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evaluation of
FARM LEVEL IMPACT OF BARAI IRRIGATION SYSTEM

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Puok District, Siem Reap Province, Kingdom of Cambodia

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Executive Summary

This study set out to determine the impact of the ILO supported improvements to the Barai Irrigation System on the farmers who use the system. The Barai Irrigation System was first constructed in the 1930s. Water is diverted from the Stung Siem Reap River and enters a series of tertiary and secondary canals with an irrigated command area of around 4,000 hectares. The ILO began working on the Barai Irrigation System in 1993 when the system had fallen into disrepair. The improvements consisted of extensive physical rehabilitation, establishing a system of user management and maintenance and supporting the government to oversee system management.

The impact of the ILO initiative was evaluated in terms of the improvements for the farming community at the household level. This included irrigation improvements leading to increased farm productivity and the efficacy of user management structures in determining equitable and adequate water supply. To gain an insight into conditions throughout the irrigation area, farmers were sampled from areas within half a kilometre, half to one kilometre and over one kilometre from the secondary canal.

The population of the area was found to have increased through expanding family numbers and immigration. The impact of irrigation on farms varied depending upon the distance from the canal. The largest improvements in productivity occurred closest to the secondary canal. In general, for all farms, the area of irrigated land under cultivation increased by 16 percent since 1993 and overall crop yield increased by 28 percent.

Improved water supply contributed to crop diversity, vegetables were found to be an increasingly important source of household income after rice. Poor soil quality may have limited crop productivity. The study found that despite the increase in population, food insecurity decreased. Seventeen percent of farmers were producing below their annual consumption needs in 1993 compared to 15 percent in 1999. The impact on farming productivity may have been increased if irrigation improvements were co-ordinated with long-term agricultural extension services.

The study found signs of increased economic activity since the ILO intervention. Farmers were less likely to rely on wage labour in Siem Reap town or small business activities. On-farm work had increased due to higher levels of farm productivity and there was an increased demand for farm wage labour. Animal ownership had increased by 30%, indicative of an increase in wealth. The impact of ILO support to the Barai Irrigation System can be summarised as follows – improved irrigation led to increase cropping intensity and higher total production. This created more demand for labour and contributed to a reduction in poverty.

Generally, farmers reported significant improvements in the distribution of water through irrigation management in terms of timing, flow rate, scheduling and duration. Water User Groups established by the ILO to co-ordinate water distribution are operating with varying degrees of efficacy and farmers reported a decrease in the number of conflicts arising over water distribution. A main problem in the functioning of the irrigation system was the limited access to irrigation for farmers furthest away from the canal – either because of low water levels or poor management. Compounding this situation, farmers close to the secondary canal built informal canals of their own, tapping water from the main canal system.

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Introduction and Background

Introduction

The Labour Based Rehabilitation Programme (LBRP) executed by the International Labour Organisation (ILO) is an employment generation programme in operation since the early 1990s. This programme generated employment for displaced persons, demobilised soldiers and rural poor people through the development and implementation of labour-based infrastructure and irrigation rehabilitation works. Through this programme, ILO has engaged in the development of roads and irrigation systems in various parts of Cambodia, including Siem Reap, Battambang, Banteay Meanchey, Takeo, Pursat and Kandal Provinces. The Barai Irrigation System in Siem Reap was one of the major projects in this programme.

Since 1993, the ILO has assisted in the construction, rehabilitation and maintenance of the Barai Irrigation System (BIS) in Siem Reap Province through three consecutive technical co-operation projects. The Department of Hydrology within the Ministry of Agriculture, Forestry and Fisheries (and later of the Ministry of Water Resources and Meteorology) was the ILO's counterpart for these activities.

Initially the ILO improved the irrigation system through physical rehabilitation. Labour-based Appropriate Technology (LBAT) was applied to the rehabilitation works, generating employment and strengthening local skills and resources. At the same time, the ILO encouraged the beneficiaries of the irrigation system to form Water Users' Groups (WUGs). Through the WUGs, a local management system was established. The ILO LBRP initiative terminated technical support to the Barai Irrigation System at the end of 2000. Although the physical achievements of the LBRP assistance to the BIS were well documented, the impact at the household level was until now not thoroughly documented.

The Center for Advanced Study (CAS) was asked to examine the impact of the ILO supported irrigation rehabilitation systems on the farmers. The study also aimed to provide information about the impact of the ILO support to the BIS for others investing in the irrigation sector or to those who may provide future support to the BIS.

The study aimed to assess the following:

- Irrigation use before and after the ILO assistance.
- The efficiency and management of irrigation and the development of Water Users' Groups.
- The impact on land use, cropping patterns and diversification.
- The impact on production, yield, consumption and surplus.
- The overall economic situation - employment, income and expenditures.

The study focussed on the direct impact of ILO initiatives at the farmers' level. The terms of reference emphasised a focus on changes in land use, crop production, productivity and on overall changes in the farmers' economy. The survey was based in the command area of secondary canal number five (SC-5) of the BIS. CAS was asked to carry out the study by taking small samples from different farming zones.

Methodology

An analysis of a complex irrigation system, like the Barai, could involve very detailed and time-consuming survey work. The most practical approach was to confine the study to the limited area formed by the command area of one canal. For this study, the Sub-Project Canal, SC-5 was chosen. This area was the subject of a 1994 baseline survey and is covered by regular water measurements. The entire SC-5 was maintained and rehabilitated in 1993 by ILO. The survey sample stretches across two districts (Puok and Siem Reap) in five communes and nine villages.

Representative samples were taken at tertiary canal level, where the impact of ILO irrigation assistance to farmers since 1993 could be compared. As the survey teams could not visit all farms, it was necessary to use farm level microanalysis to understand the changes that have occurred since the ILO support.

The samples were taken from 11 tertiary canals, with an average of six farms from each tertiary canal. Eleven tertiary canals within the SC-5 area were selected. Each tertiary canal was divided into three farming zones: upstream, central and downstream. Those farmers with irrigated land within the radius of half a kilometre from SC-5 were categorised as part of the upstream farming zone. Farmers with irrigated land between half and one kilometre from SC-5 were classified as the central farming zone and those with irrigated land more than one kilometre from SC-5 were classified as the downstream farming zone. The number of interviewees for the upstream, central and downstream farming zones were 25, 23 and 21, respectively. In total, 69 farmers were interviewed. Ten additional interviews were conducted with the chiefs of Water User Groups, making a total of 79 interviews for the study (see Appendix 2, Table 2-1).

The study used both semi-structured interviews and a formal survey. Semi-structured interviews were used to assess the management of irrigation at the farm level. The survey was used to obtain estimates of the efficiency of irrigation, land use, cropping patterns, crop production, consumption, surplus and deficits. The questionnaire was tested and adapted during the first week of the fieldwork.

The survey was carried out by two teams of two researchers. Each team consisted of one interviewer and one recorder. The first team consisted of Ms. Nguan Sokunthea (B.A) and Mr. Heng Kim Van (B.A). The second team consisted of Mr. Khat Sokha (B.A) and Ms. Mak Sophea (B.A). Fieldwork took 30 days and was supervised by the author. Interviews took three to four hours depending on the interviewee's capacity to provide the required data. Considerable interview time was reserved to help respondents concentrate and complete the task accurately. In the absence of baseline information on the situation before 1993, some questions required interviewees to recall information.

The Chiefs of Water User Groups were approached and interviewed to get basic information on irrigation management. Participating farmers were selected with the help of the WUG chiefs. Interviews were recorded on tape, with the permission of the interviewees. Survey forms were completed in Khmer and then translated into English.

All data were entered into the Integrated Microsoft Processing System (IMPS) and then processed in Microsoft Excel by CAS researchers. Dummy tables were developed to facilitate the analysis and a comparison was made between the baseline, 1993 (before the ILO support)

and the present day, 1999 (the impact of ILO support). The year 1999 was taken as present day, because it was the latest crop year that could be compared to the baseline.

In the course of the field survey, several government and non-government organisations were contacted. The following government organisations were visited: Siem Reap Provincial Department of Agriculture (PMA), Provincial Department of Agronomy (PDA), Ministry of Water Resources and Meteorology; Provincial Department of Hydrology and Tukville Research Center. Apart from the ILO, the following organisations were visited - FAO Siem Reap Office, Adventist Development and Relief Service (ADRA), Cambodia–IRRI–Australia Project, AGRIZOID, a French Agricultural Development Assistance Organisation and CARERE Siem Reap Office. Unfortunately interviews with village, commune and district chiefs were not possible due to time constraints.

Background to the ILO Intervention

The Barai Irrigation System is located approximately eight kilometres from Siem Reap town. Agriculture based on irrigation has taken place near Siem Reap since the Angkor Empire of the 11th century. The present system was designed and built by the French during the 1930's with major modifications being carried out by USAID in the 1950's. A diversion weir (Prast Keo) constructed in the 1930s on the Stung Siem Reap River presently serves the Barai. The diverted water runs to the Barai Occidental reservoir (storage capacity 40 million m^3) with full supply level of 25 meters.[1]

The system ran efficiently until the early 1970's. It was regulated and maintained by the Provincial Department of Hydrology with technical input and decision making from the central Department of Hydrology. The system was used for wet season supplementary rice irrigation and some dry season rice irrigation in the more fertile soils adjacent to the Tonle Sap Lake. Irrigation was also provided for dry season fruit and vegetable production.

During the civil war in the early 1970's, the system began to deteriorate. During the reign of the Khmer Rouge from 1975 to 1979, some changes were made to the system. From 1979 to 1989, the Barai irrigation system was working on a greatly reduced area due to deterioration of the canals. In 1989, the Adventist Development Relief Agency (ADRA), in conjunction with Siem Reap Provincial Department of Hydrology began structural repair works to the Barai system. Secondary canals two, four and five were renovated and these repairs were completed in 1991.

ILO activities began in 1992 with emergency rehabilitation work and the main ILO assistance programme started in 1993. This programme concentrated on clearing and repairing the main canal system, the secondary canals - including restoring banks - and re-building and replacing the control structures. When work began, the canal banks were below design level, 30 per cent of the banks were washed away and most of the existing structures were damaged or destroyed.
The ILO's focus was on establishing maintenance systems in the irrigation system whereby rehabilitation investments would be sustained. In this process, the ILO provided the financial resources for maintenance work and technical guidance. The WUGs maintained the tertiary canals, while the ILO supported the Provincial Department of Hydrology to employ the people needed per kilometre to maintain the secondary canals.

[1] ILO, Barai Irrigation System Socioeconomic Studies, unpublished monograph.

Subsequently, the ILO was involved with establishing and supporting WUGs. The ILO assisted in the setting up of WUGs based on tertiary canals. They instigated WUG maintenance of tertiary canals, secured agreement for a water management plan (water schedule), drafted and implemented a WUG by-law for the system through the Provincial Governors office and secured an agreement on water charges.

The ILO ceased capital assistance to the Barai irrigation system in 1998 but continued to provide technical assistance to WUGs until 2000. This assistance was in the form of support for counterparts in the Department of Hydrology to provide technical guidance and assistance to the WUGs. The WUGs now have a system to finance the routine maintenance of secondary canals using local labour paid for by water user fees collected by the WUGs.

The Barai agricultural area covers around 12,000 hectares with an irrigated command area of 4,000 hectares of double-cropped rice land served by a gravity distribution system. Three kilometres of main canal and eight secondary canals serve the irrigated area with a total canal length of approximately 50 kilometres. In the early 1990's, the population benefiting from the Barai Irrigation System was 5,465 households.

Soil

Research by the Cambodia-IRRI-Australia Project has so far identified eleven main soils in Cambodia. The soil found in the Barai Irrigation System is one of these, known as *Group 0 - Prey Khmer Soil.* This soil is estimated to exist in ten to 12 percent of Cambodia's rice-growing area. It is widely recognised that the soil in the command area of the Barai Irrigation system is very poor. The soil is sandy and lacks organic matter, which is easily washed out by the rains. Moreover, it coagulates in the dry season forming a hard layer 50 centimetres below ground level.

Increased fertiliser is needed to improve the soil of the Barai area. However, with low rice prices and high fertiliser costs, this is an unrealistic option. Standing surface water only occurs for a brief period at the height of the rainy season when the entire surface profile is saturated.[2] The Barai soil requires both natural and artificial fertilisers to increase production. This implies that increased water would not affect yield and production without sufficient fertiliser.

As the BIS soil is sandy, it has poor water holding capacity, making it difficult to estimate irrigation scheduling and water requirements. This is particularly true for rice. No intensive study on the Barai's soil mapping and land capacity has been undertaken.

Meteorology

Presently, the Department of Hydrology records rainfall, temperature, sunshine, wind and water levels at the Tonle Sap and Siem Reap River. The Siem Reap region has a tropical monsoon climate, warm, humid from May to November and almost dry for the rest of the year. Maximum daytime temperatures of 40.8^0 C and minimum night temperatures of 13.6^0 C have been recorded by the meteorological office, Siem Reap. There was an average annual rainfall of 1438.5 mm during the last 10 years (see appendix 2, Table 2-2).

[2] T. Oberthor, P.F. White, & R.T. Reyes 1996.

The total rainfall recorded in the baseline year (1993) was 142 days. In 1999, this was 193 days. Total rainfall for 1993 was 1524.4 mm and for 1999, it was 1468.3 mm. The number of rainy days per year and the total amount of rainfall per year determine the demand and the supply of irrigation.

Other Influences

Several other factors influence crop yields. These must be considered in any impact assessment. Among these are natural damage to crops, the effect of local authorities and the activities of other organisations.

Natural damage to crops
Floods, drought, plagues of mice and rats, storms and cattle disease outbreaks were all reported in both 1993 and 1999. Floods seemed to have been a more serious problem in 1993 - when six out of ten canals reported floods - than in 1999, when floods were reported in only two canals. In 1993, flooding mainly occurred in the first section of the canal (tertiary canals 1-15). Many WUGs reported droughts in both 1993 and in 1999. However, most WUGs stated that thanks to the canal and ponds, droughts were not a serious problem. Plagues of mice and rats occurred equally in 1993 and in 1999. These occurred in the same tertiary canal areas (tertiary canals 1,15,18,20 and 21) in both years.

Local authorities
The role of local authorities like the district, commune and village chiefs are also important. There were significant differences in the organisation of WUGs in Siem Reap district compared to Puok district. WUGs in Puok district are more active and better organised. According to the Department of Hydrology, support from local authorities in terms of advice and follow-up has helped WUGs in Puok to work more efficiently. The Department of Hydrology in Siem Reap has also been involved in maintaining the canal and has provided training on maintenance.

Other organisations
The services provided by international NGOs were mostly short-term compared to the ILO's six-year commitment in the area. Apart from the irrigation sector, the ILO has also rehabilitated and maintained roads in the BIS to improve infrastructure and generate employment.[3] Most other organisations worked for less than two years in the area of secondary canal five. ADRA has been involved in animal raising, gardening and pond/well digging and has provided seeds and natural fertiliser. AGRIZOID has been involved in animal raising, agricultural extension services, constructing pump wells and providing seeds and natural fertiliser. FAO/IPM has been involved in fishing and animal husbandry and has provided agricultural extension services and pest management techniques. UNICEF and ACLEDA have been involved in rural credit activities. The WFP and ILO have been involved in road construction. CARERE has set up health care activities. ADHOC has provided training on human rights.

Apart from the ILO, ADRA and AGRIZOID were most often mentioned and seem to have worked in all the tertiary canals studied. However, ADRA was active before the ILO intervention in the Barai Irrigation System and AGRIZOID has provided services since the

[3] Zweers, J., and Kassie, A., 2000.

major phase of ILO intervention ended. The ILO has been the major service provider to the BIS. Local respondents reported that ILO support to the BIS was more effective and sustainable than other organisations' activities.

The variety of activities implemented by different organisations highlights the lack of co-ordination and integration of input to the Barai Irrigation System. Inputs like agricultural extension services, training programmes, fertilisers and pesticide provision, soil surveys and agricultural research would have been more effective if they were integrated with the ILO Barai Irrigation Project. This has undoubtedly affected the expected crop yields and productivity.

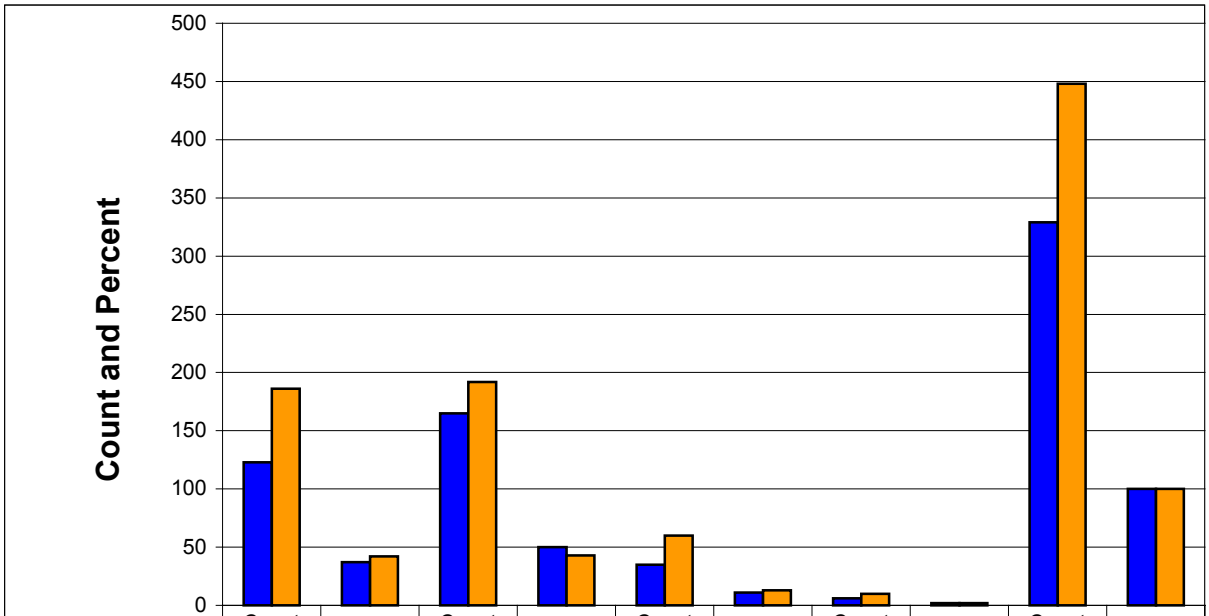
Demography, Access to Irrigation and Farm Animals

Demography

The demographic background shows the household structure of the farmers in terms of age, family size and the age-dependency ratio. In 1999, the total sample population, including farmers' family members, was 448, while the sample population in the baseline year was 329 (see Figure 1).

