

**Results of an experimental approach to community
led management of small waterbodies in Southern Lao
PDR.**

Robert Arthur, Caroline Garaway and Kai Lorenzen

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1. Introduction

Small perennial waterbodies are ubiquitous throughout southern Lao PDR in the form of 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.

Where it does exist, management of such waterbodies 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, these 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. However, because of the complex and dynamic nature of these resource systems, there are still many uncertainties associated with such initiatives.

Because of the uncertainties associated with the management of culture based fisheries, adaptive management has been suggested as an approach for improving management of small waterbody resources, for example by Lorenzen and Garaway (1998). This is because of both the potential for improvement and availability of sites allowing replicated experiments.

An experimental modelling study had shown that long-term benefits from culture-based fisheries could be improved by taking an experimental approach to management (see Arthur and Lorenzen 2002). Similarly, in other cases where an experimental approach has been taken to management, the estimation of model parameters has been improved (Sainsbury 1988, Collie and Walters 1991, McAllister et al 1992). This is in contrast to programmed approaches where there is very little opportunity for learning because there is no variation in, and hence contrast between, management. In addition, deliberately manipulating conditions though can potentially allow for even greater improvements in learning as it can allow for greater contrasts between treatments under controlled conditions (Peterman and McAllister 1993).

In addition to this generation of information aspect, the adaptive learning approach included methods to enhance the transfer of information to the resource users and decision makers (see Garaway and Arthur 2002a). This was considered to be an equally important component of the approach if results were going to be utilised by resource users to deliver improved, sustained benefits..

This report will describe the experimentation that was undertaken as part of the adaptive learning approach. The aim of the experimentation was to generate new information about fisheries enhancements in small waterbodies in southern Lao PDR through management that would be directly relevant to the management of these waterbodies.

2. Methodology

The purpose of this section is to describe the process by which uncertainties were identified, strategies to reduce many of these uncertainties developed and the final combination of strategies to be implemented – the experiment – decided.

2.1. Selecting the strategies.

Selecting strategies that could generate information and reduce uncertainty involved a selection process based on filtering out of options that were not relevant or were unsuitable for other reasons. This process is outlined in Figure 1 and described below.

2.1.1. Identifying uncertainties.

The first stage in developing an experiment was to consider the uncertainties associated with management and decide the type of information generation strategy that would be needed to address each. The results of the exploratory baseline survey were used to identify areas where there was uncertainty and to examine these strategies

