STUDY

The drainage research study is to develop and pilot field test a participatory process to assess the performance of selected pumped drainage subprojects, identify and quantify the major constraints to increased agricultural production, prepare conceptual improvement designs, specify detailed design requirements and document the participatory design process.

A local research institute/university will be engaged to implement the study over about nine months commencing around 1 March 2004. To ensure the action research meets international standards, and leads to a publication in an international research journal, the local institute will associate with a recognized international research institute. To ensure adequate participation of local stakeholders, local institutes are also encouraged to associate with a suitable NGO(s). The successful drainage research consortia will have a demonstrated capacity for participatory action research in agricultural drainage preferably in the Red River Delta.

The initial working hypothesis, to be tested, is the capacity of lower level drainage collection and delivery systems constrain the performance of pumped outfalls regardless of their evacuation capacity. Nevertheless other possible constraints will also be considered and assessed, e.g. operation of drainage outfalls etc. The proposed action research methodology is to follow a flexible participatory learning process but is likely to involve the following indicative activities:

5.1 Selection of Subprojects:

Two first RRDSP drainage subprojects will be selected on the basis of initial appraisal of their relative performance and farmer satisfaction etc;

5.2 Definition of Drainage Catchments and Flood Affected Areas:

This is an essential prerequisite of drainage research requiring the participation of concerned farmers and communes. The delta polder systems are surrounded by dykes that prevent flooding from surrounding rivers. Thus both local rainfall and excess irrigation diversions require drainage from polders. The definition of subproject catchments should include:

- Preliminary definition of the subproject drainage catchments and flood affected areas based on available records, maps and discussions with IDMCs and farmers etc;
- Identification of communes/farmer groups within the specific subproject catchments;
- Confirmation of the subproject drainage catchments, flood affected areas and beneficiaries with the elected Subproject Drainage Committee (see below) and;
- Traverse the perimeter of the preliminary subproject catchments with SDC members to identify and inventory all water intakes to, and outfalls from, the sub-polder.

5.3 Representative Subproject Drainage Committee (SDC):

The DRC will propose and implement a process to identify the main target groups, in the subproject catchment area, and assist them to elect a representative Subproject Drainage Committee (SDC). As well as households in flood affected areas, target groups will include other poor and women headed households. The SDC Chairperson and a majority of its members and other officials should be individual farmers representing the main target groups.

5.4 Initial Orientation Meeting:

The SDC and study team will then meet with IDMC and commune representatives to discuss and agree the main agricultural production constraints within the drainage area and review and revise the study methodology accordingly. They will then prepare an implementation plan including timelines and responsibilities etc.

5.5 Participatory Survey of Drainage System:

The study team and SDC will then jointly undertake a survey of the drainage system from the on-farm level to the river outfall. This will refine the diagnosis of performance constraints, provide the necessary data for hydraulic calculation of system capacity and include the following indicative activities:

- Topographic mapping of the drainage catchment area at a suitable scale & contour interval. If suitable maps are not available this will require levelling of the area;
- Topographic survey of existing drains & preparation of longitudinal & cross sections;
- Assessment of the wet season rugosity (Manning's "n") of drainage channel;
- Inventory and survey of drainage structures, junctions, culverts and bridges etc to determine their hydraulic characteristics for calculation of system capacity.

5.6 Water Balance Measurements:

The study team and SDC will also jointly measure and calculate the weekly water balance within the drainage catchment area using a simple input-output model.[10] This will involve the following complimentary activities:

- Installation, calibration and measurement of irrigation and drainage inflows;
- Installation and daily measurement of rain gauges at representative locations;
- Daily potential evapo-transpiration estimates from a representative station;
- Daily operation records (hours) for each pump in the outfall pumping station and;
- Daily records of intake and minimum and maximum river water levels at the outfall.

5.7 Survey of Flooding and Drought:

The study team and SDC will jointly design and conduct a simple survey of the extent and severity of both flooding and drought. The sub-polder catchment area is to be divided into several zones with different levels of irrigation and drainage services based on farmer perceptions of the likely impact on agricultural production. The irrigation zones might be related to the IDMCs service fee assessment (full, partial and no irrigation). Farmer's assessments of drainage services should be complimented by weekly measurements of the extent, depth and duration of flooding. This requires a network of staff gauges tied to the common survey datum. Any unplanted or unharvested areas will be identified and treated as a separate service zone. The area affected will be measured and the cause of crop failure explained.

5.8 Hydraulic Calculation of Drainage Capacity:

The study team will then calculate the capacity of the sub-polder drainage system, from field level to the outfall, accounting for fluctuations in river levels. The hydraulic model used should be as simple as possible to facilitate design of remaining SRRBSP drainage subprojects. The water balance and flood survey data should be used for model calibration. The model should also be used to assess capacity constraints and the effects of alternative measures to alleviate them.

5.9 Conceptual Designs for Improved Drainage Performance:

Based on capacities and constraints, the SDC will select a number of practical improvement options for further consideration. The study team will prepare alternative conceptual designs, and estimate their costs, to support informed inclusive farmer decision making facilitated by SDC members. Tangible equity cost contributions would enhance decision making. The preferred improvement option should then be agreed by all of the affected farmers.

5.10 Economic Evaluation:

Subproject economics will be reevaluated, and compared with appraisal estimates, using the first RRDSP Project Completion Report Methodology. The potential economics, of further drainage collection/delivery system improvements, will also be evaluated using the SRRBSP Water Sector Action Plan methodology. Both methods require compilation of commune production data, and possible reconciliation with official GSO district data, rather than special surveys of agricultural production.

5.11 Terms of Reference:

Subject to economics the study team will then prepare draft TOR for detailed design of the preferred improvement option selected by the farmers.

Process Documentation and Training: The study team will specify the participatory process in the form of an Implementation Manual for formulation and design of future drainage subprojects. Upon agreement with CPO and PME the study team will conduct a workshop to train about 30 design company staff to use the participatory process and will finalise the IM in the light of comments and feedback received from participants.

---

[1] Paper No 134. Presented at the 9th International Drainage Workshop, September 10 – 13, 2003, Utrecht, The Netherlands.

[2] First Secretary, Royal Netherlands Embassy, Viet Nam; Expert, Ministry of Agriculture and Rural Development, Viet Nam; Principal Project Implementation Specialist, Asian Development Bank, Viet Nam Resident Mission; and Project Management Expert, Technical Assistance 3892-VIE: Second Red River Basin Sector Project

[3] Using the national poverty line of about 35 cents/person/day vs the international standard of $1/person/day.

[4] The population of the Northern Highlands Region is more than 11 million but only 70% of the area is in the RRB.

[5] The high investment cost is largely because of the higher pumping rate required per hectare (up to 6 litres/sec/ha for drainage compared to about 2 litres/sec/ha for irrigation).

[6] Non-agricultural benefits were not been taken into account; these are likely to be more significant for drainage subprojects than for irrigation subprojects.

[7] ADB et al (1996) *Vietnam Water Resources Sector Review* a joint report by the World Bank, ADB, FAO, UNDP and NGO Water Resources Group in cooperation with the Institute of Water Resources Planning

[8] The data analysis and interpretation were confirmed in discussions with staff of the Dan Hoai IDMC

[9] Turral, H. et al (2002) *Development and Specification of a Service Agreement and Operational Rules for La Khe Irrigation System, Ha Dong, Vietnam* in Irrigation and Drainage Volume 51, Number 2.

[10] Perry, C.J. (1996) *The IWMI Water Balance Framework: A Model for Project Level Analysis.*