Results of the exploratory baseline study to investigate the status of community led management of small waterbodies in Southern Lao PDR

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2 Introduction

Fish is widely considered to be the major source of animal protein for the majority of people in Lao PDR. Subsistence fishing is carried out by almost everyone who has convenient access to water (Claridge 1996). Estimates for consumption in the relatively water-resource rich Provinces of Southern Laos are higher at an average of 17.5kg/household member/year (Garaway 1999). Being a landlocked country, the inhabitants rely on the inland fishery for all their fishery resources.

According to government statistics, apart from the River Mekong and its tributaries (254,000ha), the country is estimated to have 54,000ha of lakes and reservoirs (natural and man-made), innumerable ponds (9,000ha), bunded paddy fields (418,000ha) and swamps (1000ha) (Phonvisay 1994). It is estimated that between 60-65% of all Lao's fishery resources can be classified as small waterbodies as defined by (Anderson 1987):

> "small reservoirs and lakes less than 10km^2 in area; small ponds; canals including irrigation canals; small, seasonal, inland floodplains and swamps; and, small rivers and streams less than 100km^2 in length".

The following aquatic resources were excluded:

> "mangroves; large coastal and inland floodplains; coastal lagoons with intensive, well-established fisheries; and fish ponds specifically constructed for intensive aquaculture".

Enhancement of small perennial waterbodies, through stocking, is an idea gaining in popularity with the Lao government (and local communities) and is seen as one means of addressing their wider objectives, described above. Small perennial waterbodies are ubiquitous throughout southern Laos as either naturally occurring waterbodies such as natural depressions or oxbow lakes, improved depressions, for example a dammed depression that results in a larger waterbody, or man-made waterbodies created by digging out an area to create a depression. These waterbodies are an important resource for surrounding village communities, not just as a source of aquatic products but also as a source of water for household use, for irrigation and for livestock as well as being used for bathing.

Experience with enhancement initiatives have suggested that, while enhancements have the potential to yield substantial benefits, the actual outcomes (in terms of yield, distribution of benefits and institutional stability amongst others) are often different to those initially expected (Garaway 1995, Hartmann 1995, Cowan et al. 1997, Lorenzen and Garaway 1998, Samina and Worby 1993). The underlying reason for these unexpected outcomes is uncertainty about the resource systems. This uncertainty manifests itself as (a) limited prior knowledge of local conditions and (b) the complexity of environments into which enhancements are introduced.

Adaptive learning approaches have potential to improve the management of culture-based fisheries in small waterbodies. This is because of both the need to reduce the uncertainty associated with their management and the nature of the resource systems. Adaptive learning approaches involve using or creating variation in management and analysis of responses to this variation to gain information about management. Previous studies (e.g. Lorenzen et al. 1998) have indicated that the variation in management that already exists between management regimes could be used to provide information that could inform and improve management. Active experimentation, where contrast is created in management, could potentially yield even greater benefits (Peterman and McAllister 1993).

One of the first steps in the adaptive learning approach is understanding the resources, the users and managers (Garaway and Arthur 2002). In order to take an adaptive learning approach with the management of community fisheries in southern Lao PDR, it was therefore necessary to identify village communities with small perennial waterbodies who were already stocking, wishing to stock, or already managing their waterbodies in some way. Such villages/waterbodies could then form the basis for an adaptive learning experiment. This report outlines the initial steps in this procedure including the collection and subsequent analysis of baseline data concerning community-managed waterbodies in southern Lao PDR.

2.1 Specific objectives

The objectives of the baseline study were:

- To characterise the management systems, including the objectives, currently operating in community managed waterbodies within two provinces in Southern Laos.
- To collect information about the bio-physical nature of the community managed waterbodies within the study area.
- To conduct an initial assessment of whether the stocking of small waterbodies had an effect on the diversity of fish within the waterbodies.

3 Methods

The study was conducted within the Savannakhet and Khammouane Provinces of southern Lao PDR over a three-month period between September and December 1999. A total of twelve districts were included in the study, four in Khammouane province and eight in Savannakhet, selected based on information provided by government staff about the abundance of waterbodies with some type of management and/or stocking within the two provinces.

3.1 Framing the enquiry

It was important that the baseline study included an assessment not only the bio-physical aspects of the resource systems but also the institutional arrangements and socio-economic aspects. This is because it has been recognised, for example by Lorenzen and Garaway (1998), that even technical management actions can have non-technical outcomes. Because of this, it is suggested that there is a need to gain an understanding of the wider social, economic and institutional environment in which management operates (Bosch et al., 1996, Dovers and Mobbs, 1997, Lorenzen and Garaway, 1998, Scoones, 1999)

Research on common-property resources has led to the development of a framework that enables analysis of how the outcomes of management are determined by interactions between the bio-physical characteristics of the resources and the institutional, social and economic setting in which they are utilised (Oakerson 1992). This framework, shown in Figure 1, is increasingly being used in fisheries research, including fisheries enhancements (Hartmann, 1995, Cowan et al. 1997, Lorenzen and Garaway 1998).

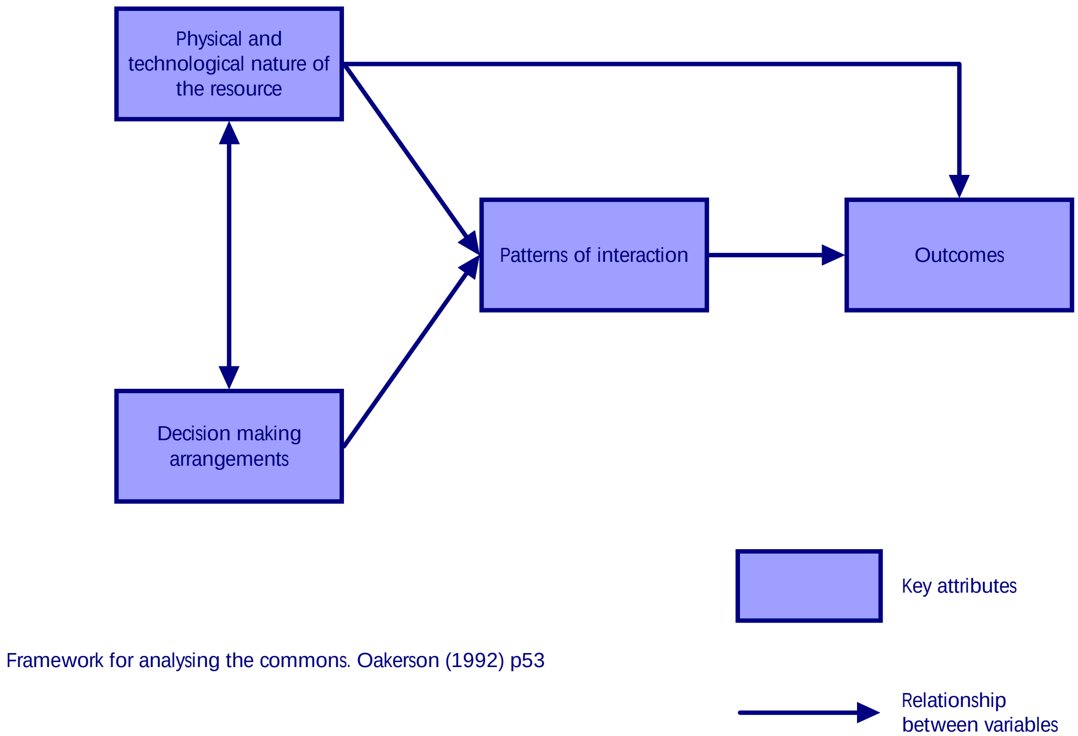

Figure 1. The Institutional Analysis and Design framework used to frame the enquiry

The framework describes the resource system in terms of four main attributes (the boxes in Figure 1) – biophysical and technical attributes of the resource, decision-making arrangements, patterns of interaction and outcomes. Decision making arrangements consist of the operational rules, i.e. rules that determine where, when, how and by whom resources may be used, conditions of collective choice, i.e. the set of rules determining how the operational rules are created and the external arrangements that constrain the rules and conditions of collective choice. The patterns of interaction are the sum of all individual actions made by resource users and the outcomes are the patterns of production and consumption from the resource system, to each of which will be attached stakeholder values.

