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Report of the Project

The Poverty Impacts of Public Irrigation Expenditures in Vietnam

(The Asian Development Bank-The World Bank Joint Research Project)

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Acronyms and Abbreviations

ADB	Asian Development Bank
CG	Control Group
CPRGS	The Comprehensive Poverty Reduction and Growth Strategy
CV	Coefficient of Variation
FGDs	Focused Group Discussions
GDP	Gross Domestic Product
GOV	Government of Viet nm
GSO	General Statistical Office
HCMC	Ho Chi Minh City
IFPRI	International Food Policy Research Institute
IGIDR	Indira Gandhi Institute of Development Research
IMC	Irrigation Management Company
IME	Irrigation Management Enterprise
JBIC	Japan Bank for International Cooperation
MARD	Ministry of Agriculture and Rural Development
MDGs	Millennium Development Goals
MKE	Mekong Economics Limited
O&M	Operation and Management
OLS	Ordinary Least Square
TA	Technical Assistance
TG	Treatment Group
US $/D	United States Dollars
VN D	Vietnam Dongs
WB	The World Bank

Currency Exchange Rates

One US Dollar = VN D 15, 200 (average in 2002)

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Executive Summary

The primary expenditure instrument used by the Government of Vietnam to improve rural incomes has been subsidized irrigation investments. Multilateral donors such as the ADB and the WB together with the GOV have invested considerable amounts of public resources for the improvement/rehabilitation of the existing irrigation infrastructure and management systems, especially after the mid-1990s. Irrigation accounts for about half of all public expenditures in the agricultural sector, and three-quarters of all capital investments (about US $250 million per year). Much of the funding is obtained through international financing agencies.

The focus of the study is *how various policy interventions in irrigation (rehabilitated infrastructure, improved management or combination of both) have had an impact at the micro-level (household level), particularly how they affect the poor?* It also assesses whether investment towards the rehabilitation of the existing infrastructure is more effective than that towards the improvement of management, or, a combination of both, in terms of its effects on poverty reduction. Specific objectives of the study are; *(i) to assess the impact of public investments towards irrigation infrastructure, the improvement of management on rice yields, farm profits, cost of production, production uncertainties, and rural poverty under the selected irrigation schemes, and (ii) to compare the impacts and efficiency of irrigation investments among three scenarios viz., rehabilitated infrastructure, improved management and combination of both.*

The study covered three irrigation schemes, Song Chu scheme in Thanh Hoa province (North region), where a part of the infrastructure was rehabilitated and also an improvement in the management, An Tranch scheme in Quang Nam province (Central region) where part of its infrastructure was rehabilitated, and thirdly, Dau Tieng scheme (Southern region) whose management was improved, being part of the scheme covering Ho Chi Minh province. Thus, each of these schemes represents a typical policy intervention, being either a combination of a rehabilitated infrastructure and improved management (Song Chu scheme), only a rehabilitated infrastructure (An Tranch scheme), and only improved management (Dau Tieng scheme).

Both qualitative and quantitative assessments were carried out to analyze the basic research questions of the study. For a quantitative assessment, in-depth household surveys were conducted over a period of March to May 2003, and farm-level data on a wide range of variables related to crop year, 2002, collected in the selected study sites. The total number of households surveyed was 1253, covering rehabilitated infrastructure or improved management, and non-rehabilitated or normal management in the selected schemes. Before selection of sample study sites, the researchers visited a number of communes/villages where interventions had taken place (infrastructure rehabilitation and/or improvement of management) and their neighboring communes/villages, which are closely similar to those in the rehabilitated and/or improved management areas under each selected irrigation scheme for as a control for qualitative assessment. Based on findings of qualitative assessment, the sample study sites were selected in such way that the socio-economic, biophysical and institutional features of both rehabilitated and/or improved management areas and their neighboring areas (non-rehabilitated and/or normal

management) are closely similar except a difference in irrigation infrastructure and/or management or both.

Baseline survey data was not available for the selected irrigation schemes, where interventions took place for rehabilitation of infrastructure and/or improvement of management. Thus, determination of counterfactual is a key concern in the study. To net out the effects caused by factors other than "interventions" on the dependant variables (impact indicators), comparison groups were formed from the sample households pool representing rehabilitated infrastructure and/or improved management, and non-rehabilitated infrastructure and/or normal management. For this, a propensity score matching technique was applied as suggested by Ravallion (2001). The aim of the propensity score matching is to find out the closest comparison group from a sample of non-rehabilitated infrastructure and/or normal management areas.

Findings from the qualitative assessment indicate that the interventions have substantially improved the availability of irrigation water, which in turn reduced production risks, improved farm income, reduced labor cost for pumping of water, and reduced poverty under selected schemes. Based on the qualitative assessment, the hypotheses tested by the quantitative analysis of survey data is that *the interventions that took place under the selected schemes have significantly improved the availability of irrigation water, which in turn increased rice yield, farm profits, reduced unit cost of production, reduced production uncertainties, improved household income, and reduced rural poverty.*

It can be concluded from the results of the Song Chu scheme that the recent interventions in irrigation (both rehabilitation of infrastructure and improvement of management) improved the availability of irrigation water, which in turn had a positive effect on yield increases, cost reduction, and income increases. On an average, there was a gain of about 18 per cent in rice yield, 22 per cent higher income, and 14 per cent higher food expenditure due to the rehabilitated irrigation infrastructure and improved management under Song Chu irrigation scheme. These improvements led to reduction of poverty by about 12 percent in the areas where the mentioned interventions took place (rehabilitated infrastructure and improved management areas). All these improvements in the household economy under rehabilitated infrastructure and improved management can largely be attributed to the increased crop/farm incomes due to improved availability of irrigation after recent interventions.

Under the An Tranch scheme (Quang Nam province), the rehabilitation of a part of irrigation infrastructure has enhanced the availability of irrigation water. There was a 22 percent reduction in owned labor costs besides increasing rice yield by 13 percent, which is a principal source of increased farm income under the rehabilitated area of An Tranch scheme.

Improved management in the Dau Tieng scheme in HCMC resulted in an increase of the total irrigated area 16 per cent in one year, however net irrigated area nearly same as in Tay Ninh. In addition, there a considerable improvement in the time efficiency for the availability of irrigation in each season due to improved management of irrigation.

This led to an increase in paddy yields by about 22 per cent. Further, the improved management also enhanced the productivity of non-rice crops, and amplified agricultural diversification.

Chu Chi, the study area representing improved management within the Dau Tieng scheme, is located relatively close to HCM City; its households have better access to many non-farm activities, therefore, the higher income from non-crop and/or non-farm sources can not soley be attributed to the multiplier effects from the improved management in HCMC. Therefore, a significant increase in food consumption thereby by reduced poverty in HCMC could not exclusively be attributed to the improved management. However, increased rice income due to improved management of irrigation could be one of the principal factors for increased consumption expenditure on food, and poverty reduction in HCMC.

Results show that farmers at the tail-ended of the canal system have been substantially benefited in increases in paddy yields, rice income, total farm income, and per capita food expenditures due to the rehabilitated infrastructure and improved management under Song Chu scheme, and to the improved management in HCMC under Dau Tieng scheme.

An important policy issues assessed is how public investments, made through different policy interventions in the selected irrigation schemes, are effective in terms of their impact on various outcome indicators especially on poverty reduction. Increases in percent terms of many outcome indicators such as rice yield, rice income, total household income and per capita food expenditure are significantly higher in HCMC where management of irrigation was improved under the Dau Tieng irrigation scheme as compared to other schemes. Poverty reduction, as estimated on a food poverty line, was also much more successful in HCMC under Dau Tieng scheme as compared to other schemes. However, increased non-farm income could have been an important factor besides the increase in rice income contributing to the rapid reduction in poverty in HCMC.

More gains in rice yields and income in absolute terms are contributed by he combined effect of an improved irrigation infrastructure and management under the Song Chu scheme as compared to by only rehabilitated infrastructure or improved management. Rehabilitated infrastructure under An Tranch scheme generated more gains in terms of increases in total household income, food consumption, and even poverty reduction as compared to Song Chu scheme. As a whole, improved management of irrigation (Dau Tieng scheme in HCMC) yielded more gains at household level than other two interventions combined.

On an average, a one US Dollar investment in the rehabilitation of infrastructure and improvement of management (combined impact) under Song Chu scheme generated US $ 1.31 worth of incremental farm output every year at the household level. The whole investment made in Song Chu scheme was recovered in just a year’s time through incremental farm output that could primarily be attributed to these interventions. However, it took 3-4 years to recover investments made in An Tranch (rehabilitated infrastructure) and Dau Tieng (improved management), the other two schemes The value

of the incremental farm output per one US $ invested in these schemes is about 0.30-0.35 every year. A further average investment of US $13-14 per household resulted in an increase of only one percent in per capita food consumption expenditure under Song Chu and Dau Tieng schemes, while the figure for the An Tranch scheme is moderately higher. The average amount invested through each intervention that brought one poor household above poverty line was lower in An Tranch scheme followed by Song Chu and then Dau Tieng scheme. Note that a large number of non-poor households were also substantially benefited with increased farm income due to the interventions under the selected schemes.

The estimated efficiency parameters for each intervention imply that public funds invested in the rehabilitation of infrastructure and improvement of management (combined effect) is more efficient in terms of additional output generated and on food consumption. However, rehabilitation of infrastructure seems to be a more effective policy intervention towards poverty alleviation, followed by the combination of rehabilitated infrastructure and improved management. Therefore, the rehabilitation of the existing irrigation systems ought to be given priority followed by improvements of its management to maximize the return farm incomes, and reduce poverty more efficiently. Results also suggest that merely investing on management does not yield more gains in terms of poverty reduction unless irrigation infrastructure is rehabilitated.

The Poverty Impacts of Public Irrigation Expenditures in Vietnam

1. Introduction

Vietnam is one of a few fast growing economies in the world since the 90s. Its GDP grew at about 7 per cent per annum during this period. Rapid economic growth contributed substantially to the reduction of poverty in the country during 90s. The proportion of poor in the total population declined from 58 to 29 percent between 1993 and 2002. However, accelerated growth has also brought considerable inequalities among rural and urban areas, and rich and poor households. The poverty rate drastically declined from 25 to 6.6 percent in urban areas while from 66 to 37 percent in rural areas between 1993 and 2002 (VDR, 2004). Poverty in Vietnam is largely a rural problem; nearly 85 per cent of the country's poor live in rural areas whose primary source of livelihood is agriculture.

The Government of Vietnam (GOV) committed to strengthen its strategies to accelerate growth with equity and reduce poverty in order to achieve Millennium Development Goals (MDGs). It targeted at halving the poverty in absolute terms by year 2010. A Comprehensive Poverty Reduction and Growth Strategy (CPRGS) was prepared by the GOV with specific action plans, and strategies to achieve MDGs in 2002. Bilateral and multilateral donors such as the Asian Development Bank (ADB) and the World Bank (WB) are actively participating and supporting the GOV to achieve its MDGs.

As poverty is widespread in the rural areas, a top priority was laid down in CPRGS to accelerate agriculture growth and rural income, thereby improve the living conditions of rural population. Several policy options and alternative strategies were identified to improve rural income. The most important issue that confronts policymakers is that which option and alternative is more effective in reducing poverty in rural areas. Where and which sub-sector needs to be given a priority for allocating more public investment in order to achieve rural transformation and reducing poverty more effectively and efficiently?

Irrigation is a lifeline for agricultural development especially for Vietnam where about 80 per cent of cropland is planted to rice, which is predominantly an irrigated crop. One of the best outcomes for improvement to the existing irrigation system (either infrastructure or management or both) will lead to a better availability of irrigation water, thereby empowering rice farming households through increased rice yields and farm incomes. Many Asian countries, including Vietnam, have invested huge public resources for the creation of new irrigation infrastructure until the 1980s. However, inadequate attention has been given towards the operation and management (O&M) aspect of the irrigation system. Many irrigation systems have been degraded due to lack of concerted efforts to O&M together with poor drainage. Therefore, the timely availability of adequate irrigation water has become a serious constraint especially for tail-ended canal areas. This led to production uncertainty particularly during droughts and floods, besides the decline in farm profits due to yield losses and cost increases. In some areas, degradation of irrigation systems has led to social conflicts among farmers for water

mainly in those areas where there was no proper O&M system for the maintaining the control of irrigation schedule as per needs.

The primary expenditure instrument used by the Government to improve rural incomes has been subsidized irrigation investments. Multilateral donors such as the ADB and the WB as well as GOV have invested considerable amount of public resources towards the improvement/rehabilitation of the existing irrigation infrastructure and management systems especially after the mid-1990s. Irrigation accounts for about half of all public expenditures in the agricultural sector, and three-quarters of all capital investments (about US $250 million per year).[1] Much of the funding is obtained through international financing agencies. The World Bank, the Asian Development Bank (ADB), and Japan Bank for International Cooperation (JBIC) currently have irrigation projects with total commitments of over US $500 million in Vietnam. The primary research question of the study is: *How effective are public irrigation expenditures in increasing rural incomes, particularly for the poor? Further, whether investment for the rehabilitation of the existing infrastructure is more effective or for the improvement of management is more effective in terms of poverty reduction effects?*

Rice is the major irrigated crop in Vietnam and rice production has soared from 20 million tons in 1990 to over 34 million tons by 2002 (GSO, 2002). Agricultural liberalization-especially 'decollectivazation' has clearly been a driving force during this expansion, but the impact of irrigation investments, which have more than doubled during the 1990s, is less clear. Although there are a few studies on impacts of irrigation sector as a whole (Ut, et al., 2000; Fan et al., 2003), there are no comprehensive studies on the impact of public investments in the rehabilitation of existing irrigation infrastructure and O&M on household income and poverty reduction. To fulfill this information gap, ADB and WB have jointly initiated a study *"The poverty impacts of the public irrigation expenditures in Vietnam"*. The principal goal of the study is to generate empirical evidence on *how effective are the public irrigation expenditures among two major interventions; either rehabilitation of the existing infrastructure or improvement of the management, or, what is the combined impact of both rehabilitated infrastructure and improved management in improving farm income and reducing rural poverty?* Further details to the requirements of the study are available in Appendix-A1 for the detailed terms of reference and concept note of the study.

The findings from the study will help improve the strategy for rural transformation, which is one of the key themes of Vietnam's CPRGS. Growth in agriculture was the driving force behind rural poverty reduction during the last decade, but in the coming decade agricultural diversification and growth in off-farm enterprises are likely to be the key to poverty-reduction. The role of irrigation interventions in this process needs to be redefined.

The study will help GOV and donors to better understand the links between government expenditure and poverty reduction in agriculture. Thereby understanding the

[1] IFPRI, "Vietnam Public Expenditure Review: Input on the Agricultural and Rural Sectors," March 21, 2000, pg. 12, Table 6.

fit in line with current efforts in aligning government and donor resource allocations to GOV's Comprehensive Poverty Reduction and Growth Strategy (CPRGS).

The 2000 Vietnam public expenditure review recommended a reallocation of spending within sectors, including agriculture. It also recommend, however, that "to decide on the extent of this reallocation will require further work on the tracking, incidence and the impact of sectorial expenditures." This study will help provide an empirical foundation for an analysis of public agricultural expenditures, and also serve to assist in project identification, and improve sector and overall economic management. The outputs of the study will be directly useful for the preparation, monitoring and evaluation of new WB, ADB and JBIC water resources projects. The information and analysis will also support implementation completion reports of on going water resource projects.

1.1. Nexus between irrigation and poverty: A macro-level view

Irrigation impacts have the economy-wide effects through backward and forward linkages, which have contributed significantly to poverty reduction in developing countries over the past three decades (Chambers 1988; Chitale, 1994; Barker *et. al.* 2000; Battarai, *et al,* 2002). The development of irrigation infrastructure contributed to crop intensification, and improved crop production, has improved farm and non-farm incomes, labor earnings, capital assets, human capital, food availability and accessibility, etc. Rural poverty was substantially low in irrigated villages as compared to the rainfed villages in Vietnam (Ut et al, 2000) as well as in other developing countries (Thakur et al, 2000; Janaiah et al, 2000). Further, the elasticity of agricultural growth to poverty reduction is greater than the elasticity of industrial growth to poverty (Mellor, 2001). Thus, irrigation has had a clear nexus with poverty reduction since irrigation is a crucial input to the accelerated growth in agriculture.

Public investments in irrigation in Vietnam were doubled during the 1990s. The production of rice, the major irrigated crop, increased by nearly 65 per cent between 1991 and 2002. Further, per capita GDP, at 1994 constant prices, increased from VND 2.0 million to 3.7 million, about an 85 per cent increase between 1991 and 2000. As Vietnam's economy is largely rural based, public investments in irrigation during the 90's contributed significantly to the increased economic growth through multiple effects. The impressive growth in the economy contributed to poverty reduction by half, from 58 percent in 1993 to 29 percent in 2002. Therefore, poverty has had a close link to the economic growth, which in turn is being influenced by agriculture growth and irrigation investments.

Many of the determinants of poverty reduction such as per capita GDP, agriculture growth, rice production, irrigation investments, etc. are inter-related. Thus, a simple OLS regression analysis could not capture the relationship between poverty and other related variables due to serious multicollinearity among them. To understand empirically the nexus between these factors particularly irrigation and poverty reduction variables at the macro-level, and overcome the multicollinearity problem, a factor analysis (Please see Appendix-A2 for details on factor analysis) was carried out using time-series and cross section data, for the time period between 1997 to 2002. A

component matrix of the factor analysis is provided in table 1.1. About 72 per cent of variance was explained by the selected variables determining the poverty, being inter-related to each other. The relationship among the variables in the first component shows that the poverty rate has a strong inverse relationship with irrigation investments. As expected, irrigation investments in turn had a strong positive association with coverage of irrigated area, and rice production. In component 2, the number of irrigated pump sets was inversely related to the share of total population engaged in agriculture (table 1.1). This implies that labor moved out of agriculture as number of irrigation pump sets increased. The inverse relationship between per capita GDP and poverty rate in component 4 in Table 1.1 further confirm that economic growth contributed to the poverty reduction across provinces in Vietnam.

1.2. Objectives of the study

A macro-level overview broadly explained that irrigation investments contributed to bolster up rice supplies, improved agriculture growth and GDP growth, which in turn led to the substantial reduction in poverty across provinces. This provided an empirical clue to set clear objectives in the study to address a key issue on how public irrigation expenditures in recent years is effective in contributing to poverty reduction. Therefore, it is expected that public investments made by donors and GOV for the rehabilitation of the irrigation infrastructure and improvement of management in various parts of Vietnam during 90s are likely to make a significant impact on the rural sector in the benefited areas. Thus, the study basically aimed at analyzing two principal objectives:

(i) *To assess the impact of public investments made in the rehabilitation of the irrigation infrastructure and the improvement of management on rice yields, farm profits, cost of production, production uncertainties, and rural poverty under the selected irrigation schemes.*

(ii) *To compare the impacts of irrigation investments among three scenarios; rehabilitated infrastructure, improved management and a combination of both.*

The study covered three irrigation schemes, Song Chu scheme in Thanh Hoa province in North region, where a part of the infrastructure was both rehabilitated and management improved, An-Tranch scheme in Quang Nam province (Central region) for which a part of its infrastructure was rehabilitated, and Dau Tieng scheme (Southern region) whose management was improved, a part of the scheme covering Ho Chi Minh province. Considerable amounts of public investments were made into these schemes by GOV as well as by other donors to rehabilitate infrastructure and/or improve management or both during the late 90s, each schemes representing a typical policy intervention;

2. Research Methodology

2.1. Design of sampling and survey

The study is primarily aimed at generating the empirical evidence on how various policy interventions in irrigation (rehabilitated infrastructure, improved management and the combination of both*)* have had an impact in the selected irrigation schemes at a

micro-level (household level). To achieve this, in-depth household surveys during March to May period in 2003 were conducted in the selected study sites, and farm-level data collected on a range of variables related to crop production in the year 2002. 1253 sample households were surveyed (table 2.1). The samples covered rehabilitated infrastructure and/or improved management, and non-rehabilitated and/or normal management in the selected schemes

Before selection of study sites, the concerned researchers visited a number of communes/villages where interventions took place within the selected irrigation schemes. Also neighboring communes/villages, which are similar to those of the rehabilitated and/or improved management areas, were visited within each selected irrigation scheme. The team had a series of a Focus Group Discussions (FGDs) with three types of people, being; the officials of the Irrigation Management Company (IMC) at a provincial level. The Irrigation Management Enterprise (IME) at the district level and, commune leaders and farmers, in the rehabilitated and/or improved management areas together with their neighboring communes/villages including non-rehabilitated and/or normal management areas. After in-depth discussions during field visits, study sites at the communes/villages level were identified for intensive household surveys in both the rehabilitated and/or improved management areas, and their neighboring communes/villages where no interventions took place. Findings of qualitative assessments during field visits and FGDs are presented in Section 4. The sample study sites were selected in such way that the socio-economic, biophysical and institutional features of both altered areas and their neighboring areas are all similar apart from a difference in its irrigation infrastructure and/or management.

The study sites, or sample households, were selected in both areas of the irrigation scheme through the stratified random sampling method in such a way that the total sample size is represented proportionally by the head, middle and tail-end of farmers in their respective irrigation canal within the identified communes. Therefore, sample size varied between study sites as each irrigation scheme had a different number of farm households living in each of them.

Song Chu Irrigation Scheme within Thanh Hoa Province: This case study covered total 347 sample households, 147 of these from three communes in the rehabilitated and improved management area, while 200 households came from one commune in the non-rehabilitated and normal management area (table 2.2). The selected sample households covered 14 village clusters, 7 in each of the altered and non-altered sites (table 2.3).

An Tranch Irrigation Scheme within Quang Nam Province: Two communes selected from rehabilitated and non-rehabilitated areas. 161 and 287 households were sampled randomly in both the rehabilitated and non-rehabilitated irrigated systems respectively (table 2.4). The selected samples spread over a total of 11 village clusters within the study area (table 2.5)

Dau Trieng Irrigation Scheme within Tay Ninh/HCMC Povince: As the density of the population is more in these provinces of South Vietnam, especially when under an irrigation scheme, the sample size should also be relatively larger for this case study.

Of the 157 randomly selected households in Chu Chi District of HCMC, nearly one-third were from each of three communes, and had an improved management of infrastructure (table 2.6). Similarly, 302 households were sampled covering three communes within two districts of Tay Ninh province, which are closely located to Chu Chi, however irrigation management is not as effective as in Chu Chi where there has been no alterations to the management of its infrastructure. 8 and 4 are the number of village clusters that exist where all samples where taken in Chu Chi of HCMC and Tay Ninh respectively (table 2.7)

A structured questionnaire was designed, which was tested for the required data from the selected sample households (Annexure-A3). The trained field investigators administered the pre-tested questionnaires through personal interviews with the mentioned households under the supervision of the researchers of the study team. The household level data collected, covering socio-economic and biophysical features of agricultural production systems, includes the collection of such variables as resource endowments, sources of income, detailed composition of expenditures on food items, assets, etc. The collected data of household surveys were properly encoded electronically, all variables edited, and finally cleaned data files were prepared.

2.2. Data processing and analytical methods

First, a cross-tabulation of the descriptive statistics of the expected outcome indicators was made, then a comparison between the two groups of sample households representing rehabilitated and/or improved management and non-rehabilitated and/or normal management was conducted. It was noted that the difference in the expected outcome indicators between these two groups was not appreciably found and for some indicators there was even a negative relationship. Then a series of regressions of the pooled households of the two groups on expected outcome variables with number of independent variables including a binary variable of type of household (1=rehabilitated infrastructure and/or improved management, and 0=non-rehabilitated infrastructure and/or normal management) were run in order to understand sources of selection bias among sample households (Appendix A4-A6).

