Impact Evaluation of Mae Lao Irrigation improvement project, Thailand

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Final report

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Abstract

The aim of the study is to make an estimate of the impact of the Mae Lao Irrigation Improvement Project (MLIIP), a component of the Sector Program Loan (ASPL) funded by Asian Development Bank (ADB) and the Japan Bank for International Cooperation (JBIC) between 2000 & 2003. This intervention invested in irrigation infrastructure construction, Water Users Association development, and agricultural technology extension.

The Impact Evaluation (IE) was based on comparison of farm plots and farm households within MLIIP areas which were expected to be affected in different ways, and comparable farm plots and farm households in neighbouring irrigation schemes not subject to the intervention. The IE focussed on the Mae Lao irrigation project (Mae Lao), and the comparison areas are within the Chiang Rai, Tamwok and Chaisombat irrigation projects[1].

Fieldwork during the study suggests that the design was partly confounded by parallel interventions made by RID in the non-intervention schemes; all schemes appear to have received some intervention during the study reference period (2000-2010).

Nevertheless, the study research included a recall component providing some before-after comparison. Although we find some perceived improvement in sufficiency and quality of water supply, and areas irrigated, these are no greater on Mae Lao than on the comparison schemes, especially Chiang Rai. We found no improvements in rice crop productivity that we could identify with the intervention. Thus the impact evaluation has been vitiated by contamination of the control group which had access to alternative interventions funded directly by the Government of Thailand. Impact evaluations using ex-post observational data are exceptionally problematic especially when access has to be negotiated through organisations which have not taken ownership of the evaluation, and, or may be implicated in the outcome of the evaluation.

[1] In the IE proposal we identified the Mae San irrigation as a suitable comparison project, but fieldwork revealed that it differed in significant ways from Mae Lao, and the comparison sites mentioned were chosen instead (see inception report).

Main Report: Impact Evaluation of Mae Lao Irrigation Improvement Project[2]

Introduction

Although Thailand is a middle income country agriculture remains an important component of the economy as a source of Gross Domestic Product (GDP), of exports, and employment, and plays a key role in poverty reduction (ODI, 2011). A high proportion of agriculture in Thailand is irrigated and irrigation is heavily supported by the Government of Thailand; some 60% of the Ministry of Agriculture (MoA) budget is allocated to the Royal Irrigation Department (RID) (Boonkerd et al., 2002). However, irrigation performance is widely perceived as unsatisfactory (Mongkolsmai, 1983; Mainuddin et al., 2000; Wongtragoon et al., 2012; Shivakoti and Bastakoti, 2004).

The Agricultural Sector Loan Project (ASLP) jointly funded by the Asian Development Bank (ADB) and the Japanese International Cooperation Agency (JICA) aimed to improve the productivity and sustainability of agriculture in Thailand (ADB, 2003) and its successor ASLP II included a substantial component for Water Resource Use and Management, and Cost Recovery (ibid:3). The ASLP ran from 1999 to 2003, and included improvement of the Mae Lao Irrigation Project (MLIP) as one of the pilot projects for the following objectives:

(i) promote participatory irrigation management (PIM) through training of Royal Irrigation Department (RID) staff and the use of irrigation community organizers (ICOs);

(ii) implement pilot schemes to contract out operation and maintenance (O&M) to the private sector;

(iii) adopt transparent procedures for selecting and implementing village pond construction programs; and

(iv) develop and implement a phased program for cost recovery in irrigation schemes.

Irrigation is a major user of scarce water, and water in irrigation is of low value compared to other uses, and is widely mismanaged. Improvements in irrigation management are crucial to the sustainable development of agricultural productivity in monsoon climates such as much of South and Southeast Asia (UNDP, 2006) and water security (UNESCO, 2012). Most medium and large scale irrigation are characterised by inefficient and inequitable water allocation. Improvement in irrigation efficiency and equity may be achieved through various infrastructural, water management (including cost recovery and water pricing), and agricultural improvements (Barker and Molle, 2004). The MLIP improvements planned under the ASPL were envisaged as a pilot project which corresponded to widely supported

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[2] This IE has been significantly delayed; in part this is due to changes in staff at CPPE, and associated delays, as detailed in working reports. The quality of the IE has been significantly impacted by this.

interventions to improve irrigation efficiency and equity, and hence an evaluation of the extent to which these objectives were achieved would be of considerable significance within the Thailand, the region and more widely.

Knowledge Gaps addressed by the study

At the same time skills and methods for assessment of irrigation projects are limited and challenging. The Impact Evaluation aimed to develop local skills in IE[3], and to test a method of IE for irrigation improvement interventions. Indeed the original objectives for this evaluation emphasised more the development of skills in IE within the particular institution (CPPE of OAE) than the particular evaluation chosen. However, the importance of irrigation in Thailand already noted (and more widely in Southeast Asia) makes it an important case.

Evaluation questions

The IE had the primary objective of exposing CPPE to modern IE methods, through the case study of the IE of expenditure funded through the ASPL on the MLIP.

The primary evaluation questions with regard to ASPL expenditure on the MLIP were:

1. what are the impacts of irrigation infrastructure improvements in the Mae Lao Irrigation Project on immediate (water availablitiy), intermediate (farm productivity), and ultimate outcome (household well-being) variables
2. what are the impacts of formation and support of Water Users' Association in the Mae Lao Irrigation Project on immediate, intermediate and final outcome variables?
3. What are the impacts of support for agricultural extension within the context the MLIP irrigation improvement project on intermediate and final outcomes?

Study design

Evaluation of irrigation schemes is particularly difficult if only because of their individual unique agro-ecological, hydro-geological and socio-economic features; at the same time they are relatively large and internally diverse. Sampling requirements are consequently high if many schemes are to be included in the study. Alternatively, a case or case control study can be used, but this militates against statistical inference, and is vulnerable to "cherry picking" (using cases which are decidedly "untypical").

Nevertheless, methods for assessing impact can be illustrated within a case study framework. In an attempt to add leverage to this method we included limited control cases, making the evaluation into a case-control study. Thus the IE aimed to initiate filling of the skills gap and to provide experience in impact evaluation methods. The specific evaluation questions were whether there were any improvements in irrigation

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[3] A short course in Impact Evaluation methods was given for CPPE staff members in Bankok18-22/12./2009. The course was of limited value because of lack of English language skillsand limited translation facilities, together with a decision by CPPE to use SPSS and Eviews rather than Stata (or R).

water supply, agricultural productivity and household well-being on the Mae Lao Irrigation Project that could be attributed to the ASPL.

The study uses a quasi-experimental design observational study; given that the ASPL ended in 2004 – more than 5 years prior to this study there was no possibility of experimental intervention. Irrigation schemes are not homogenous. The study design aimed to exploit within scheme variation, variation between on-scheme irrigated and irrigable areas and off-scheme unirrigated areas, and between-scheme variation in a cross section survey. The survey data would enable identification of the impact of the various interventions using statistical control analysis of individual farm plots and households owning or cultivating these plots. Thus the design aimed to assess the impacts of different treatments (infrastructure improvement, WUA formation, and access to Agricultural Extension) using different locations within and off the treatment irrigation scheme (MLIP) and similar on non-treatment schemes in the locality (Shiang Rai, Tamwok and Chaisombat). All schemes are based on gravity flow, run-of river diversion weirs (barrages), although the dry season irrigation supply is augmented by limited storage in the Mai Suai dam upstream of all schemes.

While the agro-ecology of the area is relatively homogeneous, and farm plots at the tail ends and neighbouring the boundaries of the irrigation schemes are similar, the nature of soils and access to canal, surface and ground water are inevitably confounded by position within the uni-directional hydro-geological environment. We aimed to proxy these location with environmental and distance parameters in our estimation functions.

Context

The north of Thailand has a sub-humid tropical climate, receiving a south-west monsoon between the months of May and September when most of the rain falls (see Figure 1). The remainder of the year receives less rain than common crops demand making substantial opportunities for supplementary and full irrigation (Marten, 1986). Rice is the dominant crop in this period and is also grown with irrigation in the dry season. Various vegetables, fruits and tobacco are also common in the dry season.

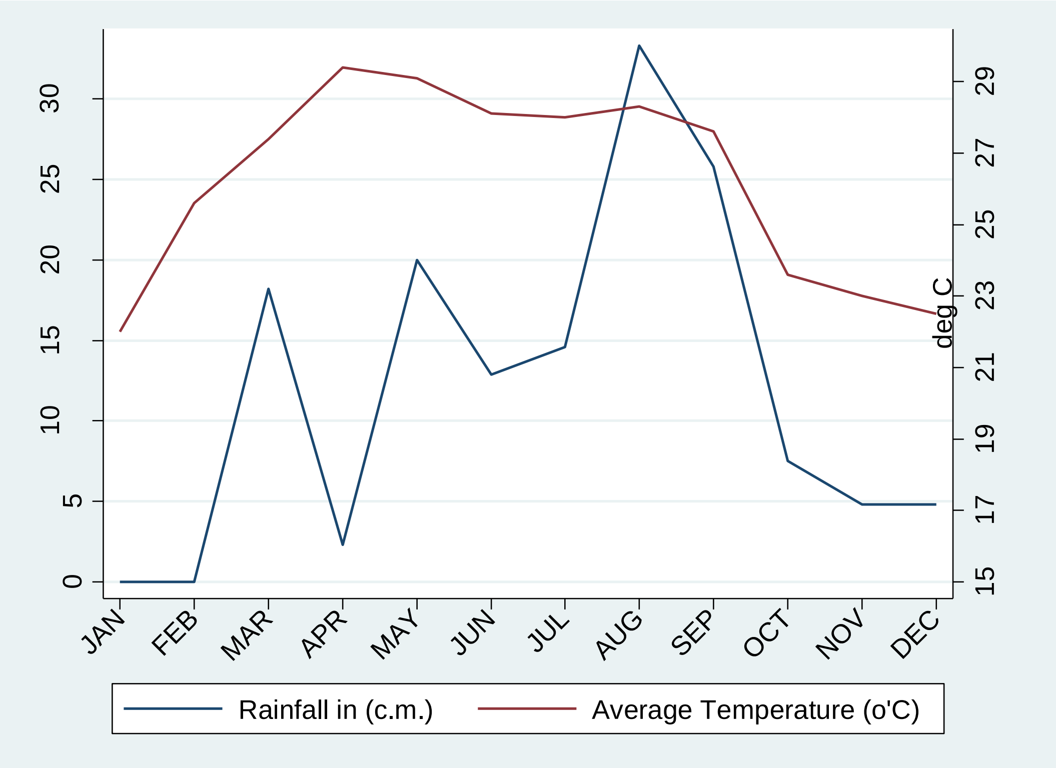


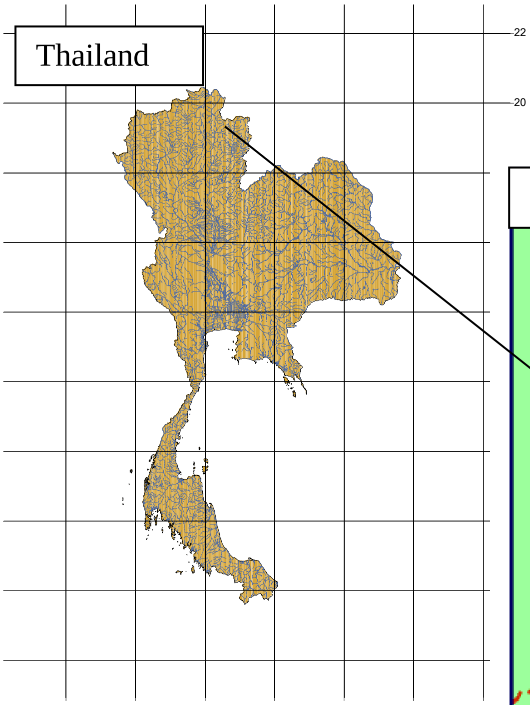
Figure 1: Average Monthly Temperature and Rainfall, Northern Thailand