By 1999, the total sample population had increased by 27 percent from the baseline. Due to a high population increase and the tradition of extended families, the average household size has substantially increased. Farmers informed the research team that improved irrigation had also attracted new families to the area.

Figure 1: Household Population and Age



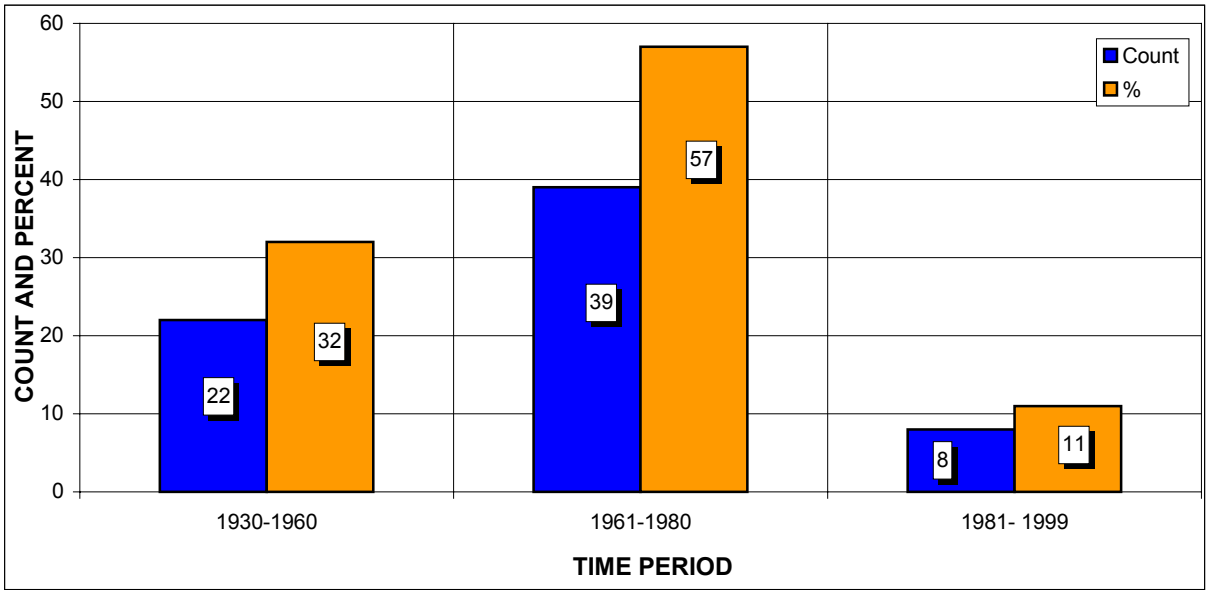
	Count 1-16	%	Count 17-45	%	Count 46-65	%	Count >65	%	Count Total	%
Baseline (1993)	123	37	165	50	35	11	6	2	329	100
Present day (1999)	186	42	192	43	60	13	10	2	448	100

The average household size in 1993 was 4.8 people, while in 1999 this had increased to 6.6 members. This suggests that more farmers could face food shortages, particularly farmers with small farming plots if family size increases and plot size remains the same. Moreover, the 1-16 age group was proportionally smaller in the baseline year (37%) than in 1999 (42%), while the productive age group 17-45 had declined from the baseline (50%) to the present day (43%). Those aged between 1-16 and over 65 are considered as dependants. When the Age-Dependency Percentage of the baseline (39%) is compared with 1999 (44%), then it is clear that the age-dependency has increased over the past six years.

Access to Irrigation

All respondents were asked when they started using Barai irrigation. Out of the 69 respondents, 39 (57%) moved to the area and started using the Barai irrigation between 1961 and 1980. Twenty-two farmers (32%) started to use Barai irrigation between 1930 and 1960. In the last two decades, eight farmers (11%) started using the irrigation service. Most of these were demobilised soldiers or refugees who returned from Thailand in the early 1990's (see Figure 2).

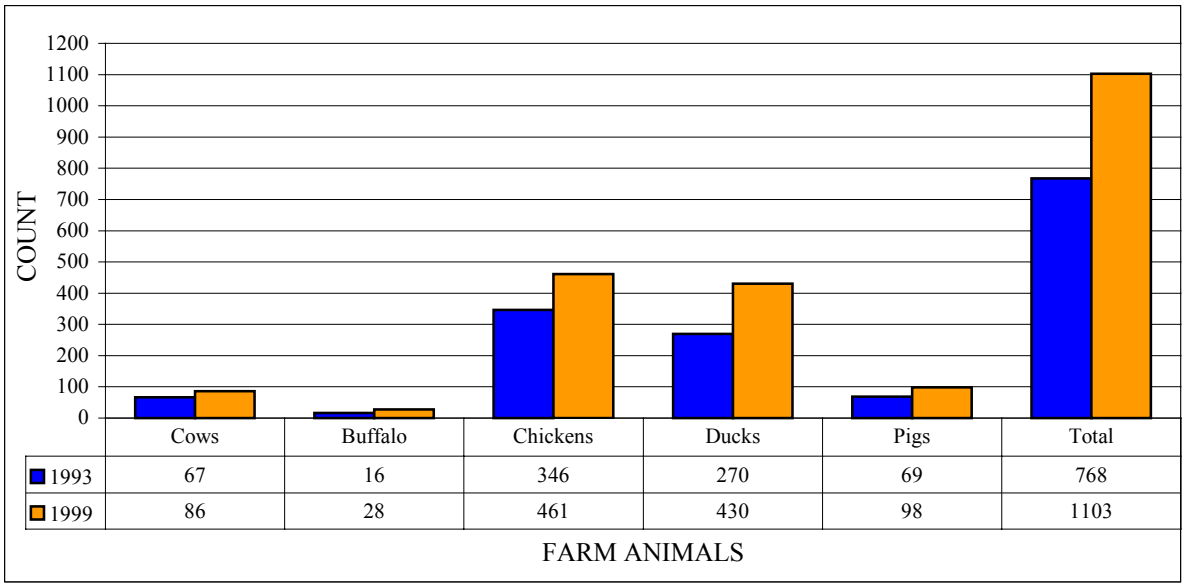
Figure 2: When did you start using Barai Irrigation?



Farm Animals

In developing countries like Cambodia, farm animals are an important part of the farming system. Respondents were asked about the type and number of animals they owned in 1993 and 1999. Most farmers interviewed owned one of the following five types of farm animals: Cows, buffalo, chickens, ducks and pigs. The aggregate number of farm animals owned by all farmers interviewed had increased from 768 in 1993 to 1103 in 1999. This represents a 30 percent increase. There was a significant increase in buffalo numbers, which were 43 percent higher in 1999. The average number of farm animals per household increased from 11.1 in 1993 to 16 per household in 1999. The increase in cow and buffalo numbers is particularly significant, as these animals are indispensable to farmers. Farm animals are used as draught animals, provide transport and are considered a sign of relative wealth in Cambodia. The dung from these animals is also used as organic fertiliser, which as mentioned earlier, is vital for the soil in the Barai area.

Figure 3: Farm Animals Owned (Total Sample)



The total numbers of farm animals for the whole sample had increased substantially since 1993. Increases were 22 percent for cattle, chickens 25 percent, ducks 37 percent and 30 percent for pigs. Demand for livestock is increasing, as is the demand for animal products - dung is used as organic fertiliser to increase the crop yield. The increase in farm animals since 1993 indicates increased wealth possibly due to improved access to irrigation.

Land Use and Cropping Patterns

All land is privately owned in the Barai irrigation command area. However, the size of land holdings varied widely across the sample, from half a hectare to eight hectares. Female-headed households tended to have smaller plots of land and lived mostly in the middle or towards the end of the tertiary canals.

The type of farmland held by a household could indicate social status and position, the less powerful and poorer farmers having obtained land with poorer irrigation potential. Moreover, households with smallholdings and limited resources (usually the case for female-headed households) might not be able to cultivate a dry season crop due to a lack of finance for farm inputs.

Secondary crops like sugar cane, soybean, watermelon and maize are grown in irrigated rice fields. Vegetables are cultivated in kitchen gardens of farming households and in larger areas for sale as cash crops.

Land Use

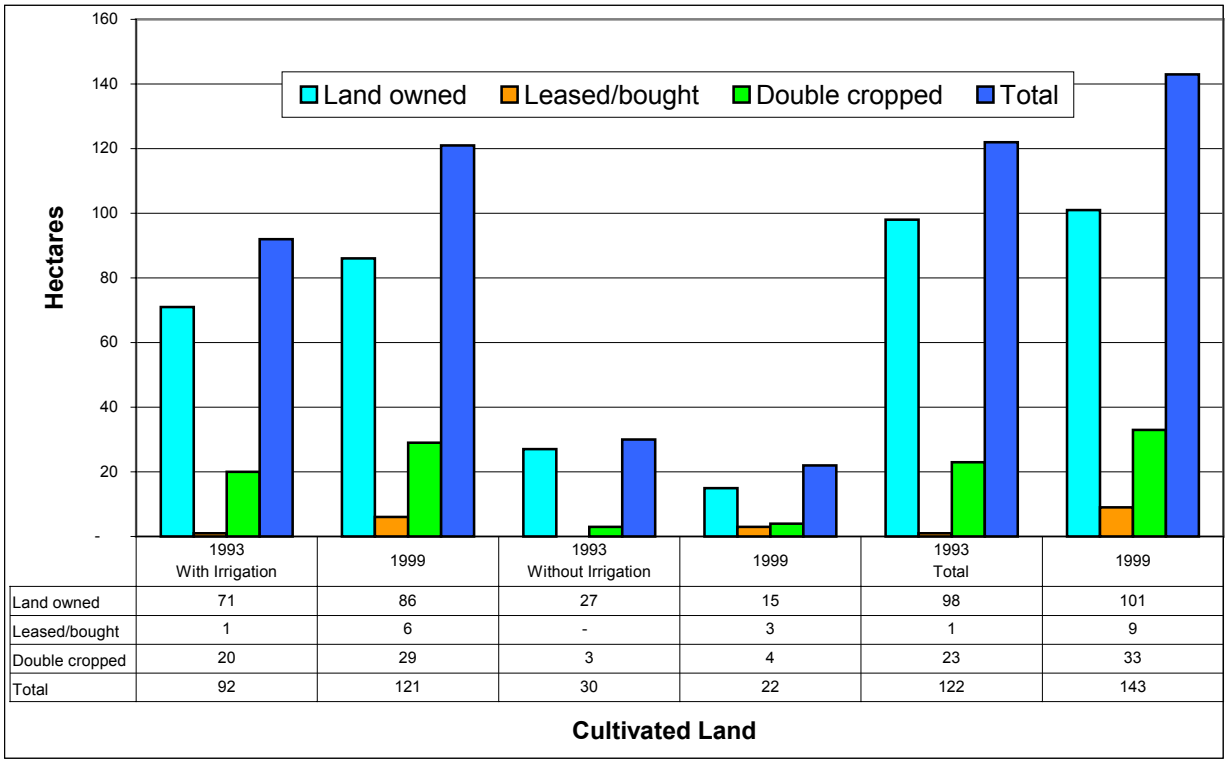
In general, the total land area under cultivation, with and without irrigation increased from 122 hectares in 1993 to 143 hectares in 1999. This includes land used for double cropping and land leased/bought. The area of double cropping was 23 hectares in 1993 and 33 hectares in 1999. The total area leased or bought was only one hectare in 1993 and nine hectares in 1999.

In the baseline, the cultivated land area with irrigation was 92 hectares. This had increased to 121 hectares by 1999. The area of cultivated land without irrigation decreased from 30 hectares in 1993 to 22 hectares in 1999 (see Figure 4).

The area used for double cropping from the total irrigated land has increased from 20 hectares in the baseline to 29 hectares in 1999. This increase in double cropping demonstrates the impact of improved irrigation access since the ILO intervention.

Land use had also increased from 1.77 hectares per household in the baseline to 2.07 hectares per household in 1999, a 20 percent increase. The total land use per family member in the present day (0.32 ha per family member) is lower than the baseline (0.37 ha per family member) due to population increase. The survey data on land use were broken down by farming zone (upstream, central or downstream).

Figure 4: Land Use (Total Sample)



	1993 With Irrigation	1999	1993 Without Irrigation	1999	1993 Total	1999
Land owned	71	86	27	15	98	101
Leased/bought	1	6	-	3	1	9
Double cropped	20	29	3	4	23	33
Total	92	121	30	22	122	143

Cultivated Land

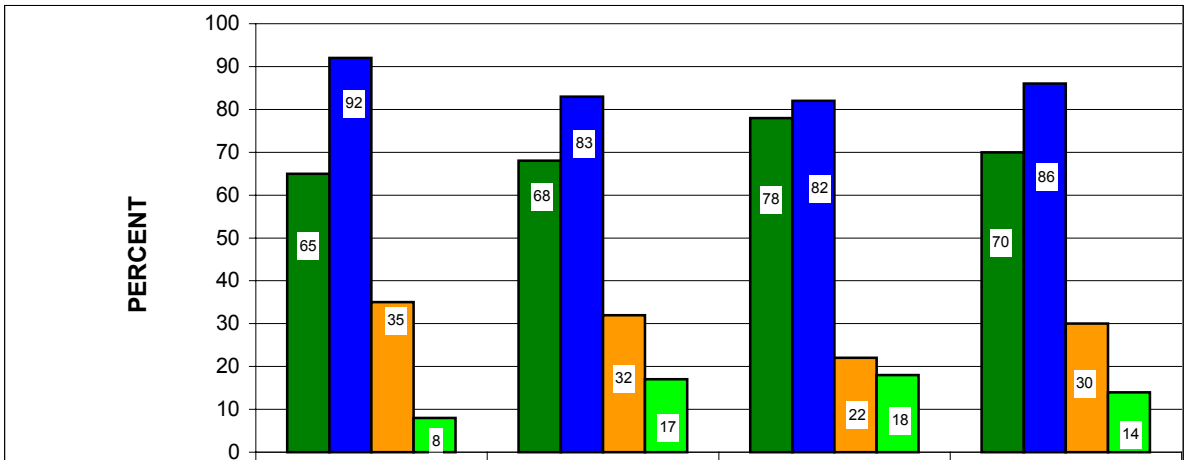
Farming zones

In 1993, 70 percent of the total land was cultivated with irrigation and 30 percent was cultivated without irrigation. By 1999, 86 percent of land was cultivated with irrigation and only 14 percent was cultivated without irrigation. This implies that the land cultivated with irrigation has increased significantly (16%) since 1993. The land cultivated with irrigation in the baseline year in the upstream zone was 65 percent, while the area of land cultivated without irrigation was 35 percent. In 1999, this was 92 percent with irrigation and only 14 percent without irrigation.

In the central zone, irrigated land made up 68 percent and non-irrigated land 32 percent of the total area under cultivation in 1993. This was 83 percent for irrigated land and 17 percent for non-irrigated land by 1999. In 1993, 78 percent of the land under cultivation was irrigated in the downstream zone and 22 percent was non-irrigated. In 1999, 82 percent of downstream zone land was irrigated and 18 percent was non-irrigated.

It can be concluded that the percentage of land cultivated with irrigation in the downstream zone in 1993 was higher, at 78 percent, than in the central or upstream zones, 68 percent and 65 percent respectively. However, by 1999 the land cultivated with irrigation in the upstream zone had increased substantially compared to the other zones. According to WUG chiefs, this was due to improved water flow since 1993, which mainly benefited the upstream farming zones. The central and downstream farming zones receive inadequate irrigation because of their distance from the tertiary canals (see Figure 5).

Figure 5: Cultivated Land and Farming Zones



	Upstream zone	Central zone	Downstream zone	Average
1993 With irrigation	65	68	78	70
1999 With irrigation	92	83	82	86
1993 Without irrigation	35	32	22	30
1999 Without irrigation	8	17	18	14

CULTIVATED LAND (FARM ZONE)

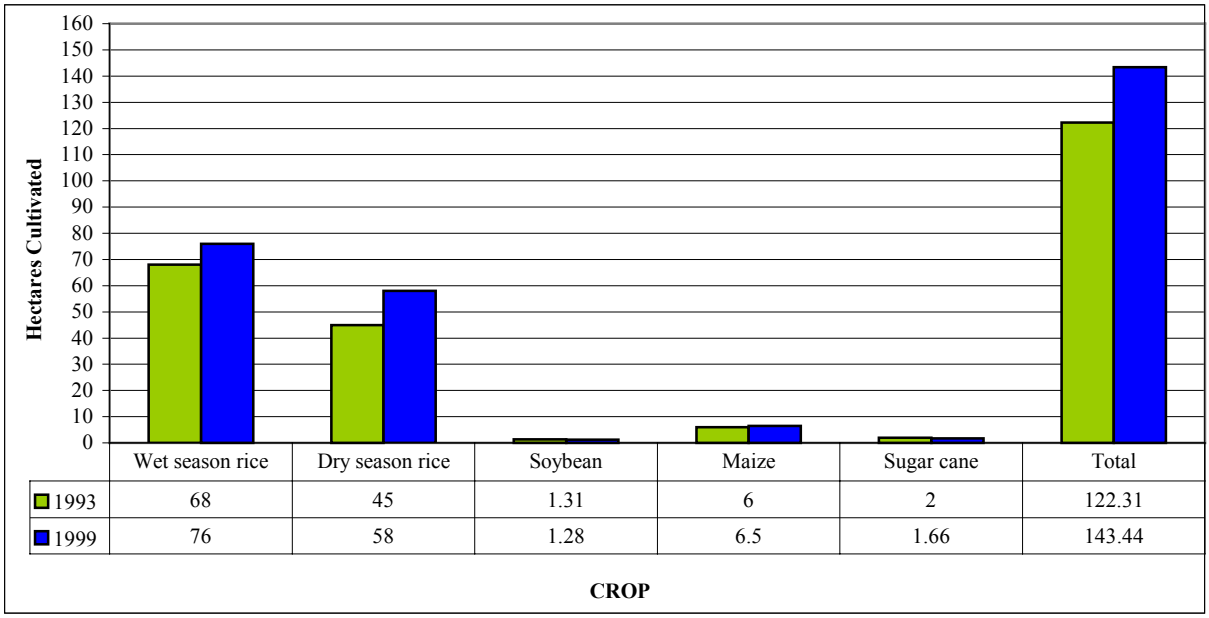
Cropping Patterns

The key determinants of cropping patterns under irrigated conditions are water availability, land conditions and farmers' willingness to adopt alternative cropping - which is partly determined by profitability. Favourable physical and market conditions may lead to crop diversification.