The baseline survey data was not available for the selected irrigation schemes, where interventions took place in the form of public investments for rehabilitation of infrastructure and/or improvement of management. Thus, there was no information on as the socioeconomic background of the households in the selected sample sites in both groups before the public investments were made. There might be some differences in the level of identified impact indicators between these two groups before interventions took place in the selected irrigation schemes. Further, the expected outcome variables (impact indicators) might have also been influenced by factors (unobservable variables) other than improved irrigation infrastructure and/or management. Therefore, a simple absolute difference in the outcome variables such as farm income between the two groups after interventions may not be attributable exclusively to the considered interventions (improved infrastructure and/or management) in the selected irrigation scheme.

Determining the results as being counterfactual is a key concern in any impact assessment study such as this one when the baseline data at the beginning of interventions are not available. To net out the effects caused by factors other than "rehabilitated infrastructure and/or improved management (interventions)" on the outcome variables (impact indicators), similar comparison groups must be formed, and where possible come from the sample households representing rehabilitated infrastructure and/or improved management, and non-rehabilitated infrastructure and/or normal management. For this, a propensity score matching technique was applied as suggested by Ravallion (2001). The aim of the propensity score marching is to find out the closest comparison group from a sample of non-rehabilitated infrastructure and/or normal management area to the sample of the rehabilitated infrastructure and improved management area. 'Closest' is measured in terms of observable variables, which is not related to the outcome indicators. Please refer to Appendix-A7 for details on the propensity score matching technique. The estimated logit regressions for computing propensity scores are shown in Appendix A8.

After propensity score matching, two comparable groups were formed; one from the sample households representing the rehabilitated infrastructure and/or improved management, and other group from the sample households of the non-rehabilitated infrastructure and/or normal management. Sample households in each comparison group have the closest propensity scores. Households whose propensity scores did not match between two groups were taken out from the sample (please see Appendix A9). The retained samples of households in the comparison groups are expected to be relatively similar with respect to various socio-economic and biophysical features, except a difference in the irrigation system (rehabilitated or non-rehabilitated infrastructure, and improved or normal management).

To verify empirically whether sample households from two comparison groups are closely similar, except a change in irrigation system, a simple OLS regressions were run for the pooled sample households of two comparison groups (after propensity score matching) using the same variables as used for the original pooled households (before propensity score matching). It was found that the variable 'type of household' representing interventions (rehabilitated infrastructure and/or improved management or non-rehabilitated/normal management) was found significantly associated with the identified outcome indicators after propensity score matching, while its effect was not significant for the pooled households of original samples (before propensity score matching). This trend was noted almost for all important outcome indicators in all cases (Please see Appendices A4.1a-A6.4b for estimated regressions, before and after propensity score matching). This confirmed that the effect of most of the unobservable variables on important outcome variables was netted out by carrying out propensity score matching.

Thus, the retained households in the two comparison groups are considered closely similar with respect to socio-economic and biophysical features except a difference in irrigation infrastructure and/or management. The survey data of these two comparable groups were finally used for the whole analysis in the study (Tables 2.8-2.10). Therefore any change in the outcome indicators between two comparison groups

can be exclusively attributable to the policy intervention in the irrigation (rehabilitated infrastructure and/or improved management).

3. Salient Features of the Selected Irrigation Schemes

Three major irrigation schemes were studied for comparison between the three typical case studies, where recent interventions took place. This section provides a brief description of selected irrigation schemes.

3.1. Song Chu Irrigation Scheme (Thanh Hoa Province)

Song Chu irrigation scheme is one of the 13 large schemes constructed by the French colonial regime. This scheme was completed in 1926 to irrigate a potential area of about 50,000 ha. This irrigation system has been operational during the past 60-70 years despite damages in some parts to the main infrastructure. During the reconstruction period after the end of Vietnam War, in 1975, the required repairs and maintenance of the main infrastructure of this scheme was not implemented adequately. Shortages of funds for such purposes have been the constraining factor for an excessive number of years. The old infrastructure seriously deteriorated and as a consequence the area irrigated under this scheme has been substantially reduced. Also, the technical and management processes for efficient O&M has been degenerated along with the deterioration of the infrastructures.[2]

Two interventions took place under this scheme in the mid 90s to improve the irrigation system. First, a part of the Song Chu irrigation scheme was rehabilitated by the GOV through an ADB funded Flood Protection Rehabilitation Project in the mid 90s. Later, it was felt that it was needed was to improve O&M, at the local level as well as the provincial level. Therefore, for the second intervention the ADB supported a TA Pilot Project (TA# 2867-VIE) to improve O&M of two pilot areas under canals B-6a and B-8b covering about 300 ha each, which was completed in 1999. Under this TA project local level institutions such as the Water Users Associations (WUAs) were created for the better management of available water resources at the local level. Introduction of WUAs, and guidance and procedures to establish and manage WUAs were provided through participatory approaches at the local level under TA Pilot programs. After successful demonstration of benefits of WUAs under ADB's TA pilot project, the Irrigation Management Company (IMC) of Song Chu scheme has extended this model to other areas within this scheme. Creation of WUAs helped to improve even-distribution of irrigation for all farmers throughout Summer and Spring crop seasons under the rehabilitated areas. The tail-ended farmers in the pilot areas were also benefited from the ADB's TA Project.

The Song Chu irrigation schemes has been selected to assess the combined impacts of 'rehabilitated infrastructure, and improved management' on various outcome indicators such as rice yields, farm income, production uncertainties and poverty.

[2] Final Report "O&M development in the irrigation ector, TA No: 2869-VIE", Asian Bank.

3.2. An Trach Irrigation Scheme (Da Nang/Quang Nam Province)

The An Tranch irrigation system consists of four weirs: An Tranch (on the Van river), Thanh Guyt (on the La Tho river), Bau Nit and Ha Thanh (on the Qua Giang river). All of them were constructed over the period of the 30 years during the French colonial regime.

Natural calamities such as droughts and floods are common problems under the An Tranch scheme area. Frequent floods due to poor drainage caused a serious waterlogging condition, and soil salinity in many communes under the scheme. Furthermore, the irrigation canals have degraded due to poor infrastructure maintenance and drainage. Thus, production risk is a serious concern for paddy farmers in this area.

The World Bank assisted the GOV in 1997 to rehabilitate a part of the scheme to improve the irrigation infrastructure, which was degraded seriously by siltation, waterlogging, and other natural phenomenon. The Dong Ho canal system under this irrigation scheme was rehabilitated with the WB's assistance by desiltation of the canal system, construction of a new pumping station (7 machines with a capacity of 1200 m3/h per machine), and by cementing the canal system. These repairs improved the quality of irrigation infrastructure in Dong Ho area of the An Tranch scheme. The Thanh Quyt canal system of An Tranch scheme had not been rehabilitated, and therefore, infrastructure was and remains very poor. However, both Dong Ho and Thanh Quyt canals are gravity fed irrigation systems in combination with a pumping station and closely situated next to each other. The only difference is that the Dong Ho system is located upstream from the Thanh Quyt system on the Thanh Quyt weir.

This scheme was selected to study the effects of 'rehabilitated infrastructure' on production uncertainties, rice yield, farm income and poverty.

3.3. Dau Tieng Irrigation Scheme (HCM city/Tay Ninh provinces)

Dau Tieng irrigation scheme is located on Saigon River basin, and is one of the largest irrigation schemes, covering a catchment area of 27,000 square kilometres having the biggest storage reservoir of irrigation water in Vietnam.. The construction of this scheme was completed in 1979 with the financial assistance from the World Bank. This scheme irrigates seven districts in Tay Ninh province, and one district (Chu Chi) in the Ho Chi Minh City (HCMC) province. About 172,000 ha of area is irrigated under this scheme, of which 20 per cent covers the Chu Chi district of HCMC, and the remaining goes towards Tay Ninh province. The Dau Tieng reservoir and their three main canals are owned and managed by Ministry of Agriculture and Rural Development (MARD), Government of Vietnam, while the IMC's (Tay Ninh and HCMC) manage the distribution schemes (primary, secondary, tertiary canals and water head works on canal) within their provincial boundaries. The MARD has invested considerable amount of public expenditures for the improvement of a part of the Eastern canal system under Dau Tieng scheme. The eastern canal system covers Duong Minh Chau and Trang Bang Districts of Tay Ninh Province, and Cu Chi District of HCMC. The government of

HCMC has significantly more financial and human resources than Tay Ninh for better irrigation management. The water fee rate in Tay Ninh province is significantly higher than in HCMC, by 87 percent in the first (Spring) season and 33 percent in the second (Summer) season. Despite the lower water fee in HCMC than in the counterpart Tay Ninh province, the section of Eastern canal system in HCMC and the canals (primary, secondary and tertiary) are well managed. Thus, irrigation management is much better in Chu Chi of HCMC than in the rest of the eastern canal system belonging to the Tay Ninh province. There is no difference in irrigation infrastructure, market access and other geographic features between these two areas except difference in irrigation management. Therefore, if there is any difference in farm income between Chu Chi area and the rest of east canal in Tay Ninh, intuitively it should be largely due to difference in irrigation management.

Thus, this scheme was selected to analyze the impacts of an 'improved irrigation management' on crop productivity, farm income and poverty reduction.

4. Presentation of Results

This section presents findings from both qualitative and quantitative assessments. Also, key hypotheses and impact indicators identified are discussed in the following section.

4.1. Findings from the qualitative assessment:

The team of researchers of the study visited 2 to 3 representative communes in the areas of the selected irrigation schemes where interventions took place recently. Also, one or two neighboring communes, where no interventions took place in each selected scheme were also researched. The team conducted Focused Group Discussion's (FDG's) with concerned officials of the IMCs, commune leaders and farmers in order to understand the farmer level differences in expected benefits of the irrigation system between two groups of communes (intervention and no intervention) in the selected schemes. Major findings of FGDs (mostly qualitative aspects) during the field visits are summarized in table 4.1.

In general, the irrigation systems that team visited had degraded over the past 10-15 years. Thus, many pumping stations have emerged over the period nearer to the main and secondary canals, both publicly managed (IMC and communes) and privately managed (individual farmers) to minimize uncertainty in the availability of irrigation water from main/secondary canals. Some communes have lost irrigation sources from canals over the period. In some communes, cropped area under rice has decreased due to non-availability of irrigation water, mainly during the second (Summer) crop season. Further, the conditions of the O&M of the selected schemes (Song Chu, An Tranch and Dau Tieng) were highly ineffective until the mid 1990s.

A part of the Song Chu scheme was rehabilitated and management was improved after the mid 1990s. Similarly, a part of the An Tranch irrigation infrastructure was also rehabilitated, while management was improved under the Dau Tieng scheme

covering Chu Chi area (HCMC). Farmers as well as communes' leaders reported that these interventions under these schemes have substantially improved the availability of irrigation water, which in turn reduced production risks and improved crop yields (Table 4.1). On contrary, the availability of irrigation water is unreliable in the non-rehabilitated and/or normal management areas, especially for tail-ended canal areas. From the FGDs with key participants it was clearly noted that under three irrigation schemes significant improvements in the agricultural production systems were under rehabilitated infrastructure and/or improved management as compared to their neighboring areas (non-rehabilitated and normal management). Farmers reported considerably higher yields coupled with lower production costs, especially lower labor cost for irrigation in the areas where interventions took place as compared to their counterparts in the neighboring areas. (Disorganized paragraph, might want to rephrase a number of sentences for more fluidity in what is desired to be express)

Prior to the interventions, household members including women and children were used to attend the manual lifting of water from small stored tanks to save crops from non-availability of water from the main and secondary canals. After rehabilitation of infrastructure and/or improvement of management under some areas of the schemes, the availability of irrigation water was improved which has a secondary effect that resulted in reduction of drudgery on women, enabling them to have more time to care for children (Song Chu and An Tranch schemes). Thus, it was also noted that the required family labor for pumping the water had drastically reduced in the areas where infrastructure was rehabilitated and or management improved, as compared to their neighboring counterparts (no interventions) in the selected scheme areas. Thus, rehabilitation of infrastructure and/or improvement of management have released more family labor from farm/irrigation activities and helped to engage them in non-farm employment. Thus, proportion of household income originating from non-crop activities (also non-farm activities in some areas) is appreciably higher under rehabilitated infrastructure and/or improved management than under non-rehabilitated and/or normal management areas. Further, availability of family labor for child-care has improved due to reduced demand for manual pumping of water after interventions took place. The improved infrastructure and management after recent interventions (Song Chu and An Tranch) has diffused conflicts among farmers for water sharing and subsequently led to more harmony and peace in the society. However, it is important to note that these social problems clearly exist in the neighboring areas where no interventions took place. Therefore, on a whole, farmer's perceptions indicated that the interventions in the selected areas have brought a significant change in the rural livelihoods of the farm and non-farm households.

4.2. Key hypotheses

Findings from the qualitative assessment, as discussed above, are largely subjective and based on perceptions of the farmers and commune leaders. It is hard to draw any empirical conclusion based on qualitative assessment. However, it provided a clear base for the identification of key issues and hypotheses to be tested by quantitative analysis from intensive survey data collected from the sample households.

Based on the qualitative assessment, the following key hypotheses were tested by the quantitative analysis of survey data. *The rehabilitation of the irrigation infrastructure (An Trench scheme), improvement of management (Dau Tieng scheme), and the combination of both-rehabilitated infrastructure and improved management (Song Chu scheme) have significantly improved availability of irrigation water, which in turn*

a) increased rice yield, farm profits,
b) reduced unit cost of production,
c) reduced production uncertainties,
d) improved household income, and
e) reduced rural poverty

These key hypotheses are tested in each of the selected scheme by quantitative analysis of farm household survey data collected from the three irrigation schemes (case studies).

4.3. Impact indicators measured and analyzed

The foremost objective of the study is to measure and analyze the net contribution of public investments made towards the improvement of irrigation infrastructure and/or management in the selected schemes for sole objective of poverty reduction. What are the measurable outcome variables (impact indicators) that could be quantified to test the above key hypotheses? Findings from the qualitative assessment provided reasonable clues on what indicators could be measured to capture the impacts of the interventions in the selected irrigation schemes. The following indicators were identified and quantified for the study.

(a) Cropping intensity
(b) Crop income
(c) Production risks
(d) Household income
(e) Food consumption expenditure
(f) Incidence of poverty

4.4. Basic features of sample households

After propensity score matching was carried out, a sizeable number of sample households (whose propensity scores were not closely matched between two groups) were dropped from both sample groups. The retained sample households after matching with propensity scores between two groups ought to be closely similar with respect to socio-economic and biophysical features, apart from a difference in irrigation infrastructure and/or management. Then, any change in the outcome variables between two comparison groups could be exclusively attributable to the interventions (improved infrastructure and/or management). However, it is essential to look at the basic features of sample households whether they are closely related with respect to important non-

outcome variables such as the location of sample farms, soil quality, and other socio-economic aspects in the selected irrigation schemes (tables 4.2-4.10).

Song Chu irrigation scheme. Nearly one-thirds of sample households are each distributed between the head, mid and end of the canal areas in both groups (rehabilitated infrastructure and improved management and non-rehabilitated infrastructure and normal management) within the Song Chu irrigation (table 4.2). By and large, the proportions of sample households located at various locations of the canal system are nearly same in both areas. Further, the distribution pattern of sample farms by soil type is closely similar to both areas (table 4.3). The other socio-economic features of sample households in both groups are nearly same apart from difference in education (table4.4). Improvements in education may also be considered as a long run indirect effect of the improved irrigation infrastructure and management.

An Tranch irrigation scheme. Most of the basic socio-economic and biophysical features of the sample households are by and large similar in rehabilitated and non-rehabilitated areas except a major difference in the location of sample households (table 4.5-4.7). More sample households in the non-rehabilitated area are located at the head canal as compared to the rehabilitated, because the non-rehabilitated area (Thanh. Quyt commune) is located at the upstream of the main reservoir. This difference is expected to uncover a part of effect that could have otherwise been attributed to the rehabilitated infrastructure. This is one of the sampling caveats experienced for this scheme.

Further note that study sites representing non-rehabilitated infrastructure are located in the industrial zone, and nearer to the main highway road. Therefore, it was expected that non-farm income of original sample would be higher in the non-rehabilitated areas than in the rehabilitated areas. However, a comparison group of households from the samples of non-rehabilitated areas was formed, which were closely similar to those samples in the rehabilitated areas after propensity score matching. Therefore, it was confirmed that there would not be a significant difference in the non-farm income between the retained sample of the rehabilitated area and that of the non-rehabilitated area.

Dau Tieng. The sample sites representing the ‘improved management’ under Dau Tieng irrigation scheme (Chu Chi district, HCMC) are located closer to HCMC. Therefore, some differences still exist between sample households in the Chu Chi (improved management) and Tay Ninh (normal management) even after forming two comparison groups through propensity score matching technique, including a few socio-economic and biophysical features. Thus, the difference in key impact indicators especially non-farm income between HCMC and Tay Ninh may not be attributable exclusively to the improved irrigation management, as sample households in HCMC will have better opportunities for non-farm activities. Tables 4.8 to 4.10 provide data collected on the main features of the sample households in both areas.

There is a considerable difference in the location of sample households between HCMC and Tay Ninh (table 4.8). About 43 per cent are located in the head canal in HCMC while only 29 per cent in Tay Ninh, as the former is closely located at the east

canal system of Dau Tieng scheme. Further, the basic household features such as age, education, and family size in HCMC (improved management) are some what different from those households representing normal management (Tay Ninh) as shown in table 4.10).

4.5. Findings from the quantitative analysis of household survey data

Major findings from the quantitative analysis of household survey data are discussed in detail below.

4.5.1. Song Chu irrigation scheme

This scheme was selected to find the impacts of the Water Users Associations (WUAs), created by the ADB's TA pilot project for improved management, which were also rehabilitated with ADB's financial assistance for improvement of infrastructure in 1997. Therefore, the results from this case study provide broadly the combined effect of rehabilitated infrastructure and improved management on the identified impact indicators. The results presented below are based on the analysis of survey data related to crops for the year 2002.

Land endowments and irrigation status. Land is a principal resource for rural livelihood in Vietnam. An average size of land holding owned by each holding in Vietnam is very small, roughly about 0.1 to 0.2 ha. Land was distributed among households during the late 1980s and early 1990s (at the time of decollectivisation of land holdings) in such way that every household gets nearly equal share of all types of soil quality. Thus, land fragments (number of parcels) are more at household level in Vietnam. Further, size of land holding owned by household vary from location to location within the same province/district depending upon availability of cultivable land and number of households living in that location.

The land holding pattern of sample households in the study sites of Thanh Hoa province under Song Chu irrigation scheme was shown in table 4.11. On average, land area owned by sample households in the rehabilitated and improved management area was 2578 m^2, which is about 90 percent higher than in non-rehabilitated and normal management area. 4 or 5 are the number of parcels of land distributed in the study sites. As land ownership was transferred to the individual households recently, land market has not yet developed. Only about 10 per cent of net cultivated area was leased, in the rehabilitated and improved management areas while it was negligible in non-rehabilitated and normal management area. Net irrigated area was about 2650 square meters in the rehabilitated and improved management area, which is about 1.5 times higher than the non-rehabilitated and normal management area. However in relative terms, about 93 per cent of net cultivated area was covered with irrigation in the rehabilitated and improved management area while only about 80 per cent in non-rehabilitated and normal management area (table 4.11).

An important finding is that the extent of irrigation availability, and drainage facilities in absolute figures (area coverage) in each season have improved in the rehabilitated and improved management area as compared to non-rehabilitated and

normal management areas (table 4.12). This confirmed that the farmers perception during qualitative assessment that the interventions under Song Chu scheme have improved available irrigation water, which will likely benefit farmers with higher crop yields, higher farm income and better living conditions in the areas where interventions took place. As a whole, the percentage of net irrigated area for which irrigation water was available at the right time is higher in the areas where interventions took place than in the counterpart areas (table 4.12). In fact, the public investments made for the rehabilitation of the irrigation infrastructure and improvement of O&M. improved mainly the quality of irrigation.

The distribution of irrigated area at various locations along the main canal in the study sites is presented in table 4.13. The share of net irrigated area located at the head-end of the main canal was higher in the non-rehabilitated and normal management areas than in the rehabilitated and improved management areas. The difference in percentage of net irrigated area to net cultivated area, and percentage of gross irrigated area to net irrigated area was not statistically significant between rehabilitated and improved management area, and non-rehabilitated and normal management areas.

Cropping intensity. It is hypothesized based on farmer perceptions during qualitative assessment that the improved irrigation infrastructure and management would allow farmers to cultivate the available land for two or three seasons in a year, increasing cropping intensity. However, the estimated difference in cropping intensity of the sample households between rehabilitated and improved management and non-rehabilitated and normal management areas was not statistically significant (table 4.14). Sample households in the both areas are located in the neighboring communes/villages under the same irrigation scheme. However, uncertainty in the availability of irrigation water is a key concern for the non-rehabilitated and normal management areas. It appears that farmers in the non-rehabilitated and normal management areas are cultivating their limited land for two seasons per year, as their counterparts in the rehabilitated and improved management areas, and therefore possibly expecting that irrigation would be available for even second crop season. Thus, the cropping intensity was on the whole the same in both the rehabilitated and improved management, and non-rehabilitated and normal management areas.

Crop incomes. The improvement in the timely and evenly availability of irrigation water is expected to increase crop incomes through three important means; a) increasing crop yield, b) reducing cost of production, specially labor cost for pumping water, and reducing the production risks. Crop income was examined, from rice crop and non-crops crops and between the rehabilitated and improved management, and the non-rehabilitated and normal management areas.

Rice is a principal crop in the study sites, accounting for nearly 85-90 per cent of the gross cultivated area in the sample farms. Thus, rice income forms a major share of farm income. A detailed cost-to-return profile for rice crop per total planted area in a year for rehabilitated and improved management, and non-rehabilitated and normal management area is summarized in table 4.15 (season-wise details are presented in Appendix A10-a). Area planted to rice crop in two crop seasons together was more than

double in rehabilitated and improved management area as compared to non-rehabilitated and normal management area. Thus, all variables comprising total paddy output, gross value, net rerun, etc. are significantly higher for sample households in the rehabilitated and improved management area than for their counterparts in non-rehabilitated and normal management area (table 4.15). However, the marketed surplus (quantity of paddy sold in a year) was about 48 per cent of total paddy output for the rehabilitated and improved management areas while it was only 35 per cent for the non-rehabilitated and normal management areas. This points out that the farm households under the rehabilitated infrastructure and improved management received more cash income from rice crops after meeting the food needs of their family. These cash income could be used for non-farm activities such as better health, education, asset creation, etc. Thus higher cash income from marketed surplus for farm households would improve the overall welfare of the households through multiple effects.

The difference in costs and returns per planted area, as shown in table 4.15, was largely due to variation in the area planted to rice between two groups of sample households. Therefore, the difference in cost and return per unit land area (per hectare) provides precisely the possible effect of change in the irrigation infrastructure and management between two groups. Table 4.16 represents per hectare average costs and returns for rice cultivation of two seasons (Season wise per hectare cost and return details are in Appendix A10-b)

There was about 12 and 27 per cent statistically significant higher yields recorded in season 1 and season 2 respectively under the rehabilitated infrastructure and improved management over the non-rehabilitated infrastructure and normal management (Appendix A10-b). Yield gain was higher in season 1 than in season 2. This indicates that the improved availability of irrigation water has shown more positive effects on crop yields in season 2 than in season 1. Thus, the effect of improved irrigation infrastructure and management on rice yields was much higher in season 2 than in season 1.