Relationships between variables are shown as arrows in Figure 1. Some attributes of the resource, such as natural productivity, will affect the outcomes of resource use independent of the actions of resource users (top arrow). Such a relationship will constrain the achievable outcomes. Other attributes will affect outcomes by influencing the actions of resource users, for example the location of the resource may make poaching an option. The attributes of the resource, along with the rules in place for its use (arising from the decision making arrangements) provide the setting in which individual users can make decisions regarding the resource. Their resulting actions, the patterns of interaction, will then directly affect the outcomes.

The framework was used as a tool to frame enquiry into enhancement fisheries and to ensure that relevant information that would provide a full picture of all attributes of the resource system was collected.

3.2 Study team

The study was to be conducted in association with Lao government staff from the Department of Livestock and Fisheries provincial offices and district offices. The Livestock and Fisheries staff were well received in the communities and this made acceptance of the study team and survey activities easier and also aided communication with community representatives. The team comprised a fisheries biologist, an institutional analyst with extensive experience of research into community managed waterbodies in the study area, and up to four provincial staff who visited the villages and assisted in the surveying as translators and in the sampling programme. In addition to this core group the district officer from the relevant district, who each had in-depth knowledge of the local area, would also accompany the group and assist in the surveying and sampling.

3.3 Initial site identification and selection

The provinces and districts in which the study was to be undertaken were selected after discussion with Lao government staff. The initial selection of these provinces by the government of Lao PDR was based on the fact that there were many discrete waterbodies within these areas that were used as an important source of aquatic products. In addition, the districts selected contained examples of the type of community managed waterbodies that were of interest, several of which were subject to stocking initiatives.

Having selected the provinces and districts in which the study was to be undertaken, basic information on waterbodies and their management characteristics was collected from each participating district. This information included details about waterbody size, whether or not the waterbody had been stocked and the type of management, if any, that the villages employed for the waterbody. The information, collated on a simple form (see Appendix 1), was based on district records and the knowledge of local staff. In some cases, information was available from a previous study that had been conducted in Savannakhet province (Garaway 1999).

The number of potential study sites in each district varied with some having as many as 29 villages that could be surveyed, others as few as one. On the basis of the information available, sites were selected as potentials for inclusion if they satisfied the following criteria:

- They were perennial waterbodies greater than 1 Ha
- They were recognised as being owned by one or two adjacent village communities

- There was evidence of past management and/or stocking

The number of potential sites was greater than the time available to survey them all and therefore a further selection was made to ensure a wide coverage of sites across all participating districts and a variety of management regimes and stocking activities. In addition some waterbodies that were neither managed nor stocked were surveyed to act as controls for some elements of subsequent analysis. A total of 67 waterbodies in 40 villages were finally included for further investigation. These are listed in Appendix 2.

3.4 Information requirements for the exploratory survey

The exploratory survey consisted of two elements: a biological sampling programme including test fishing and water quality testing to investigate the bio-physical aspects of the resource system, and informal surveys with the village administration aimed at gaining information about both the village characteristics, the management of their waterbodies and the outcomes of this management. These two elements are discussed separately in the following sections.

The data to be collected from each village, based on the was discussed with the provincial and district staff and a list of subjects based on the IAD framework considered worth exploring was drawn up and agreed upon. This list of subjects was informed by previous work carried out in the region (Garaway 1995, Garaway 1999, MRAG 1994) together with the knowledge and experience of the Lao government staff. The agreed list of subjects to explore and the data to be collected is provided in Table 1. Details of the methods used are given below.

Table 1 Information collected in the exploratory survey.

Subject area	Data to be collected	Method used
Background village information	Size and stability of village population Location of nearest markets Organisational structure of the village	Semi-structured interviews
Details of available water resources	Location, size and relative importance of nearby water resources Annual variation associated with nearby water resources Regulations associated with nearby water resources Stocking histories of the water resources	Semi-structured interviews
Management of the community waterbody	Objectives of management Management regulations in place Monitoring of the waterbody Enforcement of regulations Income estimate (if any) Relative importance of income from community waterbody Maintenance and enhancement activities Problems associated with community waterbody management Future management plans	Semi-structured interviews
Fishing practices	Gears used in the community waterbody Effort estimate Yield estimate	Semi-structured interviews
Bio-physical characteristics of the community waterbody	Waterbody area Depth Water colour Conductivity Total phosphorous Secchi depth Species composition and biomass	Measurement Measurement Water quality sampling Water quality sampling Water quality sampling Test fishing

3.4.1 Semi-structured interviews

Semi-structured interviews were used to collect information about many aspects of the villages and management of waterbodies, including the decision-making arrangements, patterns of interaction and outcomes of management. These interviews were preceded by a review of relevant secondary data for background information. Secondary data sources included project documents, government statistics from national, provincial and district level and maps of the local area. To conduct semi-structured interviews, instead of formulating detailed questions ahead of time, as in a fully structured survey method, a checklist identifying a particular set of subtopics that are relevant to the wider issues being investigated is used. Interviewing is then conducted using the checklist to guide the specific questions improvised during the interview. This allows flexibility to probe for detail and thereby gain a better understanding of local variation. The idea was to allow the respondents scope to express opinions and to describe in more detail their particular situations. These types of questions were very important in providing an understanding of why certain actions had or had not been taken.

In addition to these interviews, the informants were also asked to create maps using a large sheet of paper and coloured marker pens that detailed the position of local water resources and the village. Questions would then be asked based on the maps that had been drawn to elicit more information.

Many rules and techniques that improve the quality and efficiency of semi-structured interviewing were considered and followed during the research, particularly those set out by (Grandstaff and Grandstaff 1985). These involve issues such as: procedures for setting up interviews (who to interview and where); controlling the interview; judging the responses of informants; probing; avoiding certain question types (e.g. leading questions); and, non verbal factors (awareness of body language, dress, local protocol).

The interviews were held with members of the village administration, usually including at least the village headman and deputy headman. In several cases other members of the village administration such as representatives of the fishing group, the group renting the waterbody, women’s group and village police were also present and would provide information. The information gained was used to provide background information about the village, classify the types of management regime and provide information about the use of local water resources and any enhancement activities. Yield and effort information where known, was also collected in this way, together with estimations provided from village records.

3.4.2 Biological sampling programme

The programme incorporated three elements; a description of basic physical characteristics, a sampling programme to collect water quality measurements and a test fishing programme. These are discussed in the following sections. The sampling programme was designed to investigate the bio-physical aspects of the resource system, in particular the effect of management regimes on fish stocks and, because production from extensive culture systems depends on natural production in the waterbody, to assess waterbody productivity. The number of waterbodies sampled was intended to provide sufficient replicates for the assessment of the effect of different management regimes.