Rice is the most important agricultural product cultivated in the Barai irrigation area. Recently, vegetables like lettuce, cabbage, cauliflower, tomato and eggplant have been more widely grown, using irrigation. Other crops include fruits (like coconut, papaya, watermelon and pineapple), maize and sugar cane, though on a smaller scale than rice or vegetable cultivation.

Data collected during the survey allows comparison between the cropping patterns in 1993 and in 1999. The main crops and the area cultivated were - wet season rice (68 ha in 1993 and 76 ha in 1999), dry season rice (45 ha in 1993 and 58 ha in 1999), soybean (1.31 ha in 1993 and 1.28 ha in 1999), maize (6 ha in 1993 and 6.5 ha in 1999) and sugar cane (2 ha in 1993 and 1.66 ha in 1999). These figures exclude vegetables. The total area under cultivation for these crops was 122 hectares in 1993 and 143 hectares in 1999, a 15 percent increase (see Figure 6).

Figure 6: Cropping Patterns (Total Sample)



	Wet season rice	Dry season rice	Soybean	Maize	Sugar cane	Total
1993	68	45	1.31	6	2	122.31
1999	76	58	1.28	6.5	1.66	143.44

There was a considerable increase in the land used for growing wet and dry season rice. Wet season rice land increased 11 percent, while dry season rice land increased by 23 percent. This result, especially the increase in dry season rice cultivation, was due to improved access to irrigation.

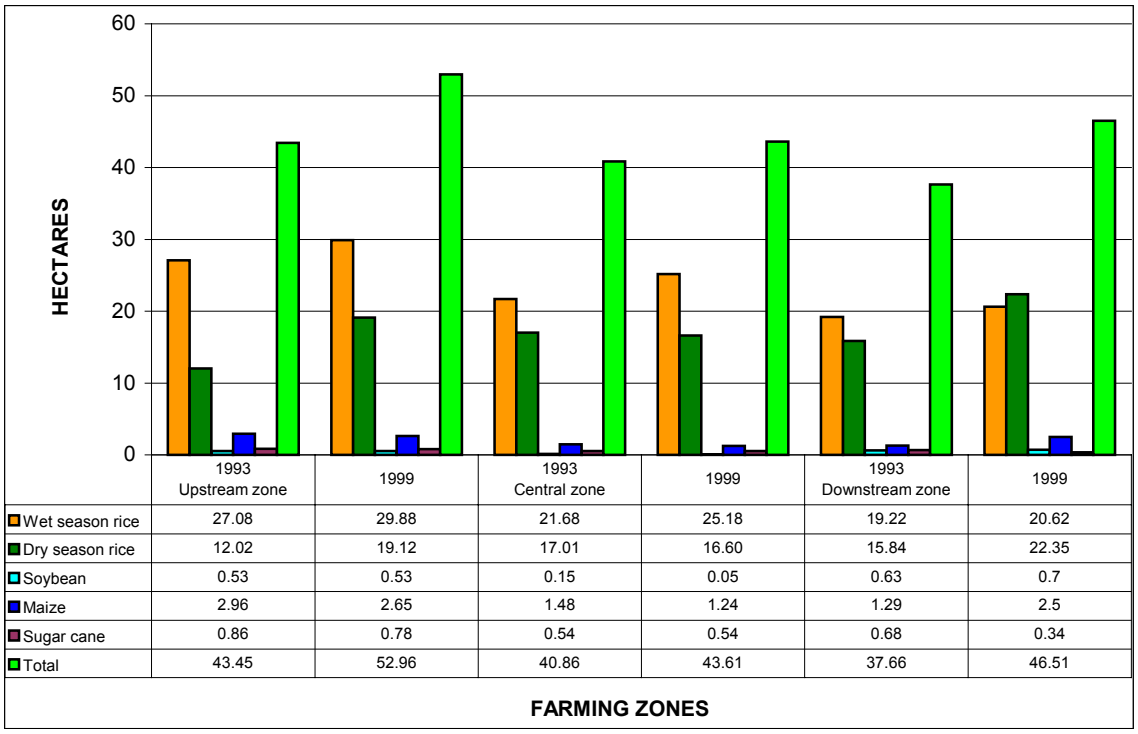
There were no significant changes in other crops: soybean, maize and sugar cane. The cultivation of soybean and sugar cane has slightly decreased. This is probably due to the increased popularity of vegetable production after the ILO intervention due to improved access to water and the increased use of vegetables as a cash crop.

Cropping by farming zone

In all three farming zones - upstream, central and downstream – the total cultivated land has increased. The land cultivated for maize, soybean and sugar cane did not increase, because other cash crops were substituted.

The land used to cultivate wet season rice in 1993 accounted for 27, 22 and 19 hectares for the upstream, central and downstream zones respectively. In 1999, the figures were 30 (upstream), 25 (central) and 20 hectares (downstream) respectively. This suggests a modest increase in wet season rice cultivation (see Figure 7).

Figure 7: Cropping Patterns by Farming Zone



	1993 Upstream zone	1999	1993 Central zone	1999	1993 Downstream zone	1999
Wet season rice	27.08	29.88	21.68	25.18	19.22	20.62
Dry season rice	12.02	19.12	17.01	16.60	15.84	22.35
Soybean	0.53	0.53	0.15	0.05	0.63	0.7
Maize	2.96	2.65	1.48	1.24	1.29	2.5
Sugar cane	0.86	0.78	0.54	0.54	0.68	0.34
Total	43.45	52.96	40.86	43.61	37.66	46.51

Dry season rice cultivation however, shows a more substantial increase. The land used to cultivate dry season rice in 1993 was 12 hectares in the upstream zone, 17 hectares in the central zone and 16 hectares in the downstream zone. The 1999 figures were 19, 16 and 22 hectares respectively. In the central farming zone, the land used to cultivate dry season rice has decreased by one hectare.

The land used for cultivating maize, soybean and sugar cane is also used to cultivate vegetables and other high value cash crops through double cropping. As this trend toward double cropping increases with improved irrigation, the land cultivated for maize, soybean and sugar cane has either remained constant or has decreased over time.

Crop Production, Yield, Consumption, Surplus and Deficit

Irrigation development, rehabilitation and maintenance programmes are primarily concerned with improving food production to meet the increased demands of the market and an expanding population. Higher food production may be the result of various factors: increased land under cultivation, intensification of land use or increased productivity. Irrigation development, rehabilitation and maintenance provide critical support for increasing the crop area and for creating an environment where yield-enhancing technologies can be used profitably.

This section will examine how crop production, yield, consumption and surplus have changed over the course of the ILO assistance in each farming zone. The findings discussed below are for the sample households (69 families).

Cultivated Land, Production and Yield

Cultivated land and production

Before ILO assistance, the total cultivated land area for the sample was 122 hectares (wet season rice 68 ha; dry season rice 45 ha; soybean 1 ha; maize 6 ha and sugar cane 2 ha). After six years of ILO assistance, the cultivated land has increased to 143 hectares (wet season rice 76 ha; dry season rice 58 ha; soybean 1 ha; maize 6 ha, and sugar cane 2 ha) an increase of 15%. The following table shows this change by crop type:

Table 1: Cultivated Land and Production

Type of crop	Cultivated land (ha)			Production (Kg)		
	1993	1999	Change	1993	1999	Change
Wet season rice	67.98	75.68	+10%	66,883	73,018	+8%
Dry season rice	44.87	58.07	+23%	71,048	124,863	+43%
Soybean	1.31	1.28	0	1,185	1,560	+24%
Maize	5.73	6.39	+10%	16,279	23,027	+29%
Sugar cane	2.08	1.66	-25%	20,370	22,760	+11%
Total	121.97	143.08	+15%	175,765	245,228	+28%

The total weight of produce for the five crops in 1993 was 175.8 tons, (wet season rice 66.9 tons, dry season rice 71 tons, soybean 1.2 tons, maize 16.3 tons and sugar cane 20.4 tons). In 1999, the total weight was 245.2 tons (wet season rice 73 tons, dry season rice 124.9 tons, soybean 1.6 tons, maize 23 tons and sugar cane 22.8 tons).

It is interesting to note that the total cultivated land increased by 16 percent while production increased by 28 percent. This evidence of more productive land use may be due to improved irrigation. The total land cultivated for wet season rice increased by ten percent while production increased by eight percent. The total land cultivated for dry season rice increased by 23 percent and production increased by 43 percent. The land used for growing soybean in 1999 was the same as in 1993 but production had increased by 24 percent. The total land cultivated for maize had increased by ten percent while production increased by 29 percent by 1999. The amount of land used to grow sugar cane decreased by 25 percent, although production increased by 11 percent.

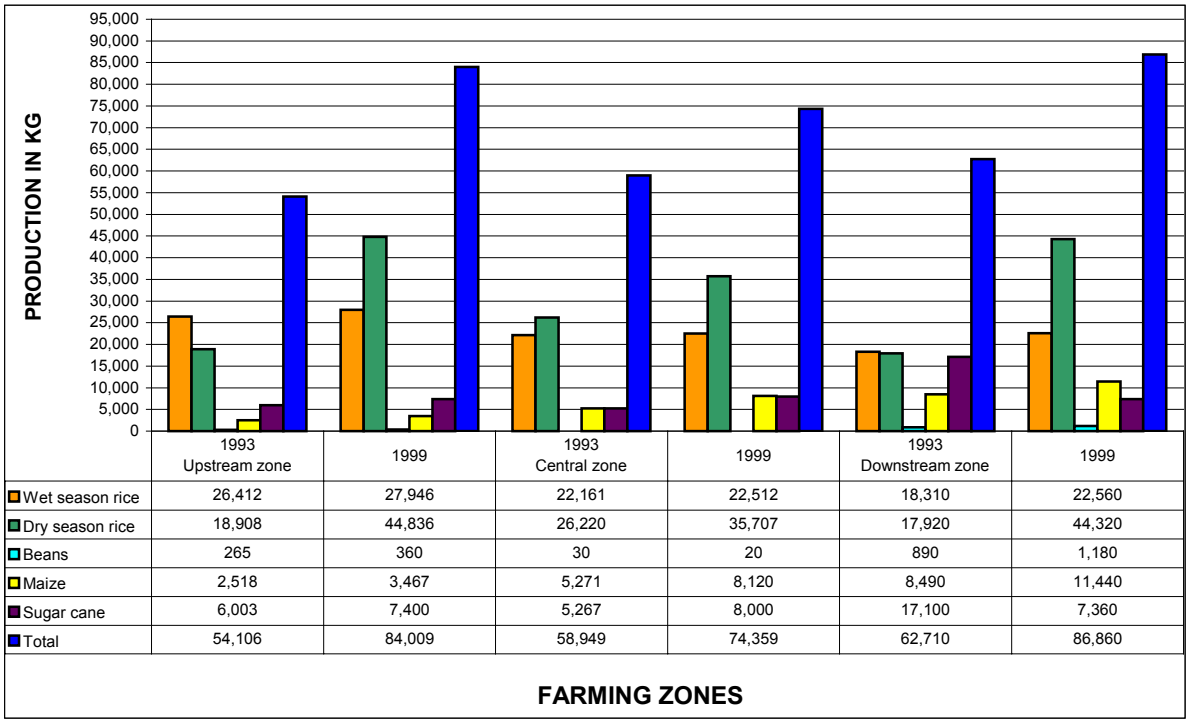
Crop production by farming zone

During the fieldwork, research teams were informed that farmers in the upstream zone received better irrigation than the other zones. This is because their farms are closer to the secondary canal. Farmers in this zone take advantage of the improved irrigation access and as a result, the total production of the upstream zone has increased from 54.1 tons in 1993 to 84 tons in 1999, a 36 percent increase (see Figure 8).

The central farming zone showed the smallest increase in production 58.9 tons in 1993 and 74.4 tons in 1999, an increase of 21 percent. According to respondents, the central zone has the worst soil of all three zones, which may explain this finding.

The downstream farming zone is close to the Tonle Sap Lake and the soil quality is much higher than the other two zones. This has a substantial impact on production. Moreover, the soil in the downstream zone is suitable for cultivating dry season rice. Thus, due to the soil factor and improved access to irrigation, production in this zone has risen from 62.7 tons in 1993 to 86.9 tons in 1999, a 28 percent increase (see Figure 8).

Figure 8: Crop Production by Farming Zone



	1993 Upstream zone	1999	1993 Central zone	1999	1993 Downstream zone	1999
Wet season rice	26,412	27,946	22,161	22,512	18,310	22,560
Dry season rice	18,908	44,836	26,220	35,707	17,920	44,320
Beans	265	360	30	20	890	1,180
Maize	2,518	3,467	5,271	8,120	8,490	11,440
Sugar cane	6,003	7,400	5,267	8,000	17,100	7,360
Total	54,106	84,009	58,949	74,359	62,710	86,860

It is important to note that although wet season rice production did not show significant changes, dry season rice production increased significantly. This was particularly true in the upstream zone, (18.9 tons in 1993 to 44.8 tons in 1999) and the downstream zone (17.9 tons in 1993 to 44.3 tons in 1999) and may be attributed to the improvement in irrigation.

Crop yield

The total average yield hectare in 1993 was 1.44 tons per hectare for all crops (wet season rice 0.98 tons, dry season rice 1.58 tons, soybean 0.91 tons, maize 2.84 tons and sugar cane 9.79 tons). In 1999 the total average yield per hectare was 1.71 tons, which was an increase of 16 percent over 1993 (see Table 2).

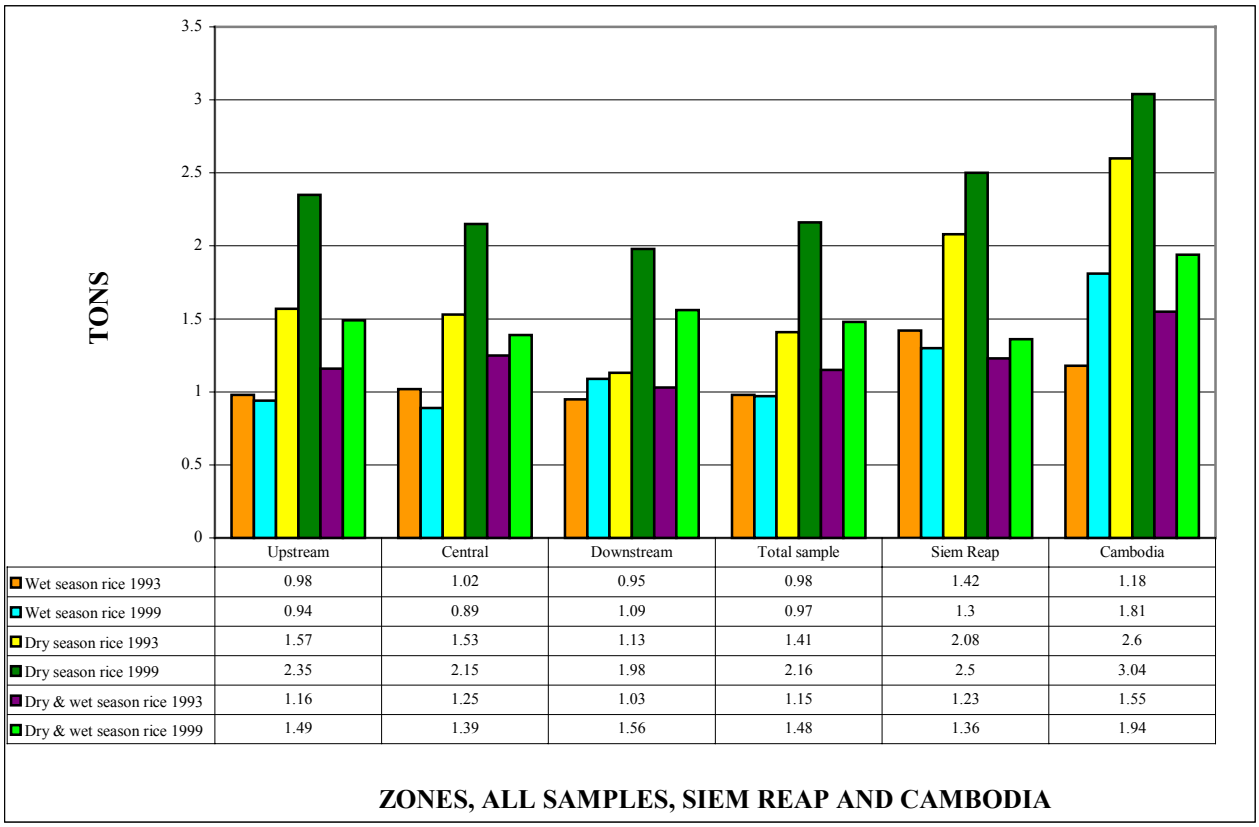
Table 2: Yield per Hectare for Major Crops

Type of crop	1993	1999	Change
Wet season rice	984	970	-1%
Dry season rice	1,413	2,160	+35%
Soybean	905	1,219	+26%
Maize	2,841	3,604	+21%
Sugar cane	9,793	13,711	+29%
Total	**1,441**	**1,714**	**+16%**

The wet season rice yield decreased by one percent in 1999 compared to 1993. Annual yield per hectare has increased considerably for other crops. The highest yield increases since 1993 were for dry season rice (35%), sugar cane (29%), soybean (26%) and maize (21%).

In 1993, the average rice yield (dry season and wet season) was 1.15 tons per hectare for the whole sample. This had increased to 1.48 tons per hectare by 1999. This was higher overall than the average rice yield for Siem Reap Province, which was 1.36 tons in 1999.[4] This is significant as the 1993 average yield for the sample was lower than the 1993 average yield for Siem Reap (1.23 tons/ha). The 1993 and 1999 yields per hectare for dry season rice were 1.41 tons and 2.16 tons respectively. Despite the significant increase, these are lower than those for Siem Reap Province (2.08 tons/ha in 1993 and 2.5 tons/ha in 1999) or for Cambodia, (2.6 tons/ha in 1993 and 3.04 tons/ha in1999).[5]

Figure 9: Dry and Wet Season Rice Yield in 1993 and 1999



	Upstream	Central	Downstream	Total sample	Siem Reap	Cambodia
Wet season rice 1993	0.98	1.02	0.95	0.98	1.42	1.18
Wet season rice 1999	0.94	0.89	1.09	0.97	1.3	1.81
Dry season rice 1993	1.57	1.53	1.13	1.41	2.08	2.6
Dry season rice 1999	2.35	2.15	1.98	2.16	2.5	3.04
Dry & wet season rice 1993	1.16	1.25	1.03	1.15	1.23	1.55
Dry & wet season rice 1999	1.49	1.39	1.56	1.48	1.36	1.94

[4] Ministry of Agriculture, Forestry and Fisheries 2000.
[5] ibid.