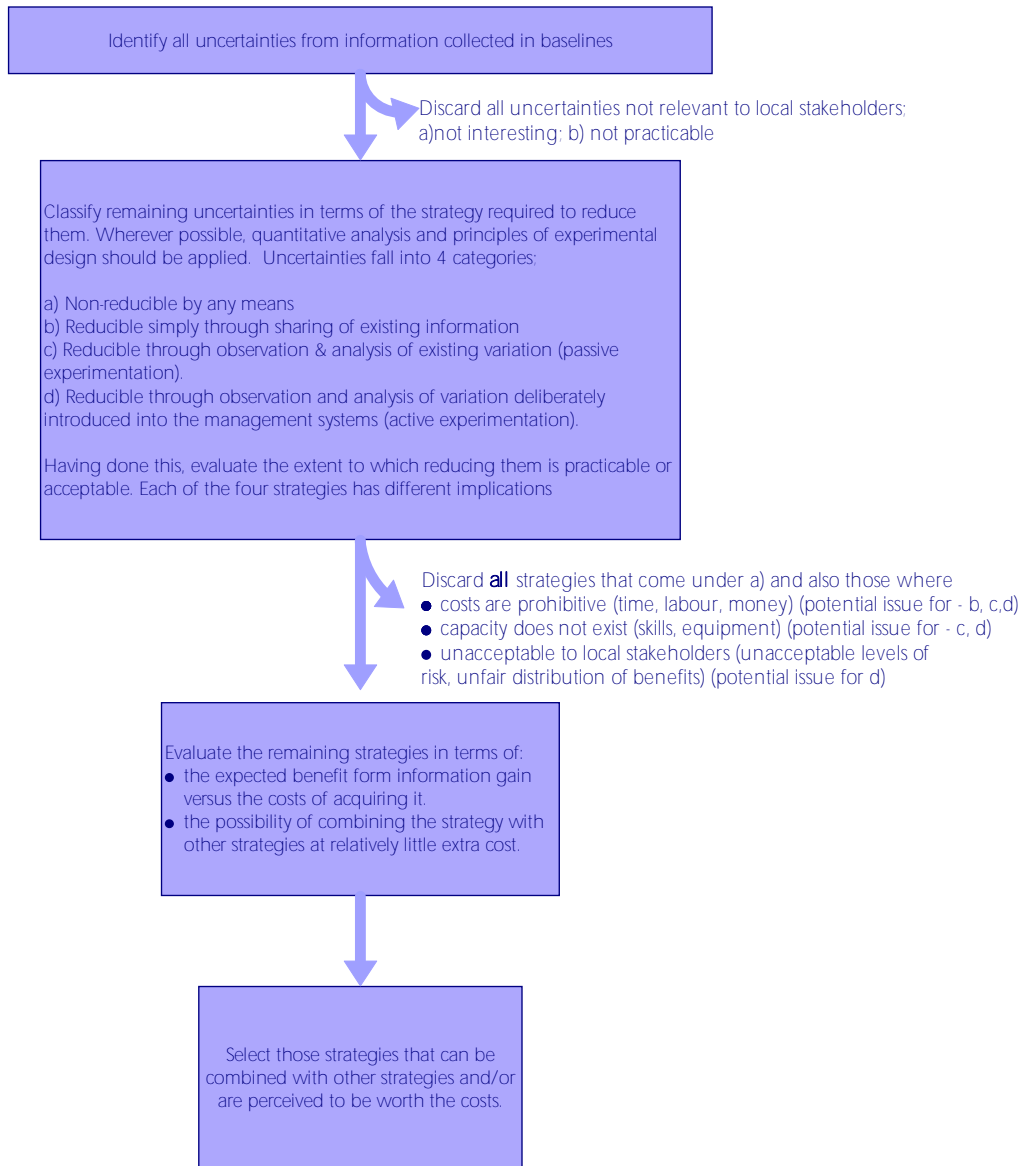


Figure 1. The process used to select an experimental management strategy.

The results of the exploratory baseline survey were used to identify a number of uncertainties associated with the management of small waterbodies, the reduction of which through an adaptive management approach could prove beneficial. For more details about the baseline survey, see Arthur and Garaway (2002). The objectives and needs of resource users, as determined through consultation during the baseline survey, were fundamental to the identification of uncertainties. Only those uncertainties that had some relevance to the priorities of the resource users were considered any further.

It seemed clear from the elements of the baseline survey that there is considerable potential for the adaptive learning approach to improve the management of these small waterbodies. Importantly, the survey indicated that there is not only a great deal of uncertainty about many aspects of

waterbody management that it would be beneficial to reduce, but that the management objectives of the village administrations suggested they would be willing to participate in an experiment.

The uncertainties identified included those associated with the biology of the resource system, such as best species to stock, technical aspects such as harvesting arrangements and institutional aspects such as the importance to successful outcomes of a strong administration. These uncertainties are shown in the first column of Table 1 below.

Table 1. Applying the selection process to the identified uncertainties

Strategy	Relevant?	Available sites?	Can use active strategy?	1 st cut – accept or reject	2 nd cut – accept or reject	Share information
Turbidity affects yields?	✓	X (B)	X (E)	X	X	X
Weeds affect fish growth?	✓	X (B)	X (E)	X	X	X
Best way to market fish?	✓	✓	X (E)	X (B)	X	✓
Best species to stock?	✓	✓	✓	✓ (G)	✓ (G)	✓
Optimise feeding?	X (A)	X	X	X	X	X
Agrochemicals affect fish?	✓	X (B)	X (E)	X	X	X
Deal with illegal fishers?	X (A)	X (B)	X (E)	X	X	X
Nursing increase yields?	✓	✓	✓	✓ (G)	X (year2)	✓
Stunting in tilapia?	✓	B	X (E)	X	X	X
Fertiliser, organic and inorganic?	X (A)	X	X	X	X	X
How much organic fertiliser?	✓	✓	✓	X (C)	X	X
How to reduce illegal fishing?	✓	X (B)	X (E)	X	X	✓
Best way to fish if many rocks?	X (A)	X	X	X	X	X
Best way to fish if water is deep?	X (A)	X	X	X	X	X
Get rid of disease?	✓	✓	X	X (B, D)	X	✓
Best management?	✓	✓	X (E)	✓ (H)	✓ (H)	✓
Get rid of predators?	✓	✓	✓	X (D)	X	✓
How long to grow fish?	✓	✓	X (E)	X (B)	X	X
Best gears to fish with?	✓	✓	X (E)	X (B)	X	✓
Optimum fingerling size?	✓	✓	✓	X (D)	X	X
Stocking density?	✓	✓	✓	✓ (G)	X (F)	✓
Effect of strong admin?	✓*	X (B)	X (E)	X	X	X
Best way to promote	✓*	✓	✓	X (C)	X	X