It is important to note from table 4.16 that cost of own labor per ha of rice cultivation is significantly lower by 27 per cent in the rehabilitated infrastructure and improved management areas as compared to their counterpart neighboring areas. This further confirms that rehabilitated infrastructure and improved management released some of family labor from rice cultivation, especially from manual pumping of water. Further, purchased input costs were about 16 per cent lower in rehabilitated infrastructure and improved management areas than in non-rehabilitated infrastructure and normal management areas, being statistically significant at 10 per cent of probability level.

Purchased inputs such costs of seeds, herbicides and insecticides, were significantly higher in the rehabilitated infrastructure and improved management areas than in non-rehabilitated infrastructure and normal management areas (table 4.17). Further, irrigation costs, mainly costs of hired labor for pumping of water, are significantly higher in the non-rehabilitated and normal management area while irrigation fees were higher in the rehabilitated infrastructure and improved management area. On a whole, sample households incurred about 21 per cent lower costs per ha for rice cultivation under the rehabilitated infrastructure and improved management than their counterparts, the non-rehabilitated and normal management areas.

Average yield gain per hectare in a year (two seasons) was 18 per cent higher between rehabilitated infrastructure and improved management areas, to that of the non-rehabilitated infrastructure and normal management areas (table 4.16). Per hectare net return to rice cultivation was nearly double in the former group than in the later group. This significant difference in net return to rice between two groups of sample households was primarily due to improved availability of irrigation water, and reduction in production costs in the areas where interventions took place (rehabilitated infrastructure and improved management).

Vietnam's agriculture is one of the fast diversifying sectors in Asia, especially after the early 90s. In addition to rice crop, non-rice crops are also becoming an important source of crop income, meeting family needs. Major non-rice crops cultivated by the sample households in the study sites under Song Chu schemes are cassava, potato, and corn. Usually, these crops are grown in-between seasons as a third crop using residual soil moisture, when canal irrigation was stopped. Further, non-rice crops are also grown in the areas especially at the tail end-canal areas where availability of water is a serious constraint for rice crops. On an average, 476 and 420 square meters of land area was planted to non-rice crops under the rehabilitated infrastructure and improved management, and non-rehabilitated infrastructure and normal management areas respectively (table 4.18). The difference in all costs and return per hectare for non-rice crops between two groups of sample was not significant. It is important to note from table 4.18 that cash income from the sales of non-rice crop products is greater for the non-rehabilitated and normal management area. Further, it indicates that the saved labor from pumping of water appears to be engaged in non-farm activities rather than in non-rice crops under the rehabilitated infrastructure and improved management.

Production risks. Improvements in the availability of water after rehabilitation of infrastructure and improvement of management have expected to minimize the risks (variability) in the crop production. To test this hypothesis, the coefficient of variation (CV) in yield of paddy (season-wise) was computed separately for groups of sample households. Coefficient of variation (CV) indicates variability in yield, which may be considered as an indicator of production risk due to various biotic and abiotic factors. If CV is greater it means that there are higher production risks.

As shown in table 4.19, the estimated coefficient of variation in rice yields was significantly higher among the sample households of the non-rehabilitated infrastructure and normal management areas as compared to the rehabilitated infrastructure and improved management area during both seasons. This points out that the production risks were significantly reduced due to rehabilitated irrigation infrastructure and improved management. Further, the positive effect of the improved irrigation system on production risk was higher in season 2 than in season 1.

To further confirm these results, a subjective assessment was made based on the perception of the sample households on the occurrence of natural calamities such as floods and droughts over the past five years (1997-2002). About 11 percent of sample households under the non-rehabilitated infrastructure and normal management area reported that floods, droughts or both have affected their farms at least for one or more

years over the past five years (table 4.20). Only 2 per cent of the sample of farms reported the incidence of floods under the rehabilitated infrastructure and improved management. Therefore, the improved irrigation infrastructure after rehabilitation, and better management through WUAs contributed to lowering the effects of natural calamities, and reduced production risks.

Structure of household income: Various sources of household income were computed for the sample households, and summarized in table 4.21. Farm-operating surplus was considered for crop income as it includes both net return and earnings (wages) to owned family labor for their work in own crop production.

Total household incomes of the farmers sampled were about VND 12 million and 10 million under the rehabilitated infrastructure and improved management, and non-rehabilitated infrastructure and normal management areas respectively (table 4.21). The difference in the household income between two areas was 22 per cent, being statistically significant. The household per capita income was 24 per cent higher in areas of interventions than in their neighboring areas.

Share of agriculture income to total household income was 52 per cent (VND 6.3 million) in the rehabilitated infrastructure and improved management areas while it was only 26 per cent (2.6 million) in the non-rehabilitated and normal management areas. Further, the share of crop income was significantly higher in the rehabilitated infrastructure and improved management area than in non-rehabilitated infrastructure and normal management area. There are two main sources of differences in crop incomes between the two groups of sample households. First, the gross cultivated area was nearly double under the rehabilitated infrastructure and improved management as compared to the non-rehabilitated infrastructure and normal management areas. Secondly, net income from crops per unit land area was significantly higher under the rehabilitated infrastructure and improved management due to increased crop yields and reduced production costs due to the improved availability of water.

The non-farm income was significantly higher under the non-rehabilitated infrastructure and normal management area than under the rehabilitated infrastructure and improved management (table 4.21). Note that the study sites representing non-rehabilitated infrastructure and normal management area under Song Chu irrigation scheme are located near riverbanks, which are popular tourist places in the area. The households in this area have more access to non-farm self-employment opportunities such as boating, transport, small-scale trade, and other tourism derived incomes because of tourists. Therefore, the share of non-farm income to the total income was nearly three-fourths (about VN D 7.2 million) under the non-rehabilitated infrastructure and normal management areas, while it was only 48 per cent (VN D 5.7 million) in the rehabilitated infrastructure and improved management areas. However, it is important to note that a part of non-farm incomes under the rehabilitated infrastructure and improved management could be attributed to the saved labor from the pumping of water, that were engaged in non-farm activities.

Food consumption expenditure Per capita food consumption expenditure is widely considered as an ideal indicator of poverty. Detailed food expenditure pattern was

collected from the sample households, and analyzed to understand the poverty effect of the rehabilitated irrigation infrastructure and/or improved management in the selected irrigation schemes. The estimated per capita food expenditure on various items for Song Chu irrigation scheme (Thanh Hoa) was presented in table 4.22.

The per capita food expenditure per person was significantly higher by about 14 per cent for the sample households under the rehabilitated infrastructure and improved management areas than their counterparts under the non-rehabilitated infrastructure and normal management areas. The sample households under the rehabilitated infrastructure and improved management areas spent significantly higher expenditures on milk and milk products, and fruits and vegetables as compared to their counterparts under non-rehabilitated infrastructure and normal management. In general, the composition of food expenditures on other items is similar in both areas. As income levels of households are high under the rehabilitated infrastructure and improved management areas due to increased crop yields and crop incomes, because of improved irrigation infrastructure and management, these households are able to consume higher nutrition value foods such as milk products, fruits, vegetables, etc. An important issue is whether the higher average food consumption is reflected in poverty reduction under the rehabilitated infrastructure and improved management areas.

Incidence of poverty. The ultimate goal of a policy intervention in the irrigation sector is to reduce rural poverty by enhancing rural income. As discussed above, on an average there was a gain by about 22 per cent higher income, and 14 per cent higher food expenditure due to the rehabilitated irrigation infrastructure and improved management under Song Chu irrigation scheme. It is important to look at whether these gains in average income and food expenditures are transferred to the poor in terms of poverty reduction under the rehabilitated infrastructure and improved management areas. This will also partly explain equity in the distribution of benefits of a policy intervention.

General Statistical Office (GSO), a department of the GOV, fixed the food poverty line at VND 1,372,774 in 2002. This threshold level of food expenditures, adjusted against food price, indices for the concerned region was used to estimate the number of sample households who are below food poverty line. These estimates of food poverty are compared with overall poverty based on wealth ranking by the concerned communes (table 4.23). The estimated poverty based on food poverty line was about 12 per cent lower in the areas where interventions took place (rehabilitated infrastructure and improved management areas) as compared to their neighboring areas (non-rehabilitated infrastructure and normal management areas). This reduction in poverty can largely be attributed to the increased in crop/farm incomes due to rehabilitated infrastructure and improved management as policy interventions. Further the overall poverty, based on wealth ranking, was also appreciably lower under the rehabilitated infrastructure and improved management areas than under non-rehabilitated infrastructure and normal management.

It can be concluded from the results of Song Chu scheme that the recent interventions in irrigation (rehabilitation of infrastructure and improvement of management) improved the availability of irrigation water, which in turn had a positive effect on yield increases, cost reduction, and income increases. On an average there was a

gain of about 18 per cent in rice yield, 22 per cent higher income, and 14 per cent higher food expenditure due to the rehabilitated irrigation infrastructure and improved management under Song Chu irrigation scheme. These improvements led to reduction of poverty by about 12 percent in the areas where interventions took place. All these improvements in the household economy under rehabilitated infrastructure and improved management can largely be attributed to the increased crop/farm incomes due to improved availability of irrigation after recent interventions.

4.5.2. An Tranch irrigation scheme (Quang Nam)

The policy intervention in irrigation in Quang Nam was the rehabilitation of a part of the An Tranch scheme area in 1999. The key hypothesis tested for this case is that the rehabilitated infrastructure has improved the availability of irrigation water, thereby reduced production risks, improved farm income, and reduced poverty under the rehabilitated infrastructure (Dong Ho canal area) as compared to non-rehabilitated area (Thanh Quyt canal area). Results from the analysis of the survey data are discussed below.

Land endowment and irrigation status. In general, average land area owned by households decreases as one move from North to South in Vietnam. On contrary, the number of land parcels owned by each household increases as one goes from North to South.

Sample households owned about 30 per cent more land in rehabilitated area as compared to those in the non-rehabilitated area under the An Tranch irrigation scheme. The net cultivated area was about 15 per cent higher for the rehabilitated area than for non-rehabilitated area (table 4.24). Further, the extent of irrigated area, for which irrigation water is available at the right time, is significantly higher in the rehabilitated areas as compared to the non-rehabilitated areas (table 4.25). Surprisingly there was no difference in drainage system between rehabilitated and non-rehabilitated areas. As the World Bank's funded works largely focused on improvement of irrigation canals in the rehabilitated areas, the drainage system was seems to be similar in both areas. On a whole, rehabilitation of a part of irrigation infrastructure has enhanced the availability of irrigation water in the rehabilitated areas.

There was a substantial difference between rehabilitated and non-rehabilitated areas with respect to the distribution of irrigated area along with main canal (table 4.26). As discussed under section 4.4, number of households located at the head canal was higher in the non-rehabilitated area (table 4.5). In contrast to this, the share of irrigated area located at the head-end of the main canal was significantly less in the non-rehabilitated than that in the rehabilitated area (table 4.26). However, the quality of irrigation infrastructure has improved due to rehabilitation, which is expected to make a difference in rural income, if any, between rehabilitated and non-rehabilitated areas.

Cropping intensity. Rice, the main crop in the study sites, accounted for 95-98 per cent of gross cultivated area in the sample farms (table 4.27). Sampled farmers cultivated their available land for two crop seasons in a year. Thus, cropping intensity was approximately same in both rehabilitated and non-rehabilitated areas (table 4.27). Although irrigation

availability is uncertain in the second season for those farmers located at the end canal, especially in the non-rehabilitated area, rice cultivation occurred for all land even in the second season. Thus, serious crop failures are quite often in the non-rehabilitated mainly in the second season due to non-availability of irrigation water. These problems are nearly absent under rehabilitated infrastructure.

Crop income. Farmers' income to rice and non-rice crops was estimated after accounting for all purchased input costs, and results are presented in tables 4.28-4.30.

Rice crop dominates the agricultural production system in the study area under An Tranch scheme. The area planted towards rice in a crop year was substantially higher in the rehabilitated area than in the non-rehabilitated area. Thus, all income and cost variables such as paddy output, gross return, purchased input costs, etc. were also significantly higher for the rehabilitated area than for non-rehabilitated area (table 4.28). Further, all available land area planted to rice in season 1 and 2 was in both rehabilitated and non-rehabilitated areas, showing no difference in cropping intensity between these two areas (Appendix-A11a).

Average paddy output from the planted area in a year was about 2 tons and 1.5 tons in the rehabilitated and non-rehabilitated areas respectively, the difference being statistically significant (table 4.28). Household members consumed about 77 per cent of paddy output (1.5 tons) in the rehabilitated area while this figure for non-rehabilitated area was 85 per cent (1.3 tons). This shows that the farmers have relatively more marketed surplus in the rehabilitated area (23 percent) than in the non-rehabilitated area (15 percent).

Per hectare cost-to-return profile for rice was presented in table 4.29. Rice yields in both seasons are appreciably higher in the rehabilitated area than in non-rehabilitated area (refer Appendix A11-b for season-wise details). On an average, sample farmers in the rehabilitated area harvested about 13 per cent higher yields/ha with marginally lower total production costs (table 4.29). However purchased input costs are marginally higher (not significant) for the rehabilitated area. On contrary, owned labor costs are significantly lower at 22 per cent for the rehabilitated than for the non-rehabilitated areas (table 4.29). Therefore, farm-operating surplus (net return plus earnings to owned labor) was significantly higher for the rehabilitated area than for non-rehabilitated area. Further, the rehabilitated infrastructure reduced the requirement of own family labor for rice cultivation, largely for the pumping of water. The released labor from rice due to rehabilitation of infrastructure could have engaged either in non-rice crop or non-farm activities. This implies that productivity to family labor was considerably more in the rehabilitated areas as compared to the non-rehabilitated area besides enhancing labor earnings from non-rice crop/non-farm activities.

From table 4.29-4.30, it can be concluded that increase in rice yield was a principal source of increased rice income in the rehabilitated areas where irrigation infrastructure was rehabilitated.

Non-rice crops played a meager role in the study areas under the An Tranch scheme. Areas planted to non-rice crops were much less i.e. less than 5 per cent of gross

sown area (table 4.31). But, net return and farm-operating surplus per hectare of non-rice crops are substantially higher in the rehabilitated area than in the non-rehabilitated area. Further, most of the non-rice crop produce was sold in the market in both areas.

Production risks and occurrence of natural calamities. Production risks are very common in the study areas due to frequent occurrence of floods and droughts. Note that 2002 was a seriously drought affected year in Quang Nam.

One of the primary objectives for the rehabilitation of a part of the An Tranch irrigation scheme was to stabilize paddy production by making irrigation water available during droughts. The variability in paddy yields was less for first season while it was more for the second season in the rehabilitated area (table 4.32). Almost all farmers reported that the crops were affected by drought in both rehabilitated and non-rehabilitated areas (table 4.33). The number of farmers affected by floods were marginally lower in the rehabilitated areas than those in non-rehabilitated areas. However, results from the quantitative analysis of household survey data are not clear on risk effects of the rehabilitated infrastructure, even though qualitative assessment showed that risks are considerably lower in the rehabilitated areas. Moreover as survey data for the study is related to 2002, a drought year, there was no substantial difference in the effect of natural calamities between rehabilitated and non-rehabilitated areas. It was noted that the rehabilitated area was much more prone to droughts before rehabilitation took place. Had the irrigation infrastructure not been rehabilitated, the production risks would have been much higher in the rehabilitated areas than in the non-rehabilitated areas.

Structure of household income: Total income of the sample households was about VND 9.7 and 7.7 million in the rehabilitated and non-rehabilitated area respectively. The difference in total income was about 24 per cent, which is statistically significant (table 4.34). Agriculture income was about VN D 4 million, which is approximately 41 per cent of total household income in the rehabilitated area; about 71 per cent higher than in the non-rehabilitated area. Further, non-crop income was significantly higher in the rehabilitated area than in non-rehabilitated area, while non-farm income was almost same in both areas (table 4.34).

As crop production is highly volatile in the study areas due to frequent droughts and floods, non-crop activities (livestock, piggery, poultry, etc), and non-farm activities (self-employment, services, business, construction, brick-making, sand-collection, etc.) are increasingly becoming major sources of household income. About 70 per cent of household income originated from non-farm sources in the non-rehabilitated area whereas 59 per cent of total income accounted for non-farm source in the rehabilitated area. On average, sample households earned about VND 2.0 million of per capita income per person in the rehabilitated area, which is nearly 18 per cent more than per capita income of their counterparts in the non-rehabilitated area (table 4.34). Thus, the improved availability of irrigation water after rehabilitation contributed substantially to increased rice income, and reduced labor costs enhanced farm income in the rehabilitated area.

Food consumption expenditure. Comparing the per capita food expenditures between rehabilitated and non-rehabilitated areas can ideally capture the poverty effect of the

difference in the irrigation system. Detailed food expenditure pattern for the sample households was summarized in table 4.35.

There was about 21 per cent increase in total per capita food expenditure for the sample households in the rehabilitated area as compared to the non-rehabilitated area. Per capita per annum food expenditure on all items was about VND 1.5 and 1.3 million in the rehabilitated and non-rehabilitated areas respectively. Among various food items, the consumption of high nutritive foods such as meat and meat products, and fruits and vegetables was significantly higher in the rehabilitated area as compared to the non-rehabilitated area (table 4.35). Thus, nutrition and health status of the household members is likely to be better in the rehabilitated area than their counterparts in non-rehabilitated area, which can largely be attributed to the increased farm income as the non-farm income was same between two areas (multiplier effects of the improved irrigation infrastructure).

Incidence of poverty: The official food poverty line provided by GSO was used to compute incidence of food poverty among the sample households in the study area. The increase in per capita food consumption expenditure has adequately reflected in reduction of food poverty in the rehabilitated area. The estimated number of sample households who were below food poverty line was 33 per cent in the rehabilitated area, which about 38 per cent lower than the food poverty in the non-rehabilitated area (table 4.36). However, the overall poverty based on wealth ranking was substantially higher than the estimated food poverty in the study areas. The overall poverty based on wealth ranking was also considerably lower in the rehabilitated area. Increase in food consumption due to increased farm income because of the improved availability of irrigation water contributed to the significant reduction of poverty in the rehabilitated area under An Tranch scheme.

4.5.3. Dau Tieng irrigation scheme (Tay Ninh/HCMC):

A part of Dau Tieng irrigation scheme that irrigates Chu Chi district of HCMC is considered as the best managed irrigation infrastructure compared to other parts of the same scheme in Tay Ninh province. However, there is no difference in irrigation infrastructure. The provincial government of HCMC has more human and financial resources for better management of the irrigation infrastructure of a part of Dau Tieng scheme within its provincial boundaries, as compared to that of Tay Ninh province. Therefore, the key intervention that took place under this scheme was the ‘improvement of management’ in HCMC while the other parts of the same scheme in Tay Ninh has ‘normal management’. The main hypothesis tested for this case is that the rural households are well off with increased farm income in Chu Chi district of HCMC (improved management as) compared to other parts of Dau Tieng covered in Tay Ninh province (normal management). Results of identified outcome indicators, originating from the analysis of survey data, are presented below.

Land endowment and irrigation status. Land holding pattern of the sample households is by and large similar in both study sites of HCMC (improved management) and Tay Ninh (normal management). Average land area owned by the sample households in all the

study sites is about 0.6 hectare (table 4.37), which is much higher than the average land area owned by households in the other two cases (Thanh Hoa and Quang Nam). The number of land parcels were less in HCMC and Tay Ninh provinces as compared to Thanh Hoa and Quang Nam provinces. Another distinguish feature in this case study is that land market is fairly existent in HCMC, as about 10 per cent (about 500 M2) of cultivated land was leased.

Almost 95-to-97 per cent of net cultivated area was irrigated in both study areas. However extent of irrigated area sown to each season was significantly higher in the HCMC in Tay Ninh (table 4.38). Total irrigated area in a year was 16 per cent higher under improved management in HCMC, although net irrigated area was nearly same in both study areas. In addition, there was also considerable improvement in the timely availability of irrigation in each season due to improved management of irrigation in HCMC. However, there was not much difference in the drainage facilities between HCMC and Tay Ninh. It implies that the availability of irrigation water has significantly increased due to improved management in HCMC as compared to Tay Ninh. This also explains that the available irrigated area is cultivated more intensively in HCMC as compared to Tay Ninh. Another distinction between these two provinces under the Dau Tieng scheme is that irrigated area located at the head-ended canal was significantly higher in HCMC than in Tay Ninh (table 4.39).

Cropping intensity. Although there is no significant difference in net cultivated area between the two study areas, gross cultivated area was about 17 per cent higher for the sample households whose irrigation management is better in HCMC as compared to Tay Ninh. Thus, cropping intensity was significantly higher in HCMC than in Tay Ninh (table 4.40). Further, crop production is highly diversified in HCMC and Tay Ninh provinces unlike in Thanh Hoa and Quang Nam. Non-rice crops such as corn, cassava, potatoes, and other vegetables, are grown in considerable land in the region.

Crop income: Rice is an important crop in the region, accounting 70 per cent of total planted area. Rice is grown thrice a year in most parts of the study sites in both in HCMC and Tay Ninh provinces. Thus, rice contributes substantially to the household income.

Cost-return details per total planted area of rice cultivation in a year (sum of all seasons) were furnished in tables 4.41-4.42. Area planted to rice was significantly higher in HCMC than in Tay Ninh in all seasons (refer Appendix A12a for season wide cost return details), although there is no significance in net cropped area between the two provinces. Therefore, all input costs and returns were also significantly more in HCMC. In all seasons together, the difference in area planted to rice was only 30 per cent between HCMC and Tay Ninh. However, total paddy output was about 5.1 tons in HCMC, which was nearly 57 per cent higher than the paddy output in Tay Ninh. Total quantity of paddy output sold in the market (marked surplus) was nearly 60 per cent of total paddy produce in both areas. This indicates that rice production is one of the major income-generating farm activities besides meeting family food needs in HCMC and Tay Ninh provinces, unlike in Thanh and Quang Nam provinces.

Is per hectare rice income higher in HCMC than in Tay Ninh? Table 4.42 shows that paddy yields are significantly higher by about 22 per cent under improved

management (HCMC) as compared to Tay Ninh (normal management). Yield gains due to improved management of irrigation system were higher in season 1 than in season 2 or 3 in HCMC (Appendix-A12b). Total costs per hectare were about 10 per cent higher in HCMC in season 2 and 3, but not statistically significant from those in Tay Ninh. Interestingly, the owned labor cost per ha was by and large same under both improved management (HCMC) and normal management (Tay Ninh) (table 4.43).

Unit cost of paddy production per ton was considerably low in HCMC in all seasons (Appendix A12b). On an average, cost of producing one ton of paddy was about 8 per cent lower in HCMC due to increased crop yields together with moderately lower costs due to improved management of irrigation system as compared to Tay Ninh. In all seasons together, rice production generated about 84 per cent higher net income per hectare to the sample farmers in HCMC as compared to their counterparts in Tay Ninh (table 4.42). Improved management of irrigation system in HCMC due to interventions by both MARD (GOV) and provincial government (HCMC) under Dau Tieng scheme is a principal factor for increased rice yields, and rice income per unit land.