In summary, the total average rice yield for the sample showed a significant increase in 1999 compared to 1993. Nevertheless, wet and dry season rice yields are still below the Siem Reap and national average. This may be due to poor soil quality and inadequate agricultural extension services.

Consumption, Surplus and Deficit

Before the ILO assistance, the annual food consumption for the sample was 106.7 tons (wet season rice 57.7 tons, dry season rice 44.8 tons, soybean 0.99 tons, maize 2.51 tons and sugar cane 0.70 tons). The 1999 annual food consumption had increased to 151.9 tons (wet season rice 59.9 tons, dry season rice 87.1 tons, soybean 1.1 tons, maize 3 tons and sugar cane 0.80 tons). This increase can partly be attributed to the population increase, although people may also be consuming more. The average total food consumption in 1999 had increased by 30 percent (wet season rice 4%, dry season rice 49%, soybean 12%, maize 17% and sugar cane 13%) from the 1993 food consumption (see Table 3).

Table 3: Consumption, Surplus and Deficit

Type of crop	Consumption in kg			Surplus in kg			Deficit in household months		
	1993	1999	Change	1993	1999	Change	1993	1999	Change
Wet season rice	57,738	59,877	+4%	9,145	13,141	+30%	137	114	-20%
Dry season rice	44,784	87,059	+49%	26,264	37,804	+31%	0	3	+100%
Soybean	990	1,130	+12%	195	430	+55%	6	3	-100%
Maize	2,508	3,011	+17%	13,771	20,016	+31%	0	0	na
Sugar cane	700	800	+13%	19,670	21,960	+10%	0	0	na
Total	**106,720**	**151,877**	**+30%**	**69,045**	**93,351**	**+35%**	**143**	**120**	**-19%**

The total surplus *(Production – Consumption = Surplus)* increased by 24 tons - from 69 tons in 1993 to 93 tons in 1999. Although farmers had surplus from all crops, some farmers were producing below subsistence levels, both in 1993 and 1999. In 1993, out of the total household months *(12 months X 69 Households = 828 household months)*, 143 household months were food deficient. This food deficiency figure decreased in 1999 to 120 household months. It can be concluded that about 17 percent of households in 1993 and 15 percent of households in 1999 were producing below their annual consumption needs.

Aquatic and Cash Crop Production, Consumption and Surplus

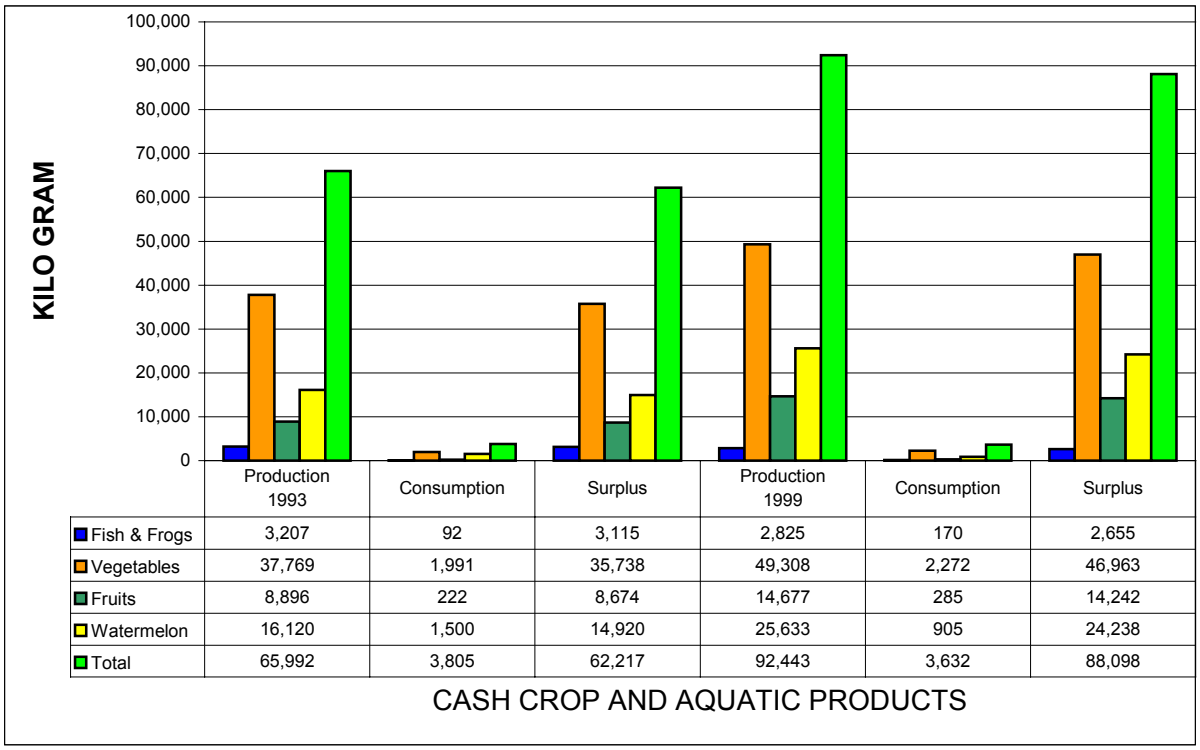
Vegetables are an important crop in the Barai area both in terms of production and consumption. Vegetables are the second largest crop after rice. They provide an important source of vitamins and minerals in what is predominantly a carbohydrate diet. They are a supplementary food source for household consumption and a source of cash income.[6]

During the survey, respondents were asked which cash crops they cultivated and the amount produced in 1993 and 1999. Most farmers produced substantial amounts of vegetables, watermelons and other fruits using irrigation. The total production of both cash crops and

[6] Ministry of Agriculture, Forestry and Fisheries, 1995.

aquatic produce in 1993 was 66 tons - fish and frogs 3 tons, vegetables 38 tons, watermelon 16 tons and other fruit 9 tons. In 1999, production had increased to 94 tons, 3 tons, 49 tons, 26 tons and 15 tons respectively (see Figure 10).

Figure 10: Aquatic and Cash Crop Production, Consumption and Surplus



	Production 1993	Consumption	Surplus	Production 1999	Consumption	Surplus
Fish & Frogs	3,207	92	3,115	2,825	170	2,655
Vegetables	37,769	1,991	35,738	49,308	2,272	46,963
Fruits	8,896	222	8,674	14,677	285	14,242
Watermelon	16,120	1,500	14,920	25,633	905	24,238
Total	65,992	3,805	62,217	92,443	3,632	88,098

The 1993 total consumption of cash crops was about four tons. Despite the population increase, the consumption of cash crops in 1999 had declined slightly to 3.6 tons. However, production of food crops (rice, maize and soybean) had increased by 1999, implying that consumption patterns had changed i.e. people consumed fewer vegetables, fruit and watermelon.

The surplus production of vegetables, fruits and aquatic products in 1993 was 62 tons (fish & frogs 3 tons, vegetables 36 tons, fruit 9 tons and watermelon 15 tons). In 1999, the total surplus had increased to 88 tons - fish and frogs 3 tons, vegetables 47 tons, fruits 14 tons and watermelon 24 tons.

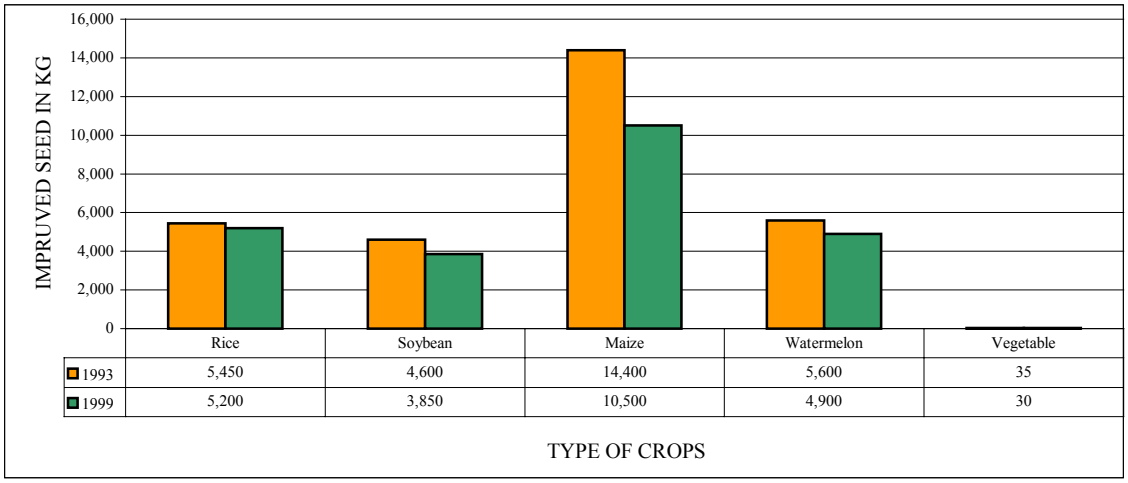
It can be concluded that the production and surplus of vegetables, watermelon and other fruits, have increased considerably. Improved access to irrigation is likely to have contributed to this increase. Consumption of these crops increased only slightly, indicating that fruits and vegetables are mainly used as cash crops.

Agricultural Inputs

Improved Seed

One of the agricultural inputs that can increase production is improved seed. Respondents were asked to indicate the type and the quantity of improved seeds they used in 1993 and 1999 (see Figure 11).

Figure 11: Improved Seed



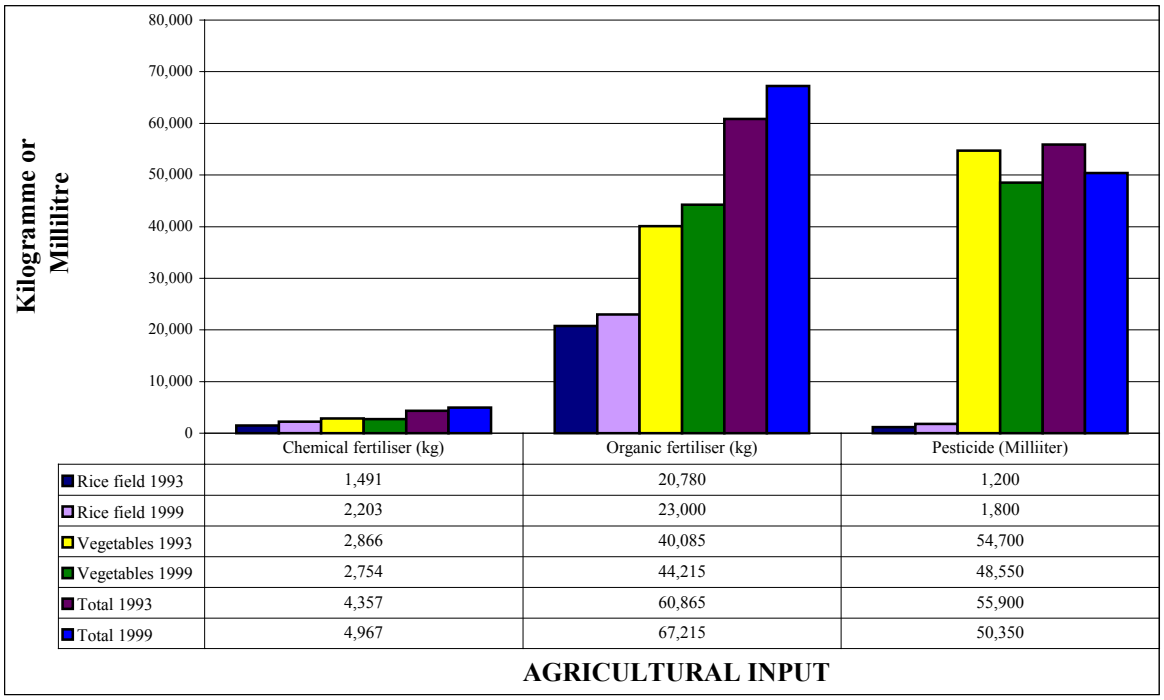
	Rice	Soybean	Maize	Watermelon	Vegetable
1993	5,450	4,600	14,400	5,600	35
1999	5,200	3,850	10,500	4,900	30

In 1993, the total quantity of improved seed used by all sample households was 31.1 tons (rice 5.5 tons, soybean 4.6 tons, maize 14.4 tons, watermelon 5.6 tons and vegetable 35 kg). In 1999, the total was only 24.5 tons (rice 5.2 tons, soybean 3.9 tons, maize 10.5 tons, watermelon 4.9 tons and vegetables 30 kg). This decrease in the use of improved seed demonstrates that this factor cannot be responsible for the increase in crop production.

Fertiliser and pesticide

The total amount of chemical fertilisers used in 1993 was four tons (rice 1 ton and vegetables 3 tons). This was five tons in 1999 (rice 2 tons and vegetables 3 tons). However, organic fertiliser was used in much higher quantities. In 1993, 61 tons of organic fertiliser was used (rice field 23 tons and vegetables 40 tons) increasing to 67 tons by 1999 (rice field 23 tons and vegetables 44 tons). Pesticide use had declined over the same period. In 1993, 56 litres of pesticide were used - 1.2 litres for rice and 54.8 litres for vegetables. By 1999 only 50 litres were used - 1.5 litres for rice and 48.5 litres for vegetables (see Figure 12).

Figure 12: Fertiliser and Pesticide Use



	Chemical fertiliser (kg)	Organic fertiliser (kg)	Pesticide (Milliiter)
Rice field 1993	1,491	20,780	1,200
Rice field 1999	2,203	23,000	1,800
Vegetables 1993	2,866	40,085	54,700
Vegetables 1999	2,754	44,215	48,550
Total 1993	4,357	60,865	55,900
Total 1999	4,967	67,215	50,350

There were no significant changes in fertiliser and pesticide application in 1999 compared to 1993.

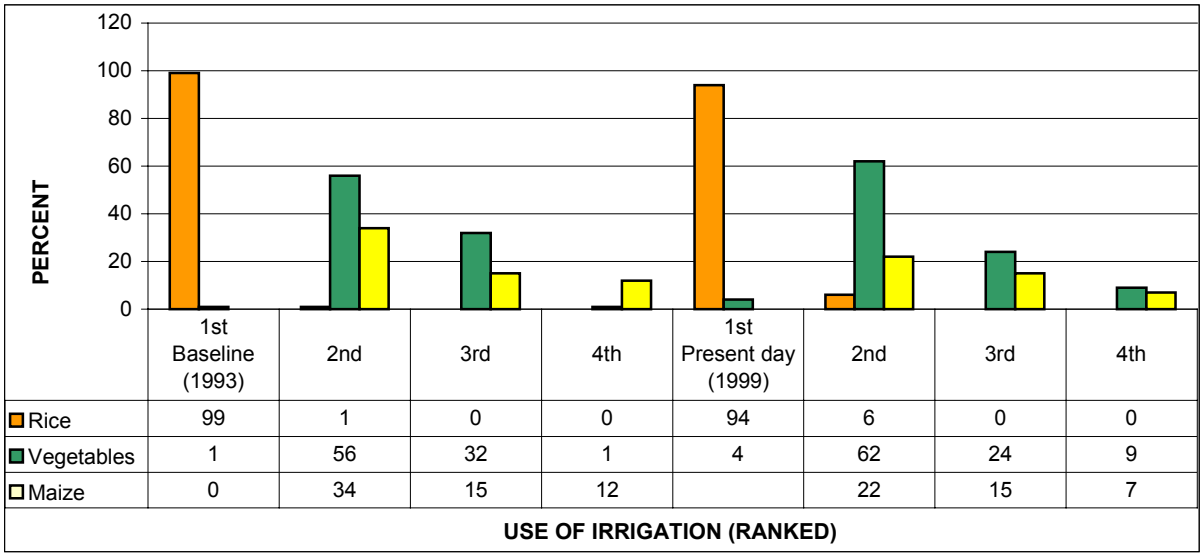
It can be concluded that the production of dry season rice, fruits and vegetables has increased considerably in 1999 compared with 1993. This increase in production cannot be attributed to increased use of improved seed, fertiliser or pesticide. Irrigation seems to have been the most important factor contributing to the increase in crop production.

Use, Management and Efficiency of the Barai Irrigation System

Use of Irrigation

The study identified three major activities and two minor activities for which farmers used irrigation in 1993 and 1999. The three major activities were growing rice, vegetables and maize and the two minor activities were animal husbandry and fruit production. Respondents were asked what they had used irrigation for in 1993 and in 1999. They were then asked to rank these activities in order from most important (1st) to least important (4th). Using irrigation to grow rice was ranked first in 1993 (99%) and in 1999 (94%). However by 1999, use of irrigation for rice had declined by five percent. This is due to increasing crop diversification, in particular vegetable and maize production, which ranked second and third, respectively (see, Figure 13). Farmers have started to grow more vegetables recently - probably due to the improved access to irrigation.

Figure 13: Use of Irrigation



	1st Baseline (1993)	2nd	3rd	4th	1st Present day (1999)	2nd	3rd	4th
Rice	99	1	0	0	94	6	0	0
Vegetables	1	56	32	1	4	62	24	9
Maize	0	34	15	12		22	15	7

USE OF IRRIGATION (RANKED)

Institutional Development

Irrigation management before ILO assistance

Farmers explained that before the ILO intervention, the secondary canals of the BIS were poorly maintained and consequently the supply of water was inadequate. Because of poor maintenance, the canal water gates did not function (they were rusted, parts were missing or broken), canal sections collapsed or were full of silt, water level gauges had disappeared, etc.

Before the ILO intervention, the Provincial Department of Hydrology managed the Barai Irrigation System in collaboration with village and commune chiefs. At that time, no specific rules and regulations existed for water distribution in the tertiary canals. Before 1993, the village and commune chiefs working at farm level were responsible for managing water distribution. Irrigation was provided on a 'first come, first served' basis. It was reported that conflicts among farmers were frequent during this time as they competed for irrigation.

Conflicts were particularly frequent between farmers in the downstream and central farming zones.