Where: A = irrelevant, B = sites unavailable, C = too costly, D = no capacity, E = unacceptable risk, F = unfair distribution of benefits/costs, G = active possible, H = passive possible, ✓* = of interest to provincial government

2.1.2. Classifying and discarding strategies

Having identified relevant uncertainties, the next stage was to identify strategies for reducing the uncertainties and decide which should be used to determine the final experiment to be implemented. This stage involved using certain criteria to filter out uncertainties that it would not be possible to implement. The first step was to classify the identified uncertainties in four ways This is shown below and in Table 1, which shows how the strategies were classified in practice.:

1. Those for which information does not exist and where there is no existing variation in management, or variation that can be created, to provide it.
2. Uncertainties for which the information already exists and which can be reduced through the sharing of this information.
3. Those that could only be reduced through the generation and sharing of new information that is obtained through careful site selection and the analysis of the variation existing between these sites (**passive** experimentation).
4. Uncertainties that can only be reduced using information that must be generated by creating variation between sites and subsequently analysing this variation (**active** experimentation)

Following this identification, criteria were used to assess and reject those options (classified as categories 2-4) that were also considered unviable (see Figure 1). Relevant strategies were considered to see if there were sufficient sites (column 3), and whether the information could be considered as an active strategy (column 4) if it could not be considered as an active strategy then it was considered as passive and the criteria applied on the basis that information generation would depend on existing variation. In the case of the information generating options, the principles of experimental design, including statistical power, were applied at this stage to assess such aspects as whether there would potentially be sufficient variation to provide sufficient contrast in the response variable and how many samples and replicates might be required. At this stage it was decided, for example, that changes in the length of time over which fish were grown, a risky strategy to implement as an active strategy so only considered as passive, was rejected, as insufficient variation existed in the study sites. It was important at this stage to ensure that experimental designs were fairly robust as implementation would require a high degree of cooperation and coordination and implementation completely in line with the design and without mishap was considered unlikely.

Stocking density was also considered as a potential experimental subject. However, the optimum stocking density would depend upon the species, or combination of species, stocked. It was felt that introducing widely different stocking densities would be unfair so this was rejected. Additionally, as uncertainty also existed as to what species combinations should be stocked this would need to be considered as well. Varying the density and the combination of species in an experiment using the available number of waterbodies resulted in an experiment with low statistical power so this idea

was rejected. It was considered that examining the species combination alone would be the better option as, following experiments to determine the optimum combination of species, subsequent experiments could then potentially be conducted to determine the optimum stocking density.

2.1.1.1 Evaluating costs and benefits associated with alternative strategies

Having rejected those options that were clearly unviable, the remainder were evaluated in terms of costs and benefits. It had already been recognised that there would be different requirements associated with the various options. While active strategies that create variation can potentially allow for even greater improvements in learning than from passive strategies because of the greater contrasts created, the costs and difficulty to implement can be higher for this type of strategy. Active experimentation, because it entails creating variation, generating the information and then sharing the information, is potentially the most difficult and most costly strategy. Thus the options had to be carefully evaluated in terms of what the costs would be and how useful the information gained would be. This stage occurred in a series of workshops with Provincial and District staff where the various strategies were discussed.