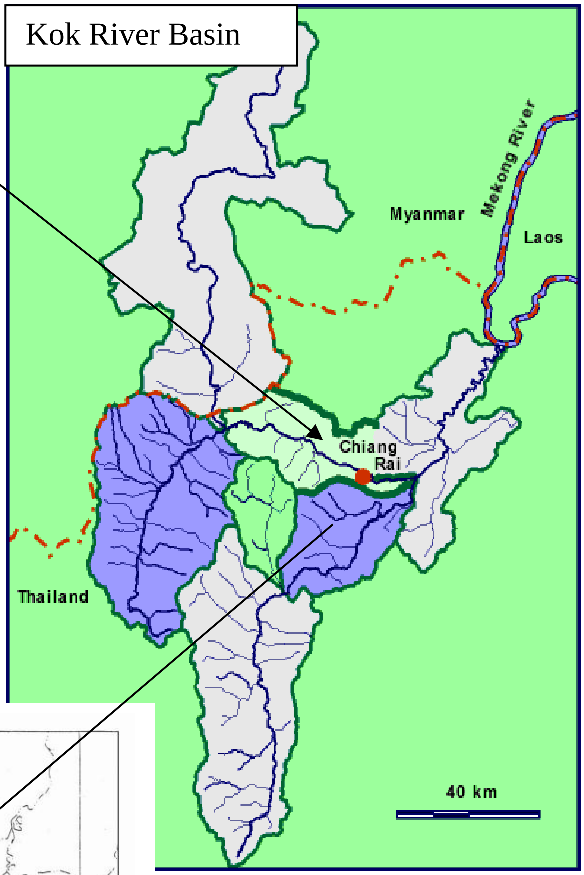
Description of Mae Lao Irrigation Project

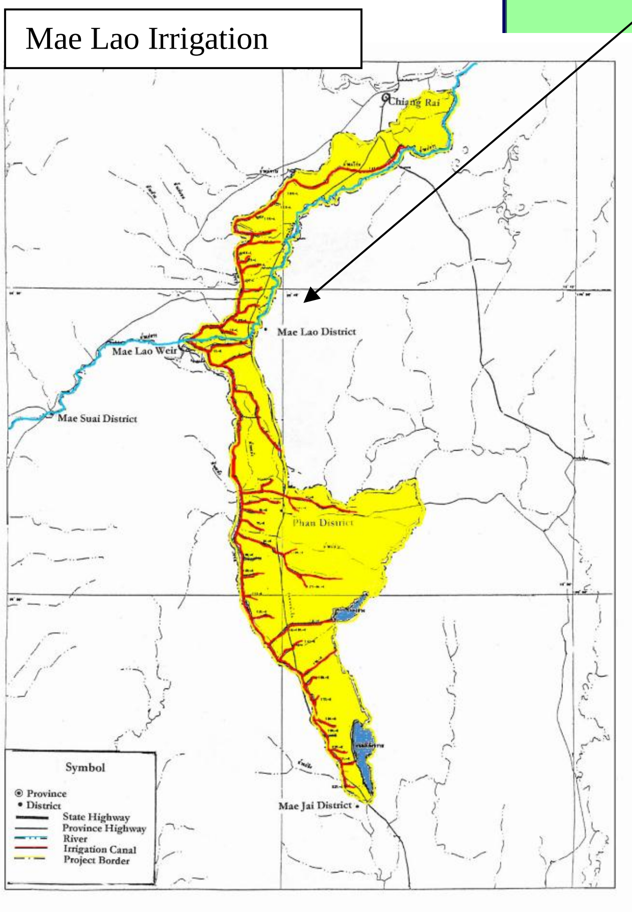
The Mae Lao Irrigation Project (MLIP) is a medium-large scale irrigation project of the Royal Irrigation Department (RID) in the north of Thailand (N19 42', E99 39') in the Kok River Basin in the north of Thailand, Chiang Rai Province (see Map 1). MLIP is supposed to provide supplemental irrigation in the wet season and, in conjunction with the Mai Suai dam, immediately upstream of the Mae Lao barrage, to provide water for dry season irrigation. There is insufficient storage in the Mai Suai dam to provide water for the entire irrigable area leading conflicts in the allocation of water (Wontragoon et al., 2012).

MLIP received substantial funds between 2000 and 2003 under the Agricultural Sector Program Loan (ASPL) project funded mainly by the Asian Development Bank and the Japanese International Aid Corporation (JICA). ASPL funded irrigation improvements (ASPLII) to the physical infrastructure, to canal and on-farm water management mainly through promotion of Water Users Associations (WUA), and to agricultural extension.

Construction of the first MLIP was initiated in early 1950s and completed in 1960s. The MLIP improvement project under the ASPL loan took place between 2001 and 2004. The headworks were improved, and main canals and some secondaries were lined; drop structures and a drainage system were (re-)constructed. Water Users Associations and agricultural extension were supported. Improvements to the canal infrastructure after ASPL funds were exhausted proceeded with GoTh funds.







Map 1Mae Lao Study Sites

The total potential command area of Mae Lao weir is some 28,160 hectares (176,000 rai), of which the canal system commands some 23,734 hectares (148,343 rai). Supplemental irrigation is provided at the beginning of the monsoon to enable transplanting of rice seedlings, and at the end of the monsoon if the monsoon is inadequate. Irrigation is scheduled for cultivation in the dry season to areas by arrangement between MLIP and the WUAs. The area receiving irrigation in the dry season is some 80,000 rai, for which the supply of irrigation water barely suffices so that it has to be rationed by implementing rotational irrigation (IRRI, 1978; Plusquellec, 2002). Farmers often circumvent planned cropping schemes, taking risks in planting crops which will require irrigation in areas scheduled for dry cultivation, in the hope that irrigation supplies will suffice. In the event of consequent water shortages farmers interrupt scheduled water supplies especially in the dry season leading to inefficient and chaotic allocations of water. Water management problems in the dry season are built into MLIP by its physical structure which was designed for supplemental irrigation by continuous flow in the wet season when water supply is not limited. Various schemes for water rationing have been tried, and Participatory Irrigation Management through WUA was expected to play the major role in bringing order, efficiency and equity to the allocation of water (Wongtragoon et al., 2012).

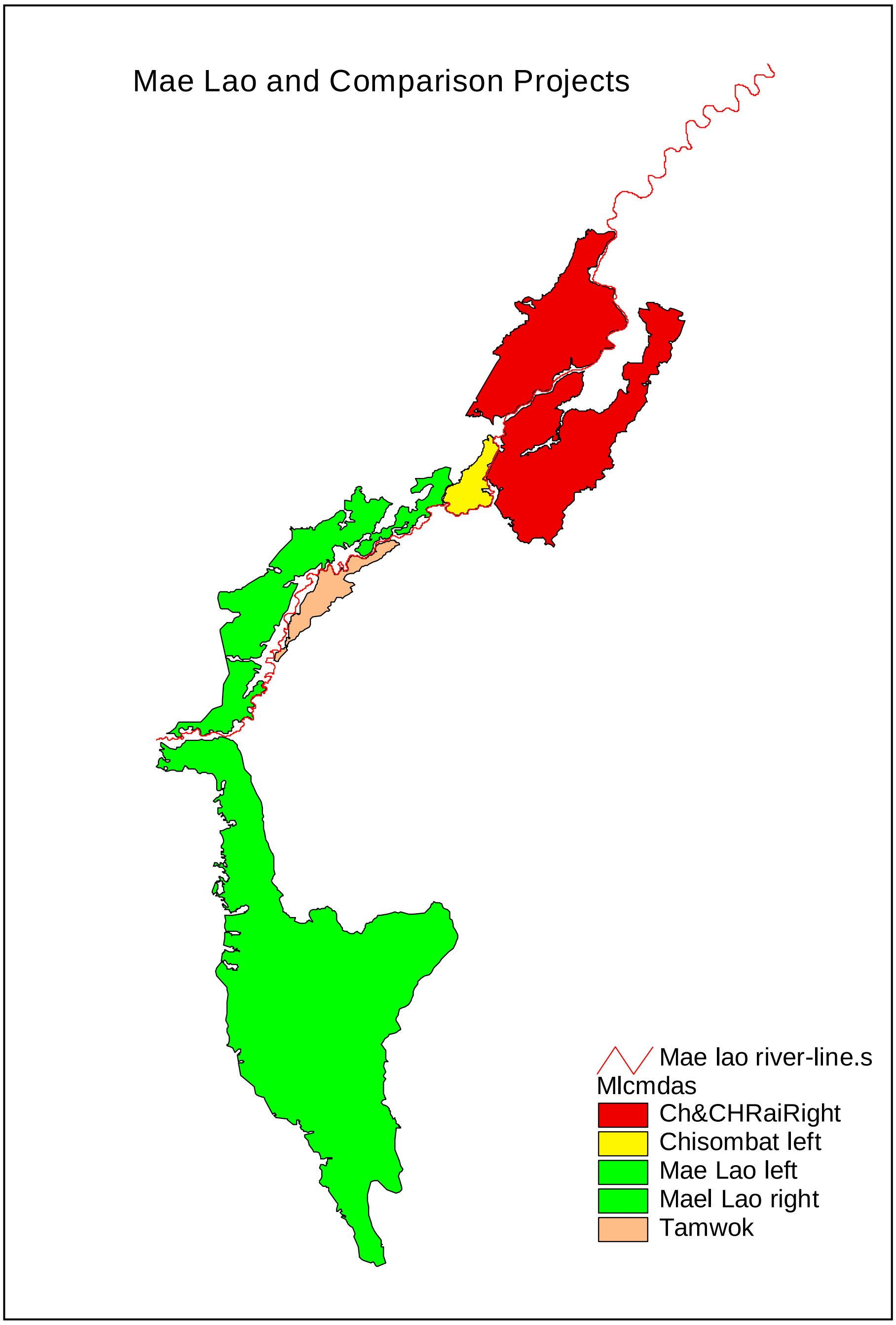
The improvements implemented through the ASPL project were phased and had some impact on cropping patterns; farmers in areas where canals were being modernised may have lacked irrigation in the dry season for one year, although there may also have been interruptions to supplies in other years and seasons affecting their farm economy.

Comparison projects

In order to construct a counterfactual three nearby irrigation projects that did not receive irrigation improvements under ASPL and were described as unimproved, were chosen. The locations of these projects are shown in Map 2.

Map 2 Location of Irrigation schemes

The three comparison projects are immediately downstream of MLIP and within the same agro-ecological region. They are in the immediate vicinity of Chiang Rai city.



Structure of the Report

The report is structured as follows; first we set out the design of the evaluation study in more detail, particularly the farm plot and household survey. Various features of the design and survey were innovative in the context. We then report results of the survey, focusing on data required to identify the outcome variables at various stages in the causal chain, and to identify the treatment variables – position in the infrastructure, infrastructure improvement, membership of WUA, and access to agricultural extension. We then report results, and provide a discussion of the outcomes. Various appedicies provide information on the details of the field survey procedures, and results not reported in detail in the text.

Intervention and Theory of Change

Details of the intervention have been given above. Further details (locations, schedules, expenditures, etc.), are not available.

Effects of Scheme

In this section we attempt to identify impacts of the MLIIP on water related problems, crop productivity and household income and expenditure. The survey reports respondent's answers to several questions relevant to the impact of the scheme. As noted above in the section headed "Project Participation" we can compare Mal Lao with the four comparison projects, we can estimate the effects of distance on productivity to assess if there remain any bottom end problems, we assess changes in perceived water relater problems, and we can see whether remaining reported water related problems impact of productivity. We can also explore reported membership WUA and its relation with reported water problems and crop productivity.

The main activities of the scheme were to improve the canal infrastructure, provide agricultural extension promoting mainly improved crop varieties and husbandry, and, most importantly, improve the organisation and activities of Water Users' Associations. The survey does not record agricultural extension or crop husbandry activities, but does provide information on a plot by plot basis of the availability of irrigation water before and after the project (sheet 2.1) and general household level responses to the sufficiency of irrigation water before and after the project (section 7.1).

Theory of Change

The simple logic of our analysis of the impact of ASLP is shown in Figure 2 below.