Irrigation management after ILO assistance

The ILO started providing assistance to the BIS in 1993. This involved routine maintenance of secondary canals i.e. greasing gates, removing vegetation from embankments, canals and drains and removing silt from canals, drains and structures. Since the intervention, the provincial Department of Hydrology has managed the Barai reservoir and the main canal with technical assistance from ILO.

The lack of proper water management procedures and systems to resolve conflicts can seriously limit the benefits of an irrigation system. Conflicts over water use occur when water distribution is inequitable. With this basic premise, the ILO's focus from 1993 to 1995 was to organise Water Users' Groups in each tertiary canal. The ILO also assigned two irrigation technicians to the Barai Irrigation System to provide technical assistance and training to the farmers using BIS irrigation.

The role of Water Users' Groups

There is one WUG for each tertiary canal. Secondary canal five has one WUG per tertiary canal, with the exception of tertiary canals, 501 and 502 which are covered by one WUG. This means a total of 28 WUGs for 29 tertiary canals. During the survey, WUG chiefs explained their main roles and activities, which are summarised as follows:

- To organise farmers to develop, operate and maintain the secondary and the tertiary canals.
- To take responsibility for managing water distribution for water users. The WUG chief supervises and co-ordinates water allocation to individual farmers. Fields located at the end of the tertiary canal (downstream zone) or far from the main canal get water first, while farmers with land closer to the canal (upstream zone) receive water later.
- To collect irrigation fees from water users.[7]
- To delegate water users to present issues or problems to the concerned body.
- To resolve small conflicts that arise between water users.

When the WUGs were established, WUG chiefs were generally either village chiefs or commune chiefs. Some still work both as village and WUG chiefs.

All WUG members are BIS beneficiaries who own land or share crop in the command area of the same tertiary canal. The WUG chief is the only executive individual in the group, meaning there is no committee or secretary, treasurer, deputy chief, etc. The organisational structure of WUGs is not strong and some work is required to enhance their institutional framework.

The WUG chief is responsible for maintaining, rehabilitating and managing the tertiary canal. The WUG chief is also responsible for settling disputes between irrigation beneficiaries. When farmers need irrigation they request the WUG chief to ask the Department of Hydrology to open the main gates for one or two days, depending on the irrigation demand.

[7] Each water user pays 30 kg of rice or 15,000 Riel each year for irrigation. In the early 1990s farmers paid water charges in kind (30-kg rice), but due to logistical and management problems, it was decided to pay in cash.

According to WUG chiefs, before the establishment of the WUGs, frequent conflicts and disputes occurred between farmers over water allocation. This situation has improved considerably since 1993.

Irrigation beneficiaries

During the survey, each WUG chief was asked how many farmers (water users) were registered in 1993 and in 1999. According to the WUG chiefs, the number of water users for the 11 tertiary canals was 528 in the baseline and 688 in 1999. This represents a substantial increase of 23 percent. In 1993, out of the total water using households, 412 (78%) were male-headed and 116 (22%) were female-headed. In 1999, 502 (72%) were male-headed households and 186 (28%) were female-headed households, indicating a four percent increase in female-headed households receiving irrigation (see Table 4).

Table 4: Irrigation Beneficiaries by Tertiary Canal

	Tertiary Canal ID Number												
	501	**503**	**505**	**507**	**514**	**515**	**516**	**518**	**519**	**520**	**521**	**Av.**	**Total**
1993(total)	**25**	**40**	**45**	**35**	**66**	**42**	**38**	**70**	**59**	**40**	**68**	**48**	**528**
a. Male	12	30	35	32	36	31	28	65	57	28	58	37	412
b. Female	13	10	10	3	30	11	10	5	2	12	10	11	116
1999 (total)	**53**	**50**	**58**	**60**	**78**	**54**	**52**	**84**	**59**	**60**	**80**	**62**	**688**
a. Male	20	35	38	52	48	38	45	79	57	40	50	45	502
b. Female	33	15	20	8	30	16	7	5	2	20	30	17	186

The average number of water users in a WUG in 1993 was 48 (37 male and 11 female). The average number of water users per WUG increased in 1999 to 62. Of these, 45 were male and 17 were female.

Irrigation Efficiency

Before the ILO rehabilitation and maintenance, the level of water in the canal was too low to allow farmers to get water into their rice fields using gravity. Now, the level of water in the canal is substantially higher, allowing farmers to gain water through the tertiary canals.

The delivery of water through efficient irrigation management is the most important service that the irrigation system operators (managers) provide to farmers. From the farmers' point of view the important factors are:

- Timing
- Flow-rate
- Farmers' participation in scheduling (planning)
- Duration of irrigation applications

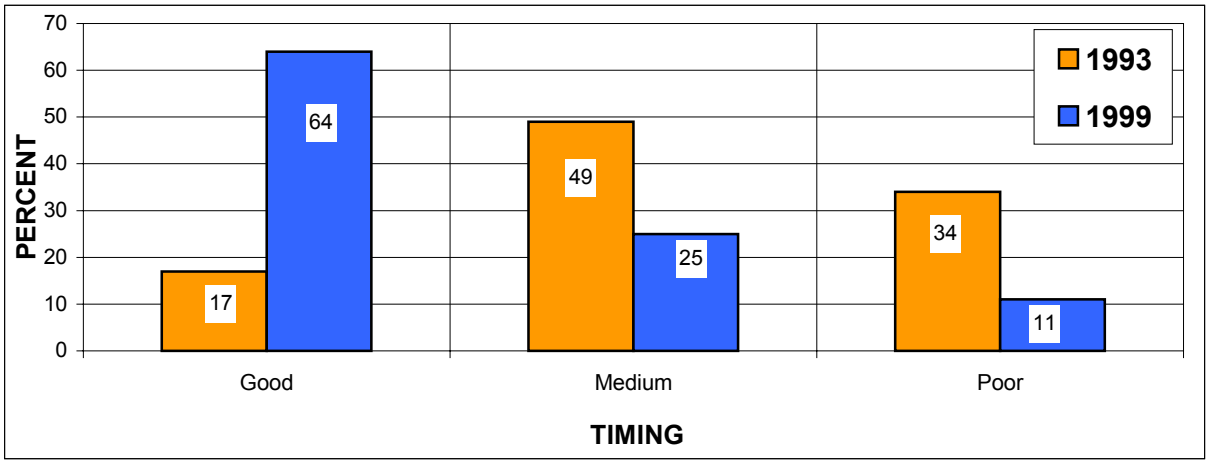
During the survey, each interviewee was asked whether irrigation supply by the central management was efficient in relation to each of these factors in 1993 compared with 1999.

Timing

Respondents ranked the timing of irrigation in one of three categories, good, medium or poor. The majority (64%) responded that the timing was good in the present day, while only 17 percent of respondents said that the irrigation timing was good in 1993. Forty nine percent of

respondents thought that the timing of irrigation in 1993 was medium, whereas only 25 percent believed that the timing was medium in 1999. Thirty four percent considered the timing of irrigation delivery poor in 1993, while only 11 percent of respondents said the timing was poor in 1999 (see Figure 14).

Figure 14: Irrigation Timing



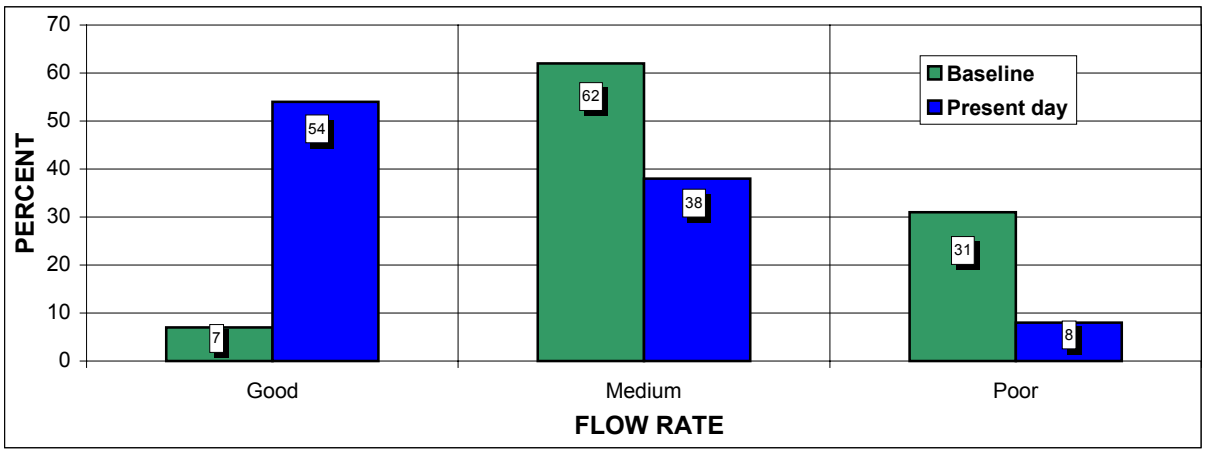
Since 1993, the ILO intervention has had a positive influence on the overall timing of irrigation. However, 25 percent of respondents believed it was still not optimal and 11 percent considered it poor.

Flow Rate

Flow rate depends upon a design that allows every farmer to take as much water as they want, at any time, for as long as they need. During the survey, each farmer was asked about the efficiency of the irrigation service in terms of flow rate. Flow was rated as either good, medium or poor.

Only seven percent of the respondents considered the flow rate to be good in 1993, whereas 54 percent said that the flow rate was good in 1999. The majority of respondents (62%) rated the flow rate of irrigation at medium in 1993, while only 38 percent believed it was medium in the present day. Thirty one percent of respondents said the flow rate of irrigation in 1993 was poor, while only 8 percent believed that the present day flow rate was poor (see Figure 15). In general, flow rate had improved considerably since 1993, although it is still not considered optimal by 38 percent and eight percent of respondents complain about poor flow rate.

Figure 15: Irrigation Flow Rate



Irrigation scheduling

Irrigation scheduling refers to setting the programme of water distribution for the coming period. The Department of Hydrology, Siem Reap Province, with technical assistance from the ILO, is responsible for setting water delivery schedules for the Barai Irrigation System. Preparing feasible schedules is vital for two reasons:

1. Farmers need to know when they will receive water (timing), how much (flow rate) and for how long (duration).
2. Irrigation system managers, in this case the Department of Hydrology, need to know when and how to adjust the gate settings.

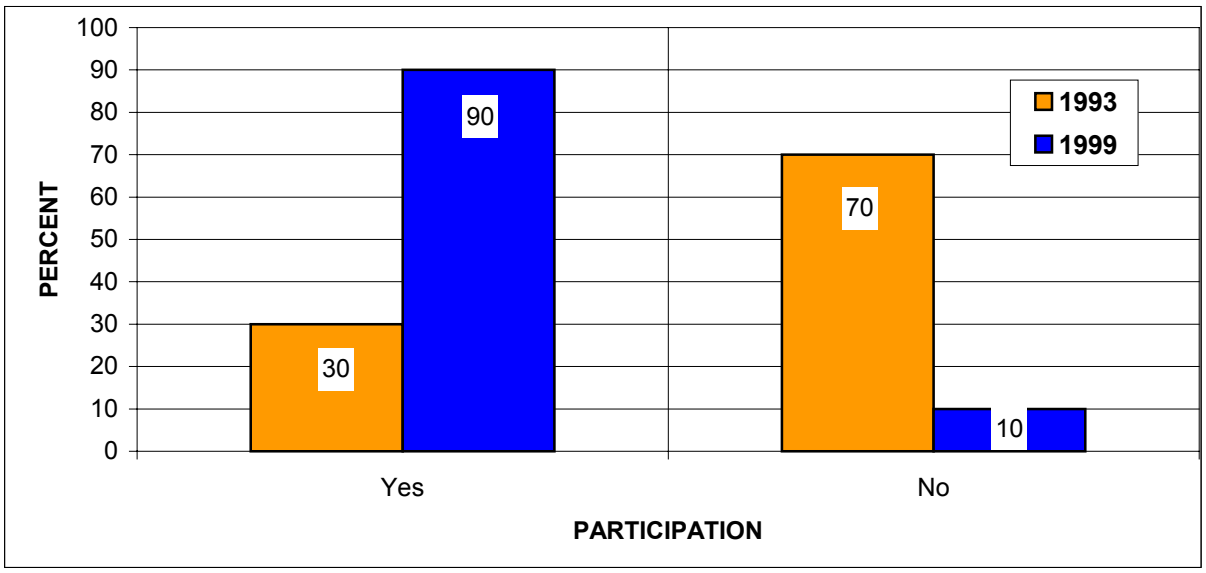
Since the ILO intervention in the Barai Irrigation System, WUG chiefs participate in irrigation scheduling. After the farmers make requests to the group, the WUG chief makes a formal request to the Department of Hydrology, indicating:

- The number of hours per day they need irrigation in their tertiary unit (canal).
- The flow rate they want to receive at the tertiary off-take.

The Department of Hydrology operators then prepare the irrigation schedule based on these requests.

The farmers were asked about their participation in irrigation scheduling. Respondents answered yes or no to the question - "Do farmers participate in irrigation scheduling?" The majority of respondents (90%) reported that there was good participation in the scheduling of irrigation in 1999. In 1993, 30 percent said that there was participation in irrigation scheduling and 70 percent stated that there was no participation by farmers in the irrigation scheduling process (see Figure 16).

Figure 16: Participation in Irrigation Scheduling

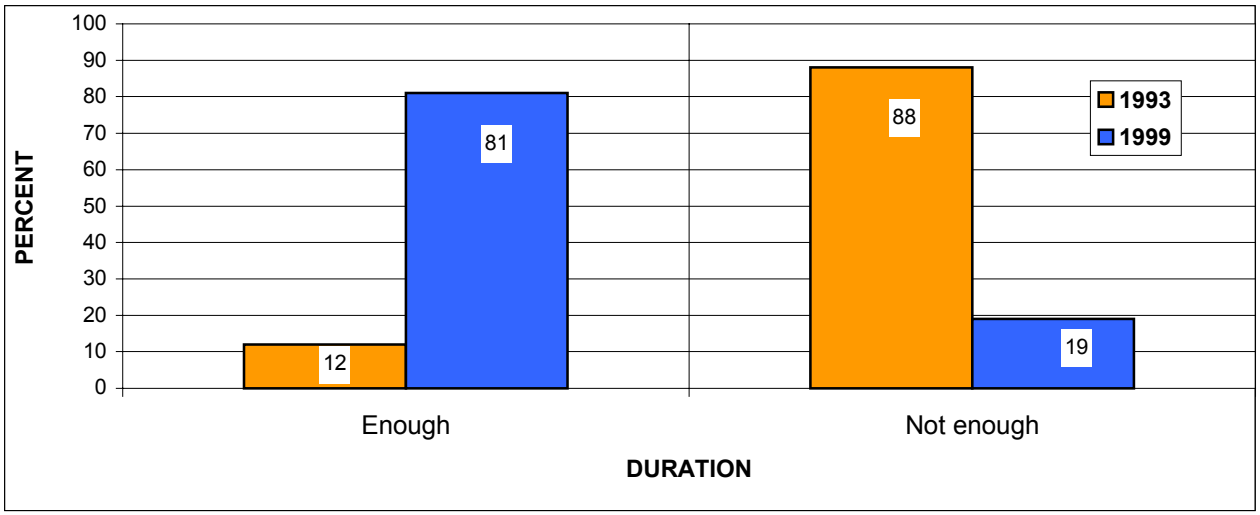


According to respondents, the scheduling and the distribution of water since 1993 has improved. Nevertheless, there are major differences between the farming zones. The farmers closest to the tertiary or secondary canals (upstream zone) get enough water, while those farmers in the central and downstream zones encounter problems accessing irrigation.

Duration of irrigation

Irrigation duration depends upon the season and the cropping patterns of the farmers. During the wet season, farmers usually request water only when there is no rain for around ten days. In the dry season, those who produce dry season rice request irrigation for a few days each month.

Figure 17: Irrigation Duration



The majority of farmers (88%) indicated that the duration of irrigation was insufficient in the baseline year. Only 12 percent believed that irrigation duration was sufficient in 1993. Conversely, the majority of farmers (81%) said that the duration of irrigation was sufficient in 1999 and only 19 percent reported that the duration was insufficient (see Figure 17).

Some constraints on the efficiency of irrigation

Almost all WUG chiefs mentioned four major problems - low water levels, problems for farmers at the tail end of secondary and tertiary canals and informal tertiary canals.

(1) One problem reported by interviewees and WUGs chiefs was low water levels due to poor canal maintenance, particularly before 1993. Low water levels are still a problem in some tertiary canals. Farmers with land near tertiary canals 501, 502, 507 and 514 were unable to get enough water. The cause is poor flow rate due to low water levels and the high level of surrounding farmland.

(2) Farmers with land at the head of the tertiary canal (near the secondary canal upstream zone) have a clear advantage over those farming near the middle. Farmers at the tail end of the tertiary canal (downstream zone) are the worst off and get the least water.

(3) The biggest problems occur at the tail end of the secondary canals. The WUG chiefs of tertiary canals 520 and 521 both complained that water flows first to the territories at the head (or the tertiary canals upstream) of the secondary canal. According to these chiefs, the gates of the other tertiary canals are often left open at night. This means that little water is left for tertiary canals 520 and 521. Water User Group 21 has stopped functioning and farmers no longer request water, because they are unable to get water when requested.

(4) The main problem affecting flow rate is the existence of informal tertiary canals. Farmers at the head of the tertiary canals make small holes in the secondary canal to get additional water outside the formal tertiary canal network.

According to the farmers and WUG chiefs, informal tertiary canals are made for two reasons:

a) An inability to get water from the formal tertiary canal because of its high water level, whereas it is easier to get water from an informal canal dug at a lower level.

b) Farmers who live between two tertiary canals (which are 500 metres from one another) are unable to receive water from either canal.

Although understandable, informal tertiary canals affect the flow rate, as much water is lost through the informal canals. Informal canals also create problems of drainage and water logging.

Employment, Expenditure, Income and Economic Patterns

According to a recent study by CDRI, the labour force in Cambodia in 1996 was estimated at 4.5 million people. Of these, 75 percent worked in agriculture (including farming, fishing and forestry), 20.5 percent worked in services (trade, transport, hotels, public administration, etc) and 4.5 percent worked in industry.[8]

The Barai area does not differ significantly from Cambodia's agricultural economy in general, which is mainly a subsistence economy. However, while rice production predominates in the Barai, farmers are also engaged in a range of non-cash and cash income generating activities. This occurs particularly after the wet season harvest, i.e. during the dry season.