2.2. The experiment

As a result of the selection process outlined above the uncertainties in Column 6 of Table 1 remained. It was decided therefore to implement an experiment that combined active experimentation to generate information about a biological aspect (species to stock), passive experimentation to generate information about an institutional aspect (best management system) and facilitating the sharing of information about some technical aspects (e.g. how to reduce illegal fishing).

The active experimentation was to investigate how the optimal combination of species might depend upon waterbody productivity, as indicated by the concentration of total phosphorous in the waterbody. This is a relevant experiment, particularly as the effectiveness of this type of culture-based fishery is dependent on the efficient use of natural pond productivity, highlighting this as an important area for investigation. As Milstein (1992) has noted, knowledge of quantitative relationships between fish species and between fish and the environment is the main tool for managing polyculture systems. It has already been noted by Milstein (1992) and Hasan and Middendorp (1998) amongst others, that there can be both positive and negative interactions between species. Understanding these interactions could have benefits for these fisheries.

The results of the baseline study appeared to indicate that 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. The experiment

would examine whether tilapias respond differently to productivity than carps and furthermore whether there is an interaction between these species that depends upon productivity.

The experiment was designed to test the hypothesis that there would be an advantage in stocking high productivity waterbodies with tilapia and low with carp. In order to do this, waterbodies categorised as high or low productivity were stocked with carp, tilapia or a mix of carp and tilapia. Waterbody productivity for the experiment was determined based on the total phosphorous level in the waterbody, as this parameter appeared to be quite closely correlated to fish biomass (see Arthur and Garaway 2002). On the basis of this, high productivity waterbodies were those having total phosphorous levels above 0.07 mg/l. The experiment was considered to be a useful experiment that would help to explore the issue of optimum species combination

The subject of the passive experimentation was the benefits and costs to communities of the different types of management. Three categories of management had been identified, group fishing, fishing day and renting (see Arthur and Garaway 2002). However, there was uncertainty as to the conditions in which each of the management types were most likely to appropriate. This was of particular interest to the government who were keen to extend the idea of community fisheries and to villages who were interested in improving their own management systems to fit with their objectives.

For a number of the uncertainties identified, for example, how best to deter poaching from a community managed waterbody, there was a great deal of experience available from those communities who were successfully managing a community fishery and who had developed systems to do just this. In such cases, mechanisms for sharing the information were included in the experimental process.

The selection process resulted in an experimental approach that combined a number of strategies in order to target particular, yet separate, uncertainties. In each case the strategies addressed issues about which there is uncertainty and which community members in Lao PDR consider important and useful to learn about. The experiment was implemented over two years, providing results from two complete production cycles.

2.2.1. Experimental design

2.1.1.2 Active experimentation

The active experiment was designed so that there were two levels of productivity, high and low, both of which would receive each of the three stocking treatments. The distinction between high and low levels of phosphorous was made on the basis of the results of the exploratory survey and those of Lorenzen et al. (1998). Within each productivity and treatment combination there would be as many replicates as possible with available

waterbodies within each productivity group randomly allocated a stocking treatment. Each stocking treatment in the experiment was to be applied using a stocking density of 3500 per hectare. This is higher than the recorded median stocking density since 1995 so would be acceptable to the administrations of the participating villages.

At the end of the first year – after one complete production cycle, it was found that recapture rates of the species that were stocked had been low and that the results of the stocking experiment were inconclusive. It was felt that the original uncertainty that the experiment had been designed to address was still valid and that the experiment should be repeated with some modifications. It was decided in the second year that, due to the low recapture rates, efforts should be made to try to enhance fingerling survival. In order to achieve this, a number of measures to improve recapture were put in place.

Efforts were made to try to source fingerlings from nearer to the waterbodies and to try to procure larger fingerlings though this proved difficult due to the lack of availability from other sources in sufficient numbers. Therefore, except in a few cases, transport times were not much reduced and the majority of fingerlings came from the single supplier as the previous year. Fingerling size at release was also small last year (3-5cms but often closer to three).

For a range of practical and economic reasons it was not possible to supply fingerlings of a significantly larger size at an appropriate density and hence 8 weeks nursing after release was recommended. This was also something that a number of villages themselves had requested. Nursing, where fingerlings are reared in net hapas in the pond for up to eight weeks, was therefore introduced with training and hapas provided to those villages that wished to take up nursing.