Agriculture is more diversified in Southern Vietnam-especially in HCMC and Tay Ninh provinces than in other parts of the country. Non-rice crops are becoming major sources of farm income. Non-rice crops are significantly higher profitable in HCMC than in Tay Ninh (table 4.44). Moreover, above 95 per cent of total non-rice crop produced was sold in the market in both provinces. Cash revenue from sale of non-rice crop produce was significantly higher for the households in HCMC than in Tay Ninh. This implies that the improved management of irrigation system enhances the productivity of non-rice crops, and bolter up the agricultural diversification.

Production risks and incidence of natural calamities. Yield variability among sample farmers, as measured by coefficient of variation, was significantly lower in season 1 and 2 than in season 3 in both HCMC and Tay Ninh provinces (table 4.45) Sample households in HCMC have experienced lower variability in paddy yield in season 1 and 2 than their counterparts in neighboring areas of Tay Ninh province. As a whole, table 4.45 explains that production risks are considerably lower in HCMC area where irrigation management was improved.

Crop year 2002,to which survey data is related, was a drought hit year in many parts of Vietnam, including HCMC and Tay Ninh provinces. Therefore, 97-98 per cent of sample households reported the incidence of either drought or floods or both that affected the crop (table 4.46). Even though 2002 was a drought year, crop yields were not considerably affected because of irrigation availability in both areas. However, production variability among sample households was lower in HCMC than in Tany Ninh due to difference in irrigation management.

Structure of household income. Various sources of household income of the sample farmers in HCMC and Tay Ninh provinces were summarized in table 4.47. Average household income and per capita income were about VND 19 million and 4.2 million respectively in HCMC, which were about 71 and 66 per cent higher in the same order as compared to Tay Ninh. Total farm income was also significantly higher in HCMC than in Tay Ninh. Share of agriculture income in the total income was nearly same in both areas.

However, rice contributed only about 14 per cent (VN D 2.6 million) in HCMC where non-rice crops (high value crops), and non-crop farm sources (livestock, fisheries, etc) accounted 36 per cent of total income. Sample households received about 77 per cent of higher non-farm income in HCMC as compared to households in Tay Ninh (table 4.47). As study sites (Chu Chi) representing the improved management of irrigation are located closer to HCM City, these households have better access to many non-farm activities. Therefore, the higher income from non-crop and/or non-farm sources could not be attributed exclusively to the multiplier effects of improved management in HCMC. Nevertheless, the improved management of irrigation enhanced rice income, and also accelerated the agricultural diversification, which resulted in higher non-rice crop income for the farm households in HCMC.

Food consumption expenditure: Households spent substantially higher expenditure on various foods items in HCMC than in Tay Ninh (table 4.48). Average consumption expenditures per person on all food items in HCMC and Tay Ninh were about VN D 1.9 million and 1.2 million respectively. Share of rice in the total food expenditure was considerably lower in HCMC (29 per cent) than in Tay Ninh (35 per cent). This is because consumption of high value food items such as meet, fish and shrimp, and fruits, and vegetables was significantly more in HCMC as compared to Tay Ninh. It is important to recognize that the increased food consumption in HCMC can not be attributed solely to the improved management of irrigation. As sample households in HCMC have more income originating from non-farm sources, there might be other factors such as more access of non-farm activities thereby increased on-farm income that could have also contributed to the improved consumption expenditure. However, increased rice income due to improved management of irrigation system could be one of the principal factors for increased consumption expenditure on food in HCMC.

Incidence of poverty. Food poverty was significantly lower in HCMC than in Tay Ninh. Nearly half of the sample households were below the food poverty index in Tay Ninh while it was only a quarter in HCMC (table 4.49). Paradoxically, overall poverty reported by sample households based on official wealth ranking was higher in the sample sites of HCMC than those sites in Tay Ninh. This calls for a critical assessment of poverty criteria adopted by the GOV to rank households whether a particular household is poor or non-poor.

4.6. Are tail-ended farmers benefited from the policy interventions?

Usually, tail-ended farmers are the worst affected ones due to the degradation of the irrigation systems due to poor O&M of the canal systems.. Thus one of the principal goals of the rehabilitation and/or improved management of irrigation infrastructure is to ensure the availability of irrigation water at the right time to the tail-ended farmers under the system. The key issue analyzed here is differential effects of rehabilitated infrastructure and/or improved management for the head-ended and tail-ended farmers across the selected irrigation schemes.

Table 4.50 shows ‘changes’ in the major outcome indicators between the areas of policy interventions and their neighboring areas (no interventions) for the head-ended and tail-ended farmers under the selected irrigation schemes. Farmers at tail-ended canal

system have been substantially benefited in terms of increases in paddy yields, rice income, total farm income, and per capita food expenditures due to the rehabilitated infrastructure and improved management under Song Chu scheme, and due to improved management in HCMC under Dau Tieng scheme. Gains in paddy yields were considerably higher during season 2 for the tail-ended farmers under Song Chu and Dau Tieng schemes. However under An Trench scheme, the tail-ended farmers were not benefited by the rehabilitated infrastructure (Table 4.50).

4.7. How effective are public irrigation expenditures across the case studies?

The discussed results above are pertained to the impacts of three main policy interventions in irrigation (rehabilitated infrastructure and improved management in Thanh Hoa, rehabilitated infrastructure in Quang Nam, and improved management in HCMC/Tay Ninh). An important policy issue assessed in this section is how public investments made through different policy interventions in the selected irrigation schemes are effective in terms of their impact on various outcome indicators especially on poverty reduction. Such analysis would generate useful information of policy relevance for GOV as well as for various donors whose objective is to eradicate poverty in rural Vietnam by efficient allocation of the limited resources among various alternatives and options.

A summary was presented in table 4.51 showing 'changes' in the key outcome indicators between the areas where various types of policy interventions took place and their neighboring areas (no interventions) under the selected irrigation schemes. Increases in percent terms of many outcome indicators such as rice yield, rice income, total household income and per capita income are significantly higher in HCMC where management of irrigation was improved under Dau Tieng irrigation scheme as compared to other schemes. Rates of poverty reduction, as estimated based on food poverty line, was much higher in HCMC under Dau Tieng scheme as compared to other schemes. As discussed previously, increased non-farm income could be an important factor besides increased rice income for rapid reduction in poverty in HCMC.

More gains in rice yields and income in absolute terms are contributed by he combined effect of an improved irrigation infrastructure and management under the Song Chu scheme as compared to by only rehabilitated infrastructure or improved management. Further, rehabilitated infrastructure under An Tranch scheme generated more gains in terms of increases in total household income, food consumption, and even poverty reduction as compared to Song Chu. As a whole, improved management of irrigation (Dau Tieng scheme in HCMC) yielded more gains at household level than other two interventions.

A simple comparison of gains in the outcome variables among various interventions, however, can not shed any light on efficiency/effectiveness of the public resources invested. Thus, it is useful from a policy perspective to look at a step ahead to translate gains of various interventions into a few key efficiency indicators. *How many US Dollars of public expenditure invested to bring one poor household above poverty line through each intervention under the selected irrigation scheme? What is incremental output vale/year (farm sources) per one US $ invested across interventions? How many*

US $ invested to increase one percent of farm income/household through each intervention? How many US $ invested per one percent increase of per capita food consumption expenditures through each intervention? Answers to these questions would broadly provide an empirical base to identify which intervention are more efficient and effective in terms of increases in farm income and poverty reduction. To estimate these indicators, required data on irrigation investments made by ADB in Song scheme, the World Bank in An Tranch scheme and MARD in Dau Tieng scheme were collected from respective agencies along with number of households covered in each benefited area under each scheme.

The estimated efficiency parameters for each intervention (case study) are summarized in table 4.52. On an average, one US Dollar investment in the rehabilitation of infrastructure and improvement of management (combined impact) under Song Chu scheme generated US $1.31 worth of incremental farm output every year at household level. In otherwise, the whole investment made in Song Chu scheme recovered just in a year in terms of incremental farm output that could primarily be attributed to these interventions. However, it took 3 to 4 years to recover investments made in the two other schemes; An Tranch (rehabilitated infrastructure) and Dau Tieng (improved management), as the value of incremental farm output per US $1 of investments in these scheme is about US $0.30-0.35 every year. Further on average, it was estimated that US $ 1.42 investment resulted in an increase of one percent in farm income/household under Song Chu scheme, while these figures are US $ 5.15 and 11.07 for An Tranch and Dau Tieng scheme respectively (table 4.52).

Another important indicator that explains efficiency and effectiveness of public investment is the amount of US $ invested that resulted in an increase of one percent in the per capita food consumption expenditure at a household level. As shown in table 4.52, an investment of US $ 13-14 resulted in an increase of one percent in per capita food consumption expenditure under Song Chu and Dau Tieng schemes, while this figure is moderately higher for An Tranch scheme. Further, the average amount invested through each intervention that brought one poor household above poverty was US $ 2773, 2692 and 1819 under Dau Tieng, Song Chu and An Tranch scheme areas respectively. Note that a large number of non-poor households were also substantially benefited with increased farm income due to the interventions under the selected schemes.

What are the policy implications of these numbers? Results from table 4.51 and 4.52 broadly imply the public investments in the rehabilitation of infrastructure and improvement of management (combined effect) is more efficient in terms of additional output generated, and its effects on food consumption. However, rehabilitation of infrastructure seems to be a more effective policy intervention in terms of poverty reduction effect, followed by the combination of rehabilitated and improved management. Therefore, the rehabilitation of the existing irrigation systems ought to be given a priority followed by improvement of its management that could help reduce poverty and improve farm income more efficiently. Results also suggest that merely investing on management does not yield more gains in terms of poverty reduction unless irrigation infrastructure is rehabilitated.

5. Conclusions and Policy Options

The primary research question of the study is shed a light on *how various policy interventions in irrigation (rehabilitated infrastructure, improved management and combine of both) made an impact at micro-level (household level) particularly for the poor?* It also assessed whether investment towards the rehabilitation of the existing infrastructure is more effective or if the improvement of management is more effective, or if the combination of both is the most effective in terms of poverty reduction effects? Specific objectives of the study are; *(i) to assess the impact of the public investments made in the rehabilitation of the irrigation infrastructure and/or the improvement of management on rice yields, farm profits, cost of production, production uncertainties, and rural poverty under the selected irrigation schemes, and (ii) to compare the impacts and efficiency of irrigation investments among three scenarios viz., rehabilitated infrastructure, improved management and combine of both.*

The study covered three irrigation schemes, viz., Song Chu scheme in Thanh Hoa province (North region), where a part of the infrastructure was rehabilitated and also improved the management; An Tranch scheme in Quang Nam province (Central region) a part of its infrastructure was rehabilitated; and Dau Tieng scheme (Southern region) whose management was improved in a part of the scheme covering Ho Chi Minh province.

Both qualitative and quantitative assessment was carried out to analyze the basic research questions of the study. For quantitative assessment, in-depth household surveys were conducted during the period from March to May 2003 in the selected study sites, and collected farm-level data on wide range of variables related to crop year 2002. Total number of sample households surveyed was 1253; covering both rehabilitated infrastructure and/or improved management, and non-rehabilitated and/or normal management in the selected schemes. The sample study sites were selected in such way that the socio-economic, biophysical and institutional features of both rehabilitated and/or improved management areas and their neighboring areas (non-rehabilitated and/or normal management) are closely similar except a difference in irrigation infrastructure and/or management or both.

The baseline survey data was not available from the selected irrigation schemes, where interventions took place for rehabilitation of infrastructure and/or improvement of management. Thus determination of counterfactual information is a key concern in the study. A propensity score matching technique was applied as suggested by Ravallion (2001) to form the closest comparison group from a sample of non-rehabilitated infrastructure and/or normal management area to the sample of the rehabilitated infrastructure and improved management area.

Findings from the qualitative assessment indicate that the interventions have substantially improved the availability of irrigation water, which in turn reduced production risks, improved farm income, reduced labor cost for pumping of water, and reduced poverty under selected schemes. Based on the qualitative assessment, hypotheses

tested by the quantitative analysis of survey data are that *the interventions that took place under the selected schemes have significantly improved the availability of irrigation water, which in turn increased rice yield, farm profits, reduced unit cost of production, reduced production uncertainties, improved household income, and reduced rural poverty*

Results from Song Chu scheme indicate that the recent interventions in irrigation (rehabilitation of infrastructure and improvement of management) improved the availability of irrigation water, which in turn had a positive effect on yield increases, cost reduction, and income increases. On an average, there was a gain of about 18 per cent in rice yield, 22 per cent higher income, and 14 per cent higher food expenditure due to the rehabilitated irrigation infrastructure and improved management under Song Chu irrigation scheme. These improvements led to reduction of poverty by about 12 percent in the areas where interventions took place (rehabilitated infrastructure and improved management areas).

Under An Tranch scheme (Quang Nam province), the rehabilitation of a part of irrigation infrastructure has enhanced the availability of irrigation water. There was 22 percent reduction in owned labor costs besides increasing rice yield by 13 percent, which is a principal source of increased farm income under the rehabilitated area of An Tranch scheme.

Improved management under the Dau Tieng scheme in HCMC resulted in an increase of total irrigated area in a year by 16 per cent, although net irrigated area was nearly same in both HCMC and Tay Ninh. In addition, there was also considerable improvement in the timely availability of irrigation in each season due to improved management of irrigation in HCMC. This led to increase in paddy yields by about 22 per cent under improved management (HCMC) as compared to Tay Ninh (normal management). Further the improved management also enhanced the productivity of non-rice crops, and bolter up the agricultural diversification. As study sites (Chu Chi) representing the improved management under Dau Tieng scheme are located closer to HCM City, these households have better access to many non-farm activities. Therefore, the higher income from non-crop and/or non-farm sources could not be attributed exclusively to the multiplier effects of improved management in HCMC. Therefore, a significant increase in food consumption thereby reducing poverty in HCMC could not exclusively be attributed to the improved management. However, increased rice income due to improved management of irrigation could be one of the principal factors for increased consumption expenditure on food, and poverty reduction in HCMC.

Results shows that farmers at the tail-ended canal system have been substantially benefited in terms of increases in paddy yields, rice income, total farm income, and per capita food expenditures due to the rehabilitated infrastructure and improved management under the Song Chu scheme, and due to improved management in HCMC under Dau Tieng scheme.

An important policy issue assessed is how public investments made through different policy interventions in the selected irrigation schemes are effective in terms of their impact on various outcome indicators especially on poverty reduction. Increases in

percent terms of many outcome indicators such as rice yield, rice income, total household income and per capita food expenditure are significantly higher in HCMC where management of irrigation was improved under Dau Tieng irrigation scheme as compared to other schemes. Rate of poverty reduction, as estimated based on food poverty line, was also much higher in HCMC under Dau Tieng scheme as compared to other schemes.

More gains in rice yields and income in absolute terms are contributed by he combined effect of an improved irrigation infrastructure and management under the Song Chu scheme as compared to by only rehabilitated infrastructure or improved management. Rehabilitated infrastructure under An Tranch scheme generated more gains in terms of increases in total household income, food consumption, and even poverty reduction as compared to Song Chu scheme. As a whole, improved management of irrigation (Dau Tieng scheme in HCMC) yielded more gains at household level than other two interventions combined.

On an average, a one US Dollar investment in the rehabilitation of infrastructure and improvement of management (combined impact) under Song Chu scheme generated US $ 1.31 worth of incremental farm output every year at the household level. The whole investment made in Song Chu scheme was recovered in just a year's time through incremental farm output that could primarily be attributed to these interventions. However, it took 3-4 years to recover investments made in An Tranch (rehabilitated infrastructure) and Dau Tieng (improved management), the other two schemes The value of the incremental farm output per one US $ invested in these schemes is about 0.30-0.35 every year. A further average investment of US $13-14 per household resulted in an increase of only one percent in per capita food consumption expenditure under Song Chu and Dau Tieng schemes, while the figure for the An Tranch scheme is moderately higher. The average amount invested through each intervention that brought one poor household above poverty line was lower in An Tranch scheme followed by Song Chu and then Dau Tieng scheme. Note that a large number of non-poor households were also substantially benefited with increased farm income due to the interventions under the selected schemes.

The estimated efficiency parameters for each intervention imply that public funds invested in the rehabilitation of infrastructure and improvement of management (combined effect) is more efficient in terms of additional output generated and on food consumption. However, rehabilitation of infrastructure seems to be a more effective policy intervention towards poverty alleviation, followed by the combination of rehabilitated infrastructure and improved management. Therefore, the rehabilitation of the existing irrigation systems ought to be given priority followed by improvements of its management to maximize the return farm incomes, and reduce poverty more efficiently.

Policy options

- Rehabilitation of irrigation infrastructure ought to be given a top priority for public spending in order to improve rural incomes especially for those farmers who live at the tail-ended canal system.

- Findings suggest that merely investing in management does not yield more gains in terms of poverty reduction unless irrigation infrastructure is rehabilitated. Thus, improvement of management after rehabilitation is to be given priority to ensure that tail-ended farmers would receive irrigation water from the rehabilitated irrigation system.

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Table 1.1. Rotated matrix among inter-related variable determining poverty in Vietnam (results of factor analysis)

Variable	Component				
	1	2	3	4	5
Per capita GDP	-0.110	0.107	-.249	**0.819**	-0.082
Per capita Ag. GDP	-0.03226	**0.368**	**0.755**	0.215	-0.141
% Ag. GDP	-0.142	0.042	**0.766**	**-0.420**	0.136
% Agri.labor to rural population	-0.0232	**-0.402**	**0.643**	-0.241	0.234
Number of irrigated pumps	0.070	**0.935**	.166	0.022	0.0008
No. of pumps per 000' ha of planted area	0.0010	**0.921**	-0.044	0.181	-0.064
% Irrigated area	**0.764**	0.0713	-0.060	-0.171	0.240
% Paddy irr. Area to total irr. Area	0.027	-0.197	0.154	0.136	**0.826**
Cropping intensity for rice	0.129	0.132	-0.048	-0.286	**0.732**
Rice yield	**0.848**	-0.075	.128	0.0126	0.151
Maize yield	0.305	0.141	**0.457**	0.391	**-0.441**
Cassava yield	-0.134	0.079	0.041	**0.664**	-0.0112
Budget for irrigation	**0.749**	0.026	-0.178	-0.156	-0.222
Poverty rate	**-0.501**	**-0.266**	0.036	**-0.442**	0.295
% Variance explained	*16.3*	*15.7*	*13.9*	*13.8*	*12.4*

Table 2.1: Sample size in the selected irrigation schemes

Type of intervention /study site	Number of sample households/ Irrigation scheme		
	Song Chu	An Tranch	Dau Tieng
1 a) Rehabilitated infrastructure & improved management	147		
b) Non- Rehabilitated & Non-improved/typical management	200		
2 a) Rehabilitated infrastructure		161	
b) Non-Rehabilitated infrastructure		287	
3 a) Improved infrastructure management			157
b) Non-improved/typical infrastructure management			302
Total	**347**	**448**	**459**

Table 2.2: Sampling design, Thanh Hoa (No. of sample households)

District	Communes	Rehabilitated and improved management	Non-rehabilitated and typical management
Quang xuong	Quang vinh		200
			(100)
Thieu hoa	Thieu chinh	54	
		(36.7)	
	Thieu hoa	46	
		(31.3)	
	Thieu toan	47	
		(32.0)	
Total		147 (100)	200 (100)

Figures in parenthesis are percentages to total

Table 2.3: Name of the village clusters covered, Thanh Hoa

District	Communes	Name of village clusters	
		Rehabilitated and improved management	Non-rehabilitated and typical management
Quang xuong	Quang vinh		Hai Minh Quang Thang Phu Thanh Thuong Tien Khang
Thieu hoa	Thieu chinh	Dan Chinh Dan Tai Dan Tien	
	Thieu hoa	Thai Duong	
	Thieu toan	Toan Hang Toan Phuc Toan Ty	
Number of village clusters		*7*	*7*

Table 2.4: Sampling design, Quang Nam *(No of households)*

District	Commune	Rehabilitated	Non-rehabilitated
DienBan	DienAn	111	---
		(68.9)	
	DienNam	50	---
		(31.1)	
	Dienngoc	---	90
			(31.4)
	DienThang	----	197
			(68.6)
Total		161 (100)	287 (100)

Figures in parenthesis are percentages to total

Table 2.5: Name of the village clusters covered in Quang Nam

District	Commune	Rehabilitated	Non-rehabilitated
DienBan	DienAn	Phongnhat Phongnhi	---
	DienNam	Thon2 Thon8 Thon8A Thon8B	---
	Dienngoc	----	Nganha Ngantrung
	DienThang	----	Thanhquyt Thanhquyt4 Viemtay
Number of village clusters		*6*	*5*

Table 2.6. Sampling design, HCMC/Tay Ninh *(No of households)*

District	Commune	Improved infrastructure management	Non-improved infrastructure management
Cu chi	Phuoc hiep	51 (32.5)	---
	Phuoc thanh	51 (32.5)	---
	Trung lap thuong	55 (35.0)	---
Duong minh chau	Loc ninh	---	101 (33.4)
Trang bang	Don thuan	---	100 (33.1)
	Loc hung	---	101 (33.5)
Total		157 (100)	302 (100)

Figures in parenthesis are percentages to total

Table 2.7: Name of the village clusters covered, HCMC/Tay Ninh

District	Commune	Improved infrastructure management	Non-improved infrastructure management
Cu chi	Phuoc hiep	Trung Vi Trungvie	---
	Phuoc thanh	Bau Trau Mit Nai Vuon Bau Vuon Tra	---
	Trung lap thuong	Donglon Rang	
Duong minh chau	Loc ninh	---	Loc Hiep
Trang bang	Don thuan		Thuanloi
	Loc hung		Loc Chan Loc Tan
Number of village clusters		*8*	*4*

Table 2.8: Number of sample households retained for final analysis after propensity score matching, Than Hoa.

District	Communes	Rehabilitated and improved management	Non-rehabilitated and typical management
Quang xuong	Quang vinh		111
			(100)
Thieu hoa	Thieu chinh	33	
		(30.3)	
	Thieu hoa	42	
		(38.5)	
	Thieu toan	34	
		(31.2)	
Total		109 (100)	111 (100)

Figures in parenthesis are percentages to total

Table 2.9: Number of sample households retained for final analysis after propensity score matching in Quang Nam

District	Commune	Rehabilitated	Non-rehabilitated
DienBan	DienAn	54	
		(60.0)	
	DienNam	36	
		(40.0)	
	Dienngoc		44
			(43.6)
	DienThang		57
			(56.4)
Total		90 (100)	101 (100)

Figures in parenthesis are percentages to total

Table 2.10: Number of sample households retained for final analysis after propensity score matching, HCMC/Tay Ninh

District	Commune	Improved infrastructure and management	Non-improved infrastructure and management
Cu chi	Phuoc hiep	35 (36.5)	
	Phuoc thanh	21 (21.9)	
	Trung lap thuong	40 (41.7)	
Duong minh chau	Loc ninh		24 (23.8)
Trang bang	Don thuan		29 (28.7)
	Loc hung		48 (47.6)
Total		96 (100)	101 (100)

Figures in parenthesis are percentages to total

Table 4.1: Findings from the qualitative assessment on farmers' perceptions of impacts of recent interventions in the selected irrigation schemes (outcomes of FGDs)

Variables	Song Chu scheme		An Tranch scheme		Dau Tieng scheme	
	RI & IM	NRI&NM	RI	NRI	IM	NM
Availability of irrigation water	Improved & reliable	Unreliable	Improved & reliable	Unreliable	Improved & reliable	Unreliable
Local institutions for water mangt.	WUAs	Absent	Absent	Absent	Strong (One representative/ village	Weak (Irrigation group)
Cropping intensity (%)	180-200	160-180	200-210	200	250-280	230-260
Rice yield in season-1 (t/ha)	6.5-7.0	6.0-6.5	6.5-7.0	5.0-6.0	4.5-5.0	3.5-4.0
Rice yield in season-2 (t.ha)	6.5-7.0	5.0-5.5	6.0-6.5	5.0-6.0	4.5-5.0	3.5-4.0
Cost of rice production (VND 000'/ton)	480-550	650-750	700-750	700-800	750-800	900-1000
Marketable surplus of rice (%)	50-55	10-15	25-30	10-15	35-40	30-35
Yield variability	Less	More	Reduced	High	Less	More
Drought effect	Low	Sever	Less	Severe	Minimum	Moderate
Family labor available for non-farm activities	More	Less	More	Less	More	Less
Drudgery on women	Minimized	Heavy	Minimized	Heavy	Minimized	Heavy
Child care	Improved	Affected	No effect	No effect	No change	No change
Conflicts among farmers for water	Reduced	Many	Absent	Occasional	Absent	Occasional

Note: RI & IM=Rehabilitated infrastructure & improved management; NRI & NM = Non-rehabilitated infrastructure & normal management; RI= Rehabilitated infrastructure; NRI=non-rehabilitated infrastructure; IM=improved management; NM= Normal management.