Basic physical characteristics

At each waterbody, descriptive information about the waterbody such as the estimated percentage weed cover, surrounding vegetation and the colour of the water were noted and a sketch map of the waterbody including sampling locations made. Measurements of depth and of area were made for each waterbody. Depth measurements were made at a number of separate locations in the waterbody to obtain an average waterbody depth. For waterbody area, a 100 metre and a 10-metre rope and a tape measure were used to measure distances around the waters edge. The circumference of the waterbody was measured for circular waterbodies, length and breadth for rectangular waterbodies or breadth and height for triangular waterbodies. Area was calculated on the basis of these measurements. In 19 cases it was not possible to take measurements, either because the waterbody was very large or the edge of the waterbody was inaccessible, in these cases the area was either estimated visually and by consulting maps.

Water quality sampling.

Several authors have examined the factors that might affect fish production potential in freshwater lakes. A number of characteristics have been identified as potentially useful for the predicting the potential yield from a waterbody including primary production (Oglesby 1977), total phosphorous (Hanson and Leggett 1982) and the morphoedaphic index (Ryder 1965). For this survey, water quality sampling was conducted using the three indicators of waterbody productivity - Secchi depth, conductivity and total phosphorous.

Secchi depth.

Secchi depths were measured using a standard 20cm metal Secchi disk; the Secchi depth values for each waterbody would give an indication of the water transparency. Secchi depth is considered to be a relatively reliable indicator of biological productivity in low productivity waterbodies (Hasan and Middendorp 1998) so could potentially provide an easily measured indication of the productivity.

Conductivity

The concentration of total dissolved solids in a water sample can be determined by measuring its electrical conductivity. The more impurities or total dissolved solids in the water, the greater its electrical conductivity. However, conductivity readings from a waterbody will not provide any information on the species of dissolved solid or the proportion of each. Conductivity measurements were not made at all the waterbodies but for those sampled (n=37) measurements were made at three separate locations in each waterbody. The average conductivity measurement was also used to calculate the morphoedaphic index (MEI) for each of the waterbodies sampled.

The MEI value for each waterbody was calculated as the total dissolved solids divided by the mean depth. Total dissolved solids is an edaphic factor reflecting the nutrient levels prevailing in the system, while mean depth is a morphometric factor. The MEI has often been used as a method for predicting fish yield, particularly for temperate waterbodies with minimal volume fluctuations. In studies, MEI has not always been found to be strongly correlated with fish production (e.g. Downing, et al. 1990, Hartmann and Aravindakshan 1995) and its applicability to non-temperate waterbodies that are subject to flooding has also been questioned (De Silva, 1988).

Total Phosphorous

Phosphorus is essential to the growth of organisms and may be the limiting nutrient in the primary productivity of some aquatic systems. It is present in water in several forms and is an important nutrient for phytoplankton. In this study total phosphorous measurements were made for each waterbody. A strong relationship has been shown in this regard between total phosphorous concentration and chlorophyll a for tropical lakes in Sri Lanka by Nissanka et al. (2000). Other studies have also suggested that the concentration of total phosphorus can potentially be used to indicate the potential fish production of a lake (Hanson and Leggett 1982). Downing et al. (1990), in a review of fish production and productivity found that total phosphorous, along with primary production and fish biomass, was significantly correlated to fish community production based on data from 23 lakes.

For the total phosphorous measurements, 50 millilitre samples were collected at three separate locations in each waterbody from 30 centimetres below the surface where the water depth was one metre. Taking samples in this way both standardised the collection procedure and also ensured that samples were taken from within the waterbody where the effect on the measurement of surface and benthic interactions might be lessened. The concentration of total phosphorous was analysed according to APHA guidelines (APHA 1989). This analysis was performed at the Asian Institute of Technology, Bangkok.

<u>Test fishing</u>

The test-fishing component of the sampling programme was conducted with two objectives. The first objective was to get an indication through the relative test fish catch per unit effort of the fish biomass in each waterbody and the second to provide an initial assessment of whether stocking had any impact on the fish diversity in these small waterbodies. For the first objective test fishing was carried out in each community managed waterbody in the village while for the second, a paired site survey was conducted with test fishing carried out in a stocked waterbody as well as a nearby waterbody that had not been stocked. By comparing the diversity of species caught in stocked and non-stocked waterbodies it should be possible to get an indication of the effect that stocking might have on the diversity of fish in such small waterbodies.

The test-fishing survey component was carried out using multi-mesh panel research gill nets, a common sampling gear (e.g. Kurkilahti and Rask 1996). Test fishing in this study was conducted using a standard multipanel monofilament gillnet consisting of six panels, each five metres long and 1.5 metres deep with mesh sizes of 1, 2, 4, 6, 8 and 10 mm (stretched mesh). For each sample the nets were set by local fishermen at about 1800 hours and retrieved at about 0600 the following day. Multimesh gillnets such as these are a useful sampling gear as they are a passive gear that is able to sample a wide range of species, of different size classes, and are not as vulnerable to saturation as some other gears (Warren, 1999, Kurkilahti and Rask 1996).

In the morning following the setting of the net, all fish were removed from the net and the total weight of wild fish and, if present, stocked fish were obtained using an electronic balance with sensitivity of +/- 0.1 grammes. The weights of stocked and wild species were recorded and all the fish were then preserved in four percent formalin for subsequent identification to species level.

3.4.3 Limitations and problems encountered

The main limitations for the information collection were of time and resources. The time that it takes to perform and interview together with the distances between villages and the need to collect fish samples overnight and record them in the morning limited the number of villages that could be included in the survey. Other constraints were the availability of government staff at both district and provincial level and transport.

4 Results

The results of the baseline study will be presented in terms of the IAD framework. The forty villages that were surveyed ranged in size from 46 to 255 households with rice farming being the main livelihood strategy for community members in these villages.

4.1 Bio-physical and technical attributes of the resource

A total of 67 waterbodies were surveyed, ranging in size from 0.1 to 200 hectares. In all cases where there was management, the management can be considered as extensive as apart from stocking the waterbody there were no other inputs (e.g. fertiliser and/or feed). Because it was the only regular enhancement activity, this aspect of the resource warranted further study.

4.1.1 Waterbody characteristics

It was found that waterbodies managed as community fisheries did not differ significantly in either size or depth from other small waterbody resources near the villages. However, it was found in this study, as it had by Lorenzen and Garaway (1998), that the managed waterbodies were, on average, closer to the village than unmanaged waterbodies.

One of the most important characteristics or attributes of these resource systems is the natural productivity of the waterbody. This is important because, as Milstein (1992) points out, in extensive culture systems, production from the system is dependent on natural production. In order to investigate this, catches from the test fishing were transformed into comparable catch per unit effort (cpue) values in terms of the grammes of fish caught per effective square metre of net per night. This value was calculated for each waterbody by dividing the total catch by the effective area of the net (30 x 1.5, or 30 x waterbody depth if the waterbody was less than 1.5 metres deep). For the purposes of analysis these values were transformed to a logarithmic scale using the formula $C = \ln(C+0.0001)$. Similarly, distributions of secchi depth, conductivity, waterbody area, waterbody depth, total phosphorous were examined and for analysis these were also transformed to a logarithmic scale.

From the results of the biological sampling, it was found that for waterbodies that were subject to some form of management there was a significant positive correlation between total phosphorous and the test fishing cpue (Pearson, 0.01 level). Of the other water quality parameters, MEI was also found to positively correlate with test fishing cpue (Pearson, 0.01 level) and Secchi depth negatively correlated with test fishing cpue (Pearson, 0.05 level). Secchi depth was also correlated with total phosphorous at the 0.05 level. There was not found to be any correlation between area or depth and the test fishing cpue.

Waterbody parameters as predictors of standing stocks.