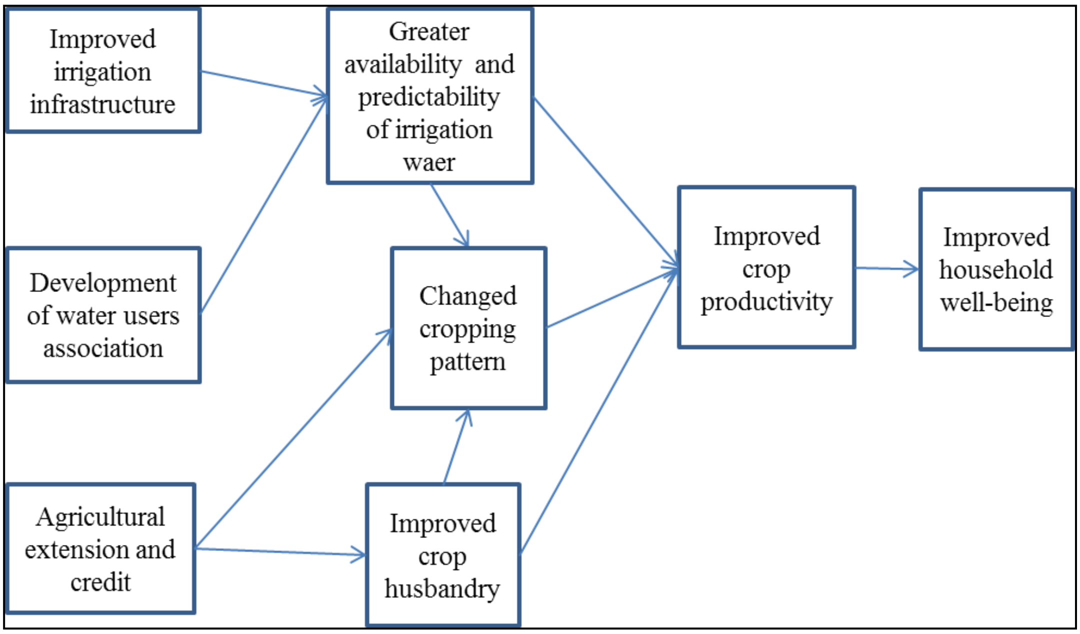


Figure 2: Causal Logic of Impact of ASLP

Lacking physical/hydrological information on the availability and use of irrigation water of or agricultural extension information transfer, we explore whether respondents report that plots have improved their access to irrigation infrastructure, and whether this is associated with improved crop productivity or net incomes. In doing so we attempt to control for variables such as distance from water source, previous poor access to water (reported as problems with water supplies), and other plausible factors which could confound relationships between scheme inspired improved irrigation access and the outcome variables mentioned.

Measurement of Impact – project theory

In order to appreciate what follows it is important to understand the impact measurement strategy embodied in the research design. It was assumed that the project would impact on income and well-being primarily through improving the availability, predictability and controllability of irrigation water supply to farmers, through infrastructure and WUA investments, in ways that would, together with agricultural extension, enable them to adopt more profitable crops, and invest more in crop production raising physical and economic productivity. The research design aimed to enable estimation of impacts of multiple treatments on various intermediate and outcome variables. Thus, to the extent that the project had primary impacts they would be reported through a farm management questionnaire, and reflected in higher gross and net productivity associated with factors representing the activities of the project. Prior to field visits it was not clear how treatments could be assessed, although conceptually it would be possible to identify three binary variables reflecting improved infrastructure, MWU membership and receipt of agricultural extension. Alternatively, one or more of the treatments could be represented by continuous or ordinal variables (quality of water supply infrastructure, quality of WUA, number of agricultural extension messages or improved agricultural practices, for example). In the event sufficient information on agricultural extension and WUA could not be collected.

The opportunity for irrigation in northern Thailand arises because of the decline in rainfall towards the end of the main rice growing season from September, and the following six months of negligible rainfall until the monsoon arrives in May-June (Figure 1). Thus added irrigation water should enable higher yields on monsoon rice, and additional and higher productivity cropping in the dry season from November through to May. Irrigation would also enable earlier and more secure raising of seedlings and transplantation to the field as irrigation water could be delivered in May and June when intermittent rainfall can delay and or otherwise harm planting.

We further assumed, congruent with reports from informal interviews with project staff and project documents, that the problems of the scheme prior to implementation lay in the limited ability to deliver water to the full requirements of the command area in the dry season (see also Wongtragoon et al., 2012), and hence shortages of water at greater effective distances from the water source (the Mae Lao diversion).

Thus it was expected that plots at a greater effective distance from the diversion (effective in the sense of accounting for distance the water flowed in canals of different types) the lower the land productivity would be, whether measured in terms of a given crop, or in terms of cropping pattern. Lower productivity plots and lower complementary crop inputs were expected to be more characteristic as distance increased. Plots without access to irrigation water would also have lower productivity.

By classifying plots by access to irrigation water and estimating the change in plot status after the project activities, we would be able to assess the effect of the project on the distribution of relevant plot characteristics and their association with productivity. It was assumed that some plots on Mae Lao, and most of those on the comparison project would approximate the condition of plots which suffered water shortage on Mae Lao prior to MLIIP.

Plot productivity

The impact of interventions would be initially assessed be estimating changes in farm plot productivity. Current productivity (y_i) will be assessed through econometric estimation using a plot survey. Plot productivity on Mae Lao would have changed in the absence of the ASPLII, but is not observed(y_j); one estimate of this may be derived from the current productivity of plots on Mai Sae irrigation scheme. Another estimate will come from current productivity of heterogenous plots on Mae Lao and in its immediate environs on the assumption that contingent on observables they mimic the counterfactual (homogeneity assumption). These estimates will be subject to robustness checks.

In addition, propensity score matching will be done to match plots across plot types and schemes, and instrumental variables will be used to address issues of endogeneity of some components of ASPLII. Location in the context of the irrigation scheme for otherwise homogenous plots will determine the way ASPLII affected the plot but not otherwise affect productivity.

Cost-benefit analysis

While we aim to estimate the difference in productivity between observed plots of different characteristics, a cost-benefit analysis requires the counterfactual distribution of plots types (and their areas). We will base our estimates of these counterfactuals on farmer report, the reports of irrigation and agricultural experts, and interpolation from the plot level GIS.

Given the areas of these different categories of plots, the productivity differences multiplied by their respective "transition matrix"[4] probabilities will give an estimate of total productivity change due to ASPLII. Thus if p_{ij} is the transition probability of plot type *i* to plot type *j* (*i*=1, …, n; *j*= 1, …, n), a_i is the area of plots allocated to type *i* on Mae Lao and those affected by the scheme in the counterfactual situation, and $y_{i,j}$ is the productivity of plots of type i and *j* respectively, then:

(1) $$I = \sum_i \sum_j a_i p_{ij} \left(y_j - y_i \right)$$

is the total impact on productivity due to ASPLII. Productivity differences $\left(y_j - y_i \right)$ may be negative of course if some plots are adversely affected; for example, improved

[4] The transition refers to the type that a plot would have been under the counterfactual and its current state. There will be some error in this attribution so that sensitivity analysis will have to be conducted.

irrigation management may have reduced tail waters or groundwater recharge, which can now no longer be used so effectively from private irrigation.

Survey design

The survey aimed to provide quantitative information on the physical (yield) and economic returns to cultivation and related activities, and on well-being, of households affected (or not) in different ways by the intervention. Since the intervention was heterogeneous, and could be expected to have heterogeneous impacts depending on geographical location and social characteristics of households and their farm plots, the research design posited comparisons of farm plots affected in different ways in different locations by the different interventions involved in MLIIP, and an aggregation over areas so affected.

The intervention can be conceived as comprising three treatments – infrastructure improvement, WUA membership and participation, and receipt of agricultural extension advice. Sampling by geographical stratification aimed to ensure coverage of plots and households affected in different ways to demonstrate and make plausible estimations of quantitative impacts.

A survey form was developed that was adapted from those used in Living Standards Measurement Surveys (LSMS) by discussion between the consultant and OAE. It seems that this was a somewhat novel survey structure and format of a survey for CPPE and may have caused difficulties with later data capture, cleaning and analysis, contributing to delays in reporting. The sampling procedure also seems to have not been carried through entirely as planned[5] leading to lower sample size than anticipated and inability to compute whole farm enterprise impacts.

The survey included a roster with education and occupation variables; detailed agricultural information by plot, season and crop over the past year (April 2009-March 2010) by recall, and reported status of the plot prior to intervention (also by recall) circa the year 2000. CPPE had conducted a survey in the early 2000s which could have provided a baseline, but the original data are no longer available and the documents reporting the results of this survey provide very little information of relevance to this study.

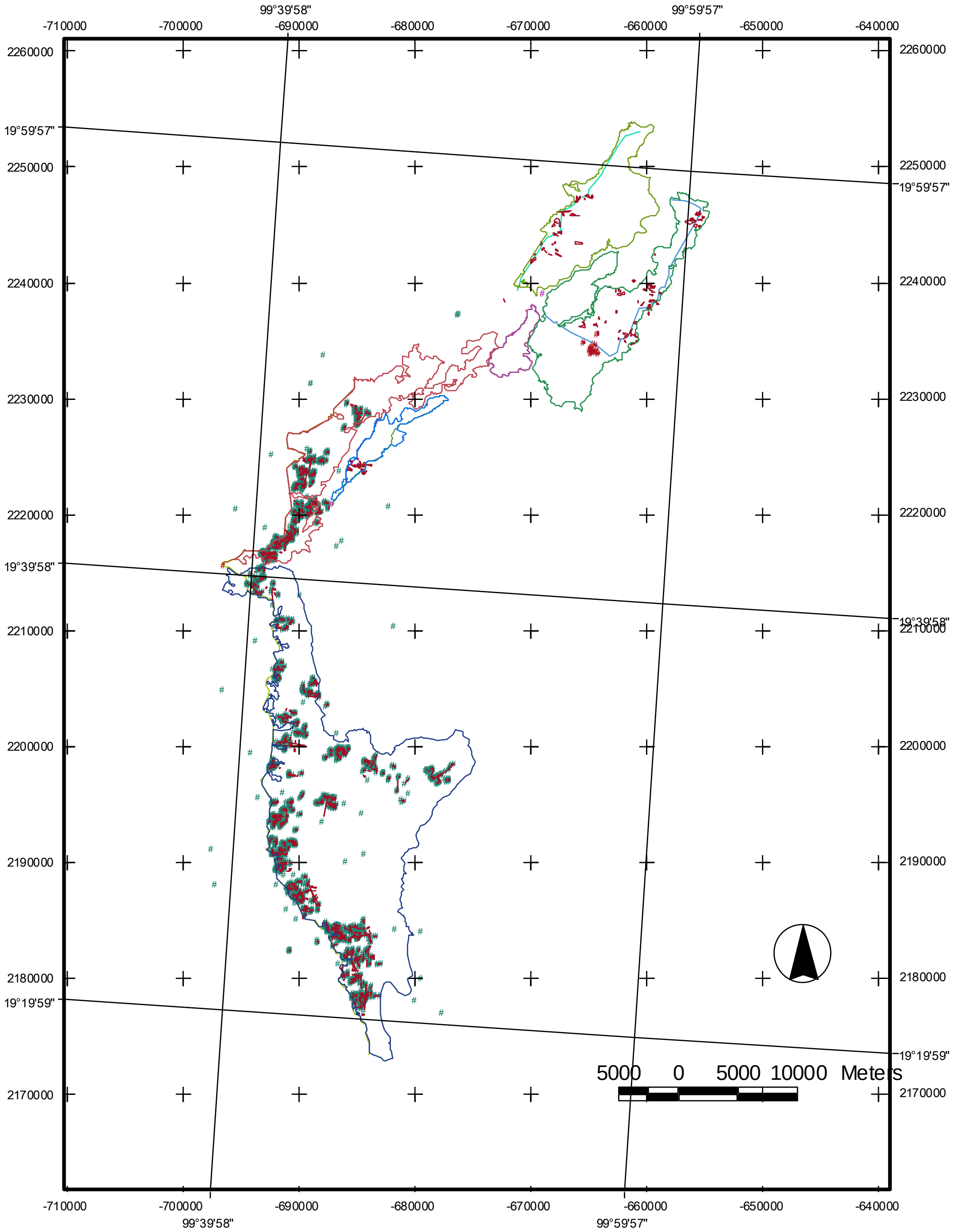
The survey instrument is available in the file MaeLao.A.xlsx.