Table 4. 2. Location of selected sample households along main canal , Thanh Hoa *(No of households)*

Location of farms	Rehabilitated and improved management	Non-rehabilitated and typical management
Head canal	34	49
	(31.2)	(44.1)
Mid canal	33	37
	(30.3)	(33.3)
End canal	42	25
	(38.5)	(22.5)
Total	109 (100)	111 (100)

Figures in parentheses are percentage to total

Table 4.3 Distribution (%) of sample households by soil quality in Thanh Hoa

Soil quality	Rehabilitated and improved management (N=109)	Non-rehabilitated and typical management (N=111)
1		2.70
2	0.92	6.31
3	13.76	12.61
4	37.61	36.04
5	36.70	35.14
6	11.01	7.21
Total	100	100

Note: Soil quality= 1 for the best quality, 2 for the good quality..…… 6 for the lowest quality

Table 4.4: Basic features of sample households in Thanh Hoa

Variables	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t-value
Age (years)	49.09	46.28	6.1	1.2
Education (schooling years)	7.82	6.46	21.0	3.2***
Family size (nos.)	4.92	5.00	-1.7	-0.3
Number of family labour	3.14	3.20	-1.9	0.4

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.5: Location of sample households along with canal in Quang Nam

(Number of households)

Location of farms	Rehabilitated	Non-rehabilitated
Head canal	34	49
	(31.2)	(44.1)
Mid canal	33	37
	(30.3)	(33.3)
End canal	42	25
	(38.5)	(22.5)
Total	90 (100)	101 (100)

Figures in parenthesis are percentages to total

Table 4.6: Distribution (%) of sample households by soil quality in Quang Nam

Soil quality	Rehabilitated	Non-rehabilitated
1		0.99
2	1.11	0.99
3		4.95
4	23.33	17.82
5	37.78	36.63
6	37.78	38.61
Total	100	100

Note: Soil quality= 1 for the best quality, 2 for the good quality..…… 6 for the lowest quality

Table 4.7: Basic features of sample households in Quang Nam

Variables	Rehabilitated	Non-rehabilitated	% Difference	t test
Age (years)	57.52	55.83	3.0	-0.1
Education (schooling years)	5.58	5.61	-0.6	-0.1
Family size (nos.)	4.90	4.68	4.6	0.2
Number of family labour	3.70	3.49	6.2	0.0

Table 4,8: Location of sample households along with canal , HCMC/Tay Ninh

(No. of households)

Location of farms	Improved infrastructure and management	Non-improved infrastructure and management
Head canal	40	24
	(41.7)	(23.8)
Mid canal	21	29
	(21.9)	(28.7)
End canal	35	48
	(36.4)	(47.5)
Total	96 (100)	101 (100)

Figures in parenthesis are percentages to total

Table 4.9: Distribution (%) of sample households by soil quality in HCM<C/Tay Ninh

Soil quality	Improved infrastructure and management	Non-improved infrastructure and management
1	1.04	7.92
2	5.21	46.53
3	37.50	45.54
4	51.04	
5	4.17	
6	1.04	
Total	100	100

Note: Soil quality= 1 for the best quality, 2 for the good quality..…… 6 for the lowest quality

Table 4.10: Basic features of sample households in HCMC/Tay Ninh

Variables	Improved infrastructure and management	Non-improved infrastructure and management	% Difference	t value
Age (years)	50.47	47.40	6.5	2.2**
Education (schooling years)	6.09	4.97	22.6	1.9*
Family size (nos.)	4.60	4.49	2.7	1.0
Number of family labour	3.22	2.76	16.5	1.4*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.11: Land holding pattern of sample households in Thanh Hoa

(Avg sq.mtrs)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
No. of parcels	4.75	3.90	21.8	1.0
Land area owned	2578	1356	90.1	4.0***
Land area leased-in	318	7	4602.7	-1.4*
Land area leased-out	52	2	2308.2	1.3
Net cultivated area	2844	1361	109.0	4.2***
Net irrigated area	2649	1082	144.7	4.9***
Net irrigated area as % of net cultivated area	93	80	16.3	0.7

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.12: Status of irrigation availability and drainage of sample households, hanh Hoa

(Area in sq.meters)

Variables	Rehabilitated and improved management	Non-rehabilitate and typical management	% Difference	t value
Net irrigated area	2649	1082	144.7	4.9***
Irrigation availability				
- in season 1	1828	669	173.3	5.0***
	(69.0)	(61.8)		
- in season 2	1835	682	168.8	4.7***
	(69.3)	(63.0)		
- in season 3	1285	588	118.7	2.7**
	(48.5)	(54.3)		
- all seasons	4948	1939	155.2	4.4***
	(186.8)	(179.2)		
Irrigation availability at right time				
- in season 1	1820	732	148.6	5.1***
	(68.7)	(67.6)		
- in season 2	1862	741	151.4	5.1***
	(70.3)	(68.4)		
- in season 3	1295	466	177.7	3.5***
	(48.9)	(43.1)		
- all seasons	4977	1939	156.7	4.8***
	(187.9)	(179.1)		
Covered with drainage				
- in season 1	1942	935	107.7	4.3***
	(73.3)	(86.4)		
- in season 2	1900	928	104.6	4.2***
	(71.7)	(85.8)		
- in season 3	1339	482	177.5	3.6***
	(50.5)	(44.6)		
- all seasons	5180	2346	120.8	4.2***
	(195.6)	(216.7)		

*Note: Figures in parentheses are percentages to net irrigated are.; ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.*

Table 4.13: Distribution of irrigated area of sample households in Thanh Hoa

(in sq.meters)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Net irrigated area	2649	1082	144.7	4.9***
Irrigated area under head of main canal	755 (28.5)	492 (45.4)	53.7	1.4*
Irrigated area under mid of main canal	891 (33.7)	365 (33.7)	144.3	-0.7
Irrigated area under end of main canal	1002 (37.8)	226 (20.9)	343.3	2.7**

Figures in parenthesis are percentages to net irrigated area

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.14: Cropping intensity in Thanh Hoa

(Area in sq.meters)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	tvalue
Gross cultivated area	4540	2303	97.1	4.3***
Net cultivated area	2844	1361	109.0	4.2***
Gross rice area	4064	1886	107.3	5.1***
Gross non-rice area	476	417	14.1	1.1
Cropping intensity-farm as a whole	1.60	1.69	-5.7	-1.2
Cropping intensity for rice	2.09	2.01	4.1	0.8

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.15: Cost-return profile for cultivation for rice in Thanh Hoa

(Sum of all seasons-total planted area in a year)

(VND 000' per planted area/year)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Area planted (M^2)	4064	1886	115.5	5.1***
Costs				
Own labour cost	1068	682	56.7	3.1***
Purchased input cost	1354	746	81.6	4.0***
Total cost	2422	1427	69.7	4.1***
Returns				
Paddy output (kg)	2764	1094	152.7	11.9***
Paddy price received (000 VND/kg)	1.71	1.76	-2.9	-0.9
Gross value of rice production	4697	1905	146.6	6.9***
Net return	2275	477	376.6	5.8***
Farm operating surplus	3343	1159	188.5	6.6***
Utilization-% rice output				
Consumed by family[a]	52.3	65.1	-19.7	4.1***
Sold in the market	47.7	34.9	166.7	5.0***

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively

[a]=Including saved seed.

Table 4.16: Cost-return profile for cultivation for rice in Thanh Hoa

(Average of all seasons per hectare/season)

(VND 000'/ha)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Costs				
Own labour cost	2628	3614	-27.3	0.1
Purchased input cost	3332	3955	-15.7	-1.5*
Total cost	5960	7569	-21.3	-0.7
Returns				
Yield (tones/ha)	6.9	5.8	19.0	14.6***
Paddy price received (000 VND/kg)	1.71	1.76	-2.9	-0.9
Gross value of rice production	11581	10104	14.6	9.8***
Net return	5621	2535	121.7	6.4***
Farm operating surplus	8249	6150	34.1	9.5***
Unit cost of rice production 000`VND/ton)	*491*	*688*	*-28.6*	*-3.2***

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.17: Input cost of rice cultivation in Thanh Hoa

(average of all seasons-per ha/season)

('000 VND/ha)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Seed	261.4	441.9	-40.8	-3.9***
Fertilizers				
- Urea	557.0	613.1	-9.2	-0.1
- Phosphorous	247.6	281.3	-12.0	1.0
- Potassium	230.7	201.4	14.5	0.8
- Complex	217.7	183.5	18.7	0.8
Total fertilizer cost	**1252.9**	**1279.2**	-2.1	-0.6
Manure	919.2	787.3	16.8	0.7
Insecticides	146.8	241.7	-39.3	2.0**
Herbicides	94.0	55.0	71.0	-2.0**
Irrigation fee	288.9	229.3	26.0	-4.6***
Irrigation cost	125.0	785.4	-84.1	3.5***
Other input cost	0.0	0.0		
Hired labour	243.8	135.0	80.6	0.4
Purchase input cost	*3332.0*	*3954.8*	*-15.7*	*2.1***
Own labour	2627.9	3614.2	-27.3	0.1
Total cost	**5959.9**	**7569.0**	**-21.3**	**3.2*** **

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.18: Cost-return profile for non-rice crops in Thanh Hoa

(per total non-rice cropped area in a year)

(000' VND)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Cultivated land to non-rice crops (m^2)	476.0	417.3	14.1	1.7*
Total cost	140.6	133.1	5.6	1.1
Output value	328.2	442.2	-25.8	-0.7
Net profit	187.6	309.2	-39.3	-0.3
Purchase cost per ha.	1748.0	1305.3	33.9	0.5
Output per ha	3944.5	4490.9	-12.2	0.4
Farm-operating surplus per ha.	2196.5	3185.5	-31.1	-1.2
Utilization-% of output value				
Consumed by family	87	30	190	2.3**
Sold in the market	13	70	-81	-2.7**

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.19: Coefficient of variation (%) of paddy yield in Thanh Hoa

Season	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference
Season 1	23.5	31.8	-26.0
Season 2	25.2	35.4	-28.9

Table 4.20: Percent of sample households affected by natural calamities in Thanh Hoa

Calamity	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Drought	0.00	10.81	-100.0	-4.1***
Flood	1.83	10.81	-83.0	-4.1***

Table 4.21: Structure of household income of the sample farmers in Thanh Hoa

('000 VND/year)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Rice income	3343.3	1159.0	188.5	6.6***
Non-rice income	187.6	309.2	-39.3	0.3
Crop income	*3531.0*	*1468.1*	*140.5*	*6.1****
Non-crop income [a]	2742.6	1123.7	144.1	1.1
Agricultural income	*6273.6*	*2591.8*	*142.1*	*4.4****
Agriculture labour wage	495.0	419.8	17.9	1.5*
Other non-farm income	4372.6	5047.2	-13.4	-1.6*
Non-farm self employment	844.1	1766.2	-52.2	-4.2***
Non-farm income	*5711.8*	*7233.2*	*-21.0*	*-2.2****
Total household income	**11985.3**	**9825.0**	**22.0**	**2.4****
Per capita income	**2437.3**	**1965.0**	**24.0**	**2.3****

[a] *includes income from livestock and fisheries*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.22: Per capita consumption expenditure on food items in Thanh Hoa

(per capita in -000 VND)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Rice	485.3	504.7	-3.8	-0.3
Other cereals and staple food	41.5	7.3	468.2	2.3**
Meet, fish, shrimp	562.8	590.8	-4.7	-1.2
Fruits and vegetables	210.9	143.1	47.4	1.5*
Milk and milk products	78.4	23.3	236.9	2.1**
Beer and industrial beverages	4.5	4.7	-3.1	-1.2
Coffee, tea, softdrinks, mineral water	125.1	54.8	128.4	1.6*
Eating and drinking outside home	0.0	0.0	--	--
Total per capita food expenditure	**1508.4**	**1328.6**	**13.5**	**2.4****
Per household food expenditure	*7151.9*	*6425.1*	*11.3*	*2.6***

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.23: Estimated incidence of poverty among sample households in Thanh Hoa

(%of total households)

Particulars	Rehabilitated and improved management	Non-rehabilitated and typical management	% Difference	t value
Food poverty[a]	39	45	-12.4	-2.6**
Overall poverty based on own assessment[b]	45	44	3.9	0.5

'a' estimated based on survey data 2003

'b' estimated based on official wealth ranking of households at commune level

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.24: Land holding pattern of sample households in Quang Nam

(Avg sq.mtrs)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
No. of parcels	3.38	2.96	14.1	-3.2***
Land area owned	1940	1602	21.2	2.7***
Land area leased-in	52	80	-35.2	1.0
Land area leased-out	57			
Net cultivated area	1934	1682	15.0	2.5**
Net irrigated area	1845	1615	14.2	2.3**
Net irrigated area as % of net cultivated area	95	96	-1.1	-0.2

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.25: Status of irrigation availability and drainage of sample households in Quang Nam

(Area in sq. meters)

Variables	Rehabilitated	Non-rehabilitated	% Difference	t value
Net irrigated area	1845	1615	14.2	2.3**
Irrigation availability				
- in season 1	1388 (75.2)	1144 (70.8)	21.3	2.2**
- in season 2	1373 (74.4)	1130 (70.0)	21.5	1.9*
- in season 3	17 (0.9)	12 (0.7)	42.1	1.4*
- all seasons	2778 (150.6)	2286 (141.5)	21.5	2.1**
Irrigation availability at right time				
- in season 1	1401 (75.9)	1169 (72.4)	19.8	2.2**
- in season 2	1387 (75.2)	1138 (70.5)	21.9	1.9*
- in season 3	21 (1.1)	12 (0.7)	74.7	1.4*
- all seasons	2809 (152.3)	2319 (143.6)	21.1	2.1**
Covered with drainage				
- in season 1	1348 (73.1)	1192 (73.8)	13.1	1.9*
- in season 2	1322 (71.7)	1161 (71.9)	13.8	1.4*
- in season 3	33 (1.8)	14 (0.9)	138.8	1.2
- all seasons	2703 (146.5)	2367 (146.6)	14.2	1.8*

Figures in parenthesis are percentages to net irrigated area

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.26: Distribution of irrigated area of sample households in Quang Nam

(Avg sq.mtrs)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Net irrigated area	1845	1615	14.2	2.3**
Irrigated area under head of main canal	962 (52.2)	399 (24.7)	140.9	3.2***
Irrigated area under mid of main canal	143 (7.7)	165 (10.2)	-13.4	1.2
Irrigated area under end of main canal	740 (40.1)	1051 (65.1)	-29.6	-1.8*

Figures in parenthesis are percentages to net irrigated area

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.27: Cropping intensity of sample households in Quang Nam

(Area in sq.meters)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t test
Gross cultivated area	3124	2762	13.1	1.5*
Net cultivated area	1934	1682	15.0	2.5**
Gross rice area	3082	2700	14.1	1.4*
Gross non-rice rea	42	61	-31.4	-1.5*
Cropping intensity-farm as a whole	1.61	1.64	-1.8	-0.6**
Cropping intensity for rice	2.01	2.00	0.6	0.4

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.28: Cost-return profile for the cultivation of rice in Quang Nam

(Sumof all seasons-per planted area in a year**)**

(VN D 000' per planted area in a year)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Area planted (M^2)	*3082*	*2700*	*14.1*	*1.5**
Costs				
Own labour cost	819	921	-11.0	-0.1
Purchased input cost	1529	1181	29.4	2.3*
Total cost	2349	2102	11.7	1.2
Returns				
Paddy output (Kg)	1978	1532	23.1	2.2**
Paddy price received (000 VND/kg)	1.79	1.73	3.3	0.8
Gross value of rice production	3541	2650	33.6	3.9***
Net return	1192	548	117.4	2.9***
Farm operating surplus	2012	1469	36.9	2.9***
Utilization-% of rice output				
Consumed by family[a]	77	85	-9.4	2.3**
Sold in the market	23	15	98.3	2.5**

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

[a] Included saved seed

Table 4.29: Cost-return profile for the cultivation of rice in Quang Nam

(average of all seasons-per hectare/season)

(VND 000' per ha.)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Costs				
Own labour cost	2659	3409	-22.0	-1.8*
Purchased input cost	4963	4376	13.4	0.1
Total cost	7621	7785	-2.1	-1.2
Returns				
Yield (tones/ha)	6.4	5.7	13.3	1.7*
Paddy price received (000 VND/kg)	1.79	1.73	3.3	0.8
Gross value of rice production	11493	9816	17.1	1.8*
Net return	3872	2031	90.7	2.3**
Farm operating surplus	6530	5440	20.0	2.1**
Unit cost of rice production (000 VND/ton)	775	767	1.0	-1.5*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.30: Input costs of rice cultivation in Quang Nam

(average of all seasons-per hectare/season)

('000 VND/ha)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Seed	509.8	492.5	3.5	0.6
Fertilizers				
- Urea	750.5	568.5	32.0	1.5*
- Phosphorous	206.8	130.6	58.3	0.3
- Potassium	169.1	170.5	-0.8	-0.8
- Complex	645.7	634.9	1.7	0.1
Total fertilizer cost	1772.1	1504.5	91.2	1.9*
Manure	522.9	291.8	79.2	1.2
Insecticides	581.6	378.9	53.5	1.9
Herbicides	264.8	247.5	7.0	-0.8
Irrigation fee	732.9	748.3	-2.1	-0.0
Irrigation cost	112.0	16.8	568.6	4.2***
Other input cost	0.0	3.5	---	---
Hired labour	466.8	691.8	-32.5	1.2
Purchase input cost	*4962.9*	*4375.7*	*13.4*	*1.6**
Own labour	2658.5	3409.2	-22.0	-1.8*
Total cost	7621.4	7784.9	-2.1	-0.2

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.31: Cost-return profile for the cultivation of non-rice crops in Quang Nam

(per planted area in a year)

(`000 VND)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Area planted to non-rice crops (m^2)	42.2	61.5	-31.4	-1.5*
Total cost	23.9	16.4	45.7	1.4*
Output	96.5	52.1	85.3	1.3
Net profit	72.6	35.7	103.5	1.8*
Purchase cost per ha.	282.4	274.9	2.8	0.9
Output value per ha.	1076.6	789.8	36.3	0.8
Farm generating surplus per ha.	794.1	514.9	54.2	
Utilization-% of output value				
Consumed by family	9	24	-63	-0.7
Sold in the market (000 VND)	91	76	33	1.9*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.32: Coefficient of variation (%) of paddy yield in Quang Nam

Season	Rehabilitated	Non-rehabilitated	% Difference
Season 1	38.2	40.7	-6.3***
Season 2	43.4	41.8	3.8***

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.33: Percent of sample households affected by natural calamities in Quang Nam

Calamity	Rehabilitated	Non-rehabilitated	% Difference	t value
Drought	97.78	100.00	-2.2	-1.4*
Flood	86.67	92.08	-5.9	-1.1

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.34: Structure of household income of the sample farmers in Quang Nam

('000 VND/year)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Rice income	2011.6	1469.0	36.9	2.9***
Non-rice income	72.6	35.7	103.5	1.3
Crop income	*2084.2*	*1504.7*	*38.5*	*3.0****
Non-crop income *	1919.9	843.1	127.7	2.8***
Agricultural income	*4004.1*	*2347.7*	*70.6*	*3.8****
Agriculture labour wage	298.1	151.5	96.8	1.7*
Other non-farm income	4572.0	4560.0	0.3	-0.3
Non-farm self employment	874.9	807.1	8.4	0.3
Non-farm income	*5745.0*	*5518.7*	*4.1*	*0.1*
Total household income	9749.1	7866.4	23.9	1.8*
Per capita income	1989.6	1679.7	18.4	1.6*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.35: Per capita consumption expenditure of sample households on food items in Quang Nam

(Per capita /annum in '000 VND)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
Rice	453.6	421.8	7.5	1.0
Other cereals and staple food	10.7	1.5	632.0	0.7
Meet, fish, shrimp	756.1	623.3	21.3	2.3**
Fruits and vegetables	193.7	142.5	35.9	1.5*
Milk and milk products	28.8	19.5	48.0	0.3
Beer and industrial beverages	15.7	4.4	254.0	1.6*
Coffee, tea, softdrinks, mineral water	91.2	70.2	29.8	1.4*
Eating and drinking outside home	0.0	0.0		
Total per capita food expenditure	**1549.8**	**1283.2**	**20.8**	**2.1****
Per household food expenditure	7430.2	5806.7	28.0	1.9*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.36: Estimated incidence of poverty among sample households in quang nam (per cent of total households)

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t test
Food poverty[a]	33	53	-37.7	-2.6**
Overall poverty based on own assessment[b]	43	47	-8.0	-2.8**

'a' estimated based on survey data 2003

'b' estimated based on official wealth ranking of households at commune level

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.37: Land holding pattern of sample households in HCMC/Tay Ninh

(sq metres)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
No. of parcels	2.00	1.83	9.2	0.2
Land area owned	5872	6211	-5.5	-1.2
Land area leased-in	499	168	196.4	1.3
Land area leased-out	20	0	---	0.1
Net cultivated area	6351	6379	-0.4	-1.4*
Net irrigated area	6156	5984	2.9	1.5*
Net irrigated area as % of net cultivated area	97	94	3.2	0.7

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.38: Status of irrigation availability and drainage of sample households in HCMC/Tay Ninh

(Area in sq.meters)

Variables	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Net irrigated area (m2)	6156	5984	2.9	1.5*
Irrigation availability				
- in season 1	3873	3109	24.6	4.1***
	(62.9)	(52.0)		
- in season 2	3830	3174	20.7	3.7***
	(62.2)	(53.0)		
- in season 3	3986	3821	4.3	0.6
	(64.7)	(63.8)		
- all seasons	11688	10103	15.7	2.9**
	(189.9)	(168.8)		
Irrigation availability at right time				
- in season 1	4181	3800	10.0	2.7**
	(67.9)	(63.5)		
- in season 2	4058	3818	6.3	2.4**
	(65.9)	(63.8)		
- in season 3	4193	4026	4.2	0.9
	(68.1)	(67.3)		
- all seasons	12433	11644	6.8	2.2**
	(202.0)	(194.6)		
Covered with drainage				
- in season 1	4130	4311	-4.2	1.4*
	(67.1)	(72.0)		
- in season 2	4085	4113	-0.7	1.6*
	(66.4)	(68.7)		
- in season 3	4326	3993	8.3	1.3
	(70.3)	(66.7)		
- all seasons	12541	12417	1.0	1.5*
	(203.7)	(207.5)		