Employment Patterns

The most important farm activities in the area of SC-5 were rice production, both in 1993 and 1999. Better irrigation encourages farmers to expend more labour producing rice, vegetables and other crops. Double cropping also increases on-farm activities. In general, a successful irrigation project generates a higher demand for on-farm labour, which is likely to lead to an increased demand for hired labour.

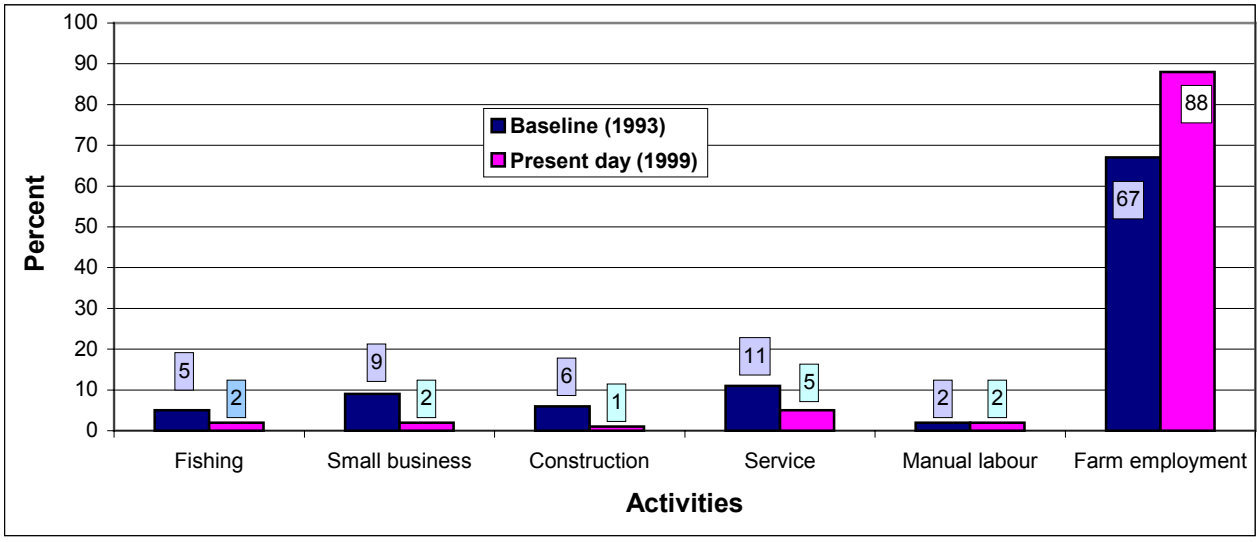
Activities can be divided into two kinds. The first are on-farm activities like rice cultivation, livestock and animal husbandry, cultivation of cash crops like soybean, sugar cane, watermelon and vegetables. The second are off-farm activities, which include fishing, small business and wage work (construction, service sector and manual labour).

This list is not exhaustive and only serves to illustrate the wide array of activities that Barai households engage in during the year. Most on-farm activities are wet season activities while most off-farm activities occur in the dry season. If there are no opportunities available in the Barai area, farmers migrate temporarily to Siem Reap town to seek employment as unskilled labourers. One important trend observed during the survey was that off-farm activities were decreasing over time due to increased on-farm activities.

According to the survey results, farming activities have become more significant for every household, particularly after the ILO intervention, which points to the importance of improved access to irrigation. Forty five percent of households in the baseline were carrying out off-farm activities like fishing (5%), small business (9%), construction work (12%), service work (11%) and manual labour (8%). The remaining 55 percent were engaged in on-farm activities. By 1999, 85 percent of households were engaged in on-farm activities and only 15 percent were involved in off-farm activities (fishing 4%, small business 5%, construction work 1%, work in the service sector 4% and manual work 1%) (see Figure 18).

[8] Murshid, K.A.S., 1998.

Figure 18: On-Farm and Off-Farm Activities



In 1999, on-farm activities had increased and off-farm activities had decreased compared to 1993. This seems to indicate that improvements to the Barai irrigation system encouraged farmers to engage in additional farming activities.

Three major patterns were apparent in the survey when comparing 1993 with 1999:

- Vegetable cultivation increased. This seemed to be the most important substitute for off-farm activities.

- In 1993, fishing and producing household equipment for sale were very popular methods of generating cash income after finishing work in the paddy field. However, these off-farm activities had reduced by 1999, as many farmers were too busy with farming activities.

- The migration of adult household members to Siem Reap town for short periods (2-3 months) to work as construction workers, hotel receptionists, motorcycle drivers or in other unskilled position has decreased since 1993.

During the survey, respondents indicated that it was now easier for poor families with small plots of land to get on-farm employment as hired labour than in 1993. This implies an increase in employment opportunities for poor farmers after the ILO assistance to the Barai Irrigation System. However, disabled households and female-headed families with young children cannot earn income from off-farm activities, as they are busy working on their own farms.

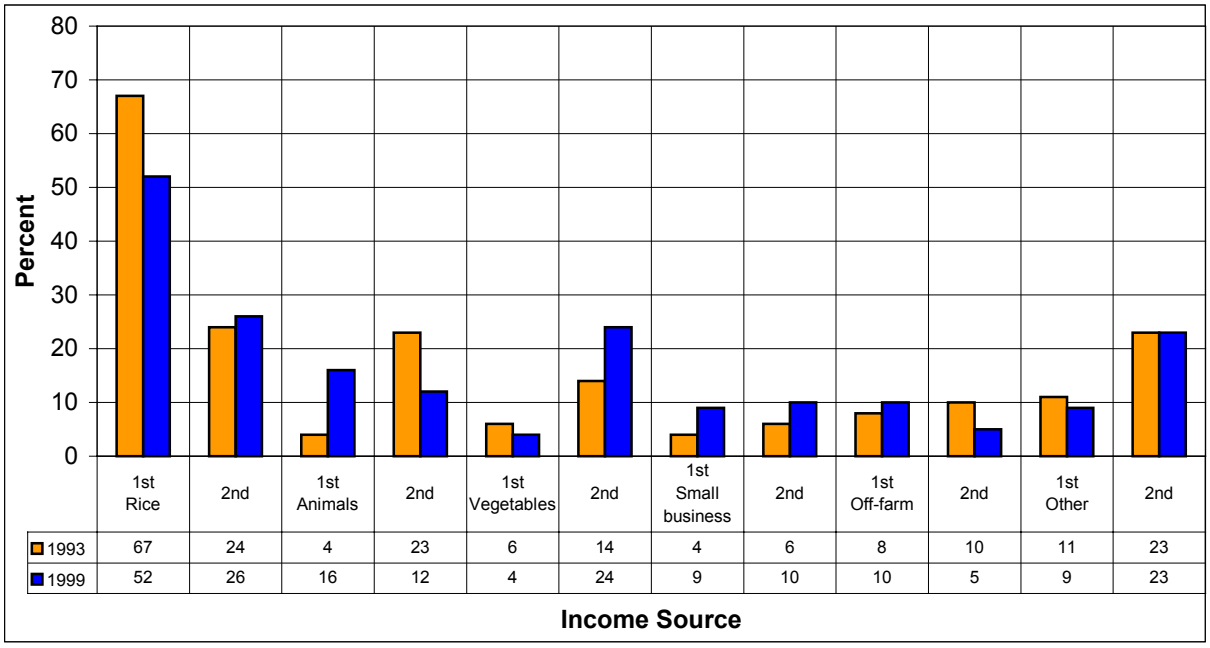
Income

During the survey, all interviewees were asked to rank the most important contributions to their annual income for 1993 and 1999. This was to determine if farm incomes had changed during the ILO intervention period. Respondents were asked to rank all income including rice and other crop production. According to the results, five items formed the major sources of

income - rice, pigs and animals, vegetables, small business and off-farm employment (see Figure 19).
As rice is an important staple in the area, every farmer interviewed produced rice for household consumption and sold the surplus.[9] In 1993, 45 interviewees (67%) ranked rice as their first major income source. In 1999, only 36 respondents (52%) ranked rice as their first source of income. In 1993, 17 farmers (24%) ranked rice as their second source of income, while in 1999 this was 26 percent.

Sixty-five of the 69 farmers interviewed earned income through the production of vegetables, which was the second most significant income earning activity in both 1993 and 1999. In 1993 and 1999 56 farmers ranked the sale of pig and animal products as the third most important income generating activity. Small business and off-farm employment were the fourth and fifth most significant sources of income respectively.

Figure 19: Income Trends



Some respondents also reported income from other activities, like fishing, savings and credit, maize and sugar cane production etc. These activities were mentioned by 11 percent of respondents in 1993 and by nine percent in 1999.

Since 1993, there has been an increase in income from pig and animal products and most significantly, from the sale of vegetables. The decreased importance of rice income since 1993 and the increased popularity of vegetable production for cash income suggest that improved access to irrigation has contributed to diversification of income generation.

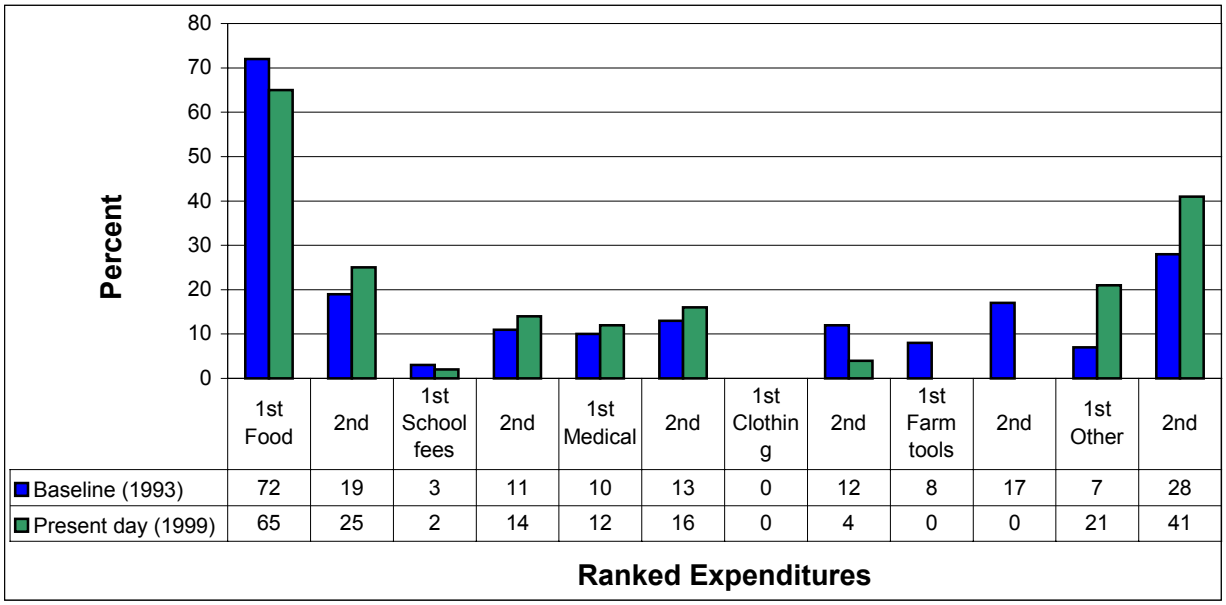
Expenditure

One of the main purposes of the study was to explore the impact of better irrigation on farmers and their families. Household expenditure patterns are a useful indicator of family

[9] In the process of ranking income sources, surplus rice production was also taken as household income.

income and poverty levels. Respondents were asked how they spent their income in 1993 and in 1999 (see Figure 20).

Figure 20: Expenditure Patterns



	1st Food	2nd	1st School fees	2nd	1st Medical	2nd	1st Clothing	2nd	1st Farm tools	2nd	1st Other	2nd
Baseline (1993)	72	19	3	11	10	13	0	12	8	17	7	28
Present day (1999)	65	25	2	14	12	16	0	4	0	0	21	41

According to the survey results, the majority of the farmers (72%) spent their income mainly on food in 1993. In 1999, only 65 percent spent their income primarily on food.[10] In 1993 and 1999, medical expenditures were ranked second (68 interviewees in each year). Seven respondents, (10%) ranked medical expenditures first in 1993. In 1999, eight interviewees (12%) ranked medical expenditures first. The third, fourth and fifth expenditures were school fees, clothing, and farm tools respectively in each year.

Economic Benefits

Almost all respondents reported an increase in rice production, particularly dry season rice. Vegetable production also increased considerably due to improved access to irrigation since 1993. Some families have started growing vegetables on a large scale, although many grow vegetables in kitchen gardens, mainly for their own consumption. According to respondents, market prices for vegetables vary. Occasional low vegetable prices are a problem for farmers.

Many respondents reported an increase in farm-employment, from three to four hours per day to eight to nine hours per day. The road rehabilitation and maintenance by the ILO was significant in facilitating access to the market. It had become much easier to carry farm produce to market and thus it was more profitable to increase production. Some respondents also mentioned that retailers came to their villages to buy farm produce. Thus, the rehabilitation of the road seems to be one of the most important improvements in the area.

During the survey, WUG chiefs were asked whether the number of rice mills had increased since 1993. According to the results, there was a clear increase in the number of rice mills,

[10] During expenditure ranking, rice consumption was considered a household expense, although it was a household product.

which may indicate either an increase in rice production or an increase in wealth after the ILO intervention (see Table 5).

Table 5: Rice Mills in 1993 and 1999

	Tertiary Canal ID Number										Total
	501	**503**	**505**	**507**	**514**	**515**	**516**	**518**	**520**	**521**	
1993	0	0	0	0	3	4	2	0	0	1	**10**
1999	5	2	4	2	5	7	1	1	1	2	**30**

There were only ten rice mills in the area in 1993, but this figure had increased to 30 by 1999, an increase of 67 percent. In 1993, most villages had insufficient rice mills, so farmers travelled to neighbouring villages, or to Puok market. Waiting times for rice milling were from one to two days. Waiting time is now between one and two hours.

Most farmers explained that their economic conditions had improved since the ILO support. More children go to school because living standards have improved. All respondents reported that the ILO support was preferable because it lasted for a significant period and because it was sustainable.

Conclusions

This study aimed to assess the impact of the ILO supported BIS and maintenance on land use, crop production and diversification and to measure the overall socio-economic changes on households. In total, 79 interviews were conducted, 69 with farmers who were direct beneficiaries of the BIS and ten with WUG chiefs interviewed at their tertiary canals.

The total population for the sample increased from 329 in 1993 to 448 in 1999. The average household size in the baseline year was 4.8, while the average household size in 1999 was 6.6, surpassing the national average of 5.5 members per household. One reason for this high population increase was the increased availability of irrigation, which attracted people from other areas to the Barai Irrigation System area. There was also a higher age dependency ratio (44%) in 1999 than in 1993 (39%).

Most farmers (57%) began using the Barai irrigation between 1961 and 1980. Some farmers (11%) were demobilised soldiers and refugee returnees who began using the irrigation more recently.

Land use and cropping patterns

There was a wide range in the size of land holdings in the sample. Holdings ranged from half a hectare to eight hectares. Most female-headed households had smaller plots of land and had farms in the central and downstream zones where access to irrigation is poorer.

In general, the total land area under cultivation increased from 122 hectares in 1993 to 143 hectares in 1999. This includes land used for double cropping, which was 23 hectares in 1993 and 33 hectares in 1999. Land leased/bought increased from one hectare in 1993 to nine hectares in 1999. This increase in double cropping demonstrates the improved access to irrigation. Due to the high population growth, the total land use per family member in 1999 was 0.32 hectares, down from 0.37 hectares in 1993. The land use per household increased from 1.77 hectares per household to 2.07 hectares per household in 1999.

In 1993, 70 percent of the total land was cultivated with irrigation and 30 percent without irrigation. In 1999, the land cultivated with irrigation was 86 percent and 14 percent was cultivated without irrigation. In 1993, the total area of cultivated land with irrigation for the upstream, central and downstream farming zones was 65 percent, 68 percent and 78 percent respectively. In 1999, these figures were 92 percent for the upstream, 83 percent for central and 82 percent for the downstream farming zone. It seems that farmers in the upstream zone had better access to irrigation than the other two farming zones. Those farmers with cultivated land in the central and the downstream farming zones receive inadequate irrigation because of their distance from the tertiary canals.

Data on cropping patterns showed a substantial increase in land area cultivated for major crops. The land cultivated for wet season rice in 1993 was 68 hectares and increased to 76 hectares in 1999. Dry season rice cultivation was 45 hectares in 1993 and 58 hectares in 1999. Soybean accounts for 1.31 hectares in 1993 and 1.28 hectares in 1999, maize six hectares in 1993 and 6.5 hectares in 1999 and sugar cane two hectares in 1993 and 1.66 hectares in 1999. In all farming zones, the total cultivated land had increased, but the land used for cultivating maize, beans and sugar cane did not increase, because vegetables and other cash crops were substituted.

Crop production
In 1993, the total production for the five major crops was 175.8 tons (wet season rice 66.9 tons, dry season rice 71 tons, soybean 1.2 tons, maize 16.3 tons and sugar cane 20.4 tons). The total production in 1999 increased to 245.2 tons (wet season rice 73 tons, dry season rice 124.9 tons, soybean 1.6 tons, maize 23 tons and sugar cane 22.8 tons).

The total cultivated land increased by 15 percent while total production increased by 28 percent. This is likely to be the result of improved access to irrigation. The total cultivated land for wet season rice increased by ten percent while production increased by only eight percent in 1999, compared with 1993. In 1999, the total land cultivated for dry season rice increased by 23 percent and production increased by 43 percent. The total land cultivated for soybean in 1999 was the same as 1993 but production had increased by 24 percent. The total land cultivated for maize increased by ten percent while production increased by 29 percent. The cultivated land area for sugar cane decreased by 25 percent, although production increased by 11 percent.

Wet season rice production did not show significant change after the ILO intervention. Dry season rice production however, increased significantly, particularly in the upstream (18.9 tons in 1993 to 44.8 tons in 1999) and downstream zones (17.9 tons in 1993 and 44.3 tons in 1999). This could also be attributed to improved access to irrigation.

Crop yield
The total average yield in 1993 was 1.44 tons per hectare for all crops (wet season rice 0.98 tons, dry season rice 1.58 tons, soybean 0.91 tons, maize 2.84 tons and sugar cane 9.79 tons). In 1999, it was 1.71 tons per hectare, which was an increase of 16 percent over 1993.