Sampling design

The survey aimed to create representative samples of plots of different "types" according to access to irrigation and irrigation services which were the target of the irrigation improvement intervention. Plots would transit from different states as a

[5] The sampling procedure (see further below) was to stratified random select blocks of land within defined areas (quadrats) on and adjacent to three irrigation schemes and to record plot input output variables on all plots of all cultivators who had plots within the quadrat whether that plot was within the quadrat or not. This would produce information on contiguous blocks of land and also on whole farm enterprise. A substantial number of plots both within quadrats (as revealed by GPS plots of the plot boundaries) and reported by farmers (in their farm plots census) do not appear to have data reported in the survey database.

result of the intervention, and by multiplying the impact of each type of transition by the number (or rather area) of plots undergoing that transition, and summing over all types of transition, an estimate of the impact of the intervention could be made. Sampling was designed to be based on choice of 100sqm grid cells and interview of all farmers cultivating plots of land with at least 50 falling within in these grids; farmers would be interviewed about all their plots whether within or outside the grid. The non-farming impacts of the intervention would be assessed by reference to the social and health correlates of households with differential experience of the intervention.



Map 3: Location of sampled plots in relation to irrigation command area

Sampling procedure

The original intention was to use a grid overly on the irrigation scheme boundaries, with stratified (over schemes) random selection of grid cells to ensure wide spatial reference for the sample. Actual sampling was done at the time of fieldwork in October 2010; it is not clear how final sampling was done. There appear to be clusters of plots (Map 3) but it is not clear how these were chosen, and no information has been provided on the implementation of the sampling design. It appears that no clusters were chosen for significant areas in Mae Lao, especially those further from the main canal infrastructure, and none outside or bordering the scheme areas, thus reducing the IE design by not having farm plots neighbouring to but off-scheme. Most sampled plots seem to be along the main canals of the various schemes; hence, it is not clear that the original purpose of sampling plots on the periphery and also in the interior of schemes has been achieved (the scheme boundaries have to be taken as approximate since no information on the exact layout of the reticulation system or boundaries of the irrigation schemes has been provided). It may well be that our identification strategy was not carried through particularly effectively.

Project Participation

There is no very obvious way to classify households as participating or not in the ASLP funded irrigation improvements at Mae Lao, except to classify them by whether their plots are on the Mae Lao scheme, and whether all the farm plots they cultivate are in or out of an irrigation scheme. 480 households are classified as "on" Mae Lao, of which 5 report having no land under the scheme. The remaining 107 households belong to other schemes (Chiang Rai, Tamwok, or Chaisombat), and it is reported that all their plots are on these schemes. These other schemes may have been recipients of improvements funded by RID outside the MLIIP, and so use of this comparison sample only enables comparison of ASLP funded project relative to other investments made to improve productivity.

Apart from farm productivity, it is expected that, should the MLIIP have any significant impacts on well-being, then it would manifest itself in indicators such as non-farm income, health status, schooling, expenditures of various types especially on health and education); however the pattern of education on well-being is also dependent on education and other factors. Since the sample with no on-scheme plots is so small the only potential control group are those on the other schemes. Thus a first comparison is between participants on Mae Lao with those on other schemes.

Within schemes intensity of benefits would be expected to be related to initial disadvantage, and subsequent improvements. Initial disadvantage was expected to be related to geographical location in relation to the water source – the typical top-end-bottom-end problem, modified by the particular topography and layout of the irrigation scheme. In this case, given the information we were able to gather from the project management, there was no reason to think that disadvantage on Mae Lao would not be related to distance from the water source (river diversion). We have calculated this distance as described above (on the assumption that farmer's plots were not more dispersed throughout the scheme than indicated by the location of those plots for which we have GPS points[6]).

We also have reported plot specific information on water sufficiency and quality before and after "the project". Since there are no plot specific improvements supplied

[6] We had intended to record the location of the residence of respondents, and of all their cultivated plots using a national level high resolution image on tablet pcs. This was not carried through for reasons we are not clear about. As noted above, fewer than half of reported plots have GPS points to identify their location.

by the project, only improvements to canals and water management and non plot specific agricultural extension, we cannot identify specific plots or farmers affected by the project. However we can identify membership of WUA, and the formation of new WUA (section 6.2).

Thus we have a number of candidates for indicators of participation and or benefit. First there is the difference between Mae Lao plots/farms and those on the comparison schemes. Second, there is distance from the source of water; unfortunately for approximately half the plots we have no distance or other location information. However, we have a distance to at least one plot for nearly all the households, so we take the average distance from the source and the average x, y coordinates of those plots there are as location information. Third there are perceived problems with water sufficiency at plot and household level before and after the "project". Fourth, there is new membership of a WUA (whose formation may be attributable to project activities). Finally, we have a binary variable reporting disputes as causes of irrigation water problems. We can lot all these variables for each household. Only the average distance to source of water shows any clear geographical pattern.

As we will see later, but it will be useful to warn the reader here, there appears to be little explanatory capacity in these measures of participation in the project. This failure to find evidence of impact underlies the way in which the processing of the raw survey data that are discussed next. However, the major problem seems to be that the comparison schemes received irrigation improving investments over the same period as the MLIIP; it was only during fieldwork and when comparing the maps of the Chiang Rai scheme provided by the Royal Irrigation Department (RID) with the canals visible in Google Earth, that it became apparent that Chiang Rai had received considerable inputs from the Royal Irrigation Department, realigning and reconstructing canals and son on. Our failure to realise this prior to designing the IE has reduced the usefulness of this IE considerably..

Reliability of information on cultivated areas

Accurate estimates of crop areas planted are essential to measures of crop productivity. We have three measures of area – that reported in the plot census (1452), that estimated by GPS (916) and that estimated using reported GPS boundary points (799). Pearson r among these measures for plots which have them (pairwise) are quite low (< 0.3). Lack of reliable information on the area of cultivated plots is of course a major problem for this study which aims to match plot productivity to plot characteristics to estimate how productivity changes when plot characteristics change. Given our doubts about the quality of the entered GPS data we discarded the area measure using GPS boundary points; we also discarded the GPS estimated areas because they are available for only about half the cultivated plots. Thence, we have used the farmer estimated planted areas in our estimates of productivity.

Use of GIS to map plots and interview farmers

The original design of the study had been to interview cultivators with a GIS image on a tablet PC on which the cultivator could identify the plot being discussed. The boundaries of the plot could be drawn in the GIS during the interview, and matching of the plot and questionnaire plot identification should have been straightforward.

There were various delays in trials of this approach, but it was validated using Google Earth in the absence of the high quality GIS image during the field visit in November 2009. Plots can be identified in Google Earth and matched to GPS boundary traverses. Interviewers had problems identifying farmer plots but this was attributed to lack of locally knowledgeable RID staff who would be able to identify plots on the GIS. In the event no use of this approach seems to have been made during interviewing.

Location in relation to irrigation infrastructure

Location of the plot in relation to the irrigation infrastructure is an important correlate of a number of characteristics of considerable agricultural significance including access to irrigation facilities, drainage and (potentially) groundwater, and soils. Unfortunately the variables in the survey included to record the position of each plot in relation the formal structure of canals was not reported. For plots for which there are GPS positions, as first approximations, we computed two measures of distance. Firstly Euclidian distance from headworks can be calculated using the locations of the headworks and plot centroid (label) position. Secondly, we digitized a set of canals using Google Earth, and then computed distance from the plot centroid to the nearest canal, and distance along the canal to the water source[7]. Ideally each plot would have had an effective distance computed from distance along main and minor canals to the plot allowing for different seepage losses for different types of canal (Wongtragoon et al., 2012), but we have no information on seepage losses by canal[8].

Plot labels and the current file of plot boundaries are available in .kml format for display in Google Earth (MaeLaoPoints.kml; mlllgeo.kml).

For plots of farmers for which there are no GPS points we assume that their position is the average coordinates of other plots cultivated by the farmer. Plot fragmentation and dispersion does seem to be great in these areas.

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[7] The correlation coefficient between the two measures described above is> 0.99

[8] This can be accomplished using ArcInfo route information but requires each pot to be connected to the canal from which it receives water. Again, this is not difficult but was too time consuming for this project, and is unlikely to have produced a measure much different from the second of the two measures described

Results

First we assess the effects of intervention

The basic evaluation design is a switching regression model with multiple treatments expressed in equation (2 in the proposal which is reproduced here

(2) $$Y^{i}_{lk} = \alpha_i + \beta_i X_{jkl} + \gamma_l L_{kzl} + \delta_z Z_{kz} + \gamma^{f}_{ijklz} + \gamma^{v}_{ijklz} + \varepsilon_{ijklz}$$

where

Y_{ikl} is outcome *i* caused by intervention *j* in project *k* on plot *l* (or for household z which cultivates plot *l*);

Y is caused by:

X_{jkl} vector of project inputs *j* affecting farm plot *l* (of farmer *z*) (e.g. irrigation);

L_{kzl} vector of plot characteristics - soil, crop, and farm inputs - on plot *l* on or in the vicinity of scheme *k* cultivated by household *z*

Z_z vector of household/cultivator characteristics such as age, household demographics, ethnicity, education, etc.;

$\gamma^{f,v}_{ijklz}$ are vectors of fixed (geographical) and time-varying contextual variables respectively specific to this location; and

ε_{ijklz} is the error term.

X_{jkl} is the vector of project inputs the coefficients of which express the impact of the that "treatment". Components of the vector X may be dichotomous dummy variables or interval/ratio variables. Conceptually, and perhaps practically, this equation can be estimated with all X simultaneously[9], or separating out the individual treatments or combinations of treatments for evaluation, representing each as a dummy treatment variable. In this case matching occurs for this set of treated plots (eg those with improved irrigation - by a specified metric) with other plots with other irrigation treatments and no irrigation included as potential matches. Results from this approach can be compared with those that include all plots and covariates with a complete set of treatment dummies, estimated without matching.

The first task is therefore to identify characteristics of farmers/plots which enable classification by treatment – i.e. to define the variables in the X_{jki} vector.

This proved impossible; there were no records of which farmers or farm plots had received benefits of improved canal infrastructure, WUA formation or agricultural extension inputs. Instead we examine the perceived quality (predictability, controllability) and sufficiency of irrigation water availability reported by respondents. There is no information on contacts with agricultural extension in the survey instrument although there is information on membership of farmers organisations and WUA membership.

[9] In a matching context we could estimate propensity scores either by multinonmial logit or by pairwise comparisons. Routines such as mtreatnb.ado can estimate impacts of multiple treatments simultansously.

Sufficiency and quality of irrigation

Since the basic design aims to classify plots by productivity in before and after situations and transitions between these states in we first attempt characterize farmers and plots by their characteristic irrigation qualities, and their transitions between before and after contexts. The assumption is that more plots will be characterized by sufficient or good quality irrigation after the scheme interventions and that improvements (form insufficient to sufficient/poor quality to good quality) will be associated with characteristics such as distance from source of water and presence of reported irrigation problems. Given the characteristic top-end-bottom end problems we expect plots further away from the source of irrigation water to be less likely to be reported as experiencing sufficient/good irrigation and be more likely to be reported as experiencing improvements.

Reported sufficiency and quality of water supply[10] before the project varied significantly (Table 1 & 3 panel A), after the project (panel B), as did improvement (panel C); surprisingly, improvements were least on Mae Lao, which was the beneficiary of the ASPL irrigation improvement project. Respondents on Chiang Rai on the other hand perceived significant improvements in water supply almost certainly associated with the non-ASPL improvements under taken by the RID. This finding reflects what we had not known when designing the IE, namely that the “control” schemes had themselves received improvements in recent years. This clearly undermines our strategy for identifying project impacts.

There are two sources of data for these results; reports at the plot level in answer to questions about irrigation “quality” and “sufficiency” (schedule 2.1), and secondly information at farm level about sufficiency of irrigation and reasons for insufficiency (schedule 7.1). The results may not be consistent.

Tables 2, 4, 5, 6 & 7 report logit estimations of responses about sufficiency and quality of irrigation water of Mae Lao at the farm and plot levels.

(3) $$y_{s,i} = \alpha + \beta_1 S_i + \beta_2 D_{s,i} + \beta_3 S_i D_i + \gamma . X + e$$

Where $y_{s,i}$ is a binary variable of the reported sufficiency/quality of irrigation supplies of farmer/plot *i* on scheme *s*; S_i is the scheme indicator (either 1 = Mae Lao, or S_i is a set of indicators taking the value 1 for each of the three control schemes). D_i is an measure of distance of plot *i* from the diversion serving the scheme, and X, is a matrix of covariates of farmer/plot *i* , in this case representing reported issues with irrigation.