Selection of waterbodies for the experiment

Waterbodies were selected for the active experiment based on the information collected during the exploratory survey. Waterbodies under 0.3 hectares were excluded from the experiment as they were considered to be too small while waterbodies over 40 hectares were also excluded on the basis that they would be too expensive to stock. Waterbodies where there would be problems restricting access, or where the village administration were unwilling restrict access, were not included as this would have led to problems in collecting data on catches and effort.

In all cases where waterbodies were selected for the active experiment it was important that the it was discussed with the village administration and that their views were taken into consideration. In two cases, discussion with village administration led to a waterbody being excluded but another suitable nearby waterbody included in the experiment. A total of 35 villages were involved in the active experiment in the first year and 38 in the second.

Selection of fish species to be stocked

The species chosen for the stocking experiment were tilapia (*Oreochromis niloticus*), mrigal (*Cirrhinus mrigala*), rohu (*Labeo rohita*) and, in the second year, bighead carp (*Aristichthys nobilis*). These are all species that have been used in stocking initiatives within the study area previously and are acceptable to the communities. Other species that could have been selected were common carp (*Cyprinus carpio*), silver barb (*Barbodes gonionotus*) and silver carp (*Hypophthalmichthys molitrix*).

Common carp, a species that can establish self-recruiting populations in the conditions, were not selected as it has been suggested that returns from stocking common carp are typically low (Lorenzen, et al. 1998; Sugunan 2000) believes that the low returns with this species might be attributable to the fact that the species, because of its slow moving nature, is vulnerable to predators and is also not particularly liable to be caught with passive fishing gears. In addition to this, the species was not recommended for stocking by the government due to possible adverse environmental effects associated with stocking them.

Despite being popular with consumers, silver barb were also not selected for the stocking experiment. Stocking silver barb, an indigenous species, might have led to difficulties in distinguishing the stocked specimens from those occurring naturally in the waterbodies. While this problem is by no means insurmountable, for example through tagging or fin clipping, either of these approaches might have affected mortality and would have entailed excessive costs. An additional factor in this decision was that, like common carp, silver barb have been found to offer low returns from stocking (Lorenzen, et al. 1998).

Of the remaining species, both the Chinese carps (bighead and silver carp) and the Indian carps (mrigal and rohu) are similar in that they are unable to establish self recruiting populations under the conditions found in the study area. Whilst all were reported by communities to grow well in the conditions, silver carp were the least popular in terms of consumer preference and were not included in the experiment.

The selected species were stocked using three treatments, a carp only treatment that was 50:50 mrigal and rohu (33% each mrigal, rohu and bighead in the second year), a tilapia only treatment and a treatment that was 50% tilapia and 50% carps. Using these three treatments, the experiment was designed to allow the estimation of the optimal species combination based on waterbody productivity.

All the waterbodies were to be stocked using these treatments at a density of 3500 fingerlings per hectare using three to five centimetre fingerlings. The exceptions to this were two larger waterbodies (over 20 ha) that were stocked at half density for reasons of cost, and one smaller waterbody that was

accidentally overstocked. The stocking density used is higher than the recorded median stocking density since 1995 as this would be acceptable to the administration of the participating villages. Additionally communities did not have to pay any of the costs associated with stocking as it was felt that this would make the experiment more acceptable and easier to implement.

Allocation of experimental treatments.

The treatments were to be allocated randomly within each of the productivity categories but this was not entirely possible due to the previous stocking histories in some of the selected waterbodies. In a number of cases, waterbodies had previously been stocked with tilapia and these waterbodies were not considered suitable for stocking with the carp only treatment. Apart from this limitation, the treatments were randomly allocated to the available waterbodies. The final numbers of waterbodies that were to be stocked at the experimental stocking density for each treatment are shown below in Table 2 for each treatment and productivity category there are at least five replicates. The experiment and the results from the experiment are to be discussed more fully in the following chapter.

Table 2 Number of waterbodies to be stocked at the experimental stocking density for each stocking treatment by productivity category.