The total average rice yield for the sample showed a significant increase by 1999. However, poor soil and inadequate agricultural extension services may explain why the dry and wet season rice yields were still below the Siem Reap and national averages.

Consumption, surplus and deficit
Before the ILO assistance, total annual food consumption for the sample was 106.7 tons. By 1999, annual food consumption had increased to 151.9 tons, which can be partly attributed to population increase. The average total food consumption for 1999 had increased by 30 percent.

The total surplus increased by 24 tons, from 69 tons in 1993 to 93 tons in 1999. In 1993, out of the total household months of food consumption, 143 months were food deficient. This food deficiency figure decreased in 1999 to 120 household months.

Cash crop production, consumption and surplus
Vegetables are an important crop in the BIS both in terms of production and consumption. Vegetables are the second largest crop produced after rice. They provide an important source of vitamins and minerals in a predominantly carbohydrate diet.

The total cash crop production in 1993 was 66 tons - fish and frogs three tons, vegetables 38 tons, fruit nine tons and watermelon 16 tons. In 1999 production increased to 94 tons - three tons, 49 tons, 15 tons and 26 tons respectively. The 1993 total consumption of cash crops was

about four tons and despite the population increase, the consumption of cash crops had slightly decreased to 3.6 tons in 1999.

The cash crop surplus in 1993 was 62 tons. By 1999, this surplus had increased to 88 tons. Thus, production and surplus of fruit, vegetables and watermelon have increased considerably, probably due to the improved access to irrigation.

Use, management and efficiency of the Barai irrigation

The use of irrigation for rice growing was ranked first by respondents in 1993 (99%) and in 1999 (94%). However, irrigation use for rice declined by five percent in 1999 due to increased crop diversification, particularly vegetable and maize production, which ranked second and third, respectively.

The total number of water users for the 11 tertiary canals studied was 528 in the baseline and 688 in 1999, indicating a substantial increase of 23 percent. In 1993, 412 (78%) were male-headed households and 116 (22%) were female-headed households. By 1999, 502 (72%) were male-headed households and 186 (28%) were female-headed households, indicating a four percent increase in female-headed households.

Conflicts over water use occur between farmers when water distribution is inequitable. To reduce these conflicts, the ILO's focus from 1993 until 1995 was to organise Water Users' Groups (WUGs) by setting up one WUG for each tertiary canal. This was successful and WUGs now function in most tertiary canals.

Irrigation efficiency in terms of timing was reported to be good in 1999 by the majority of interviewees (64%). Only 17 percent of respondents reported that irrigation timing was good in 1993. Forty nine percent reported that the timing of irrigation in 1993 was medium, whereas only 25 percent of respondents believed the timing was medium in 1999. Thirty four percent of respondents considered timing poor in 1993, while only 11 percent said that the timing of irrigation was poor in 1999.

The efficiency of irrigation in terms of flow rate showed that only seven percent of respondents considered that the flow rates were good in 1993, while 54 percent said that the flow rate was good in 1999. The majority of respondents (62%) said that in the baseline year, the irrigation flow rate was medium, while only 38 percent believed the flow rate in the present day was medium. Thirty one percent of respondents said the flow rate was poor in the baseline, while only eight percent believed it was poor in 1999.

The majority of respondents (90%) agreed that there was user participation in scheduling irrigation in 1999, whereas in 1993 only 30 percent reported user participation. Seventy percent reported that there was no user participation in scheduling irrigation in 1993.

The majority of farmers (88%) indicated that the duration of irrigation was insufficient in 1993. Only 12 percent believed that there was sufficient duration of irrigation in 1993. This situation had reversed by 1999, when 81 percent said that the duration of irrigation was sufficient. Only 19 percent of respondents reported that the duration of irrigation was insufficient in 1999.

Socio-economic patterns

The most important farm activity in the area of SC-5 area was rice production, both in 1993 and in 1999. The increased availability of irrigation encouraged farmers to expend more labour producing rice, vegetables and other crops. Double cropping also increased on-farm activities. A successful irrigation project creates higher demand for on-farm labour, which increases the demand for hired labour generally.

Farming activities have become more important for all households since the ILO intervention. This highlights the importance of improved access to irrigation. In 1993, 45 percent of households were carrying out off-farm activities like fishing (5%), small business (9%), construction work (12%), service work (11%) and manual work (8%). Only 55 percent of households were doing on-farm activities. By 1999, 85 percent were engaged in their own farm activities and only 15 percent of households were involved in off-farm activities.

On-farm activities had increased by 1999 and off-farm activities had decreased. This seems to indicate that improvements to the Barai Irrigation System encouraged farmers to engage in more farming activities.

Since 1993, there has been increased income from the sale of pig and animal products and most significantly, from the sale of vegetables. The decreased importance of rice income since 1993 and the increased popularity of vegetable production for cash income suggest that improved access to irrigation has contributed to a diversification of income sources.

In 1993, the majority of farmers (72%) spent their income mainly on food, whereas in 1999 only 65 percent spent their income primarily on food.[11] In 1993 and 1999, medical expenditures ranked second (68 interviewees in both years). Ten percent of the respondents ranked medical expenditures first for 1993, while 12 percent did so for 1999. The third, fourth and fifth expenditures were school fees, clothing, and farm tools respectively for both years.

It seems that substantial agricultural, ecological and socioeconomic changes have taken place in the communities of the Barai irrigation area. Although not all of these changes can be attributed to improvements in the irrigation system, there is no doubt that these improvements had a significant impact on land use and production. The dynamics can be summarised as follows - improved irrigation leads to higher crop intensity and higher total production, creating higher incomes and more demand for labour, which in turn reduces poverty.

[11] During expenditure ranking, rice consumption was considered a household expense, although it was a household product.

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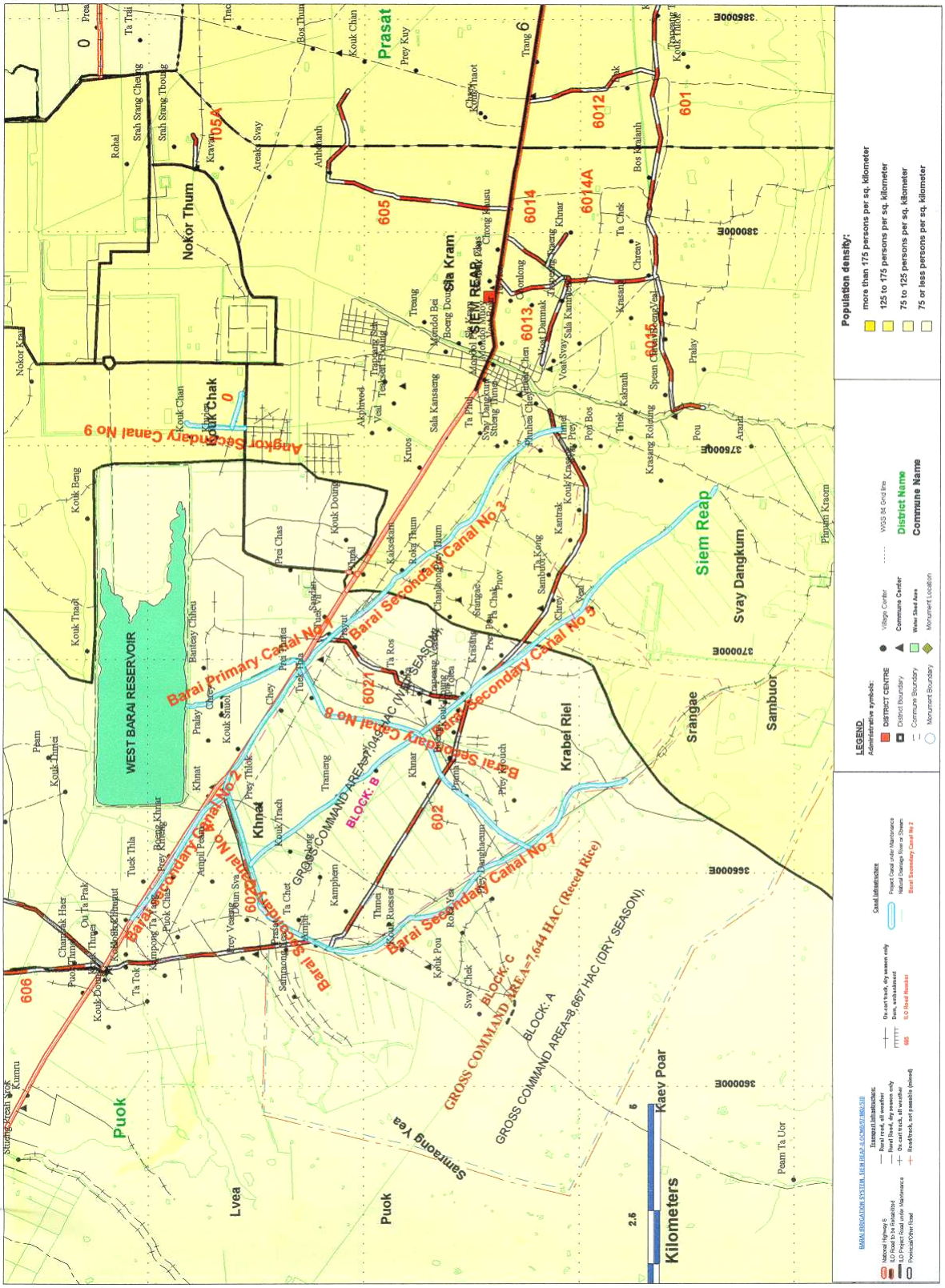
APPENDICES

Appendix 1 - ***Map of the Barai Irrigation System***



Appendix 2 - ***Survey Figures and Tables***

Table 2-1: Survey Sample by Sex and Tertiary Canal

Tertiary Canal ID Number	Upstream Zone			Central Zone			Downstream Zone			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
501	2	1	3		1	1	1	1	2	3	3	6
503	2		2	1	1	2	1	1	2	4	2	6
505		1	1	3	1	4	1	1	2	4	3	7
507	2	2	4	3		3	1		1	6	2	8
514	2		2	2		2	2		2	6		6
515	2		2	1		1	2	1	3	5	1	6
516	1	1	2	1	2	3	1		1	3	3	6
518	2		2		1	1	2	1	3	4	2	6
519	3		3		1	1	1	1	2	4	2	6
520	1	1	2	1	1	2	2		2	4	2	6
521	2		2	2	1	3	1		1	5	1	6
Total	**19**	**6**	**25**	**14**	**9**	**23**	**15**	**6**	**21**	**48**	**21**	**69**

Figure 2-1: Sample by Sex and Farming Zone

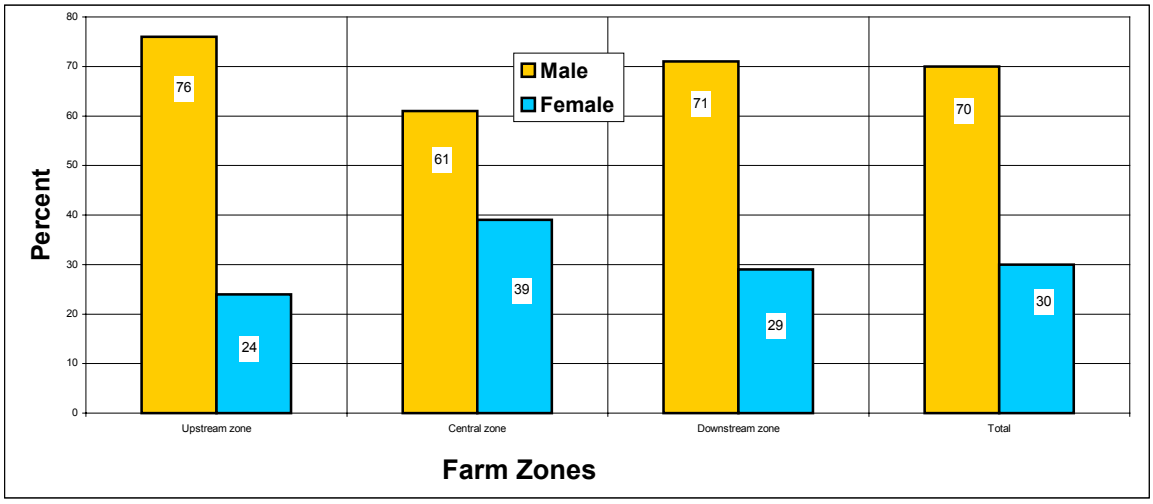


Table 2-2: Rainfall Data from 1990 to 1999

Siem Reap Provincial

Water Resource and

Meteorology Department

Document on Pluviometer in Siem Reap Meteorology Station 1990-1999

Line of Latitude: 13^{O} 24' 65" North

Line of Longitude: 103^{O} 48' 97" East

Level: 15 (High)

Meteorology and Hydrology Bureau

Year / Days	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1990	15	0	28.3	117.9	112.7	329.6	64.8	94	306	187.2	47.9	0	1303
Days	2	1	9	9	18	26	18	19	24	23	9	2	160
1991	-	0.1	50	71	49.3	249.3	240.1	306.1	427	250.6	0	0	1643
Days	0	1	2	5	17	22	21	27	25	25	5	1	151
1992	63.7	0	-	4	56	159.3	197.8	354.4	120	174.7	9.7	18	1158
Days	4	2	0	3	16	24	19	29	20	20	6	6	149
1993	3.7	-	17.2	30.5	43.7	340.2	172.9	199.6	280	408.9	12.2	15	1524
Days	3	0	10	4	12	19	17	26	19	23	6	3	142
1994	-	0.6	66.3	8.7	102.3	237.9	179.8	257.9	283	34.8	8.3	0.5	1180
Days	0	2	9	4	17	22	23	21	17	10	4	1	130
1995	-	-	22	28.5	178.2	221.6	240.7	230	512	301.9	13.3	18	1766
Days	0	0	3	6	15	15	18	13	26	15	4	3	118
1996	-	7.4	0.1	67.7	186.1	285.7	104.1	156.5	264	235.8	149.5	5.4	1463
Days	0	1	1	6	21	23	17	14	26	19	14	3	145
1997	-	20.7	10.5	132.4	149.4	147.4	384.7	193.2	355	135.2	21.8	0.8	1551
Days	0	6	5	10	14	17	24	18	18	21	8	1	142
1998	-	1.3	-	18.2	92.3	145.1	180.8	259	299	106.5	209.7	16	1328
Days	0	2	0	6	13	24	19	21	26	17	13	4	145
1999	2.9	2.8	17.1	106.3	237.3	309	222.2	72.7	162	182.2	144.9	8.7	1468
Days	4	1	7	17	26	23	23	21	25	23	18	5	193

Figure 2-2: Management of Irrigation

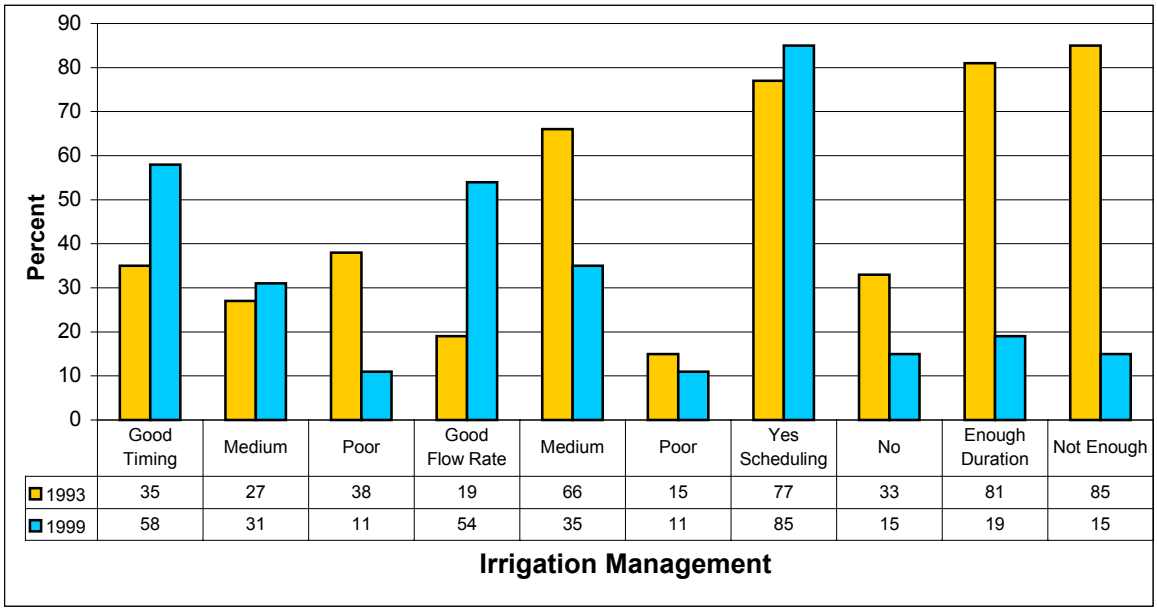


Figure 2-3: Land Use (Upstream Zone)

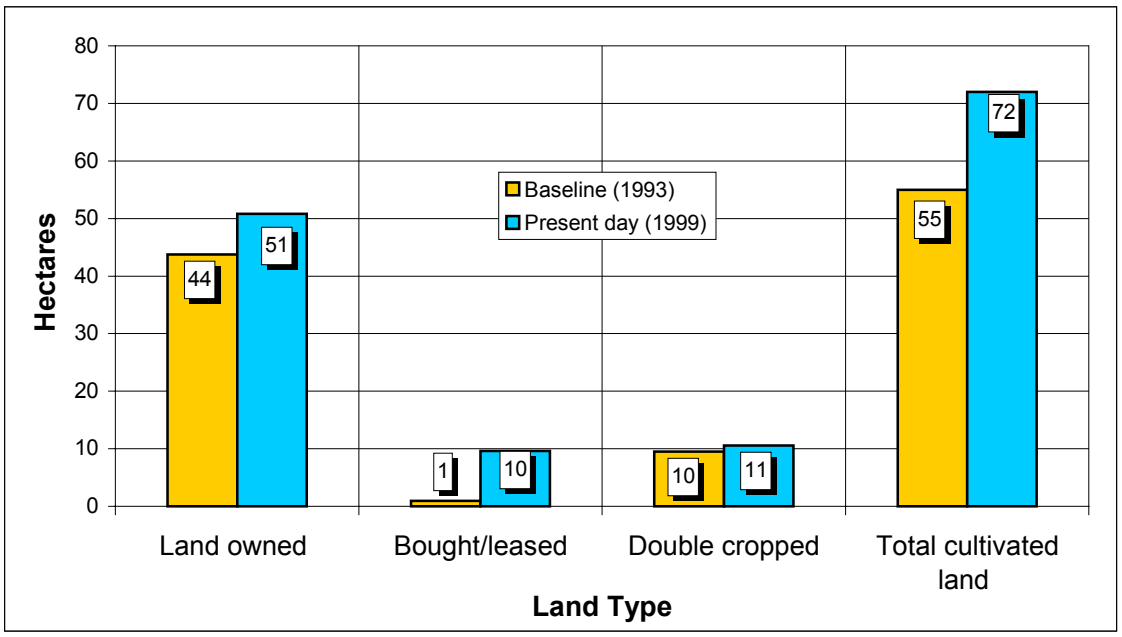


Figure 2-4: Land Use (Central Zone)