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[10] The data contain a code 0 which is undefined for answers to questions 7.1.1 (having sufficient water all year round). The following codes are given
1 – Sufficient
2 – insufficient
3 – no irrigation water
4 – no agriculture

In consultation with CPPE we decided that code 0 meant that the plot was not irrigated or there was no meaningful answer. Only 3 plots reported codes 3 or 4.

The specification includes "distance from [water] source" measured as above, and interactions of this continuous variable with scheme (or the set of all control schemes), to assess if the typical top-end, bottom-end problem of irrigation schemes appeared as lower perceived sufficiency of water at greater distance from the source, and to assess whether sufficiency (or quality of water supply) was lower prior to the irrigation improvement scheme (column (1) than after (2), and whether at individual plot level there were improvements in water supply (columns 3).

Respondents whose farms are on Mae Lao and Chaisombat reported higher sufficiency of irrigation before the project (Table 1); respondents on Chiang Rai and Tamwok schemes were significantly more likely to report improvement in water supply sufficiency. respondents also were (much) more likely to report improvement.

Table 1: Sufficiency of water by scheme and period

Panel A: Sufficiency before[11]		
scheme	sufficient	insufficient
MaeLao	57.52	42.48
ChiangRai	31.94	68.06
Tamwok	21.43	78.57
Chaisombat	66.67	33.33
Total	53.03	46.97
Pearson chi2(3) =	22.31 Pr = 0.000	
Panel b: Sufficiency after		
MaeLao	55.71	44.29
ChiangRai	75.95	24.05
Tamwok	66.67	33.33
Chaisombat	71.43	28.57
Total	59.18	40.82
Pearson chi2(3) =	12.164 Pr = 0.004	
Panel c: Sufficiency improved		
	No change	improved
MaeLao	88.54	11.46
ChiangRai	50.00	50.00
Tamwok	62.50	37.50
Chaisombat	85.71	14.29
Total	82.28	17.72
Pearson chi2(3) = 77.3 Pr=0.000		

Note: Farm level information

Farmers whose average distance from the source of water, usually an indicator of water insufficiency, do not report any significant negative association with sufficiency of water, or indeed improved supply (Table 2: Insufficiency of irrigation water before and after project (farmer level). Mae Lao farmers are less likely to report

[11] Note: Farm level responses

improvements in insufficiency (from insufficient to sufficient) than farmers on control plots. Respondents who reported disputes over water were less likely to report insufficient water but more likely to report improvements, as were respondents who reported that irrigation ditches were too high relative to the water level.

Table 2: Insufficiency of irrigation water before and after project (farmer level)

	1= insufficient. 0 = sufficient		
	before	after	Improvement[1]
Schemes	(1)	(2)	(3)
Mae Lao (vs all others)	-0.834	1.098	-2.113**
	(-1.15)	(1.52)	(-2.96)
Average distance from source	0.0000777	-0.0298	0.0449
	(0.00)	(-0.38)	(0.67)
Distance[2] * Scheme			
Mae Lao * ave_dist_from_source	0.00274	0.0188	-0.00668
	(0.04)	(0.24)	(-0.10)
– no water from project	0	2.298*	-0.644
	(.)	(2.28)	(-0.61)
– damage to irrigation ditches	1.797	-0.390	1.741
	(1.26)	(-0.31)	(1.30)
- ditches high than water level	0.913	0.738	-0.0486
	(0.63)	(0.59)	(-0.03)
Disputes among water users	0	-2.327**	0
		(-2.65)	
_cons	0.455	-1.063	-0.760
	(0.66)	(-1.54)	(-1.25)
N	450	498	481

t statistics in parentheses
* p<0.05 ** p<0.01 *** p<0.001"

Note: 1: insufficient before, sufficient after
2. adding squared distance terms does not make substantive difference

A somewhat different picture emerges when addressed at plot level. Table 3 shows that while water was perceived to be sufficient by 72% overall before the project(s) that increased to 80% after; the improvement was again most noticeable for Chiang Rai, but was hardly present in the Mae Lao and Chaisombat. This gap between perception of water sufficiency for households as a whole and at plot level may be due to biased selection of plots towards those which had indeed benefitted from the scheme. This is not inconsistent with the evidence from our GIS plot of the location of plots sampled that have GPS points are particularly close to the main and important secondary canals (Map 3).

At plot level, the irrigation water sufficiency reported in Table 3 is higher than in Table 1. Consequently, improvements are reported to be less.

The negative association of perceived improvement in water sufficiency with distance from source at plot level (Table 4Table 3, col (3)) is unfortunate, in that it implies the project has not been particularly successful in spreading water to those in less favoured locations with regard to access to irrigation water. The variables "water quality" before, after and improvements, also show similar results (Table 7: Irrigation Quality before, after, and improvement (plot level)

Distance may be negatively associated with likelihood of reporting improvements in sufficiency of irrigation at plot level on Mae Lao (Table 4). Reporting disputes as a problem is negatively associated with sufficiency before the project, as is reporting a problem with the irrigation ditch being higher than the water and positively associated with improvements. However, reporting disputes is positively associated with improvements.

Table 3 Irrigation Sufficiency Before and after (plot level)

	before	
Scheme	sufficient	insufficient
MaeLao	76.21	23.79
ChiangRai	45.81	54.19
Tamwok	45.83	54.17
Chaisombat	55.56	44.44
Total	71.82	28.18
Pearson chi2(3) = 102.5 Pr = 0.000		
	after	
MaeLao	79.95	20.05
ChiangRai	78.64	21.36
Tamwok	87.50	12.50
Chaisombat	87.88	12.12
Total	80.09	19.91
Pearson chi2(3) = 3.9102 Pr = 0.271		
	improved h2o sufficiency	
	No change	improvement
MaeLao	95.48[1]	3.36
ChiangRai	82.23	17.77
Tamwok	80.95	19.05
Chaisombat	100.00	0.00
total	93.72	5.28
Pearson chi2(3) = 91.6 Pr = 0.000		

Note: 1. 1% of plots reported deteriorated water sufficiency

Table 4: Sufficiency of irrigation water before and after project (plot level)

	1= sufficient. 0 = insufficient		
	before	after	Improvement[1]
Schemes	(1)	(2)	(3)
2.Chiang Rai	-1.306*	-0.104	0.752
	(-2.47)	(-0.23)	(1.36)
3 Tamwok	-0.394	-9.446	-4.231
	(-0.12)	(-1.61)	(-1.23)
4.Chaisombat	-12.58	-27.91	2.338
	(-1.25)	(-1.61)	(0.23)
Average distance from source	0.00346	0.00166	-0.0253**
	(0.59)	(0.29)	(-3.06)
Distance[2] * Scheme			
2.scheme#c.ave_dist_from_source	-0.00171	0.0101	0.0639
	(-0.03)	(0.22)	(1.17)
3.scheme#c.ave_dist_from_source	-0.212	2.491	1.321
	(-0.28)	(1.69)	(1.64)
4.scheme#c.ave_dist_from_source	1.380	3.480	-0.126
	(1.15)	(1.62)	(-0.10)
– no water from project	0.103	-1.053**	1.091*
	(0.20)	(-2.61)	(1.99)
– damage to irrigation ditches	0.530	0.979	-0.866
	(0.99)	(1.62)	(-1.26)
- ditches higher than water level	-1.273*	-1.145	1.267
	(-2.42)	(-1.92)	(1.94)
Disputes among water users	-0.918**	0.730	1.631***
	(-3.06)	(1.87)	(4.93)
_cons	1.219***	1.353***	-1.761***
	(9.18)	(10.53)	(-10.32)
N	1756	2150	1750

t statistics in parentheses (not adjusted for clustering at household or sample strata levels)
* $p<0.05$ ** $p<0.01$ *** $p<0.001$"

Note: 1: insufficient before, sufficient after
2. adding squared distance terms does not make substantive difference

.

Table 5: Irrigation Sufficiency (plot level)

	water sufficient (1=sufficient)		
	before	after	improved
	(1)	(2)	(3)
Treatment l scheme (Mae Lao)	1.266***	-0.335	-0.993*
	(3.29)	(-0.89)	(-2.42)
ave_dist_from_source	0.00140	-0.0230	0.0168
	(0.03)	(-0.59)	(0.40)
Treatment scheme*.	0.00205	0.0247	-0.0420
ave_dist_from_source	(0.05)	(0.63)	(-0.97)
No irrigation	0.0953	-1.116**	1.065
	(0.19)	(-2.77)	(1.94)
Canal broken	0.516	0.924	-0.907
	(0.97)	(1.53)	(-1.33)
Canal too high for water	-1.271*	-1.124	1.291*
	(-2.42)	(-1.88)	(1.97)
disputes	-0.919**	0.746	1.629***
	(-3.06)	(1.90)	(4.93)
_cons	-0.0465	1.689***	-0.768*
	(-0.13)	(4.77)	(-2.05)
N	1756	2150	1750

t statistics in parentheses(not adjusted for clustering at household or sample strata levels)

="* p<0.05 ** p<0.01 *** p<0.001"

1. All control schemes have relatively short distances from their source of water to the sample plots. The mean distance is considerably larger for Mae Lao.

Table 6: Irrigation Sufficiency (plot level) (no constant)

	water sufficient (1=sufficient)		
	before	after	improved
	(1)	(2)	(3)
Treatment schemes	1.220***	1.351***	-1.759***
	(9.19)	(10.52)	(-10.31)
ave_dist_from_source	-0.00356	0.161***	-0.0653***
	(-0.24)	(10.16)	(-4.19)
Treatment scheme* .ave_dist_from_source	0.00702	-0.159***	0.0402*
	(0.44)	(-9.46)	(2.27)
No irrigation	0.0909	-1.014*	1.016
	(0.18)	(-2.50)	(1.83)
Canal broken	0.511	1.078	-1.018
	(0.96)	(1.79)	(-1.48)
Canal too high for water	-1.268*	-1.184*	1.350*
	(-2.42)	(-1.99)	(2.05)

disputes	-0.919**	0.730	1.625***

t statistics in parentheses (not adjusted for clustering at household or sample strata levels)
="* p<0.05 ** p<0.01 *** p<0.001"
All control schemes have relatively short distances from their source of water

The results presented in Table 4, Table 5 & Table 6 report answers to the “irrigation sufficiency” question, Table 7 reports for the “irrigation quality” questions. It is not clear what the distinction between these two questions is, but the outcomes of the estimations are similar. Thus the results in Table 7 are not particularly different, although the dummy variables for the reported problems of “canal water too high” and “disputes” are now strongly negatively (and significantly) associated with reports of improvements in “good” quality irrigation supplies.

Table 7: Irrigation Quality before, after, and improvement (plot level)

	Quality (1 = good)		
	before	after	improved
	(1)	(2)	(3)
Treatment_schemes	2.104***	0.876	-1.912***
	(3.62)	(0.78)	(-3.37)
ave_dist_from_source	0.0695	0.123	-0.0428
	(1.17)	(0.91)	(-0.75)
Treatment _scheme* ave_dist_from_source	-0.0828	-0.152	0.0493
	(-1.36)	(-1.12)	(0.84)
No irrigation	1.328	0.102	-0.732
	(1.89)	(0.15)	(-1.05)
Canal broken	1.359	0.799	-1.095
	(1.83)	(0.86)	(-1.42)
Canal too high for water	-3.511***	-2.820**	2.455***
	(-4.99)	(-3.15)	(3.41)
disputes	-2.919***	-1.669***	2.617***
	(-8.34)	(-3.66)	(7.27)
Constant`	1.640**	3.623***	-1.637***
	(3.28)	(3.38)	(-3.37)
N	1710	2122	1698

t statistics in parentheses (not adjusted for clustering at household or sample strata levels)
="* p<0.05 ** p<0.01 *** p<0.001"

In summary, we find that the Mae Lao irrigation project had different (higher) levels of satisfaction with irrigation water supplies prior to the project (at least as reported in this survey), and less improvement compared to the controls. The control projects improved perceived irrigation quality more. There is some evidence that improvements in irrigation sufficiency, or quality, are associated with reported problems with canals of disputes over irrigation, but these occurred on control as well as treatment projects. There is no evidence that, for plots on Mae Lao, distance from the irrigation source is associated with greater improvements in irrigation sufficiency or quality more. It is hard here to see any beneficial impacts of improvements in either irrigation sufficiency or quality associated with MLIIP.