Several authors have used waterbody parameters in order to try to predict either waterbody yield or standing stocks (Oglesby 1977, Hanson and Leggett 1982, Lorenzen et al. 1998, Downing et al. 1990, Nissanka et al. 2000). In examining the use of some of the waterbody parameters as predictors of the standing stocks models, were developed that tried to relate the parameter to test fishing cpue. In the modelling, the natural logarithm transformed values were used. Models were tested that used a number of the waterbody parameters to predict the test fishing cpue. The models tested included:

$$\ln(\text{test cpue}) = a + b\ln(TP)$$
$$\ln(\text{test cpue}) = a + b\ln(MEI)$$
$$\ln(\text{test cpue}) = a + b\ln(SD)$$
$$\ln(\text{test cpue}) = a + b\ln(TP) + c\ln(\text{area})$$
$$\ln(\text{test cpue}) = a + b\ln(MEI) + c\ln(\text{area})$$
$$\ln(\text{test cpue}) = a + b\ln(SD) + c\ln(\text{area})$$

Where TP stands for total phosphorous and SD for Secchi depth.

The results of the modelling suggested that none of the models were able to explain much of the variance in the data, with the best fits being:

$$\ln(\text{test cpue}) = 3.738 + 0.651\ln(TP) \quad r = 0.544 \quad P<0.05$$
$$\ln(\text{test cpue}) = 2.548 + 1.621\ln(MEI) \quad r = 0.501 \quad P<0.05$$

$$\ln(\text{test cpue}) = 3.953 - 0.534 \ln(SD) \quad r = 0.363 \quad P<0.1$$
$$\ln(\text{test cpue}) = 3.665 + 0.69 \ln(TP) + 0.155 \ln(\text{area}) \quad r = 0.568 \quad P<0.05$$
$$\ln(\text{test cpue}) = 2.338 + 1.69 \ln(MEI) + 0.156 \ln(\text{area}) \quad r = 0.530 \quad P<0.05$$
$$\ln(\text{test cpue}) = 3.945 - 0.55 \ln(SD) + 0.058 \ln(\text{area}) \quad r = 0.369 \quad P<0.1$$

Some of the plots of the water quality parameters against test fishing cpue are shown in Figures 2 to 4, with regression lines from the above models added.

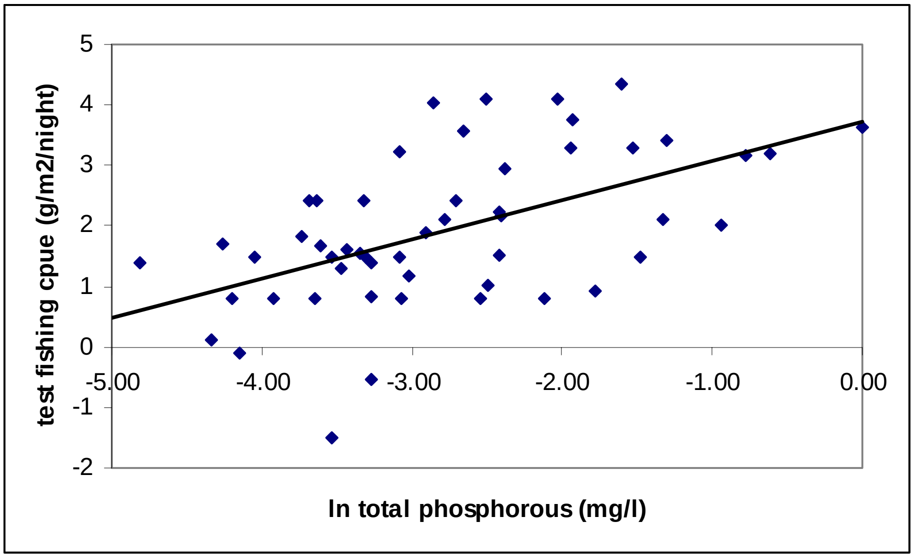

Figure 2 Regression of test catch per unit effort and total phosphorous.

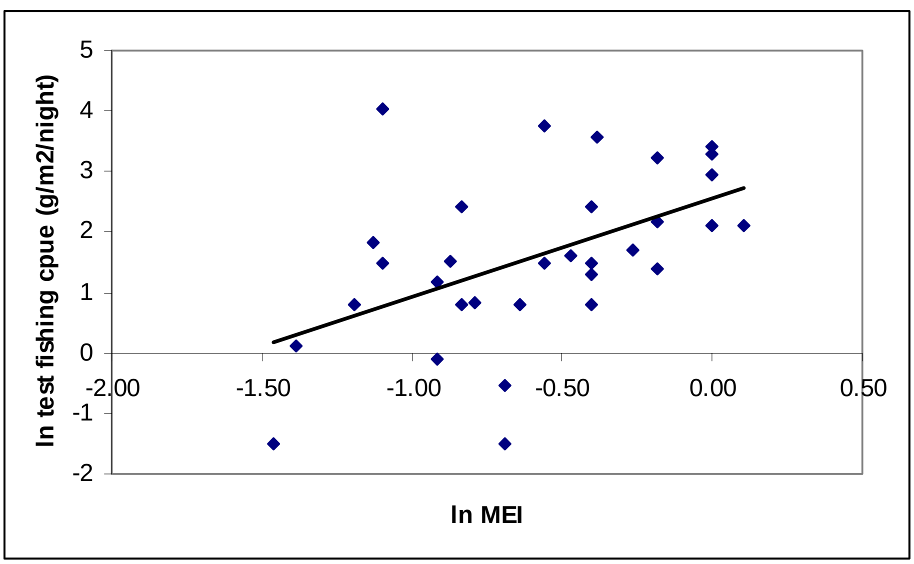

Figure 3 Regression of test catch per unit effort and morphoedaphic index.

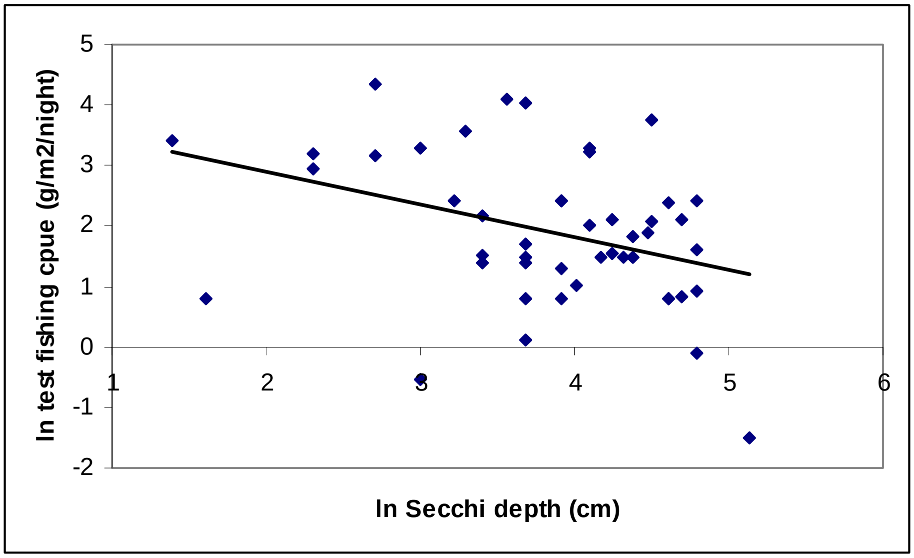

Figure 4 Regression of test catch per unit effort and Secchi depth.