Figures in parenthesis are percentages to net irrigated area

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.39: Distribution of irrigated area of sample households in HCMC/Tay Ninh

(sq.meters)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Net irrigated area	6156	5984	2.9	1.5*
Irrigated area under head of main canal	2636 (42.8)	1719 (28.7)	53.4	3.3***
Irrigated area under mid of main canal	1566 (25.4)	1852 (31.0)	-15.4	-0.9
Irrigated area under end of main canal	1953 (31.7)	2413 (40.3)	-19.1	-1.7*

Figures in parenthesis are percentages to net irrigated area

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.40: Cropping intensity in HCMC/Tay Ninh

(Area in sq.meters)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	T value
Gross cultivated area	15945	13672	16.6	3.2**
Net cultivated area	6351	6379	-0.4	1.4*
Gross rice area	12506	9591	30.4	4.0***
Gross non-rice area	3439	4081	-15.7	1.8*
Cropping Intensity-farm as a whole	2.51	2.14	17.1	1.9*
Cropping intensity for rice	2.51	2.53	-0.8	0.87

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.41: Cost-return profile for cultivation of rice in HCMC/Tay Ninh

(Sum of all seasons-per planted area in a year)

(VND 000' per planted area in a year)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Area planted (M^2)	*12506*	*9591*	*30.4*	*4.0****
Costs				
Own labour cost	1636	1159	41.1	1.1
Purchased input cost	4553	3156	44.3	3.2**
Total cost	6189	4315	43.4	3.1**
Returns				
Paddy output (Kg)	5084	3246	56.6	7.2***
Received (000 VND/kg)	1.40	1.27	10.2	1.6*
Gross value of rice production	7140	4127	73.0	6.5***
Net return (000 VND)	951	-189	-604.1	2.1*
Farm operating surplus (000VND)	2587	971	166.5	2.4**
Utilization-% of rice output				
Consumed by family[a]	39	40	-2.5	1.0
Sold in the market	61	60	1.7	1.2

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

[a] = Included saved seed

Table 4.42: Cost-return profile for cultivation for rice in HCMC/Tay Ninh

(Average of all seasons-per ha/season)

(VND 000' per ha/season)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Costs				
Own labour cost	1308	1209	8.2	-2.5**
Purchased input cost	3641	3291	10.6	0.2
Total cost	4948	4499	10.0	0.4
Returns				
Yield (tones/ha)	4.1	3.4	20.1	5.3***
Paddy price received (000 VND/kg)	1.53	1.53	-0.2	-0.7
Gross value of rice production	6225	5195	19.8	5.3***
Net return	1277	695	83.6	2.3**
Farm operating surplus	2585	1904	35.8	2.0**
Unit cost of rice production (000VND /ton)	895	972	-7.9	-2.6**

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.43: Input costs of rice cultivation in HCMC/Tay

(Average of all seasons-per ha/season)

('000 VND / ha)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Seed	345.5	367.5	-6.0	-0.5
Fertilizers				
- Urea	527.8	467.5	12.9	0.8
- Phosphorous	83.4	104.9	-20.6	-1.3
- Potassium	50.0	123.0	-59.4	1.4*
- Complex	900.2	575.8	56.3	0.5
Total fertilizer cost	1561.3	1271.3	-10.7	1.2
Manure	211.0	67.3	213.7	1.9*
Insecticides	460.4	292.3	57.5	1.0
Herbicides	209.5	239.5	-12.5	-1.2
Irrigation fee	110.3	196.3	-43.8	-3.1***
Irrigation cost	21.8	103.4	-78.9	-1.8*
Other input cost	3.1	0.0		
Hired labour	717.7	753.2	-4.7	-1.3
Purchase input cost	*3640.5*	*3290.7*	*10.6*	*0.2*
Own labour	1307.9	1208.6	8.2	2.5**
Total cost	4948.4	4499.3	10.0	0.4

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.44: Cost-return profile for non-rice crops in HCMC/Tay Ninh

(per planted area in a year)

(000' VND)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Area planted to non-rice crops (m^2)	3439	4081	-15.7	-1.8*
Total cost	2081	2002	4.0	1.0
Output value	6063	4757	27.4	1.1
Net profit	3982	2755	44.5	1.9*
Purchase input cost per ha.	4423	3285	34.7	1.5*
Output value per ha.	12670	7607	66.6	1.1
Farm operating surplus per ha.	8247	4322		
Utilization-% of output value				
Consumed by family	2.3	4.1	-44	-1.5*
Sold in the market (000 VND)	97.7	95.9	1.9	-0.9

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.45: Coefficient of variation (%) of paddy yield in HCMC/Tay Ninh

Season	Improved infrastructure management	Typical infrastructure management	% Difference	T value
Season 1	67.4	89.5	-24.7	-4.2***
Season 2	72.4	86.4	-16.2	-3.1***
Season 3	121.1	112.0	8.1	2.1**

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.46: Per cent of sample households affected by natural calamities in HCMC/Tay Ninh

Calamity	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Drought	97.92	97.03	0.9	1.0
Flood	97.92	98.02	-0.1	1.4*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.47: Structure of household income of the sample farmers in HCMC/Tay Ninh

('000 VND/year)

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Rice income	2586.8	970.5	166.5	2.4**
Non-rice crop income	3978.4	2753.4	44.5	1.0
Crop income	*6565.1*	*3723.9*	*76.3*	*1.7**
Non-crop farm income *	3097.5	2129.7	45.4	1.8*
Agricultural income	*9662.6*	*5853.6*	*65.1*	*2.5***
Agriculture labour wage	2144.8	1378.5	55.6	-0.3
Other non-farm income	4811.1	2463.5	95.3	1.3
Non-farm self employment	2432.0	1459.0	66.7	1.6*
Non-farm income	*9387.8*	*5300.9*	*77.1*	*0.9*
Total household income	**19050.4**	**11154.5**	**70.8**	**2.4****
Per capita household income	**4137.6**	**2487.0**	**66.4**	**2.2****

** includes income from livestock and fisheries*

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.48: Per capita consumption expenditure on food items for sample households in HCMC/Tay Ninh

(Per capita / annum in VND 000')

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Rice	546.6	430.7	26.9	1.9*
Other cereals and staple food	1.0	0.3	184.1	---
Meet, fish, shrimp	1050.2	617.4	70.1	1.8*
Fruits and vegetables	178.0	137.9	29.1	0.7
Milk and milk products	20.7	4.5	356.7	0.8
Beer and industrial beverages	21.4	0.0		-1.0
Coffee, tea, softdrinks, mineral water	78.4	44.3	76.8	0.7
Eating and drinking outside home	0.0	0.0		
Total per capita food expenditure	1896.2	1235.2	53.5	1.7*
Per household food expenditure	7870.9	5276.9	49.2	3.5***

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.49: Estimates of incidence of poverty (per cent of total households) among sample households in HCMC/Tay Ninh

Particulars	Improved infrastructure management	Typical infrastructure management	% Difference	t value
Food poverty[a]	23	49	-52.8	-2.3**
Overall poverty based on own assessment[b]	47	42	10.1	-1.0

'a' estimated based on survey data 2003

'b' estimated based on official wealth ranking of households at commune level

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Table 4.50: Change in the key outcome indicators between rehabilitated and/or improved management and non-rehabilitated and/typical management areas for head-ended and tail-ended farmers under the selected irrigation schemes

Outcome indicator	Song Chu irrigation scheme	An Tranch irrigation scheme	Dau Tieng irrigation scheme
Nature of intervention	*Rehabilitation and improved management*	*Rehabilitation*	*Improved management*
HEAD-ended farmers			
Paddy yield-season-1 (t/ha)	0.7* (10.9)	0.9* (14.8)	0.2 (4.7)
Paddy yield-season-2 (t/ha)	1.8** (32.1)	1.1 (19)	0.8** 21.6)
Rice income (VD 000 / ha	135* (19.4)	199** (35.8)	222*** 740)
Total farm income (VND 000)	3321*** (131)	2595** (144)	6928*** (109)
Total income (VND 000)	1201* (13.5)	250 (2.7)	7243*** (68.4)
Per capita food expenditure (VND 000)	142* (10.5)	-0.74 (-4.9)	421** (27.6)
TAIL-ended farmers			
Paddy yield-season-1 (t/ha)	0.5 (7.9)	0.1 (1.5)	0.9** (25.7)
Paddy yield-season-2 (t/ha)	2.1** (39.6)	-0.8* (-11.8)	0.9** (34.6)
Rice income (VD 000 / ha	302*** (52.3)	-54 (-9.7)	100** (43)
Total farm income (VND 000)	2357*** (70.8)	833** (33.3)	1530** (29)
Total income (VND 000)	520 (4.3)	3024*** (42)	10730*** (102)
Per capita food expenditure (VND 000)	74* (5.7)	607** (56.7)	986*** (94.6)

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively
Figures in parentheses are per cent change

Table 4.51: Change in the key outcome indicators between rehabilitated and/or improved management and non-rehabilitated and/typical management areas under the selected irrigation schemes

Outcome indicator	Song Chu irrigation scheme	An Tranch irrigation scheme	Dau Tieng irrigation scheme
Nature of intervention	*Rehabilitation and improved management*	*Rehabilitation*	*Improved management*
Paddy yield (t/ha)	1.0*** (18.0)	0.7** (13.3)	0.7*** (20.1)
Unit cost of paddy production (VND 000 / ton)	-199*** (-28.6)	-8* (-1.0)	-22** (-7.9)
Rice income (VnD 000 / ha	2100** (34.1)	1090** (20.0)	681** 35.8)
Total farm income (VND 000)	3682*** (132.1)	1656*** (70.6)	3809** 65.1)
Total income (VND 000)	2160*** (22.0)	1883* 23.9)	7895*** 70.8)
Per capita food expenditure (VND 000)	180** (13.5)	267** 20.8)	661*** 53.5)
Food poverty (%)	-7.0** (-12.4)	-20** (-37.5)	-26*** (-52.8)
Cropping intensity (%)	-9 (-5.7)	-3 (-7.7)	37* (17.1)

Note: ***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively

Figures in parentheses are per cent change

Table 4.52: Estimated efficiency indicators of public investments through various policy interventions in the selected irrigation schemes

Efficiency indicator	Song Chu irrigation scheme (Thanh Hoa)	An Tranch irrigation scheme (Quang Nam)	Dau Tieng irrigation scheme (HCMC/Tay Ninh)
Nature of intervention	*Rehabilitation and improved management*	*Rehabilitation*	*Improved management*
Value of annual incremental paddy output per 1 US $ investment (US $)	1.04	0.24	0.11
Value of annual incremental farm output per 1 US $ investment (US $)	1.31	0.30	0.35
Investment per one percent increase of farm income/household (US $)	1.42	5.15	11.07
Investment per one percent increase of per capita food consumption (US $)	13.85	17.49	13.48
Amount spent on irrigation to bring one poor household above poverty (US $)	2,692	1,819	2,773

Data source: ADB, WB and MARD (investment made until 1997)
Official exchange rates, 1997: 1 US $ = VN D 11360 ; 2002: 1 US $ = VN D 15,000

Appendix 1: Original concept note & ToRs, prepared by WB & ADB

The Poverty Impact of Public Irrigation Expenditures in Vietnam

Concept note/ Draft Terms of Reference

April 10, 2002

A. Introduction

1. The Government of Vietnam (GOV) is committed to achieving rapid reductions in poverty, which is also the priority objective for multilateral and bilateral donors. Eighty-percent of Vietnam's population lives in rural areas, and 70% of the labor force depend on agriculture. About one third of the population lives below the poverty line, and 85% of the poor live in rural areas. The primary expenditure instrument used by the Government to improve rural incomes has been subsidized irrigation investments.[3] Irrigation accounts for about half of all public expenditures in the agricultural sector, and three-quarters of all capital investments (about 2.5 TD, or $250 million per year).[4] Much of the funding is obtained through international financing agencies. The World Bank, the Asian Development Bank (ADB), and JBIC currently have irrigation projects with total commitments of over $500 million.[5] The primary question posed by this study is: ***How effective are public irrigation expenditures in increasing rural incomes, particularly for the poor?***

2. Rice is the major irrigated crop in Vietnam and rice production in Vietnam has soared from 20 million tons in 1990 to over 30 million tons by the end of the decade. Agricultural liberalization has clearly been a driving force in this expansion, but the impact of irrigation investments, which have more than doubled during the 1990s, is less clear.[6] A study by IFPRI in 2000 concluded that there is a weak relationship, on a per-capita basis, between agricultural output and public expenditures in the provinces.[7] Paradoxically, amidst the growth in rice production, Vietnamese rice farmers face a stagnant farm income, primarily due to low farm-gate prices, and inappropriate government policies on a number of fronts.[8]

3. The findings from the study will help improve the strategy for rural transformation, which is one of the key themes of Vietnam's CPRGS. Growth in agriculture was the driving force behind rural poverty reduction in the last decade, but in the coming decade agricultural diversification and growth in off-farm enterprises are likely to be key to poverty-reduction. The role of irrigation in this process needs to be redefined.

4. The study will help GOV and donors to better understand the links between government expenditure and poverty reduction. This will fit in well with current efforts in aligning

End Notes for Annexure-1

[3] The term irrigation is used in the broad sense to cover all agricultural water control infrastructure, including drainage, flood control, and supply of water for crops.
[4] IFPRI, "Vietnam Public Expenditure Review: Input on the Agricultural and Rural Sectors," March 21, 2000, pg. 12, Table 6.
[5] Figures presented at MARD Water International Donor Support Meeting, March 2001.
[6] IFPRI, pg. 11.
[7] IFPRI, pg. 6.
[8] ADB, "O&M Development in the Irrigation Sector" (TA No. 2869-VIE), pg. 93.

government and donor resource allocations to GOV's Comprehensive Poverty Reduction and Growth Strategy (CPRGS).
The 2000 Vietnam public expenditure review recommended a reallocation of spending within sectors, including agriculture. It also recommend, however, that "to decide on the extent of this reallocation will require further work on the tracking, incidence and the impact of sectoral expenditures.[9]" The study will help provide an empirical foundation for an analysis of agricultural public expenditures, and also serve to assist in project identification, and improve sector and overall economic management. The data collected will be directly useful for the preparation, monitoring and evaluation of new WB, ADB and JBIC water resources projects. The information and analysis will also support implementation completion reports of on going water resource projects.

B. Study Hypotheses: Improving irrigation and drainage service is a powerful instrument for reducing poverty.

5. According to the 1998 Vietnam Living Standards Survery (VLSS) data, although agricultural diversification is increasingly important in raising farm family incomes, rice production still accounts for approximately 43% of the average family's agricultural revenue.[10] Moreover, rice grown on the family farm is the major subsistence crop. The profitability of rice has decreased dramatically over the last few years as the international (and domestic) price of rice has declined by almost 50% since 1998.[11] The decline in the farm-gate price of rice has had a dramatic negative impact on rural incomes. The key to escaping from this poverty trap is to both diversify and improve rice profit margins, and improved irrigation service is central for both objectives.

6. Diversification into perennial crops, industrial crops, and fruit trees, has potentially greater returns but also greater risks than traditional rice production. Larger initial investments are often required and one of the major risks is inadequate irrigation, i.e., insufficient water at the required time, and inadequate drainage. Given particular market conditions, improvement of irrigation service would reduce risk and encourage diversification. Rice will still remain, however, the most important crop for the majority of farmers over the next decade. Given the declining profitability of rice, renewed efforts on reducing production costs and increasing yields are critical to boosting profit margins. Many farmers, in particular poor farmers at the tail-end, receive unreliable gravity irrigation service which may reduce yields, and also result in higher production costs as they must pump (or manually transfer) water from low-level irrigation canals, drainage canals, or shallow wells.[12] These additional costs erode already razor-thin profit margins. This study will help MARD policy-makers at various levels to decide whether investments in irrigation are important for overcoming poverty and growth, and if yes, what the best approach is for further improving the performance of irrigation systems in Vietnam.

C. Case Studies

7. The methodology will apply both qualitative and quantitative assessments. The qualitative assessment will consist of focus group discussions with various groups of farmers (e.g.

[9] World Bank, "Proposed Poverty Reduction Support Credit: Report and Recommendation to the President," April 23, 2001, pg. 27.
[10] Vietnam Development Report 2000: Attacking Poverty, pg. 52
[11] According to the Bank's Commodity Price Data newsletter, the March 2001 international price of Thai Rice (A1) was $134/ton, compared with around $250 in 1998
[12] This is well documented in Black & Veach, "Phuoc Hua FS Annex E: Water Management Institutions in Dau Tieng," 2001.

with and without the irrigation measure) including special discussions with ethnic minorities if present, female-managed households, and various others sub-groups (e.g. tail-enders and top-enders), to deepen our understanding of the issues. The quantitative study will apply agricultural household surveys in different types of irrigation schemes to test the study hypothesis. There are two major routes to improved irrigation service:

- Better Infrastructure
- Better Irrigation Infrastructure Management

8. The quantitative assessment will attempt to control as many variables such as scheme water availability, market conditions, by focusing on differing conditions within the same basic irrigation schemes. The case studies selected by the World Bank and the ADB are listed below. Alternative suggestions are welcome.

9. ***Case 1: Testing the Impact of Irrigation Infrastructure Management: Dau Tieng.*** The Dau Tieng scheme is located in the southeast of Vietnam, to the northeast of Ho Chi Minh City. The scheme consists of a 1.5 billion cubic meter reservoir and approximately 72,000 ha of irrigation command area, of which 58,000 ha are in Tay Ninh and 14,000 ha in the Chu Chi District of Ho Chi Minh City. The Dau Tieng reservoir and main canals are owned and managed by MARD, while the IMCs manage distribution off the main canals within their provincial boundaries. The provincial government of HCMC has significantly more financial and human resources than Tay Ninh with which to address irrigation management problem. A quick inspection tour by World Bank and ADB staff indicates that the HCMC IMC is among the best-run companies in Vietnam, and the farmers are relatively more prosperous than their Tay Ninh counterparts. Since the HCMC IMC is located downstream of Tay Ninh, scheme water availability would not account for this difference. In a similar manner, since the two schemes are located in the same general market, availability to market should not be a major factor affecting farmer incomes. If there is a significant difference in farmer incomes in the two schemes, through lower production costs, diversification, or yields, then the major explanatory variable could be the difference in the management of the infrastructure.

10. ***Case 2: Testing the Impact of Infrastructure Rehabilitation: Da Nang or Quang Nam.*** The World Bank and the ADB have financed a number of irrigation rehabilitation projects in Vietnam. This case would look at differences in farmer incomes on two different irrigation schemes within the same province. One of the schemes would be a rehabilitated scheme financed by the World Bank, the other scheme would be a non-rehabilitated scheme. (Alternatively, different parts of the same scheme, one section rehabilitated, the other not, could be studied). This case would control for irrigation management since both schemes would be managed by the same IMC. Since the schemes will be in the same climatic zone, scheme water availability will be partially controlled for. Differences in farmer incomes could there be explained primarily by improved infrastructure. Since these schemes were financed under IRP, the data collected can be useful for the ICR.

11. ***Case 3: Infrastructure Rehabilitation and Improved Management: Song Chu or North Nghe An:*** The GOVN, through the ADB-financed Irrigation and Flood Protection Rehabilitation Project (IFPRP), has rehabilitated part of the Song Chu (Thang Hoa province) and North Nghe An (Nghe An province) schemes in the mid-1990s. However, it became apparent that this was also necessary to improve O&M at the local level. Under ADB TA grant 2869-VIE (completed 1999), a TA program was established to focus on two small pilot areas, around 300 ha each. An

interesting comparison could therefore be made between the i) non-rehabilitated areas, and ii) the rehabilitated areas with the intensive pilot TA program.

12. **Case 4: Poor Infrastructure and Typical Management: Cam Son**. The Cam Son irrigation system is located to the northwest of Hanoi, covers approximately 24,000 ha and is supplied by the 228 million cubic meter Cam Son Dam. The infrastructure appears to be degraded and the management is not exceptional. The study would therefore survey farmer incomes at different locations in the scheme to see if there were significant differences between head-enders and tail-enders. The assumption would be that head-enders have significantly higher incomes than tail-enders, and investments in infrastructure and improved management would help reduce poverty. Instead of Cam Son we could include a set of households in Tay Ninh without any irrigation at all. This would enable a comparison of the 'no irrigation' case with the 'with irrigation infrastructure (without improved management)' case, both in Tay Ninh.

13. A summary of the case studies and their tests are:

Test	***With***	***Without***
1. Improved Management	a. HCMC	b. Tay Ninh g. Cam Son
2. Improved Infrastructure	c. Quang Nam-Rehabilitated	d. Quang Nam-Not Rehabilitated g. Cam Son
3. Improved Infrastructure and Management	e. Song Chu (TA Pilot and Rehabilitated)	f. Song Shu (Not Rehabilitated and No TA)

D. Survey Methodology

14. The methodology presented below is suggested by the World Bank and the ADB. Well-justified alternatives will be welcome. There will be at least seven data sets:

a. HCMC
b. Tay Ninh
c. Quang Nam-Rehabilitated
d. Quang Nam-Not Rehabilitated
e. Cam Son
f. Song Chu-Rehabilitated with TA
g. Song Chu-Not Rehabilitated and without TA

15. For each data set, one head-end and one tail-end primary canal will be selected. For each primary canal system, three "irrigation units" will be selected for household surveys: head-end, middle, and tail-end units. An irrigation unit is defined as an on-farm irrigation and drainage system that is managed by the farmers, and not the IMC. Typically, an irrigation unit would cover around 250 ha and be serviced by a tertiary system. Not all farms within the irrigation unit belong to "water user groups" and pay irrigation service fees because they do not receive reliable service. Since the average farm size is around 1 ha, this typically means 250 families per irrigation unit, of which 10% (say 25 families) should be interviewed. The selection of households should be based on geographical location only, without consideration of economic status or crop type in order to maintain a non-biased sample. The sample selection of households should be geographically dispersed within the irrigation unit. For each data set, the sampling would consist of six irrigation units (150 families), consisting of the following: I) Head-end Primary Canal-three irrigation units; ii) Tail-End Primary Canal-three irrigation units. The total number of households survey would be approximately 1,000 (150*7).

16. One other option that maybe worth considering is to, before the field work, identify households in the study areas that have been interviewed earlier for the VLSS 1998. This may help understand distribution of poverty levels within a scheme, which could be used to guide further sample design. Also, these households could then be re-interviewed to assess changes in poverty levels and to determine how much of these changes are related to irrigation measures. However, the VLSS 98 sample design maybe too small for this and these possibilities need to be reviewed first by the international consultant and the statistician for their feasibility.

17. The information to be collected in the household surveys will be partly determined by the outcome of the qualitative studies. But the types of information would include for the last calendar year:

- Farm Size and Cropping patterns for the last three seasons: dry season; pre-monsoon; and monsoon.
- Actual farm budgets, covering all i) production costs: fertilizer, seed, hired labor, equipment, irrigation fees, pumping costs, taxes, etc., and ii) revenues based on crop yields and farm gate prices; this should enable calculations of household agricultural and non-agricultural net income
- Household expenditures to calculate total household income
- Household labor inputs
- Socioeconomic household information: number of family members, education levels, and family members engaged in agriculture, etc.
- Names of families so that follow-up households surveys can be done.