Other treatment indicators

While we have not been able to identify any meaningful indicators of infrastructure investment through MLIIP, we also have variables which could indicate formation and activities of WUA and of farmer extension groups or cooperatives.

WUA membership

The vast majority of respondents on all schemes were members of WUA at the time of the survey, and most reported that the WUA existed prior to the project intervention.

There is no evidence of an association of either membership of a WUA, or formation of the WUA since the initiation of the project (about 10% of respondents reported become members of a WUA between 2005 and 2009), and indicators of productivity (yield, gross or net income per unit area, or change in irrigated area).

We cannot find a treatment indicator in these data that proxies for the WUA activities of MLIIP and is positively and significantly associated with indicators of productivity.

Farmer's group membership

More than half the respondents reported being members of farmer's groups and, or agricultural cooperatives. We do not have information on when the respondent became a member of a farmer's group.

There is some indication of a negative association of gross and net income per unit area and membership of both a WUA and a farmer's group, but, while the size of the effect is substantial (more than 50% of the gross value of output) it is significant only at 96%. It is not clear whether membership of a farmer's group reflects extension activities under MLIIP.

Rice Production and Productivity

The question that then arises is whether there are any detectable impacts on productivity, income or well-being. As noted in Appendix 1 we computed gross and net (income) margins per unit area[12].

Focus on rice

We focus on rice because it occupied most of the cultivated land (95%) and provided most (>95%) of crop income (Table 21 & Table 22). Irrigation improvements were supposed mainly to increase coverage and productivity of rice in the dry season,

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[12]
```
gen GrossMargin_plot_season = outputvalue - lab_cost_cash - fuelnequip_cost -
input_cost
gen NetIncome_plot_season = GrossMargin_plot_season - lab_cost_imputed
gen giplot_season_rai =   GrossMargin_plot_season / planted
gen niplot_season_rai =  NetIncome_plot_season / planted
gen rice_yld = distribution / planted if rice == 1
```

although some improvements in the wet season were also to be expected. Rice was also the predominant crop in the dry season, and was planted on nearly as much land as in the wet season (87% of plots - 80% of the planted area - planted in the wet season to rice also cultivated rice in the dry season). The plots not planted with rice that had dry season crops were planted to vegetables or “other crops”; the majority of the area not under rice appears to have been not cultivated (i.e. there is no reported entry for these plots in the dry season).

Rice yields and productivity

Rice yields were higher in the dry than wet season, and on Chiang Rai and Tamwok schemes compared to Mal Lao and Chaisombat, however the differences are not statistically significantly different. Indeed we can find no meaningful association of yields, gross or net income per unit area .with any of the variables we would expect. For example, we expect distance from source of water, and the reported occurrence of irrigation water problems to be negatively associated with indicators of productivity. However, this is not the case in these data (Table 4). Similar results are obtained with regressions of gross and net incomes. In no case do we find a significant coefficient,

Table 8: Regressions of Rice Productivity (Yields)

	(1)	(2)	(3)	(4)	(5)
	rice_yld	rice_yld	rice_yld	rice_yld	rice_yld
Chiang Rai	76.51	127.7	140.2	308.4	121.8
	(1.64)	(0.64)	(0.68)	(0.76)	(0.58)
Tamwok	62.26	846.8	670.5	-54.75	236.4
	(0.57)	(0.48)	(0.37)	(-0.02)	(0.13)
Chaisombat	-22.06	1048.3	782.0	35.26	603.7
	(-0.17)	(0.33)	(0.24)	(0.01)	(0.18)
Distance from source		1.190	1.365	2.663	0.991
		(0.63)	(0.68)	(1.06)	(0.48)
Chiang_Rai* distance		-4.710	-4.080	-26.85	-2.881
		(-0.22)	(-0.19)	(-0.60)	(-0.13)
Tamwok * distance e		-173.5	-130.2	45.83	-31.00
		(-0.41)	(-0.29)	(0.05)	(-0.07)
Chaisombat*distance		-128.5	-96.25	-1.289	-74.24
		(-0.34)	(-0.25)	(-0.00)	(-0.19)
Water sufficient now			50.47	82.27	56.08
			(1.25)	(1.58)	(1.17)
Disputes			-178.2		-187.5
			(-0.39)		(-0.41)
Improved quality				-73.69	
				(-0.53)	
Improved sufficiency				80.52	
				(0.99)	
_cons	754.1***	794.6***	719.2***	757.2**	696.2***
	(38.59)	(150.9)	(165.7)	(281.2)	(173.0)
N	1720	1116	1046	778	1046
r2	0.00143	0.00176	0.00364	0.00706	0.00967

Irrigated areas

While there seems to have been no increase in productivity of irrigated crops there were increases in the areas reported to have been irrigated. However, the area irrigated increased also on the control schemes, and indeed was far larger on the Chiang Rai scheme than on Mae Lao. However, the increase in irrigated area did appear to be greater the further the farmer's plots were from the source of irrigation (or proportion of maximum distance from source), but this did not vary between schemes. Thus, while this does suggest that the irrigation improvement schemes had effects, it does not provide a basis for identifying a treatment indicator that can be used to estimate impacts of the particular intervention with which we are concerned.

Estimation of Impact

As noted above yields, and gross or net productivity are not associated with either distance or proportional distance from source of irrigation, or by participation in WUA or farmer's groups. Although we can identify plots (farmers) a greater proportion of whose land is reported as irrigated and cropped in the dry season after the project, we find no difference between schemes in this statistic. Since we have no basis on which to attribute changes in either productivity or area cultivated to project interventions we cannot estimate the transition probabilities between plots with different levels of treatment

Under these circumstances it is impossible to attempt any sort of impact assessment. There is no association of productivity either with treatment (being on Mae Lao) or the only proxy for treatment (distance from source of water) with which to show some sort of immediate impact of the intervention. If there is no direct impact on productivity or then it is unlikely that there are second order effects on consumption or well-being.

Summary and Policy Conclusions

This impact evaluation has been unable to identify substantive impacts of the intervention largely because of contamination of control groups by access to a similar interventions funded though different sources. This source of contamination was not identified during preliminary fieldwork, and was discovered only during analysis.

While increases in irrigated areas did occur, and did occur to a greater extent further from water sources, as one would expect, they were no different on treatment schemes compared to control schemes. Thus, we are unable to identify impacts of MLIIP. In part this may be because the control schemes received interventions from ToTH funds over the period between the before situation and the time of the survey, making retrospective evaluation impossible.

Impact evaluation using an ex-post observational approach is fraught with problems; these are amplified when the IE is conducted in conjunction with institutions which have to negotiate access to the field through the institution which are responsible for the intervention (in this case the RID), and may have conflicting mandates and do not take ownership of the evaluation process.

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Appendix 1: Some details of the Survey Data, Data Capture and Analysis

Power calculation

We intended to use a cluster sample. As described in the text the sampling procedure actually used is not clear, but there is some clustering. The power calculation follows Hayes and Moulton, 2009, Chapter 7 for calculation of cluster numbers with 95% confidence ($Z_{\alpha/2}$) and 80% power (Z_{β}). We assume that the minimum difference in yield/gross/net income per unit area between treated and untreated will be 20%, the between clusters coefficient of variation (k) of mean mpce is 0.4, and the standard deviation of mpce is .1 * mean for members and non-members.

Our retrospective power calculations (using means and standard deviations was approximately 3000Bhat/rai with average sd of 7000.

These assumptions with a (constant) sample size of 30 per cluster suggest 34 unmatched clusters in each treatment and control groups, and 19 clusters if the treatment and control clusters are matched.

			Cluster numbers	
		values	Unmatched CRT[1]	Matched CRT[2]
$Z_{\alpha/2}$	z-value for upper tail of standard normal distribution with probability α/2 (α = probability of Type 1 error)	1.96	34	19
Z_{β}	z-value for upper tail of standard normal distribution with probability β (β = probability of Type 2 error)	0.84		
σ_{wo}	Sd. control	3000		
σ_{wi}	Sd. treatment	3600		
m	Obs. Per cluster	30		
k	Between clusters cv. (k_m is the cv between clusters within matched pairs)	0.3	k_m	.2
m_0	Mean control	6000		
m_1	Mean treatment	4800		
	Total households		1017	565

Notes: 1 & 2. Formulae (1) and (2) apply.

$$c_{unmatched} = 1 + \left(z_{a/2} + z_{\beta}\right) * \frac{\left(\left(\sigma_{wi}^2 + \sigma_{wo}^2\right)/m\right) + k^2\left(\mu_0^2 + \mu_1^2\right)}{\left(\mu_0 + \mu_1\right)^2} \tag{1}$$

$$c_{matched} = 2 + \left(z_{a/2} + z_{\beta}\right) * \frac{\left(\left(\sigma_{wi}^2 + \sigma_{wo}^2\right)/m\right) + k_m^2\left(\mu_0^2 + \mu_1^2\right)}{\left(\mu_0 + \mu_1\right)^2} \tag{2}$$

These calculations suggest a total sample size of over 1050 in 35 clusters.

However, the sample eventually chosen by CPPE did not respect the power calculation either in clustering or number of samples per cluster. While there are no cluster indicators in the data, the GIS distribution of plot GPS suggests there are more than 30, although the number of households per plot are not uniform. There are 576 households in about 30 clusters, but nearly 1300 individual plots of 576 households. The power appears to be rather low.

Survey Instrument

The survey instrument (MaeLaoA.xlsx) was derived from common LSMS type multi-topic surveys, but was somewhat novel to CPPE. Details of the data capture and basic descriptive statistics are given here.

Data Capture

The data consist of 5 Excel files containing data entered by OAE; four files contain the survey data (MaeLao.xls, ChiangRai.xls, Chaisombat.xls, and Tamwok.xls) and the other the GPS data for each measured plot (GPS.xls). These are registered as odbc sources and individual worksheets access from Stata. The individual worksheets are described below.

Survey data

There are worksheets for each section of the questionnaire in the spreadsheets of each irrigation scheme. The survey contains 21 sheets as set out inTable 9:

Table 9: Survey components

Section	topic	domain	content
'1#1$'	Household Roster	Persons	Education and occupation (site)demogNhealth.dta
'1#2$'	Health and anthropometry	Person health episode	" No reliable anthropometry
'1#3$'	Land ownership and use	Plot – 1858 plots	(site)plots (site)landareas
'2$'	Farm	Plot season crop	(site) 2Cropping
'2_orig$'			
'3#1Fisheries$'	Fisheries units	Enterprise (i.e. type of livestock * enterprise)	Site)3.1
'3#1Livestock$'	Livestock Units	By household enterprise	
'3#2Fisheries$'	Fisheries inputs	"	
'3#2Livestock$'	Livestock iinputs	"	
'3#3Fisheries$'	Fisheries outputs	"	
'3#3Livestock$'	Livestock outputs	"	

'4#1$'	Agriculture income	"	
'4#2$'	Fisheries income	"	
'5#1$'	Credit and debts	By loan	
'5#2$'	Farm assets	asset	
'6#1$'	Membership of institutions	Household/hhh (477)	
'6#2$'	WUA membership	Household/hhh (477)	
'6#3$'	Participation in WUA activities	Household head	
'7#1$'	Problems with Water	"	
'7#2$'	Changing use of farm labour	"	
'7#3$'	Problems in farming	"	
GPS.xls	5 worksheets with gps points and plot areas		

GPS data

One spreadsheet contains worksheets containing GPS coordinates of plot verticies and GPS estimated area for each irrigation scheme (two for Tamwok, one of which was and is incomplete). Not all cultivated plots for which there are input-output data have GPS data, and many plots reported as cultivated have neither input-output nor GPS data.

Data are extracted using "capture_gps.do". This file extracts the data for each scheme using odbc, and writes a Stata file for each plot with area as measured by the GPS (reported in the data file) in the field, and .gen line and point files for use in ArcInfo. ArcInfo files were input with GENERATE and using the lines mis-entered points were identified visually and corrections made in the Excel file manually. This process was iterated until all major errors were corrected, although the corrections were often rough (by taking the average of non-erroneous points). This was an imperfect process. Plot areas reported in the data from the original GPS recordings are used in calculations requiring plot areas.

There are many errors in the GPS data – mainly errors in transcription which should have been voided by downloading the GPS data directly to computer, and quite a few did not correspond to plots – these were corrected manually.