4.1.2 Stocking

Thirty-four of the community waterbodies had been stocked at some time. In 11 cases stocking had been a one-off event while in 23 stocking had occurred more than once. Stocking occurs once in a year, either in the period May to July or, where a waterbody is liable to flood during this period, in October or November. Fingerlings were obtained from either government hatcheries or from private suppliers in either Lao PDR or Thailand and were generally stocked at a size of between two and five centimetres. There were few cases where the respondents indicated that fingerlings had been nursed in hapas, suspended small mesh net cages placed in the waterbody, prior to release. Payment for the fingerlings also varied with the Lao government subsidising stocking in a number of cases.

The species that were reported in this survey as having been stocked include those that are able to establish self recruiting populations such as Nile tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*), silver barb (*Barbodes gonionatus*) and some wild cyprinids. Other species that are used that cannot reproduce and therefore require periodic restocking include the Chinese carps (bighead carp *Aristichthys nobilis* and silver carp *Hypophthalmichthys molitrix*) and Indian carps (mrigal *Cirrhinus mrigala* and rohu *Labeo rohita*).

Stocking densities were variable both spatially (1999, n=16 maximum = 35294/ha; minimum = 375/ha; median = 2697/ha) and temporally and in many villages socking initiatives were not always sustained over time. The stocking and recapture procedure did not appear to have a scientific basis but rather to be based on the availability of both community resources to pay for stocking and of fish fingerlings. Evidence for this included higher stocking densities in the smaller waterbodies and the responses of key informants when questioned about stocking strategies. This is by no means unusual and a similar situation has been described for both small waterbodies in northern Vietnam and for reservoirs in Sri Lanka (Nguyen et al. 2001, De Silva and Amarasinghe 1996).

4.1.3 Effect of stocking on standing stocks

The waterbodies sampled could be divided into three categories, there were those that were neither stocked or managed, those that were managed in some way but were not stocked and waterbodies that were both stocked and managed. The waterbodies did not significantly differ from each other in terms of physical properties such as depth, area or water quality parameters. Examining the test fishing cpue for these three categories it was found that the waterbodies that had been both stocked and managed had the highest test fishing catches per unit effort (see Figure 5).

Whilst the test fishing cpues were not significantly different between the categories, the stocked and managed waterbodies did have a higher mean cpue than either of the unstocked waterbodies. The wild fish catches per unit effort were similar for all three categories and the test fishing cpue was higher in the stocked and managed waterbodies due to the contribution of stocked species to the catch. For all stocked and managed waterbodies, stocked fish represented 35.83% of the catch by weight while for the same category of waterbody where some stocked fish were recorded in the catch they represented 71.65% of the catch by weight.

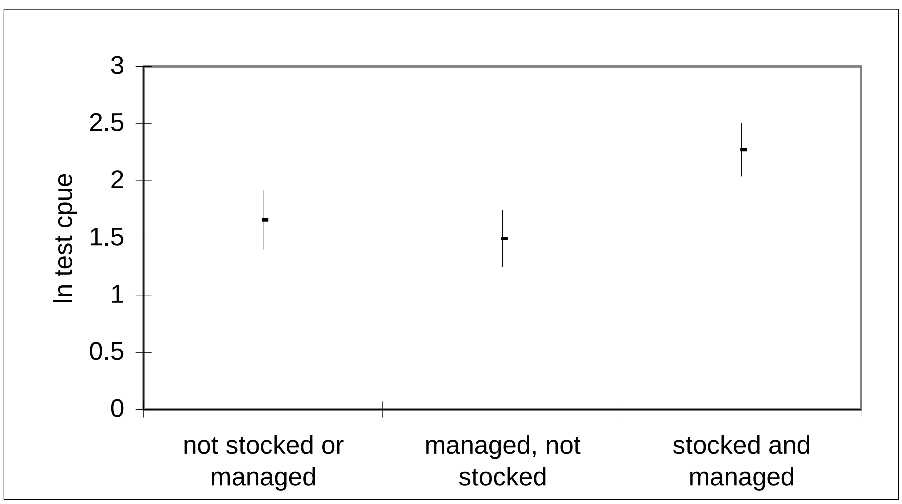

Figure 5 Test catch per unit effort by waterbody management category. Bars represent standard error of the mean.

While it has been found in a previous study that stocking and managing could lead to higher standing stocks in the waterbody and higher stocks of wild fish than in waterbodies that had not been stocked and managed (see Lorenzen and Garaway 1997), only the former was found here.

Within the group of waterbodies that had been stocked in 1999, the effect of stocking density on the test fishing cpue was examined. Stocking density was categorised as high if it was higher than the median stocking density for 1999 and low if lower. It was found that there was no significant difference in the mean test fishing cpue between those waterbodies stocked at high stocking densities and those with low stocking densities.

4.1.4 Effect of stocking on wild fish populations

In order to examine if there was any effect on populations of wild fish from stocking paired sites sampling was conducted. A stocked waterbody was test fished as described above and a nearby waterbody that had not been stocked was also fished in the same way. At the end of the sampling programme this provided 23 pairs of waterbodies from the study area with a range of sizes. The fish caught were transferred to the Natural History Museum in London where they were identified to the species level. Statistical analysis indicated that there were no significant differences between the stocked and not stocked waterbodies in terms of the depth, area, volume, Secchi depth and total phosphorous levels (paired t-test, $P<0.05$).

Catches from the stocked and non-stocked waterbodies were compared in order to see if there was any significant impact on the indigenous wild fish populations from stocking these waterbodies. This was done in two ways, firstly the frequencies with which species were caught in stocked and non-stocked waterbodies were tested using a chi-square test and secondly diversity indices were calculated for the waterbodies and the mean diversity indices compared. The biodiversity indices used were Simpson’s diversity and equitability indices and the Shannon diversity and equitability indices.

The results of the analysis indicated that there was no significant difference in either the composition of the catches or the species diversity between the stocked and non-stocked waterbodies. The diversity indices were tested to see whether, within these waterbodies, there was any correlation between the diversity indices and various waterbody parameters including waterbody productivity (total phosphorous, MEI and Secchi depth), area and depth. No significant correlations were found between the diversity indices and the waterbody parameters tested.

4.1.5 Water quality in waterbodies containing stocked fish

The waterbodies to be considered in this analysis are only those where stocked species were caught in the test fishing. In the test fishing the stocked species encountered in the catches were either tilapia or carps. While there was no significant difference in the area or depth of the waterbodies in which the two were found, the productivity of the waterbodies differed. Test catch and water quality data was used from waterbodies that had been stocked with both types of fish and one or other had been caught in the test fishing. The data suggests that the tilapia appear more likely to be caught in waterbodies that have higher productivity while carp are more likely to be caught in waterbodies that have lower productivity (see Figure 6). The values are back-transformed means of the log transformed distributions and are significantly different (P<0.05).

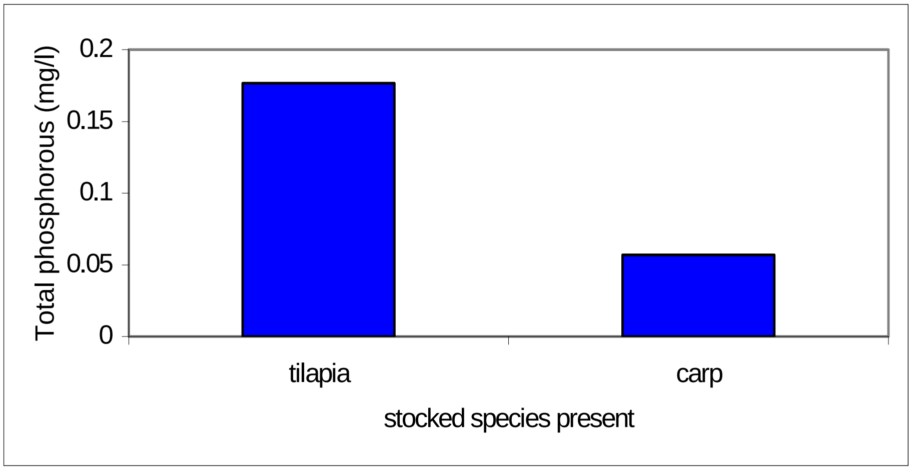

Figure 6 Mean total phosphorous in waterbodies where either tilapia or carp were caught

4.2 Decision making arrangements

When it comes to an examination of the decision making arrangements, it is important to understand the context in which decisions making is occurring including the opportunities and constraints that presented by the external arrangements and those inherent in the community. In addition the types of rules arising from the decision-making arrangements are described.