E. Analysis of Survey Results

18. The qualitative information will be summarized for their main conclusions as they relate to irrigation policy measures. These will also serve to further develop the hypotheses for testing in the quantitative study, and to explain some of the relationships that will be found in the quantitative study. The data sets will be statistically analyzed to test the following *draft* hypotheses that:

- ✓ There will be a statistically significant difference in farmer incomes (mean, median, and standard deviation) between HCMC (a) and Tay Ninh (b) that can be attributed primarily to better provincial management.
- ✓ There will be a statistically significant difference between the rehabilitated (c) and non-rehabilitated (d) in Quang Nam.
- ✓ There will be a statistically significant difference in Song Chu between the rehabilitated areas with TA (e), and those without (f).
- ✓ There will be differences between head-enders and tail-enders in all data sets, with the most pronounced difference being in Cam Son (g).

19. In addition to testing these hypotheses, the impact also needs to be quantified and set against the background of national household expenditures quintiles. These analyses will be assessed on the use of matching techniques. This will match households in 'treatment' groups with households in 'comparison groups' ensuring both households are similar in observed variables that are not related to the irrigation intervention. The impact of the irrigation interventions can then be established by determining the difference between the treatment and the matched comparison households in the different outcome indicators associated with the project. A similar method is being applied in an on-going impact evaluation of rural road rehabilitation[13]. This information will help assess likely impacts of future irrigation projects (WB, ADB, JBIC), and also into broader sectoral programming issues over the value of infrastructure and management investments, and into priority setting and public expenditure decisions within MARD.

F. Consultant Staffing Needs:

20. The Consultant Team could consist of the following staff, although the Consultant is free to propose an alternative-staffing plan:

International Team Leader (ITL): The ITL should be an agricultural economist with at least 10 years experience in analyzing the economic impacts of rural investments in developing countries, with specific experience in Asia and experience in irrigation. The ITL should have demonstrated expertise in conducting participatory studies as well as formal rural household surveys, including survey design, methodology, and statistical analysis of results. The ITL should have a record of academic and professional publications/reporting in the general field of rural poverty reduction. Expected inputs are approximately 70. The ITL, in conjunction with the NTL, will be responsible for the overall design and management of the surveys, analysis, reporting of results, and liaison with the World Bank, other donors, and the Government of Vietnam.

National Team Leader (NTL): The NTL should have a similar profile to the ITL, but should be Vietnamese and affiliated with a recognized Vietnamese research institute.

[13] Van de Walle (2002). Impact evaluation of a rural road rehabilitation project in Vietnam : a research proposal. DECRG, World Bank , Washington DC.

Survey Team Leader (STL): This person should have significant experience in the design, implementation, and management of rural household surveys. The STL should be able to train, organize, and manage a team of field surveyors, and have a relevant college degree, preferably at the graduate level.

Field Surveyors: The field surveyors should have college degree in a relevant discipline, and previous experience conducting rural household surveys.

Statistician: This person should have a degree in statistics or agricultural economics, and be actively involved in the design of the surveys, take a lead role in the statistical analysis of results, and assist in the ITL and NTL in the reporting.

G. Time frame

21. The assignment is expected to be of six months duration, with the following reporting schedule and payment schedule. All reports shall be in English, submitted to the World Bank, ADB and JBIC and the appropriate government agency (to be determined later). A final presentation workshop will be organized. The final report should also be in Vietnamese.

- Contract Signing: (20%)
- Month 1: Inception Report with detailed study methodology: (20%)
- Month 2: Qualitative field studies
- Month 3-4: Formal household surveys, with Status Report in Month 3: (20%)
- Month 5: Analysis of Data and Draft Final Report at end of Month 5: (20%)
- Month 6: Review and Comment, Final Report (20%)

H. Estimated Inputs

22. The following table provides an estimate of the number of days input for guidance purposes only. The total cost of the assignment shall not exceed US $95,000.

Name	Days
International Consultant	70
Lead National National Consultant	120
Survey Team Leader	120
Local Surveyors	175
Statistician	30

Appendix A2: Methodology on factor analysis

Exploring the fuzzy data picture sometimes requires a wide-angle lens to view its totality. At other times it requires a close-up lens to focus on fine detail. Analysis should take both these aspects into consideration. Most social science systems are complex because they involve many variables and there are many interactions among the variables. Therefore, they are forced to rely upon multivariate statistical and mathematical tools to uncover interactions and reduce the dimensionality of the data.

Two closely related techniques, principal component analysis and factor analysis, are used to reduce the dimensionality of multivariate data. In these techniques correlations and interactions among the variables are summarized in terms of a small number of underlying factors. The methods rapidly identify key variables or groups of variables that control the system under study.

What is Factor analysis?

Factor analysis refers to a variety of statistical techniques whose common objective is to represent a set of variables, which are inter-related, but influencing a common variable. To illustrate factor analysis more clearly, there are *X* number of variables which have a bearing on poverty, if these have to be grouped into homogenous groups to facilitate comparisons among the variables poverty, such as per capita GDP, per capita agriculture GDP, share of agriculture to GDP, irrigated area, irrigation budget, paddy yield, etc.

The fist step in the analysis is to examine the interrelationship among the variables. This can be effectively done through the correlation matrix. Inspection of this will show that some are positively correlated and some negatively correlated and the relationship between one subset of variables is greater than the other subset. Factor analysis approach may then be used to address whether these observed correlations could be explained by the existence of a small number of hypothetical variables. These kinds of questions can be handled by factor analysis and principal component analysis.

At the outset the researcher will have no idea regarding the number of underlying relationships, referred to as dimensions there are, in a given data set. Factor analysis will help in determining the minimum number of underlying relationships, which can explain the underlying dimensions that explain the co-variation among the variables.

The method of Factor Analysis involves the computation of the correlation matrix among the variables in the data set. From this matrix the eigan root and eigan vectors are extracted. The eigan root is a measure of the importance of each eigan vector. The importance of the eigan vector progressively reduces and where the value of the eigan root drops below unity the remaining eigan vectors are ignored. By this procedure the size of the problem is reduced. The eigan vector helps in constructing a new variable, which is a linear combination of the old variables. The weights assigned to each variable in the new variable are called the principal component coefficients. The principal component vectors are rotated to get the Factor vectors. The coefficients are altered when the eigan vectors are rotated in order to make each vector unique using a method called the varimax rotation. The coefficients of the rotated matrix are the factor analysis coefficients, also called the factor loadings.

Each vector of the factor matrix is scrutinized and the relatively large coefficients identified. The variables associated with these coefficients are deemed to have an underlying relationship, which could be inverse if the coefficients are negative and positive. In a similar fashion the second vector is scrutinized and another set of relationships between the variables are identified, this procedure is continued till all the components with eigan values grater than unity are scrutinized and relationships identified. It should be noted here that the strength of the identified relationship decreases as the number of the component from which it is identified increases. Factor analysis doe not recognize dependent and independent variables. However, if one is specifically interested in one variable, like poverty in this case. Then the component where poverty has a large coefficient can be examined and the variable associated with it in that component can be studied for the nature and extent of relationship. Factor analysis is ideally suited in explanatory studies where the relationship between variables is not clearly understood.

Appendix A3: Questionnaire used for the survey

(To be added)

Appendix A4: Estimated regression models on determinants of the key outcome indicators for the pooled sample households in Thanh Hoa

1a.. Determinants of rice income in Thanh Hoa, Before Propensity Score Matching

Coefficients		Beta	Std. error	t
1	(Constant)	-317.832	403.572	-.788
	HAGE	.855	4.423	.193
	HEDU	-45.586	22.153	-2.058**
	HHSIZE	77.818	37.839	2.057**
	PARCEL	-151.060	39.722	-3.803***
	LABR	.554	.071	7.788***
	FERTCOST	-.188	.294	-.638
	FSIZE	.729	.062	11.841***
	IRRIGATION	9.617	2.566	3.748***
	LOCDUMM1	-5.420	118.725	-.046
	SOILQ	-72.203	110.189	-.655
	HH-GRUOP	574.997	148.331	3.876***
	R2	.653		
	F	57.393***		
	N	347		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

1.b Determinants of rice income in Thanh Hoa, After Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	-738.118	532.346	-1.387
	HAGE	9.099	5.548	1.640
	HEDU	-38.205	27.312	-1.399
	HHSIZE	85.040	48.361	1.758*
	PARCEL	-129.792	59.104	-2.196**
	LABR	.536	.084	6.361***
	FERTCOST	-.341	.389	-.877
	FSIZE	.643	.095	6.739***
	IRRIGATION	8.510	3.641	2.338**
	LOCDUMM1	185.326	156.137	1.187
	SOILQ	-196.021	137.473	-1.426
	HH-GRUOP	1085.224	189.258	5.734***
	R2	.677		
	N	220		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.a Determinants of agriculture income in Thanh Hoa, Before Propensity Score Matching

coefficient		Beta	Std. Error	T
1	(Constant)	-1794.370	1381.752	-1.299
	HAGE	10.015	15.151	.661
	HEDU	41.463	75.883	.546
	HHSIZE	154.765	128.718	1.202
	PARCEL	113.748	132.214	.860
	LABR	.264	.240	1.100
	FSIZE	1.153	.172	6.694***
	IRRIGATION	12.291	8.775	1.401
	LOCDUMM1	-313.197	406.125	-.771
	SOILQ	-176.451	377.360	-.468
	HH-GRUOP	1063.079	498.572	2.132**
	R2	.335		
	F	16.928***		
	N	347		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.b Determinants of agriculture income in Thanh Hoa, After Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	-1716.657	1827.164	-.940
	HAGE	22.000	19.012	1.157
	HEDU	48.024	93.374	.514
	HHSIZE	29.356	165.806	.177
	PARCEL	20.045	199.115	.101
	LABR	.215	.283	.761
	FSIZE	1.400	.297	4.716***
	IRRIGATION	11.109	12.494	.889
	LOCDUMM1	-273.369	535.176	-.511
	SOILQ	-114.767	471.963	-.243
	HH-GRUOP	1140.948	639.246	1.785*
	R2	.346		
	F	11.047***		
	N	220		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.a. Determinants of total household income in Thanh Hoa, Before Propensity Score Matching

coefficient		Beta	Std. error	T
1	(Constant)	-6456.522	3562.584	-1.812
	HAGE	55.373	39.066	1.417
	HEDU	186.732	203.026	.920
	HHSIZE	1021.026	328.556	3.108**
	PARCEL	450.729	340.692	1.323
	TOTASSET	5.214E-02	.025	2.102**
	FSIZE	.895	.442	2.024**
	IRRIGATION	48.926	22.600	2.165**
	LOCDUMM1	-903.097	999.441	-.904
	SOILQ	403.372	970.556	.416
	HH-GRUOP	-1138.806	1275.296	-.893
	R2	.127		
	F	4.877***		
	N	346		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; FSIZE= total cropped area (M2); TOTASSET= total assets (VND 000') IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.b Determinants of total household income in Thanh Hoa, After Propensity Score Matching

coefficient		Beta	Std. Error	t
1	(Constant)	-2278.103	4331.444	-.526
	HAGE	29.277	45.189	.648
	HEDU	-124.624	223.930	-.557
	HHSIZE	1385.993	395.746	3.502***
	PARCEL	52.039	468.286	.111
	TOTASSET	7.974E-02	.038	2.078**
	FSIZE	1.413	.687	2.056**
	IRRIGATION	19.846	29.615	.670
	LOCDUMM1	-1556.909	1242.194	-1.253
	SOILQ	-421.301	1118.263	-.377
	HH-GRUOP	76.931	1521.516	.051
	R2	.175		
	F	4.422***		
	N	220		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; FSIZE= total cropped area (M2); TOTASSET= total assets (VND 000') IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.a Determinants of per capita food consumption expenditure in Thanh Hoa, Before Propensity Score Matching

coefficient		Beta	Std. error	T
1	(Constant)	2053.525	326.418	6.291***
	HAGE	2.581	3.678	.702
	HEDU	45.639	18.569	2.458**
	HHSIZE	-195.194	30.633	-6.372***
	FSIZE	2.035E-03	.042	.048
	HHAI	1.142E-02	.013	.858
	IRRIGATION	.668	2.148	.311
	LOCDUMM1	14.968	90.380	.166
	SOILQ	-23.680	91.787	-.258
	HH-GRUOP	-201.623	120.698	-1.670*
	R2	.128		
	F	5.496***		
	N	347		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; FSIZE= total cropped area (M2); HHAI= total agriculticulture income of HH (VND 000'); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.b Determinants of per capita food consumption expenditure in Thanh Hoa, After Propensity Score Matching

coefficient		Beta	Std. error	T
	(Constant)	1828.983	310.053	5.899***
	HAGE	-.741	3.408	-.217
	HEDU	21.537	16.826	1.280
	HHSIZE	-123.898	29.411	-4.213***
	FSIZE	3.279E-02	.048	.689
	HHAI	1.106E-02	.012	.888
	IRRIGATION	.119	2.250	.053
	LOCDUMM1	-47.997	85.104	-.564
	SOILQ	-83.374	83.913	-.994
	HH-GRUOP	41.730	114.546	.364
	R2	.116		
	F	3.049***		
	N	220		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH;HHAI=total agriculture income of HH (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

Appendix A5: Estimated regression models on determinants of the key outcome indicators for the pooled sample households in Quang Nam

1.a: Determinants of rice income in Quang Nam, Before Propensity Score Matching

coefficient		Beta	Std. Error	T
1	(Constant)	687.979	414.475	1.660*
	HAGE	2.354	3.868	.609
	HEDU	-4.080	17.837	-.229
	HHSIZE	-1.279	33.558	-.038
	PARCEL	27.507	58.978	.466
	LABR	1.739E-02	.058	.300
	FERTCOST	.647	.211	3.063***
	FSIZE	.353	.092	3.830***
	IRRIGATION	-1.416	2.330	-.608
	LOCDUMM1	327.524	106.113	3.087***
	SOILQ	-163.348	121.267	-1.347
	HH-GRUOP	-435.412	114.593	-3.800***
	R2	.155		
	F	7.271***		
	N	448		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

1.b: Determinants of rice income in Quang Nam, After Propensity Score Matching

cvoefficient		Beta	Std. error	t
1	(Constant)	802.584	568.834	1.411
	HAGE	1.620	5.603	.289
	HEDU	-3.575	27.144	-.132
	HHSIZE	-57.764	48.278	-1.196
	PARCEL	-88.477	79.119	-1.118
	LABR	.136	.075	1.808*
	FERTCOST	-.219	.268	-.818
	FSIZE	.704	.137	5.126***
	IRRIGATION	-1.015	2.443	-.416
	LOCDUMM1	352.631	154.093	2.288**
	SOILQ	-153.682	161.096	-.954
	HH-GRUOP	275.242	147.147	1.871**
	R2	.288		
	F	6.592***		
	N	191		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.a: Determinants of agriculture income in Quang Nam, Before Propensity Score Matching

coefficient		Beta	Std. error	t
	(Constant)	676.396	1144.996	.591
	HAGE	.386	10.711	.036
	HEDU	20.172	49.388	.408
	HHSIZE	244.631	92.268	2.651***
	PARCEL	-56.591	161.236	-.351
	LABR	.326	.150	2.177**
	FSIZE	.837	.255	3.278***
	IRRIGATION	-1.278	6.446	-.198
	LOCDUMM1	-20.449	293.801	-.070
	SOILQ	-693.622	334.692	-2.072**
	HH-GRUOP	-519.583	316.442	-1.642
	R2	.117		
	F	5.781***		
	N	448		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.b: Determinants of agriculture income in Quang Nam, After Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	747.549	1458.275	.513
	HAGE	-10.629	14.460	-.735
	HEDU	74.448	70.058	1.063
	HHSIZE	57.087	123.836	.461
	PARCEL	-375.122	203.360	-1.845*
	LABR	.188	.191	.983
	FSIZE	1.373	.355	3.872***
	IRRIGATION	3.292	6.291	.523
	LOCDUMM1	43.999	397.706	.111
	SOILQ	-454.103	414.477	-1.096
	HH-GRUOP	1331.287	370.420	3.594***
	R2	.226		
	F	5.258***		
	N	191		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.a: Determinants of total household income in Quang Nam, Before Propensity Score Matching

coefficient		Beta	Std. error	T
1	(Constant)	-1827.565	3284.288	-.556
	HAGE	34.039	31.651	1.075
	HEDU	193.441	145.665	1.328
	HHSIZE	1126.718	275.194	4.094***
	PARCEL	-308.560	477.510	-.646
	TOTASSET	.175	.020	8.824***
	FSIZE	1.179	.752	1.566
	IRRIGATION	-3.781	18.777	-.201
	LOCDUMM1	-56.198	863.734	-.065
	SOILQ	-2344.127	984.115	-2.382**
	HH-GRUOP	-2360.193	898.351	-2.627***
	R2	0.263		
	F	15.553***		
	N	448		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; TOTASSET= total assets (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.b Determinants of total household income in Quang Nam, After Propensity Score Matching

Coefficient		Beta	Std. error	t
1	(Constant)	-3944.720	3377.327	-1.168
	HAGE	52.147	34.912	1.494
	HEDU	333.779	168.452	1.981**
	HHSIZE	210.127	309.445	.679
	PARCEL	-928.559	497.574	-1.866*
	TOTASSET	.132	.024	5.580***
	FSIZE	2.939	.862	3.409***
	IRRIGATION	7.679	14.988	.512
	LOCDUMM1	771.874	950.348	.812
	SOILQ	-1112.865	1000.002	-1.113
	HH-GROUP	1080.706	887.976	1.217
	R2	0.309		
	F	8.039***		
	N	191		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; TOTASSET= total assets (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.a Determinants of per capita food consumpyion expenditure in Quang Nam, Before Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	1925.201	359.405	5.357***
	HAGE	2.780	3.425	.812
	HEDU	17.946	15.858	1.132
	HHSIZE	-177.458	30.271	-5.862***
	FSIZE	-5.356E-04	.058	-.009
	HHAI	3.737E-02	.016	2.410**
	IRRIGATION	.495	2.026	.244
	LOCDUMM1	193.621	95.048	2.037**
	SOILQ	256.259	109.131	2.348**
	HH-GRUOP	-181.792	98.975	-1.837*
	R2	0.108		
	F	5.873***		
	B	448		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; HHAI= total agriculture income of HH(VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.b Determinants of per capita food consumption expenditure in Quang Nam, <u>After</u> Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	1581.168	386.164	4.095***
	HAGE	-3.608	3.987	-.905
	HEDU	-7.091	19.307	-.367
	HHSIZE	-85.092	34.545	-2.463**
	FSIZE	1.459E-02	.069	.211
	HHAI	1.239E-02	.021	.603
	IRRIGATION	2.067	1.684	1.228
	LOCDUMM1	15.535	108.643	.143
	SOILQ	263.226	114.649	2.296**
	HH-GRUOP	285.299	105.440	2.706***
	R2	.105		
	F	2.351**		
	N	191		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; HHAI=total agriculture income of HH (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

Appendix A6: Estimated regression models on determinants of the key outcome indicators for the pooled sample households in HCMC/Tay Ninh

1.a. Determinants of rice income in HCMC/Tay Ninh, Before Propensity Score Matching

Coefficient		Beta	Std. error	t
1	(Constant)	2912.628	2201.219	1.323
	HAGE	-15.995	19.728	-.811
	HEDU	-4.153	91.734	-.045
	HHSIZE	-156.227	161.838	-.965
	PARCEL	-177.782	199.305	-.892
	LABR	.179	.070	2.577**
	FERTCOST	.325	.130	2.503**
	FSIZE	.144	.033	4.353***
	IRRIGATION	-4.899	14.505	-.338
	LOCDUMM1	514.137	503.321	1.021
	SOILQ	-357.302	920.761	-.388
	HH-GRUOP	220.367	572.196	.385
	R2	.143		
	F	6.807***		
	N	459		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

1.b. Determinants of rice income in HCMC/Tay Ninh, After Propensity Score Matching

coefficient		Beta	Std. error	t
1	(Constant)	4308.802	2873.316	1.500
	HAGE	-17.420	20.344	-.856
	HEDU	23.501	85.688	.274
	HHSIZE	-91.709	157.856	-.581
	PARCEL	-273.502	203.833	-1.342
	LABR	.370	.146	2.528**
	FERTCOST	-.169	.179	-.947
	FSIZE	.306	.052	5.852***
	IRRIGATION	-6.191	22.000	-.281
	LOCDUMM1	762.539	518.227	1.471
	SOILQ	-2886.723	1534.424	-1.881*
	HH-GRUOP	1006.290	499.953	2.013**
	R2	.298		
	F	7.144***		
	N	197		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.a Determinants of agriculture income in HCMC/Tay Ninh, Before Propensity Score Matching

coefficient		Beta	Std. error	t
	(Constant)	6298.603	4190.584	1.503
	HAGE	-93.359	37.583	-2.484**
	HEDU	103.365	174.650	.592
	HHSIZE	179.524	308.092	.583
	PARCEL	877.142	378.874	2.315**
	LABR	.102	.109	.932
	FSIZE	.416	.062	6.709***
	IRRIGATION	24.527	27.633	.888
	LOCDUMM1	-143.700	956.070	-.150
	SOILQ	-2887.138	1754.009	-1.646*
	HH-GRUOP	3709.297	1088.792	3.407***
	R2	.179		
	F	9.775***		
	N	459		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

2.b Determinants of agriculture income in HCMC/Tay Ninh, After Propensity Score Matching

coefficient		Beta	Std. error	t
	(Constant)	1608.615	6559.519	.245
	HAGE	-43.602	46.741	-.933
	HEDU	54.626	197.042	.277
	HHSIZE	442.963	362.626	1.222
	PARCEL	951.217	468.159	2.032**
	LABR	1.820E-02	.314	.058
	FSIZE	.726	.109	6.635***
	IRRIGATION	61.523	50.583	1.216
	LOCDUMM1	2820.835	1174.217	2.402**
	SOILQ	-7994.879	3405.884	-2.347**
	HH-GRUOP	2213.974	1141.229	1.940*
	R2	.356		
	F	10.292***		
	N	197		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; LABR=total labor cost incurred for rice cultivation (VND 000'); FERTCOST= total fertilizer cost for rice (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.a: Determinants of total household income in HCMC/Tay Ninh, Before Propensity Score Matching

coefficient		Beta	Std. error	t
	(Constant)	556.528	5391.290	.103
	HAGE	-61.636	48.668	-1.266
	HEDU	195.309	225.235	.867
	HHSIZE	2006.908	394.863	5.083***
	PARCEL	1720.253	489.880	3.512***
	TOTASSET	8.494E-02	.019	4.433***
	FSIZE	.277	.080	3.471***
	IRRIGATION	31.082	35.550	.874
	LOCDUMM1	-1765.049	1249.141	-1.413
	SOILQ	-4865.772	2271.618	-2.142**
	HH-GRUOP	5115.646	1520.446	3.365***
	R2	.259		
	F	15.650***		
	N	459		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; TOTASSET=total assets (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

3.b. Determinants of total household income in HCMC/Tay Ninh, After Propensity Score Matching

coefficient		Beta	Std. error	t
	(Constant)	-854.606	10430.002	-.082
	HAGE	28.789	76.758	.375
	HEDU	364.453	312.996	1.164
	HHSIZE	2056.918	569.227	3.614***
	PARCEL	1004.547	762.660	1.317
	TOTASSET	4.156E-02	.030	1.372
	FSIZE	.631	.172	3.659***
	IRRIGATION	45.612	80.278	.568
	LOCDUMM1	-1656.468	1928.197	-.859
	SOILQ	-10363.731	5395.276	-1.921*
	HH-GRUOP	4787.277	2095.915	2.284**
	R2	.291		
	F	7.643***		
	N	197		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.
Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; TOTASSET=total assets (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.a: Determinants of per capita food consumption expenditure in HCMC/Tay Ninh, Before Propensity Score Matching

Coefficient	Beta	Std. error	t
(Constant)	1203.230	319.552	3.765***
HAGE	2.984	3.002	.994
HEDU	14.156	13.856	1.022
HHSIZE	-182.097	24.181	-7.531***
FSIZE	1.795E-02	.005	3.538***
HHAI	6.674E-03	.004	1.792*
IRRIGATION	5.795	2.160	2.683***
LOCDUMM1	149.357	75.281	1.984**
SOILQ	-29.151	138.871	-.210
HH-GRUOP	433.620	86.565	5.009***
R2	0.230		
F	14.940***		
N	459		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; HHAI=total agriculture income of HH (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

4.b. Determinants of per capita food consumption expenditure in HCMC/Tay Ninh, After Propensity Score Matching

Coefficient		Beta	Std. erroe	t
	(Constant)	848.341	699.539	1.213
	HAGE	3.577	5.106	.701
	HEDU	15.368	21.087	.729
	HHSIZE	-261.791	39.050	-6.704***
	FSIZE	1.944E-02	.013	1.525
	HHAI	8.799E-03	.008	1.113
	IRRIGATION	9.098	5.403	1.684*
	LOCDUMM1	133.942	126.951	1.055
	SOILQ	237.761	375.591	.633
	HH-GRUOP	589.498	123.277	4.782***
	R2	0.325		
	F	9.997***		
	N	197		

***, ** and * indicate 1%, 5% and 10% probability levels of significance respectively.

Note: HAGE= Age of household head (years); HEDU= Education of HH head (schooling years); HHSIZE= Number of HH members; PARCEL= number of partcels owned by HH; HHAI=total agriculture income of HH (VND 000'); FSIZE= total cropped area (M2); IRRIGATION= % irrigated area; LOCDUMMY= 1 if farm is located at head-end canal and 0 therwise; SOILQ=Soil quality type-binary 1 if it is soil types 1-3 (good quality); and 0 for 4-6 (average quality); HH-GROUP=household group (1 if HH is from TG and 0 for CG).