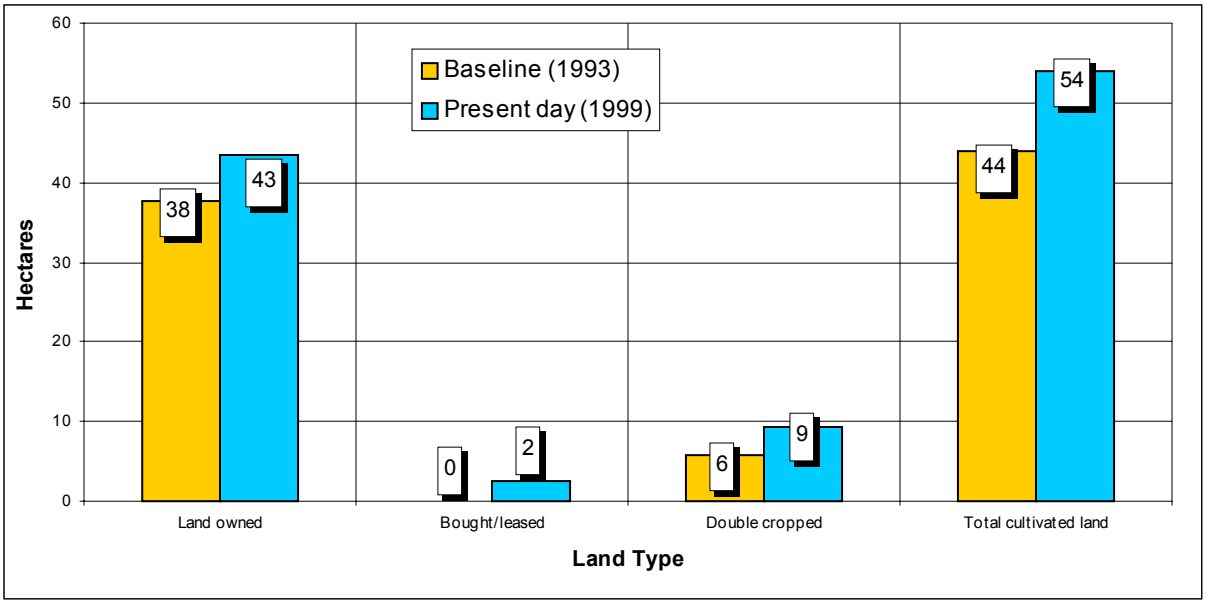


Figure 2-5: Land Use (Downstream Zone)

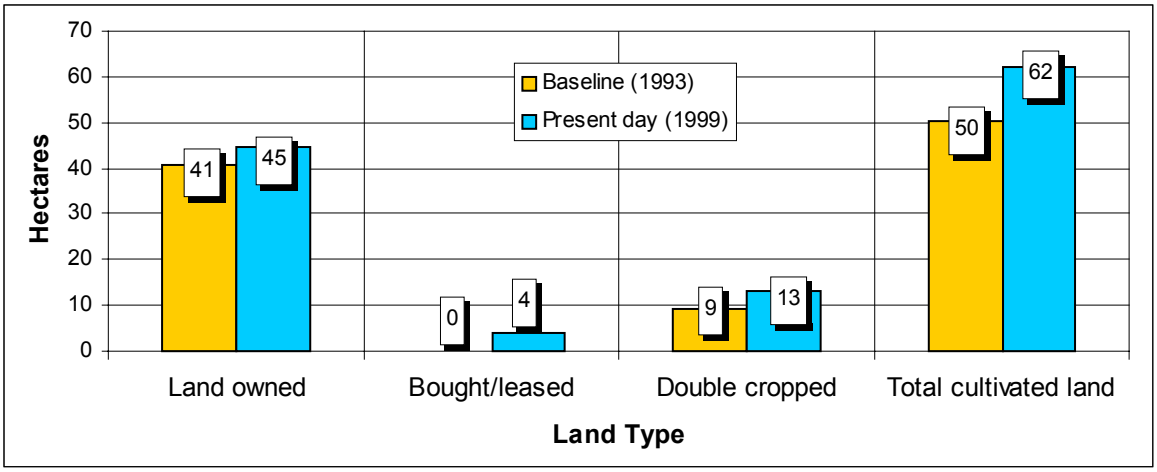


Table 2-3: Wet and Dry Season Rice Yields in 1993 and 1999

Zone, total sample, Siem Reap & Cambodia	Wet season rice ton/ha		Dry season rice ton/ha		Dry & wet season rice ton/ha	
	1993	1999	1993	1999	1993	1999
Upstream farming zone	0.98	0.94	1.57	2.35	1.16	1.49
Central farming zone	1.02	0.89	1.53	2.15	1.25	1.39
Downstream farming zone	0.95	1.09	1.13	1.98	1.03	1.56
Mean yield for the total sample	0.98	0.97	1.41	2.16	1.15	1.48
Mean yield for Siem Reap	1.42	1.30	2.08	2.5	1.23	1.36
Mean yield for Cambodia	1.18	1.81	2.6	3.04	1.55	1.94

Figure 2-6: Crop Production (Upstream Zone)

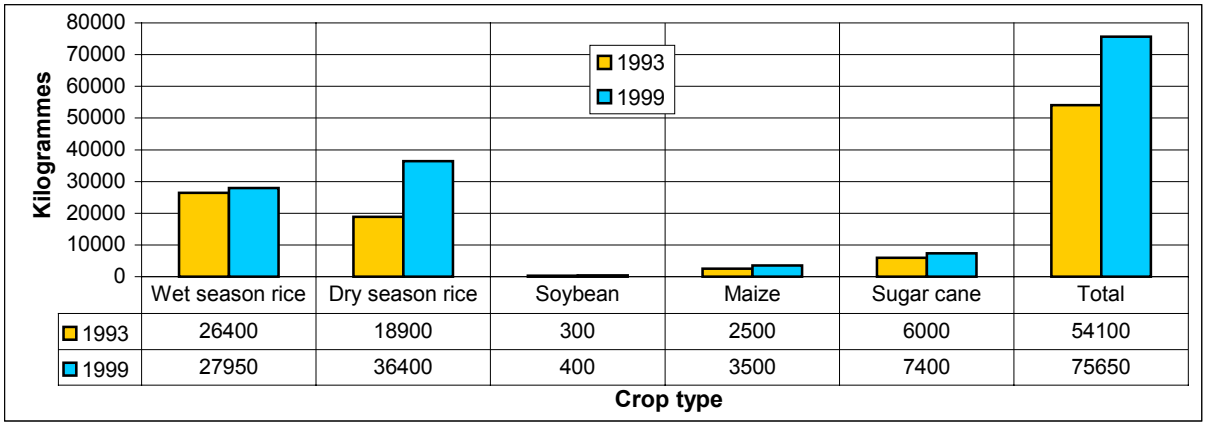
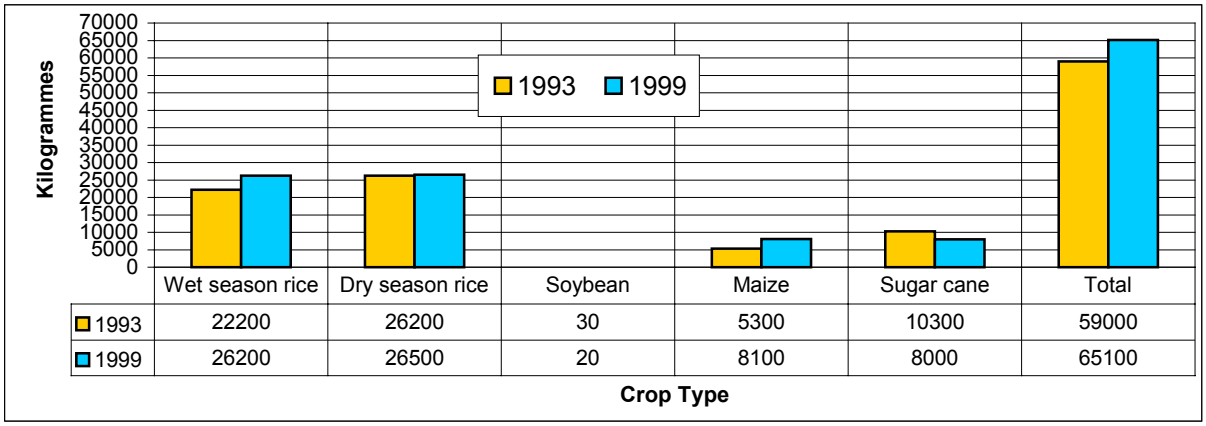
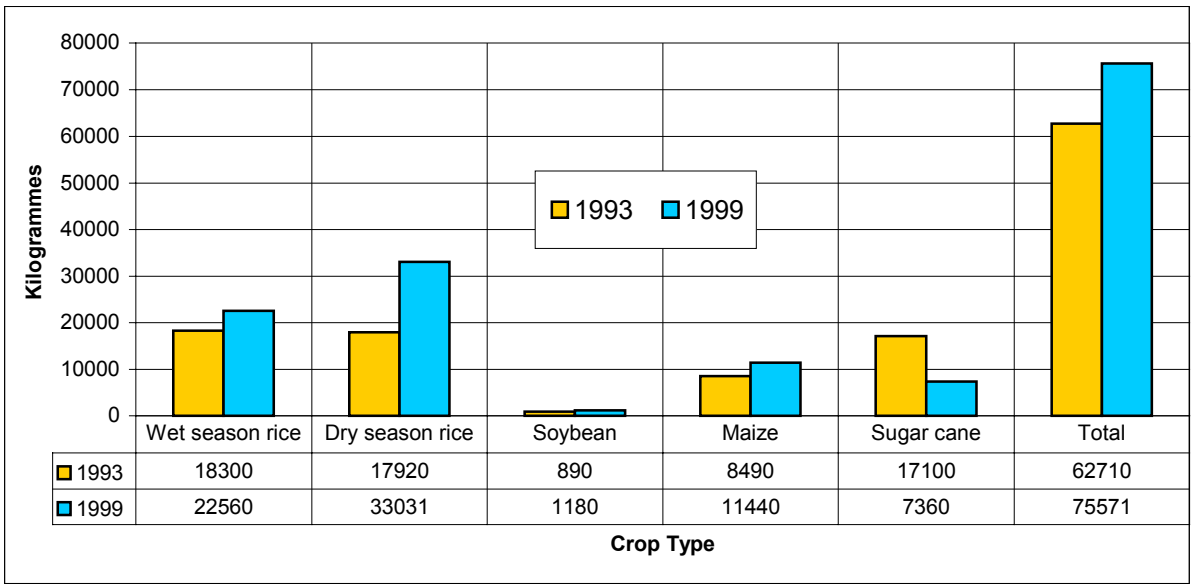


Figure 2-7: Crop Production (Central Zone)



	Wet season rice	Dry season rice	Soybean	Maize	Sugar cane	Total
1993	22200	26200	30	5300	10300	59000
1999	26200	26500	20	8100	8000	65100

Figure 2-8: Crop Production (Downstream Zone)



	Wet season rice	Dry season rice	Soybean	Maize	Sugar cane	Total
1993	18300	17920	890	8490	17100	62710
1999	22560	33031	1180	11440	7360	75571

Table 2-4: Local Seed Varieties Used in 1999 and 1993

	Rice (kg)	Soybean (kg)	Maize (kg)	Sugar cane (kg)	Watermelon (kg)	Vegetable (gram)
1993	17582	10292	12800	5150	950	32420
1999	27955	10100	9900	5350	1100	37400
Change	+37%	-2%	-29%	+4%	+14%	+13%

Table 2-5: Cultivated Land With and Without Irrigation in 1993 and 1999

Tertiary Canal ID Number	With Irrigation		Without Irrigation	
	1993	1999	1993	1999
501	57%	76%	43%	24%
503	55%	69%	45%	31%
505	46%	85%	54%	15%
507	68%	84%	32%	16%
512	72%	85%	28%	15%
515	60%	75%	40%	25%
516	77%	77%	23%	23%
518	90%	90%	10%	10%
519	70%	78%	30%	22%
520	86%	86%	14%	14%
521	67%	76%	33%	24%
Average	**68%**	**80%**	**32%**	**20%**

Table 2-6: Household Income Generating Activities in 1993

	Farm Income Ranking								Total
ID	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**Count**
Rice	45	17	6						**68**
Pigs and Animals	3	16	18	14	2	2	2	2	**59**
Fishing	8	8	3	2	2	2	1	1	**27**
Chickens	2	6	3	7	11	6	2	1	**38**
Watermelon		1	4	2	2	6	2	2	**19**
Vegetables	4	10	12	15	10	7	6	4	**68**
Fruit		1	2	7	8	4	3	3	**28**
Small Business	3	4	10	3	3	2	2	2	**29**
Service Sector Work	2	2	1	1			1		**7**
Construction Work		1	1	1	2	1	1	1	**8**
Manual Work			2	1	1	1	1	1	**7**
Maize			2	3	4	4	3	3	**19**
Savings & Credit		1	1	4	3	2	1	1	**13**
Other		3	5	5	3	2	2	1	**21**
Total	**67**	**70**	**70**	**65**	**51**	**39**	**27**	**22**	**411**

Table 2-7: Household Income Generating Activities in 1999

	Farm Income Ranking								Total Count
Type of income	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	
Rice	36	18	9	2		2			**68**
Pigs and animals	11	8	11	13	3	3	5	4	**58**
Fishing	4	8	4	1	1	3	2	2	**25**
Chickens		2	4	10	10	5	4	4	**39**
Watermelon		3	3	3	3	3	2	2	**19**
Vegetables	3	15	10	14	9	7	4	3	**65**
Fruit	1	1	4	8	10	2	2	2	**30**
Small Business	6	7	8	2	3	2	2	1	**31**
Service Sector Work	3	3					2	1	**9**
Construction Work	2	1	1	3	1		1	1	**10**
Manual Work	2		2	1			1	1	**7**
Maize		1	3	2	5	2	4	2	**19**
Savings & Credit			3		3	2	2	2	**12**
Other	1	1	7	4	1	1	2	2	**19**
Total	**69**	**68**	**69**	**63**	**49**	**32**	**34**	**27**	**411**

Table 2-8: Ranked Household Expenditures for 1993

	Expenditure Ranking																	Total Count
Type of Expenses	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	
Food	49	13	6															**68**
School fees	2	7	9	5	4	9	6	1	4	4		6	2	3	2	2	2	**64**
Medical	7	9	5	9	2	4	6	7	7	3	4	2	2	1				**68**
Clothing		8	14	4	10	6	5	14	3	5								**69**
Farm inputs		2	8	7	4	8	5	4	4	10	4	1	3	5	1	1		**67**
Farm tools & animals	5	11	3	12	6	4	5	4	7	2	1	1		1				**66**
Business & investment	1	1	2	4	3	1		3	1	3	1	2	1	2	2	2	1	**30**
Household equipment	3		1			1	4	3	5	9	7	9	1	2	2	2	2	**51**
Luxury goods	1	4	2	4	2	6	4	3	3	3	3	1	2	2	4	4	3	**51**
Entertainment		3	4	9	16	6	6	4	4	3		1	1	1	1	1		**60**
Weddings		4	5	5	9	12	3	8	5	4	3	1	1	1				**61**
Religious		1	2		7	3	14	10	12	5	9	3	1					**67**
Land tax												1	1		1	2	1	**7**
Irrigation fees								1	6	6	7	5	9	4	5	2	2	**47**
Hired labour		3	4	4	2	4	7	1	4	2	8	1	4	3	3	1	1	**52**
Debt repayment		1	2	3	1	2	1	1	1	1		1	1	2	3	2	2	**24**
Others		1	3	3	3	2		4	1	3	2	3	4	1				**30**
Total	**68**	**68**	**70**	**69**	**69**	**68**	**66**	**68**	**68**	**64**	**49**	**38**	**33**	**28**	**24**	**18**	**14**	**882**

Table 2-9: Ranked Household Expenditures for 1999

	Expenditure Ranking																Total
Type of Expenses	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Count**
Food	44	17	4	2								1					**68**
School fees	1	9	13	5	10	3	2	6	4	7	2	2					**64**
Medical	8	11	5	4	4	4	4	11	7	7	2	1					**68**
Clothing		3	10	12	5	8	9	4	2	4	4	3	3	2			**69**
Farm inputs		1	2	5	10	5	12	6	8	2	6	2	1	4	3		**67**
Farm tools & animals			8	7	10	9	5	2	5	8	5	3	1	2			**65**
Business/investment	3	2	1	2	3	3	1	3	4	2	1	2	1	1	1		**30**
Household equipment	3	1	1	1	1	2	3	4	4	5	5	11	4	5		1	**51**
Luxury goods	3	8	4	3	1	1	5	2	3	2	4	5	2	4	2	2	**51**
Entertainment		1	5	10	7	11	6	6	2	2	3		2	2	5	3	**63**
Wedding		6	4	6	7	8	5	8	2	5		3	3	2	2		**61**
Religious purposes	2	1	4	2	3	6	6		16	5	9	5	4	2	1		**67**
Land tax							1	4		1	1						**7**
Irrigation fees					1		1	4	3	7	8	7	5	5	3	3	**47**
Hired labour		2	5	7	2	3	7		4	1	4	3	3	4	3	2	**50**
Debt repayment	1	5	1	1	2	3	2	3	1	1		3	1				**24**
Others		1	2	2	3	3			2	2	3	2	2	4	3	1	**30**
Total	**65**	**68**	**69**	**69**	**69**	**69**	**69**	**63**	**67**	**61**	**57**	**53**	**32**	**37**	**23**	**12**	**882**

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