Under the laws of Lao PDR, any regulations created by village administrations are fully recognised and the administration is entitled to enforce them (Baird 1996). However, it is important to note that whilst such rights exist, leading to systems of common property rather than 'open access,' active management of such waterbodies, including enhancement, is still minimal. Where it does exist, management generally consists of creating rules regarding access to/or use of the waterbody (e.g. permanent and seasonal closures; limitations/prohibitions on specific harvest techniques; protection of particular species or groups) and can also include enhancement efforts such as increasing the size of the waterbody by building or enlarging a dyke and stocking the waterbody with wild or hatchery produced fish. Increasingly, waterbodies are being utilised to provide income for community development and new management regimes are emerging to achieve this objective. Stocking is often an important component of these management strategies, being seen as an important means of increasing the value of the resource and hence the income obtainable.

Out of a total of 67 waterbodies surveyed, ranging from 1-200Ha, 51 were managed by the village administration of one, or sometimes two, villages and therefore had some form of rules governing access and/or use. These are discussed in the following section. In the 17 waterbodies that were not subject to management, fishing was conducted by members of the community, and sometimes also of nearby communities, as a year round activity. The fisheries are multi gear and multispecies with fishing an activity pursued by men, women and children. Although fishing is conducted all year, these waterbodies tend to be most heavily fished during the dry season as during this time there are fewer available water resources. During the rainy season people will often prefer to fish flooded areas and the channels through which many species are migrating.

4.2.1 Objectives of management

In each village, the informants were asked about the primary objectives of their waterbody management. Results are presented in Figure 7, which also shows the 17 unmanaged waterbodies. As can be seen, six priority objectives were identified,

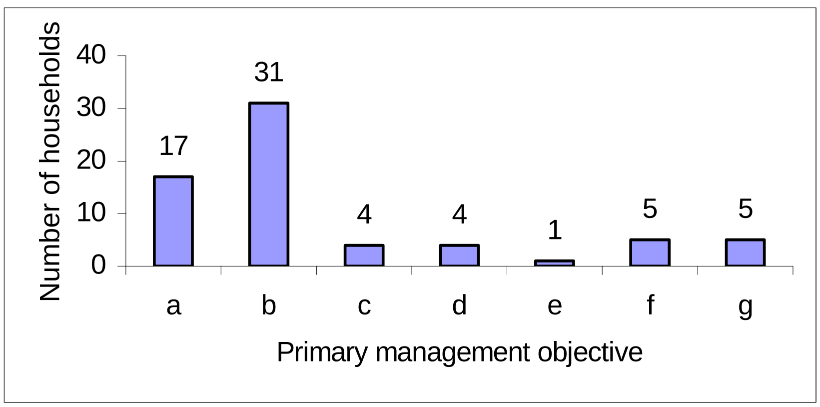

Figure 7 Primary objectives of waterbody management. a) unmanaged; b) income for community development; c) fish for guests/community work; d)water for household use; e) preservation of sacred place; f) conservation of fish stocks; g) preserving fish for harvesting at specific times of year.

the most common being income generation for community development. Whilst this result may have been partly influenced by the initial site selection (with district officers being more aware of these management initiatives than of others), many of the villages where income was being generated had other waterbodies that could be subjected to management, but in the vast majority of cases they remained unmanaged. District officers were also encouraged to provide as full census as possible of waterbodies in their districts. It is believed therefore that, as suggested in previous research (Garaway 1999), income-generating potential is a major catalyst for more active management.

The types of management regime employed for income generation are discussed in the following section. Of the remaining waterbodies, only five waterbodies were managed primarily for fish conservation though in several other cases this was a secondary objective or a by-product of the management regime. Rules created in pursuit of this objective included limiting gears (to protect certain species or certain age groups) and prohibiting fishing in certain areas of the waterbody. In five cases fishing was restricted to certain times of the year. The main purpose of this was to enable all the community, and in some cases surrounding communities, to benefit from the resource at a time of low agricultural labour demand and in such cases fishing pressure was relatively intensive.

4.2.2 Management regimes in income- generating waterbodies

In the 31 cases where waterbodies were managed for community income, the income was used for purposes such as improving the village school or temple, improving the road to the village and providing electricity for the village. Improvement was almost completely in the hands of the village as there was little government funding for development at this level. Infrastructure development was therefore seen as a priority, and community income generating activities took high priority in village life.

For management with the objective of providing community income, the type of management could be broadly categorised either as group fishing, rental or fishing day systems (see Table 2).

Table 2 Management categories for waterbodies managed to provide community income.

Description of management	Number of cases (1999)	Broad management category
Group fishing, drain pond for income, community access restricted	1	Group fishing
Group fishing throughout year, community access restricted	8	Group fishing
Rented all year	2	Rented
Rented for harvest only	9	Rented
Sub-areas of the waterbody rented for part of the year	1	Rented
Rental for period exceeding one year	3	Rented
Fishing day, community access restricted prior, no restrictions after	5	Fishing day
Fishing day, community access restricted all year	2	Fishing day

Group fishing

A group fishing system was often found in association with stocking initiatives. The waterbody would be stocked in June/July and then access for fishing by community members would be prohibited. During the dry season, in the following March/April, a group, or groups, of fishers who would be selected by the village administration, would undertake fishing

Rental systems

Rental systems involved the renting out of the community waterbody for all or part of the year for a fixed sum. The waterbody was rented to either one family or a group of families from within the village. Where a waterbody was not stocked access might not be completely restricted to community members except during the harvesting season (March/April) when the renters have exclusive harvesting rights. In one case, community members were allowed access to the waterbody for fishing during the year until the harvesting season. In the harvesting season, a time when water levels in the waterbody are low, if the water level in this waterbody was sufficiently low it would mean that the waterbody would effectively become a number of smaller waterbodies. If this was the case then one of these small waterbodies, and it is the same one each year, would be offered to renters while community members would still be allowed to fish in the others. If the water level did not fall far enough for this to happen then renting was not considered.

Where a waterbody had been stocked, it was, with one exception, the case that access to community members would be completely restricted and the renters would have exclusive harvesting rights for the year. In some cases the waterbody had been stocked by the village administration and then rented, in other cases the waterbody was rented for the whole year and stocked by those renting. In the exceptional case the waterbody was large (18.5 hectares) and was the only water resource available to the community. In this case the waterbody was stocked and community members were allowed to fish only with certain gear types. The waterbody was then rented during the harvesting season.

Fishing days

Fishing days are events held during the dry season where the waterbody is essentially harvested on one day with a restricted selection of gear types. Traditionally, fishing days were events where it was free to participate however, in the waterbodies managed to provide community income, charges for participation had been introduced. In several cases it was stocking of the waterbody, either by the government or village administration that had led to the introduction of charges. For income generation, the village administration arranged the sale of tickets to those members of the community and from other nearby villages who wished to participate with ticket charges based on the type of gear used. Usually following the fishing day the waterbody will be open for subsistence fishing by members of the community until June/July when it may be restocked.