Merging Survey with GPS points

Each cultivated plot should have a corresponding GPSs label should merge with the plot listing (1.3). However, even for plots listed as "cultivated" about 42% did not match a corresponding GPS plot (Table 10).

Table 10: Matching between Plot Listing and GPS Data (numbers of plots)				
Land use	GPS plots only	Plot Listing (1.3) only	Both Plot Listing and GPS	Total
residence	0	294	50	344
cultivation	0	405	562	967
tree crops	0	56	17	73
livestock or fish	0	57	34	91
other	0	14	11	25
missing	66	177	181	424
Total	66	1,003	855	1,924

There seem to be errors in the descriptions of plots recorded in interviews; 50 plots designated to be residences by respondents were measured in the GPS survey presumably because there was cultivation on them. Many plots designated as cultivated were not measured in the GPS survey. The high proportion of plots for which GPS matches did not occur is unfortunate because GPS estimated areas would provide valuable evidence on the respondent-reported areas.

Further inconsistencies in the number of plots emerged from comparing the plots reported in sheet 1.3 (a census of plots) and those for which there are some cropping information. In principle one can have several crops in one plot in a single season as shown in Table 11.

Table 11: possible cropping patterns				
Identification	Cropping Season	Crop (code) (examples)	Cropping 1 (Mix/sequence)	Comments
Scheme, sample, plot	Wet 2009	Rice (1)	Seasonal planting (1)	Rice is planted on more than 95% of the reported cultivated area
		Banana (5)	"permanent" crop (3)	If more than one variety of rice of planted, then code for crop would be rice and reported as seasonal crop (2 = second crop in plot)
	Dry 2009-2010	Rice (1)	Seasonal planting (1)	
		vegetables	Seasonal planting (1)	
		(banana not reported)	Implicit permanent crop)	

Merging the plot census with the cropping information showed that there were 1990 plots reported in all of which 490 had no census information – 132 with cropping information but no census data, and 358 plots are in the census but without land use information. 378 plots are reported as not being residences are not reported as having crop, tree, or fishing enterprises, but 167 residence plots are reported as having cropping information. One concludes that the plot census and land use schedules were either not well understood or were filled in with errors.

Of the 1,990 plots with cropping information only 897 have GPS information; 24 with GPS information have no cropping information, and 1093 have cropping information but no GPS. 303 plots have no measure of area, 200 reported as having at least one crop grown on them in 2009-10.

Table 12: Data on plot location				
	Plot census (1.3)			
	y		n	
	gps		gps	
Cropping (2)	y	n	y	n
y	855	1003		
N	42	90	24	
	897	1093	24	

Total = 2014

Survey Data

This section explains the data available from the survey conducted in October-November 2010.

As noted above the raw data are not clean and contain many missing observations. The data were handed over raw after single direct data entry unmediated by a data checking or passage through a data validation programme. A thorough cleaning process is required but cannot be afforded in this study, only selected cleaning has been undertaken.

Demography, education and health

Demography

The survey data contain information on 583 households with1987 people (Table 13). The age distribution (Figure 3) is unusual containing too few young children (<5); there seem to be too many 10-14 year olds and perhaps too few 30-34, although the relative absence of this group could be due to migration..

Table 13: Household numbers, size, and gender composition

	households		Gender (number)	
scheme	number	size	Male	Female
Mae Lao	477	3.41	835	791
Chiang Rai	84	3.57	158	142
Chaisombat	15	3.67	27	28
Tamwok	7	4.14	14	15
Total	583	3.45	1023	964
Oneway ANOVA (all variables)	$p < 0.25$			

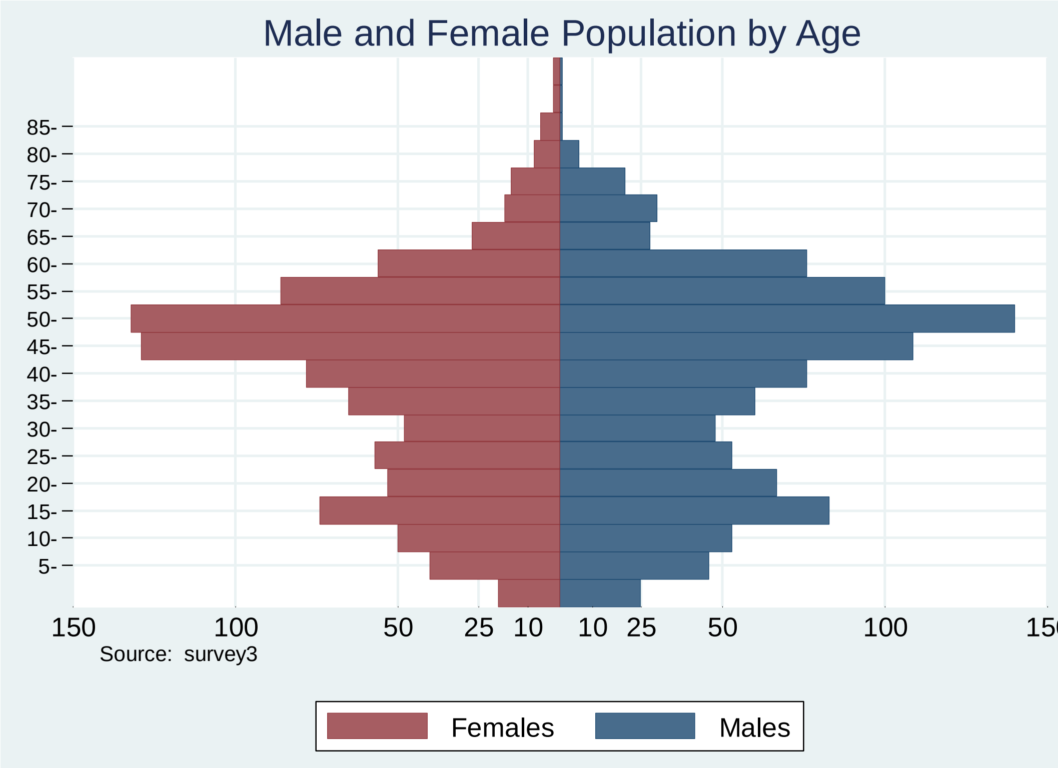

Figure 3: Sample Age Pyramid.

Education

For those who have finished their schooling, nearly all have completed the compulsory levels; there is no evidence of gender bias in educational achievements (Table 14; (p chi2 < 0.522)). There appears to be no significant difference in levels of education attained on the different schemes (Table 15). This finding holds for younger persons whose schooling might have been affected by PLIIP activities, and who have yet to complete their schooling (results not shown).

There is some indication that males spouses may be slightly more educated than their wives (Table 16),but the difference is marginal. There is no evidence of gender bias in access to education among younger children (results not shown).

Table 14: Levels of education				
	Gender			
Levels	male	female	Not given	Total
no education	28	40	0	68
not completed compuls	73	67	0	140
completed compulsory	507	503	1	1,011
secondary school	131	102	0	233
higher school/vocation	123	84	1	208
junior college/higher	50	35	0	85
Batchelor's degree	72	85	0	157
graduate school	4	6	0	10
Total	988	922	2	1,912

Table 15: Differences in Education Levels between Schemes	
	Mean Levels of education
scheme	Mean
Mae Lao	3.65
Chiang Ra	3.85
Chaisombat	3.74
Tamwok	3.64
Total	3.68
Oneway anova	p<0.226
Kruskall-Walis chi2	P < 0.366 (with ties)

Note: although these are ordinal data, the means give adequate evidence of no diffference

Table 16: Education of Spouses									
	Female spouse education								
male_spouse_education	no	Education	notcompleted	completed	completed secon	Higher junior	Junior college	Batchelor	Total
no education	6		0	6	0	0	0	0	12
not completed compulsory	1		1	5	1	3	0	0	11
completed compulsory	15		7	292	12	2	0	0	328
secondary school	0		0	29	7	1	1	0	38
higher school/vocation	0		0	10	6	2	0	2	20
junior college/higher	0		0	1	1	1	0	1	4
Batchelor's degree	0		0	1	0	0	1	0	2
Total	22		8	344	27	9	2	3	415

Note: for all persons, the pattern is similar with males having slightly more education

Occupations

We lack codes for occupations at the time of. writing. Table 17 reports the raw codes. There appears to be very little difference in occupational patterns between schemes for either gender. In a multinomial logit of Main occupation on scheme, p > chi2 = 0.20 or more, for both males and females). Again, there appears to be no difference in the distribution of occupations by gender or scheme (results available from the author).

Table 17: Occupations by Gender (%)				
main	Gender			
occupation	|Male	Female	Not given	Total
1	65.21	60.75	0.00	63.02
2	17.72	16.16	50.00	17.02
3	2.41	1.82	0.00	2.13
4	1.64	4.98	0.00	3.22
5	0.00	2.43	0.00	1.15
6	2.52	2.92	0.00	2.70
7	10.50	10.94	50.00	10.75
Total	100.00	100.00	100.00	100.00

Table 18: Distribution of main and secondary Occupations								
main	Secondary occupation							
occupation	1	2	3	4	5	6	none	Total
1	3	1	115	72	5	3	449	648
2	3	0	0	0	0	1	0	4
3	6	0	4	3	0	1	6	20
4	6	0	4	0	0	0	2	12
5	0	0	1	1	0	0	0	2
6	3	0	0	0	1	0	0	4
None	18	3	3	0	0	0	3	27
Total	39	4	127	76	6	5	460	717

Health

Health is an important indicator of well being, intrinsically and also instrumentally; good health is a good in itself, and poor health leads to low productivity. Higher productivity is expected to lead to better health (although not always to perceptions of better health). The health section of the survey instrument asked about incidence of illness, costs of health centre, hospital and other treatments, and impacts on ability to work. It also asked for information on heights, weights and age in months for children under five; the anthropometry data were not usable[13].

While quite extensive information was collected on health episodes and expenditures no entries were reported for the question “days off work (due to illness)”. Many

[13] Without going into details, there were 62 persons with age < 5 reported which is far fewer than would be expected from a population of 583 households. This is supported by the population pyramid (Figure 3). In all only 4 values for weight, 63 for height were given, of which none and 5 were for persons reported as under 5. Age in months was not reported. Some values for weights may have been mis-recorded in the “position” variable, which should have reported whether height was taken in the standing or lying position.

observations for other health variables are missing even when an illness episode is reported. This suggests that the design of the questionnaire was not well understood[14].

A total of 761 ill-health episodes were reported (385 for males, 376 for females), for which 542 reported some sort of expenditure (273 male, 269 female). Mean and total expenditures per reported ill-health episode for which there are expenditures were significantly higher for females than males (Table 19, Figure 4). This pattern is repeated across schemes. It is noticeable that average health expenditures per household are greater for non-project schemes although the differences are statistically significant for males. The differences might be related to proximity of control schemes to Chiang Rai town.

Table 19 Health expenditures by scheme

	Health expenditures (Bhat, out of pocket)			
Scheme	total	Male	Female	per person
Mae Lao	1950	703	1196	560
Comparison schemes	3666	1559	2107	788
Total	2207	831	1333	594
t-test p(H0~=0)	.075	0.0.04	0.28	0.40

Source: survey, 2009.