Dependent variable is in VND 000'

Appendix A7: Methodology on application of propensity score matching technique

Let consider sample households representing the project areas where policy interventions took place in the selected irrigation schemes as 'treatment group' (TG); and their counterparts in the neighbouring project areas where no interventions took place as 'control group' (CG). In the absence of baseline information in both areas of TG and CG at the start of interventions, determination of a counterfactual is crucial to disassociate the effect caused by factors other than interventions on the outcome indicators. Thus, a simple difference between TG and CG after a few years of project intervention could not be exclusively attributable to such interventions. This is because the groups are heterogeneous with respect to non-outcome variables and therefore the comparison is not fair.

Although random sampling technique was followed to select sample households from TG and CG, sometimes the samples may not be closely similar with respect to non-outcome parameters. Then it will be very difficult to assess the impact of the project interventions unless sample households from both TG and CG are closely similar with respect to non-outcome variables. These non-outcome variables such as various socio-economic and biophysical features, which may not be influenced by initiation of policy interventions, but are likely to affect outcome variables such as farm income, total income and food expenditure.

Let Pi denote intention in the project areas i^{th} household. If i^{th} household belong to TG then $P_i = 1$, and otherwise (CG) Pi = 0. Consider key outcome variable income Y_{1i} for the i^{th} household of TG which indicates household income *Y* when P = 1. Then Y_{0i} for i^{th} household of CG, when P = 0. The expected gain, *G* from the project intervention can then be expressed as:

$$G = E(Y_{1i} - Y_{0i}) \mid P=1)$$

This is the conditional mean impact for i^{th} household due to the belonging to project area (TG) where intervention took place. It is sometimes called the average treatment effect or the average treatment effect. However *G* cannot consider as a gain in the income due to intervention in the project area, because there could be other unobservable variables that might be causing outcome variables in both Tg and CG groups.

$$D = E(Y_{ii} \mid P=1) - E(Y_{0i} \mid P=0)$$

Then *D* and *G* can be linked as

$$G = D + B$$

Then *B* is considered as a bias in the estimate, which can be expressed as

$$B = E(Y_{0i} \mid P=1) - E(Y_{0i} \mid P=0)$$

The reason why the differences in the impact between treated and untreated groups is not visible is due to the bias in the data. This may not have happened if the entire sample was randomly selected and then post-stratified into treatment and control group, which is a difficult task when interventions were took place at community level. Although both sample households for both groups have been randomly selected in this study, however they likely to give considerable biased results because the irrigation interventions were not took place at household level. Therefore it will underestimate or overestimate the effect of the project intervention. Sometimes, we will find that the project intervention is producing no benefit even though it is actually producing benefits.

To overcome the problem of this bias, two groups of households should be made comparable closely with respect to non-outcome variables. That is to select a control group, which is similar in character to the group of treated households. This is a difficult task if one were to do it manually as for each treated household and it would be difficult to find an identical control household. A propensity score matching technique suggested by Ravallion (2001) was applied to over the problem, and formed two comparison groups from the entire sample

This was done by regressing TG and CG which are given values 1 and 0 respectively on a set of non-impact independent variables such as age of the head of the household, family size, education of the head of the household, soil type, distance from main canal and so on for the pooled sample.

As dependent variable in this case is a binary, the logistic regression is estimated as for the pooled data (combined TG and CG), which may be expressed as

$P = a + b_1X_1 + b_2X_2 + \ldots + b_pX_p + e.$

Where *P* are binary values (*1* for TG, and *0* for CG), X_1, $X_2 \ldots X_n$ are selected non-outcome variables, *e* = random disturbance term

Estimated logit models were furnished in Appendix A8.

The probabilities of each sample household is calculated using the formula:

$P(1) = 1/(1 + e^{-p})$.

These probabilities (P(1)) are called propensity scores. Frequency distribution of computed propensity scores were presented in Appendix A9

Then sample households from TG, whose propensity scores are closely matched to those households from CG are selected and the rest eliminated, and formed two comparison groups (one for TG and other for CG). These comparison groups were finally considered for estimation of gain *G.*

$G = i(Y_{1i} \mid P=k) - E(Y_{0i}) \mid P=k\}$, where k is some constant range of propensity score, and that could be attributable mainly to the project interventions

Appendix A8: Estimated logistic regressions on factors influencing the proect intervention in the selected irrigation schemes

(a) Thanh Hoa

---------- Variables in the Equation ----------

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
HAGE	.0408	.0104	15.4652	1	.0001	.1687	1.0416
HHSIZE	-.2179	.0915	5.6696	1	.0173	-.0881	.8042
LOCATION			.9738	2	.6145	.0000	
LOCATION(1)	-.3241	.3304	.9620	1	.3267	.0000	.7232
LOCATION(2)	-.2076	.3219	.4159	1	.5190	.0000	.8125
DROUGHT(1)	2.2686	1.0919	4.3170	1	.0377	.0700	9.6661
FLOOD(1)	.9223	.7151	1.6631	1	.1972	.0000	2.5149
PARCEL	.5217	.0895	33.9859	1	.0000	.2601	1.6850
HGENDER(1)	.1501	.2779	.2918	1	.5891	.0000	1.1620
SOILQUA	.5224	.1330	15.4167	1	.0001	.1684	1.6861
Constant	-8.4517	1.5538	29.5857	1	.0000		

Estimation terminated at iteration number 4 because
Log Likelihood decreased by less than .01 percent.

-2 Log Likelihood	385.674
Goodness of Fit	361.433
Cox & Snell - R^2	.222
Nagelkerke - R^2	.299

Classification Table for GROUP
The Cut Value is .50

Observed	Predicted 0	Predicted 1	Percent Correct
0	0	166	83.00%
1	1	90	61.22%
	Overall		73.78%

Results of Propensity Matching

	Untreated	treated
0.31 to 0.69	155	114

(b) Quang Nam

---------- Variables in the Equation ----------

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
HAGE	.0115	.0077	2.2173	1	.1365	.0193	1.0116
HHSIZE	-.1130	.0751	2.2652	1	.1323	-.0213	.8932
LOCATION			1.4821	2	.4766	.0000	
LOCATION(1)	-.0957	.2711	.1247	1	.7239	.0000	.9087
LOCATION(2)	-.3394	.2838	1.4301	1	.2317	.0000	.7122
DROUGHT(1)	1.1661	1.2133	.9238	1	.3365	.0000	3.2095
FLOOD(1)	.7323	.3838	3.6413	1	.0564	.0530	2.0799
PARCEL	.6519	.0979	44.3453	1	.0000	.2690	1.9192
HGENDER(1)	-.0105	.2311	.0020	1	.9639	.0000	.9896
SOILQUA	-.4183	.1244	11.3087	1	.0008	-.1261	.6582
Constant	-.3686	.9376	.1545	1	.6943		

Estimation terminated at iteration number 3 because
Log Likelihood decreased by less than .01 percent.

-2 Log Likelihood	505.733
Goodness of Fit	436.651
Cox & Snell - R^2	.162
Nagelkerke - R^2	.223

Classification Table for GROUP
The Cut Value is .50

Observed	Predicted 0	1	Percent Correct
0	0	251	87.46%
1	1	66	40.99%
	Overall		70.76%

Results of Propensity Matching

	Untreated	treated
0.28 to 0.65	207	125

(c) HCMC/Tay Ninh

---------- Variables in the Equation ----------

Variable	B	S.E.	Wald	df	Sig	R	Exp(B)
HAGE	.0222	.0116	3.6718	1	.0553	.0532	1.0225
HHSIZE	-.1309	.1058	1.5290	1	.2163	.0000	.8773
LOCATION			12.2805	2	.0022	.1185	
LOCATION(1)	1.1246	.3773	8.8833	1	.0029	.1080	3.0790
LOCATION(2)	-.2118	.3896	.2954	1	.5868	.0000	.8092
DROUGHT(1)	1.4046	.9458	2.2053	1	.1375	.0187	4.0739
FLOOD(1)	.9586	1.0314	.8638	1	.3527	.0000	2.6080
PARCEL	.0799	.1219	.4295	1	.5122	.0000	1.0832
HGENDER(1)	.5614	.3277	2.9351	1	.0867	.0398	1.7532
SOILQUA	2.5712	.2483	107.2361	1	.0000	.4224	13.0819
Constant	-9.2617	1.1375	66.2994	1	.0000		

Estimation terminated at iteration number 5 because
Log Likelihood decreased by less than .01 percent.

-2 Log Likelihood	294.421
Goodness of Fit	2273.075
Cox & Snell - R^2	.474
Nagelkerke - R^2	.656

Classification Table for GROUP
The Cut Value is .50

Observed	Predicted 0	Predicted 1	Percent Correct
0	286	16	94.70%
1	39	118	75.16%
		Overall	88.02%

Results of Propensity Matching

	Untreated	treated
0.18 to 0.5	75	95

Appendix A9: Frequency distribution of sample households based on propensity scores in the selected provinces/irrigation schemes

(a) Thanh Hoa

Range	Group			
	Rehabilitated and TA area		Non-rehabilitated and non-TA area	
	N	%	N	%
0.00 to 0.10	8	5.4	12	6.0
0.11 to 0.20	14	9.5	48	24.0
0.21 to 0.30	***7***	***4.8***	***7***	***3.5***
0.31 to 0.40	***17***	***11.6***	***18***	***9.0***
0.41 to 0.50	***13***	***8.8***	***13***	***6.5***
0.51 to 0.60	***22***	***15.0***	***22***	***11.0***
0.61 to 0.70	***20***	***13.6***	***20***	***10.0***
0.71 to 0.80	***30***	***20.4***	***31***	***15.5***
0.81 to 0.90		0.0	14	7.0
0.90 to 1.00	16	10.9	15	7.5
Total	147	100	200	100

Note: Bolded and italicized ranges were considered as the closest matches for final analysis

(b) Quang Nam

Range	Group			
	Rehabilitated		Non-rehabilitated	
	N	%	N	%
0.00 to 0.10	5	3.1	19	6.6
0.11 to 0.20	31	19.4	49	17.1
0.21 to 0.27	15	9.4	72	25.1
0.28 to 0.30	***14***	***8.8***	***15***	***5.2***
0.31 to 0.40	***23***	***14.4***	***26***	***9.1***
0.41 to 0.50	***16***	***10.0***	***18***	***6.3***
0.51 to 0.60	***15***	***9.4***	***17***	***5.9***
0.61 to 0.70	***12***	***7.5***	***13***	***4.5***
0.71 to 0.80	***10***	***6.3***	***12***	***4.2***
0.81 to 0.90	11	6.9	25	8.7
0.91 to 1.00	8	5.0	21	7.3
Total	160	100	287	100

Note: Bolded and italicized ranges were considered as the closest matches for final analysis

HCMC/Tay Ninh

Range	Group			
	Improved infrastructure and management		Non-improved infrastructure and management	
	N	%	N	%
0.00 to 0.10	7	4.5	35	11.6
0.11 to 0.14	7	4.5	44	14.6
0.15 to 0.20	6	3.8	14	4.6
0.21 to 0.30	***5***	***3.2***	***5***	***1.7***
0.31 to 0.40	***11***	***7.0***	***12***	***4.0***
0.41 to 0.50	***10***	***6.4***	***10***	***3.3***
0.51 to 0.60	***14***	***8.9***	***16***	***5.3***
0.61 to 0.70	***8***	***5.1***	***9***	***3.0***
0.71 to 0.80	***12***	***7.6***	***12***	***4.0***
0.81 to 0.90	***23***	***14.6***	***23***	***7.6***
0.90 to 0.94	***7***	***4.5***	***14***	***4.6***
0.95 to 1.00	47	29.9	108	35.8
Total	157	100	302	100

Note: Bolded and italicized ranges were considered as the closest matches for final analysis

Appendix A10.a: Season-wise (per planted area) cost-return profile for rice cultivation in Thanh Hoa

(VND 000' per planted area)

Particulars	Rehabilitated and TA area	Non-rehabilitated and non-TA area	% Difference	t test
SEASON-1				
Area planted (M^2)	1941	938	107.0	5.0***
Own labour cost	522	327	60.0	3.0***
Purchased input cost	675	385	75.3	4.2**
Total cost	1197	711	68.3	4.1***
Paddy output (kg)	1320	573	130.4	8.2***
Paddy price received (000 VND/kg)	1.71	1.75	-2.5	-0.8
Gross value of rice production	2248	996	125.9	6.3***
Net return	1051	284	270.1	4.5***
Farm operating surplus	1574	611	157.7	5.8***
SEASON-2				
Area planted (M^2)	1941	938	107.0	5.0***
Own labour cost	521	354	47.3	3.1***
Purchased input cost	633	359	76.2	3.7***
Total cost	1154	713	61.9	4.0***
Paddy output (kg)	1360	510	166.7	10.3***
Paddy price received (000 VND/kg)	1.70	1.77	-3.5	-0.8
Gross value of rice production	2290	899	154.8	6.7***
Net return	1136	186	511.1	6.1***
Farm operating surplus	1657	540	207.1	6.4***

Note: Since average area planted rice during season-3 was only 180 mt^2 and 10 mt^2 in rehabilitated and TA area and non-rehabilitated and non-TA area respectively, cost-return details were not furnished separately for season-3, but they were included for all seasons-average.

Appendix A10.b: Season-wise (per hectare) cost-return profile for rice cultivation in Thanh Hoa

(VND 000' per hectare)

Particulars	Rehabilitated and TA area	Non-rehabilitated and non-TA area	% Difference	t value
SEASON-1				
Area planted (M^2)	1941	938	107.0	5.0***
Own labour cost	2691	3482	-22.7	-0.1
Purchased input cost	3476	4105	-15.3	-1.2
Total cost	6167	7587	-18.7	-0.7
Yield (tones/ha)	6.8	6.1	11.8	7.8***
Paddy price received (000 VND/kg)	1.71	1.75	-2.5	-0.8
Gross value of rice production	11584	10617	9.1	6.0***
Net return	5416	3030	78.8	4.5***
Farm operating surplus	8108	6512	24.5	6.4***
Unit cost of rice production (000`VND/ton)	512	676	-24.3	-3.9***
SEASON-2				
Area planted (M^2)	1941	938	107.0	5.0***
Own labour cost	2684	3772	-28.8	0.2
Purchased input cost	3261	3831	-14.9	-1.6*
Total cost	5945	7603	-21.8	-0.6
Yield (tones/ha)	6.9	5.4	27.6	12.3***
Paddy price received (000 VND/kg)	1.70	1.77	-3.5	-0.8
Gross value of rice production	11797	9586	23.1	9.6***
Net return	5852	1982	195.2	7.3***
Farm operating surplus	8536	5754	48.3	8.7***
Unit cost of rice production (000`VND/ton)	471	706	-33.3	-4.9***

Note: Same as in appendix 10.a

Appendix A11.a: Season-wise (per planted area) cost-return profile for rice cultivation in Quang Nam

(VND 000' per planted area**)**

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
SEASON-1				
Area planted (M^2)	1532	1350	13.4	1.3
Own labour cost	401	460	-12.9	-0.2
Purchased input cost	767	592	29.5	2.1**
Total cost (000 VND)	1168	1052	11.0	1.0
Paddy output (Kg)	1006	770	30.7	2.4**
Paddy price received (000 VND/kg)	1.81	1.73	4.3	0.9
Gross value of rice production	1819	1332	36.6	4.0***
Net return	652	280	132.9	3.0***
Farm operating surplus	1052	740	42.2	3.0***
SEASON-2				
Area planted (M^2)	1550	1350	14.8	1.4*
Own labour cost	418	460	-9.1	-0.1
Purchased input cost	763	589	29.4	2.4**
Total cost	1181	1050	12.5	1.3
Paddy output (Kg)	973	762	27.8	2.3**
Paddy price received (000 VND/kg)	1.77	1.73	2.3	0.3
Gross value of rice production	1722	1318	30.6	3.6***
Net return (000 VND)	541	269	101.3	2.7**
Farm operating surplus (000VND)	959	729	31.6	2.7***

Appendix A11.b: Season-wise (per hectare) cost-return profile for rice cultivation in Quang Nam

(VND 000' perha**)**

Particulars	Rehabilitated	Non-rehabilitated	% Difference	t value
SEASON-1				
Costs				
Own labour cost	2618	3409	-23.2	-1.8*
Purchased input cost	5006	4385	14.2	0.2
Total cost	7624	7794	-2.2	-1.2
Returns				
Yield (tones/ha)	6.6	5.7	15.4	1.8*
Paddy price received (000 VND/kg)	1.81	1.73	4.3	0.9
Gross value of rice production	11878	9867	20.4	1.6
Net return	4254	2073	105.3	2.3**
Farm operating surplus	6872	5482	25.4	2.3**
Unit cost of rice production (000VND ton)	761	770	-1.1	-1.5*
SEASON-2				
Costs				
Own labour cost	2699	3409	-20.8	-1.8*
Purchased input cost	4920	4366	12.7	0.1
Total cost	7619	7775	-2.0	-1.2
Returns				
Yield (tones/ha)	6.3	5.6	11.2	1.6*
Paddy price received (000 VND/kg)	1.77	1.73	2.3	0.3
Gross value of rice production	11108	9766	13.7	0.8
Net return	3489	1990	75.3	2.1**
Farm operating surplus	6188	5399	14.6	1.9*
Unit cost of rice production (`000 VND ton)	784	774	1.3	-1.5*

Appendix A12.a: Season-wise (per planted area) cost-return profile for rice cultivation in hcmc/Tay Ninh

(VND 000' per planted area)

Particulars	Improved infrastructure and management	Non-improved infrastructure and management	% Difference	t value
SEASON-1				
Area planted (M^2)	4286	2727	57.2	2.6**
Own labour cost	688	465	47.9	1.4*
Purchased input cost	1671	987	69.2	3.2***
Total cost	2359	1453	62.4	3.1***
Paddy output (kg)	1910	1001	91.0	6.3***
Paddy price received (000 VND/kg)	1.28	1.07	18.8	4.6***
Gross value of rice production	2445	1071	128.3	5.9***
Net return	86	-382	-122.5	-2.2**
Farm operating surplus	774	83	827.6	2.5***
SEASON-2				
Area planted (M^2)	5068	3785	33.9	1.2
Own labour cost	623	402	55.1	0.8
Purchased input cost	1776	1193	48.9	3.7***
Total cost	2399	1594	50.5	3.5***
Paddy output (kg)	1923	1201	60.1	6.1***
Paddy price received (000 VND/kg)	1.44	1.18	22.8	5.6***
Gross value of rice production	2769	1417	95.4	5.3***
Net return	370	-178	-308.1	2.0
Farm operating surplus	992	224	343.3	2.3
SEASON-3				
Area planted (M^2)	3152	3079	2.4	1.0
Own labour cost	325	292	11.1	0.9
Purchased input cost (000 VND)	1106	976	13.3	2.0*
Total cost	1431	1268	12.8	1.9*
Paddy output (kg)	1251	1044	19.8	3.1***
Paddy price received (000 VND/kg)	1.54	1.57	-1.8	-1.4*
Gross value of rice production	1926	1639	17.5	2.5**
Net return (000 VND)	495	371	33.6	1.1
Farm operating surplus (000VND)	820	663	23.7	1.2

Appendix A12.b: Season-wise (per hectare) cost-return profile for rice cultivation in hcmc/Tay Ninh

(VND 000' per ha)

Particulars	Improved infrastructure and management	Non-improved infrastructure and management	% Difference	t value
SEASON-1				
Costs				
Own labour cost	1606	1707	-5.9	-2.2**
Purchased input cost	3898	3621	7.6	0.7
Total cost	5504	5328	3.3	0.2
Returns				
Yield (tones/ha)	4.5	3.7	22.3	4.7***
Paddy price received (000 VND/kg)	1.28	1.07	18.8	4.6***
Gross value of rice production	5704	3927	45.3	5.2***
Net return	200	-1401	-114.3	2.3**
Farm operating surplus	1806	306	490.2	2.0**
Unit cost of rice production ((000VND/ton)	872	990	-12	1.5*
SEASON-2				
Costs				
Own labour cost	1229	1061	15.8	-2.4**
Purchased input cost	3505	3151	11.2	1.1
Total cost	4734	4212	12.4	0.4
Returns				
Yield (tones/ha)	3.8	3.2	18.9	5.7***
Paddy price received (000 VND/kg)	1.44	1.18	22.8	5.6***
Gross value of rice production	5463	3743	46.0	4.9**
Net return	729	-469	-255.4	2.1**
Farm operating surplus	1958	591	231.1	1.7*
Unit cost of rice production (000VND /ton)	927	991	-6.5	1.0
SEASON-3				
Costs	3152	3079	2.4	1.0
Own labour cost	1030	949	8.5	-1.7 *
Purchased input cost	3509	3169	10.7	0.0
Total cost	4538	4119	10.2	-0.4
Returns				
Yield (tones/ha)	4.0	3.4	16.9	2.6 **
Paddy price received (000 VND/kg)	1.54	1.57	-1.8	-1.4 *
Gross value of rice production	6110	5323	14.8	2.0 **
Net return	1572	1205	30.5	1.4 *
Farm operating surplus	2602	2154	20.8	1.1
Unit cost of rice production (000VND /ton)	883	932	-5.3	0.3