In all these systems, the rules put in place and the resulting restrictions accounted for the objectives of the community, the characteristics of the community, and the attributes of the resource. This accounts for the variety of management seen in Table 2. As Garaway and Lorenzen (1998) note, rules are chosen to minimise the costs of management, hence the waterbodies selected for management would be near to the village.

4.3 Patterns of interaction

The patterns of interaction describe essentially the monitoring, enforcement and fishing activities. In this respect, 72% of the waterbodies that had some form of management restrictions also had some form of monitoring in place to prevent illegal fishing. Most often this monitoring would be in the form of villagers watching the waterbody during their daily activities and reporting infringements to the village administration. However, in four waterbodies there monitoring and enforcement was the responsibility of the village soldiers who were paid a percentage of the yield from the fishery in return for this service. Respondents indicated that there was believed to be little illegal fishing. While it might be thought that a waterbody, particularly one that had been stocked, would be tempting, the availability of alternative sources of fish and other aquatic resources and the fact that the resource was restricted in order to bring benefits to all were given as reasons individuals might not transgress.

Fishing effort in the managed waterbodies was highest during the period of low agricultural labour demand. The pattern and duration of fishing in the waterbodies varied in nature depending upon the management type and is discussed here in relation to the three types identified.

Group fishing

Fishing by the groups would be performed usually using cast nets, gill nets or both. In one case the fish were harvested only after a number of years and the method used was to de-water the waterbody by draining it to obtain the fish. The catch harvested by the fishing groups would be sold, either within the village, to traders or both, the fishers receiving some form of payment for the fishing in the form of fish or money.

Renting

Harvesting of rented waterbodies took place in a variety of ways and could include a group fishing approach by the rental group similar to that outlined above, intensive harvesting using gillnets and scoop nets and dewatering through pumping of the waterbody or draining. The fish harvested would generally be sold within the village or to visiting fish traders.

Fishing days

These are traditionally quite social events where many members of the community fish on the day. Fishing is usually conducted with some combination of cast nets, scoop nets, push nets and lift nets.

4.4 Outcomes

4.4.1 Yields and income in managed waterbodies

It was found in villages managing their waterbody to generate village income that the income generated from small waterbodies was very significant when compared to other income generating sources such as the village festival, or obtaining money from relatives abroad. In 15 of these cases the waterbody represented the primary source of income, in six it was the secondary source, in seven it was one of many sources of income and for the remaining three the relative importance of the waterbody to community income was unknown.

Estimates of fish yields and fishing effort were difficult to determine through questioning of key informants apart from in those villages that operated a community fishery that utilised a fishing group and had kept records of catches and sales. This problem has also been encountered by other researchers investigating these types of fishery, for example, Garaway (1999). In many cases the respondents did not feel that they could adequately estimate either catches or effort. In addition fishing activity can be seasonal in both effort levels and the gears employed making effort levels for a particular waterbody difficult to estimate. Despite these difficulties, it was found that respondents generally perceived that managing a waterbody by organising group fishing would provide the highest level of income.

Yield and income estimates from harvesting during 1998/1999 were available for eight waterbodies managed using group fishing and four waterbodies that were managed by having a fishing day. No estimates were available for waterbodies that had been rented. The median values for these estimates are shown in Figure 8. As can be seen, although the yield per hectare values are fairly similar, the income per hectare is much higher for waterbodies managed using group fishing. The probable reason for this is that fishing days, which are a traditional and important cultural occasion that is also valued for the contribution it makes to village solidarity, may require that ticket prices are affordable and attractive to households, which may mean that some income is foregone. Thus, although the waterbodies were managed with the same overall objective of generating income for community development, the outcomes of the management process were quite different.

In those waterbodies that had a closed season, informants explained that by limiting the fishing to the dry season, management had the benefit of preserving brood stocks and juvenile fish, active at other times of the year. Fish conservation was also a by-product of those waterbodies that were either considered sacred or use for household water. In these cases both the gears used and the quantity of fishing allowed was heavily restricted if not entirely prohibited.

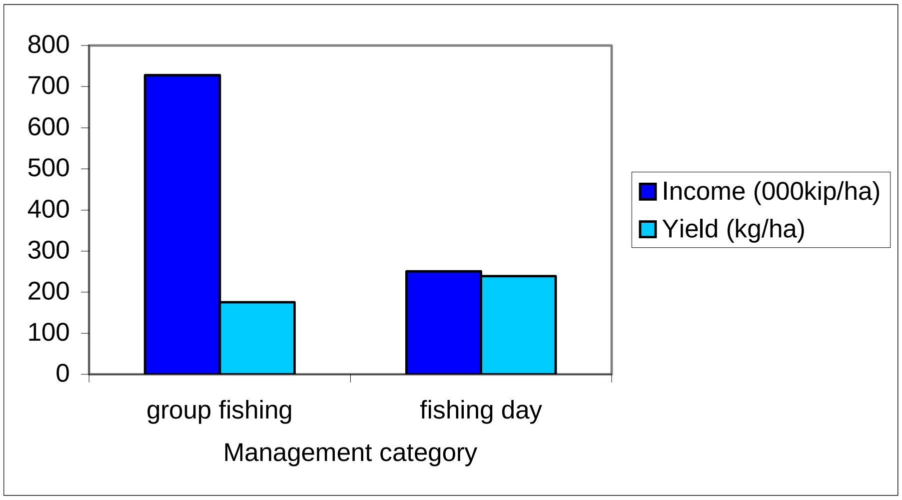

Figure 8 Median income and yield per hectare in community managed waterbodies by management category.

5 Discussion

Small waterbodies in southern Lao PDR, as a number of studies have noted, are important sources of aquatic products for communities. Framing enquiry into the management of these resource systems using the IAD framework has allowed a systematic investigation that encompasses both the technical, bio-physical aspects of the resource system and the institutional, socio-economic aspects that also affect outcomes.

Many of the waterbodies in the study area, and a number of those surveyed, were used by community members for subsistence fishing activities. In several cases village administrations had imposed regulations on the use of nearby waterbodies, either for income generation, conservation, cultural reasons or because of water use issues. Because of this, a wide variety of management systems were identified as being used in the management of small waterbodies by communities within the study area.

In a number of cases, more often than not associated with the generation of community income, management had included the stocking of the waterbody. Stocking of these waterbodies did not appear to have any scientific basis and was more to do with fingerling and financial resource availability. The outcome of stocking appears to be a higher standing stock in the stocked waterbodies with a considerable proportion of this consisting of stocked fish. The increased standing stocks, through the relationship with outcomes, can potentially allow greater yields. However, as Garaway and Lorenzen (1998) have pointed out, stocking can also lead to changes in the rules regarding access (the decision making arrangements), in turn leading to changes in fishing effort (the patterns of interaction), that in turn lead to the potential yield increases not being realised.

Where the management of the waterbody was pursued with the aim of income generation, there were three main categories of management, namely group fishing, rental or fishing days. On the basis of limited data on yields, it appeared that, while the yields were similar for group fishing and fishing day systems, the community income generated was higher for group fishing systems.

Productivity of the waterbody is an important aspect to examine in these small waterbodies because, as Lorenzen et al. (1998), Quiros and Mari (1999) and Milstein (1992) amongst others suggest, in extensively managed systems the yields are likely to be influenced by the trophic level of the waterbody and the stocking density. While a lack of yield data means that this cannot be fully tested, the indication from the test fishing cpue data is that there is a greater fish biomass present in waterbodies with higher levels of productivity as measured using Secchi depth MEI and total phosphorous and therefore potential for higher yields.