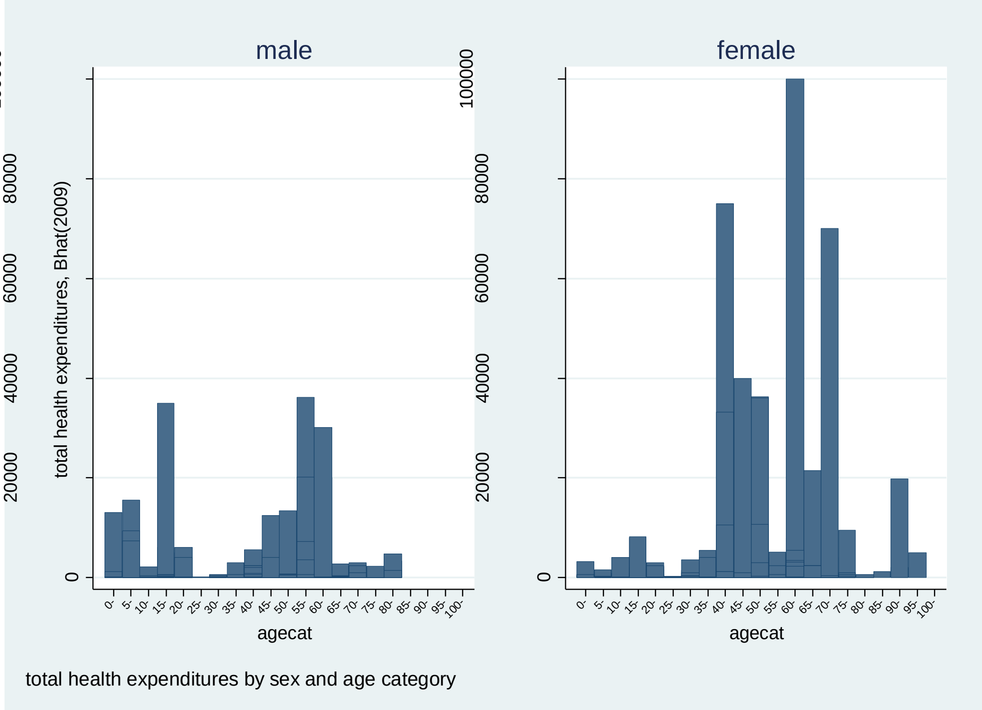

Figure 4: Health Expenditures by Gender and Age

Cropping

Five Excel worksheets provide information on cropping for each scheme;

[14] Following the principle that information should be sought at the most disaggregated level possible (Deaton and Grosh (2000)), respondents were to asked about illness episodes in the previous year, and for each recalled episode

1.3 plot specific information including geographical location (GPS points)

2.1 cropping information and irrigation characteristics

2.2 crop production and distribution

2.3 inputs and factors of production (two sheets)

As noted above, we have information on 2014 plots. Since the area is characterised by multiple (several crops sequentially in a year) and mixed (growing more than one crop in a plot) cropping there can be more than one crop per plot and per season. We a classify cropping into two seasons (wet and dry), but within each season it is possible to grow more than one crop on a plot. The cropping information shows a total of 2442 plot/crop/season observations.

Paddy is the predominant crop; of the 4660 acres gross cultivated area (for which we have information), 94.5 % was cultivated with rice. Although rice is very widely cultivated this figure may be an exaggeration because of the apparent focus of the survey implementation sampling of plot within the irrigation schemes rather than on their periphery.

These files are processed and combined in the Stata “cropping.do” file, by scheme and then appended. Gross Value of Output, total variable input costs, and Gross and Net returns are computed. The cropping data are matched with the plots listed in the plot listing and the GPS data. However, as noted above there are problems with the area data; not all cultivated plots have gross net or cropped area.

Coding of crop input-output

Since the agricultural system in this area involves both multiple and multi cropping, and permanent crops, and cultivators have several plots, data entries are organised by scheme, sample, plot, season, crop, and sequence (Table 20). Crop inputs seem to have been entered as if they are shared within seasons on plots, but this means that inputs must be aggregated as “mean” while outputs are aggregated as “sum”.

Table 20: Identification of crop input-output relations

Title	Description	variable	Comments
scheme	Scheme identifier	scheme	
sample	Household identifier	sample	
plot	Plot identifier	plot	Sub-plots not allowed
season	Wet, dry, 2009/10	cropping	
sequence	Sequence within plot	cropping1	Values 1 & 2 – not clear how this variable is to be interpreted
Crop	Crop identifies	crop	
Inputs	mean	(multiple variables)	Values in Bhat
Outputs	sum	(multiple variables)	Values in Bhat

As noted above, 95% of plots and cropped area are reported to be growing rice; of 2582 reported crops 2342 were rice of different varieties (32), and 240 were of other crops – mainly vegetables (70), "field crops" (79) fruit trees (85), and others (6). Rice contributed 93% of the gross value of output, and there is no significant difference in mean Gross or Net Margins of rice and no-rice crops (p not equal t< 0.412). We focus on the rice crop.

We calculate the gross value of output and subtract the sum of variable input costs excluding imputed labour to arrive at the gross margin.. We then subtract imputed labour costs to arrive at an estimate of the net margin. Although there is extensive mechanisation and considerable value of farm assets (buildings, etc.)[15] we make no allowance for these fixed costs. Neither imputed cost of working capital (mean 42k Bhat),interest payments, or land rent are included in Gross or Net Margins, except where paid out of output. In the case of interest payments they cannot be attributed to farm working capital, and land rent is excluded because of difficulties of imputing rental value to owned land; tenancy occurs on about 30% of plots.

The main reason we make no attempt to include these variables is because, as shown below, even estimated gross margins are generally negative even without including these costs. Furthermore there are some extreme values which we have no grounds for excluding.

Crop Areas

Most of the area is cultivated with rice (Table 21), with roughly 10% of farm plots on cultivated with non-rice crops. 571 our 586 households grow rice, with an average of 22 rai planted to rice per household (median 18.6)

Table 21: Cropping - Plots and Areas			
		rice_1	
scheme	Non-rice	rice	Total
Mae Lao			
N	157	1,503	1,660
Mean area(rai)	3.72	6.25	6.01
Chiang Rai			
N	23	244	267
Mean area(rai)	4.04	8.95	8.53
Tamwok			
N	0	36	36
Mean area(rai)		8.11	8.11
Chaisombat			
N	1	24	25
Mean area(rai)	20	8	8.48

Note 1 rai ≈0.39 acres

[15] Mean value of farm (cropping) machinery was reported to b more than 52k Bhat, buildings 28k Bhat, and land value 796k Bhat.

Rice Yields

Rice yields are calculated as total production (gross of rent and other distributions out of output) divided by reported planted area. Winsorized yields on Chiang Rai and Tamwok were apparently significantly greater than Mae Lao and Chaisombat ()

Table 22: Rice Yields (kg per rai)				
Variable	Obs	Mean	Std. Dev.	Groups (p<0.05)
yield	1805	697.77	628.27	
Winsorized[1]	1805	650.81	238.96	
Mae Lao	1501	632.66	242.24	1
Chiang Rai	244	747.20	200.21	2
Tamwok	36	742.43	167.69	2
Chaisombat	24	668.79	227.64	1
Total	1805	650.81	238.96	

Note: top and bottom .05% of observations excluded.

Rice Values

The gross value of rice output was obtained by multiplying the reported unit price by the gross production, on a plot by plot basis. Out of some 2340 plots with rice recorded rice output, nearly 400 did not have a value observation. These were replaced with mean values (over all schemes[16]) for the rice variety reported.

[16] There were no statistically significant differences in unit rice values between schemes (F (3,2208) = 0.36), although there were significant differences between varieties of rice (F (31, 208)=12.46).

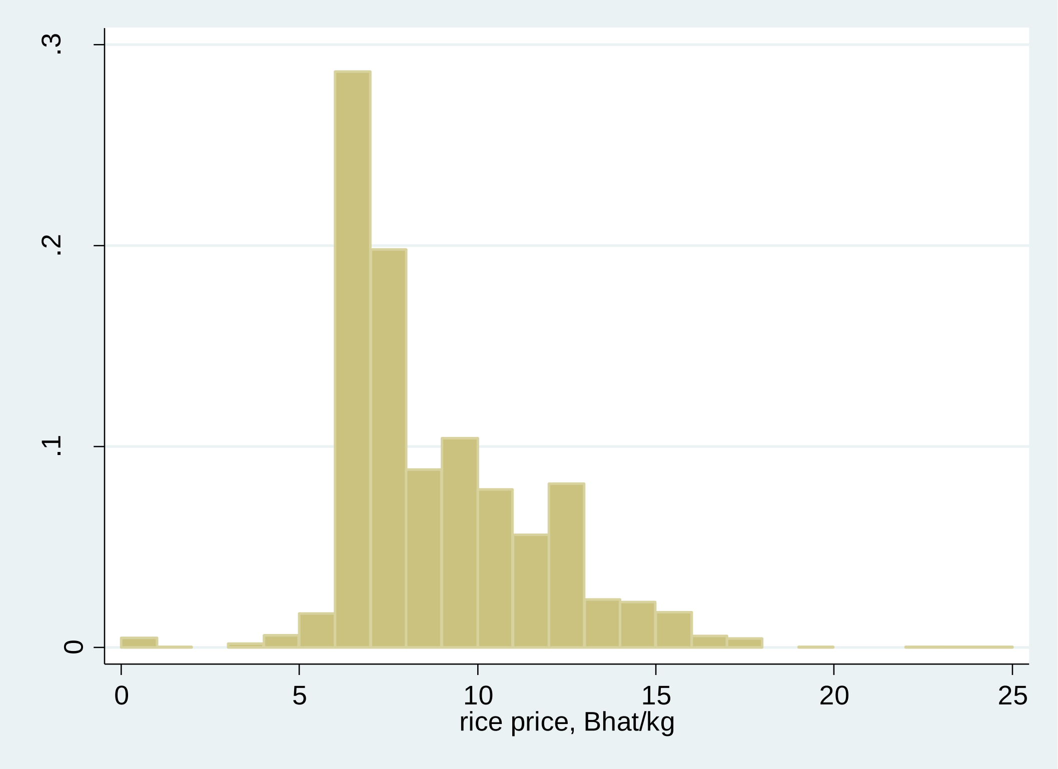

Figure 5: Reported Rice Prices

Value of Crop Output

Most of the variables included in the estimates of crop production and its financial value are strongly positively skewed, implying some extreme values are due to misplaced digits. Also, a significant number of observations have the value 0 (zero) when a positive value is expected (e.g. for output). Winsorizing the top and bottom 0.5% of observations reduces mean gross output of rice per plot by nearly 15%, and rice yields by 6%, for example.

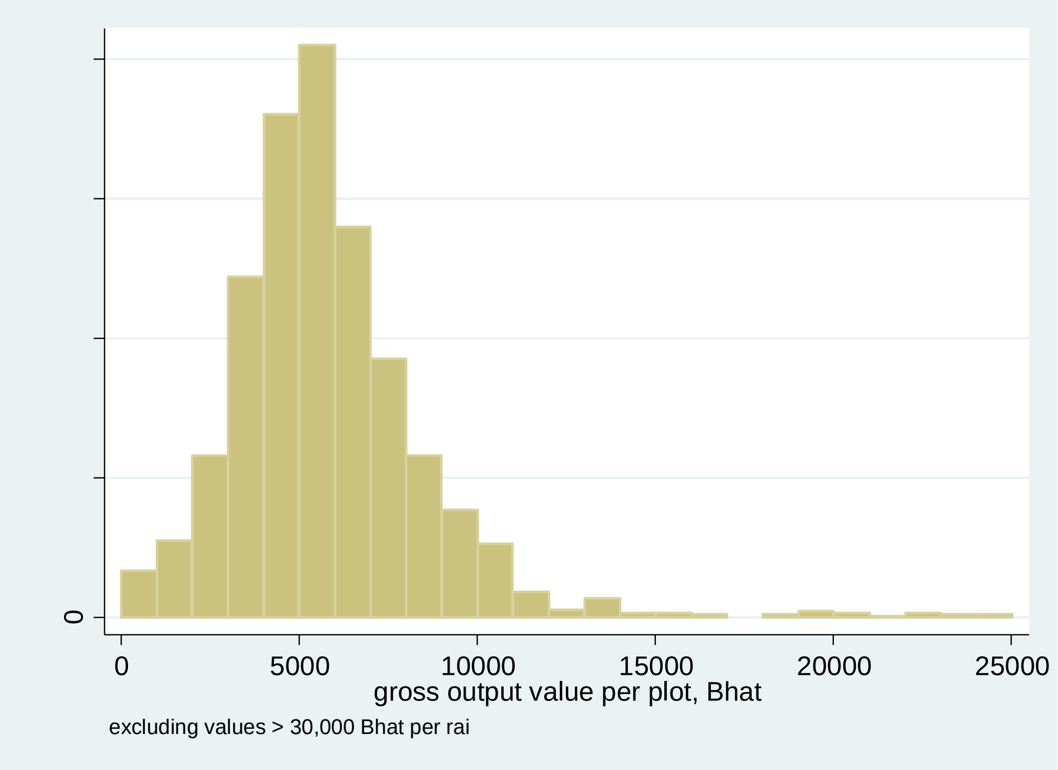

Figure 6: Gross value of output of Rice, Bhat per Rai

Livestock & Fisheries

While both livestock and fisheries enterprises are important components of household incomes, we have yet to analyse these data, in part because they appear to have about the same density of data errors as the cropping information.