In this survey it was found that total phosphorous was the best predictor of fish biomass in the waterbodies. Other researchers have also found that total phosphorous is a useful predictor of fish biomass and yield from waterbodies (Downing, et al. 1990; Lorenzen et al. 1998; Hanson and Leggett 1982). However, in this survey there was a great deal of variance and other factors to do with waterbody management such as gears used, fishing effort and stocking strategies might also have affected the fish biomass and therefore the relationship. Secchi depth was found to be less reliable as an indicator of fish biomass, possibly because of the fact that a number of the waterbodies in the study were fairly small and were susceptible to becoming turbid. The morphoedaphic index was also not found to be less useful as an indicator of fish biomass. In studies, MEI has not always been found to be strongly correlated with fish production (e.g. Downing et al. 1990) and its applicability to non-temperate waterbodies that are subject to flooding has been questioned (De Silva, 1988; Hasan and Middendorp 1998).

Test fishing catches, as well as indicating that stocking could increase standing stocks, suggested that in waterbodies where either carp species or tilapia were caught, and both were stocked, there might be advantages in stocking low productivity waterbodies with carp and more productive waterbodies with tilapia. This result is similar to that obtained by (Lorenzen, et al. 1998) in northeast Thailand who also found that tilapia tended to dominate in the more fertile waterbodies suggesting that the optimal combination of species may depend upon trophic status.

Additionally, The initial results looking at the effects of stocking exotic species on indigenous wild fish populations suggest that the impact has been minimal. Both the catch composition and the species diversity were not significantly different between stocked and non-stocked waterbodies in this survey.

The information from this baseline survey would be used to identify uncertainties associated with the management of community fisheries and subsequently to design an experiment to generate information relevant to the needs and objectives of local stakeholders that will reduce some of the uncertainties and lead to improved outcomes. This process is outlined in Arthur et al (2002).

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Appendix 1 Survey form to collate existing knowledge about waterbodies and their management

<u>Waterbody form</u>   For waterbodies in the district that are both: 1) Larger than 1 hectare   2) Have water all year

Village name or village names if there are more than one	**Waterbody name**	**Waterbody size (hectares)**	**Has it ever been stocked? Yes/No/Don't know**	**Is the waterbody natural or man-made?**	**What type of management is it? (see workshop notes)**

6 Appendix 2 Table of waterbodies surveyed

village name	waterbody description	district name	province name	area (ha)
Ho Meung	Nong Pa Phor	Atsapanthong	Savannakhet	5.52
Liamxai	Nong Noi	Atsapanthong	Savannakhet	1.27
Buk Thong	Nong Ybou	Champhon	Savannakhet	3.85
Buk Thong	Nong Sim	Champhon	Savannakhet	0.29
Dong Deng	Nong Leung	Champhon	Savannakhet	3.4
Dong Deng	Nong Deun	Champhon	Savannakhet	6
Dong Mi	Bung Phai	Champhon	Savannakhet	2
Dong Mi	Nong Sala	Champhon	Savannakhet	0.43
Huay Sai	Nong Haeng	Champhon	Savannakhet	1.83
Huay Sai	Nong Cadeau	Champhon	Savannakhet	0.43
Nong Hong	Nong Hong	Champhon	Savannakhet	18
Pang Haeng	Nong Kham Panay	Champhon	Savannakhet	0.32
Pang Haeng	Phai Noi	Champhon	Savannakhet	3.2
Nong Deun	Nong Bua	Khantabouli	Savannakhet	6
Dong Noy	Bung Ngam	Outomphone	Savannakhet	4.73
Kang Phosy	Nong Kham Yard	Outomphone	Savannakhet	5.48
Na Khu	Nong Sim	Outomphone	Savannakhet	2.27
Na Khu	Nong Hin	Outomphone	Savannakhet	3.16
Samphatvillai	Nong Luum Nung	Outomphone	Savannakhet	0.87
Samphatvillai	Nong Luum Song	Outomphone	Savannakhet	1.72
Sanamxai	Nong Pang	Outomphone	Savannakhet	0.68
Bung Xiang	Nong Bung Xiang	Sonbouli	Savannakhet	7
Bung Xiang	Nong Phai	Sonbouli	Savannakhet	4
Dong Boun	Nong Kak Het	Sonbouli	Savannakhet	6
Dong Boun	Nong Thapon	Sonbouli	Savannakhet	4
Kong Knak	Khoud Long	Sonbouli	Savannakhet	2.31
Kong Knak	Khoud Kong Knak	Sonbouli	Savannakhet	4.5
Naho luang	Nong Tam Nung	Sonbouli	Savannakhet	2
Naho luang	Nong Puay	Sonbouli	Savannakhet	1
Naho luang	Nong Khe	Sonbouli	Savannakhet	8
Nong Khu	Nong Sim Baheu	Sonbouli	Savannakhet	4
Nong Khu	Nong Sim Nua	Sonbouli	Savannakhet	4
Tam Nge	Phai Nong Sim	Sonbouli	Savannakhet	20
Tam Nge	Nong Luum	Sonbouli	Savannakhet	0.25
Xieng Hom	Nong Bua	Sonbouli	Savannakhet	1.84
Xieng Hom	Khoud Nong Bua	Sonbouli	Savannakhet	5.48
Xieng Hom	Nong Ngau	Sonbouli	Savannakhet	0.83
Bahn Khan Kaeng	Nong Itu	Songkhon	Savannakhet	1.5
Bahn Songkhon	Nong Ba Tau	Songkhon	Savannakhet	17.4
La Ha Nam Tong	Lam Pa Tet	Songkhon	Savannakhet	12
La Ha Nam Tong	Nong Kang Seng	Songkhon	Savannakhet	49.74
Lo Ha Ko	Nong Luum	Songkhon	Savannakhet	1.82
Lo Ha Ko	Nong Puan	Songkhon	Savannakhet	0.3
Sing Tha	Nong Lam Tuay	Songkhon	Savannakhet	40
Don Mak Fai	Kham Noi	Xayaputhong	Savannakhet	20
Pohn Thad	Nong Luang	Xayaputhong	Savannakhet	3.2
Pohn Thad	Nong Phai Lom	Xayaputhong	Savannakhet	0.17
Pohn Than	Nong Luum	Xayaputhong	Savannakhet	2.4
Pohn Than	Khoud Ta Po	Xayaputhong	Savannakhet	19.98
Pohn Than	Nong hong hian tung	Xayaputhong	Savannakhet	0.1
Bung Xe	Bung Pai	Xaybouli	Savannakhet	4
Nau Nua	Bung Si Ngan	Xaybouli	Savannakhet	125
Nau Nua	Bung Hor	Xaybouli	Savannakhet	6.6
Nong Sa	Nong Sa	Xaybouli	Savannakhet	3.38
Nong Saphang	Nong Sa Ngai	Xaybouli	Savannakhet	3.24
Nong Chang	Nong Chone	Hinboun	Khammouane	0.7
Nong Chang	Nong Dane	Hinboun	Khammouane	2.5
Nong Chang	Nong Chang	Hinboun	Khammouane	4
Don Mak Ba	Nong Bua	Saybanfai	Khammouane	200
Na Kom Tang	Huay Sai	Saybanfai	Khammouane	30
Nong Miang	Nong Miang Ngai	Thakek	Khammouane	15
Tha Ngam	Nong Bung Ban	Thakek	Khammouane	56.25