Treatment	Productivity category	
	Low	High
Tilapia only	6	5
Carp only	5	6
Carp and tilapia	6	5

2.1.1.3 Passive experimentation.

The passive experiment concerning the costs and benefits of management types, required less coordination as it would be based on the analysis of variation that already existed in management type between communities (see Arthur and Garaway 2002). While changing the types of management villages' use would be ethically dubious anyway, the ethos of small waterbody co-management in Lao is that it is the villages and not the government who ultimately determine what, if any, management will occur. However, with over 30 villages taking part in the experiment and several distinct management regimes, there was plenty of scope for useful comparative analysis. The communities that were involved in the active experiment were studied and a further three communities were also included that were stocked with a nominal amount

Establishing 'best practice' for management was an important objective of the Lao government and was also of utmost importance to the villages. During workshops with villages, it was these aspects of 'how to do' that dominated discussion. Therefore an investigation of this subject was highly relevant.

Allocation of treatments was not an issue because the passive experimentation relied upon existing practices but the baseline survey suggested that each treatment would have at least 7 replicates (see Table 3).

Table 3. Number of villages implementing each management system in 2000-2001.

	Group fishing	Fishing days	Renting
Number of sites	9	12	7

2.3. Implementing the experiment.

2.3.1. Consulting communities.

The first stage in implementing the experiment was to consult with those communities that had been involved in the baseline survey and had suitable water resources. While the strategies that had been selected had been based on information provided by the communities during the baseline survey, it was important that they were consulted about the resulting experiment. This was to ensure that the villages were aware of what was planned, could assess whether it was indeed relevant to them and whether they wished to participate further, and helped increase understanding and make the experiment easier to implement.

2.3.2. Monitoring the experiment

As part of the consultation process an agreement was drawn up with village representatives. In this, it was agreed that waterbodies would be stocked in accordance with the experimental design and that the experiment would then be monitored and the results shared with the villages. In return village representatives indicated whether the community would be able to manage the waterbody as a community fishery and would assist in monitoring the experiment.

Primarily the communities and the District staff conducted monitoring of the experiment with some assistance from the Provincial staff. The monitoring programme was designed so that only information that would be relevant to the experiment and to reducing management uncertainty was collected. This was to ensure that the workload of the District staff, who also had other duties, was not too onerous. In order to assist the monitoring, a number of forms were developed together with the provincial and district staff. Monitoring activities included:

- Recording details of the stocking events. Information, including fingerling source and stocking mortality, was collected by the Provincial staff at each stocking event (see Appendix A).

- Recording details of fish nursing. Communities that nursed fish (in the second year) kept records of nursing duration and daily mortalities (see Appendix B).
- Test fishing and waterbody conditions. Every two months, District staff visited the waterbody and checked physical parameters such as waterbody depth and Secchi depth and fished the waterbody with a multimesh gillnet (see Arthur and Garaway (2002) for details of the net). This was left overnight from approximately 6pm to 6am and then the catch separated, weighed and recorded (see Appendix C).
- At the same time that they conducted the test fishing, every two months, District staff would also meet with representatives from the village administration to discuss the management of the waterbody, including details of management and any problems that had been encountered over the previous two months (see Appendix D).
- Recording catches, fishing effort and sales, by species, was the responsibility of the communities. They were best placed to be able to monitor what was often a daily activity and to facilitate this, each village was issued with a standardised logbook in which to record this information.
- In the case of fishing days, where all the fishing occurred on one day by, in some cases, several hundred fishers, a form for recording catches and fishing effort by species was developed. Completion of these forms on the fishing day was the joint responsibility of communities, District and Provincial staff.

2.3.3. Stocking

Stocking of the waterbodies in participating villages occurred in July of each year, except for those waterbodies that were known to flood, which were stocked in October. Stocking was in accordance with the experimental design and waterbodies, with the exceptions already mentioned, were stocked at a density of 3500 fingerlings per hectare with 3-5 centimetre fingerlings.

Fingerlings were transported in oxygen filled plastic bags with approximately 500 fingerlings per bag, a method commonly used for fingerling transportation in the area. Stocking was directly into the waterbody, unless the community had decided to nurse fish before release, and all attempts were made to ensure that it occurred before noon.

3. Results

3.1. Results at the end of the first year

Despite attempts to design a robust experiment, a lack of stocked fish in the catches, which meant that the result of the experiment was inconclusive, was the most noticeable result at the end of the first year. In many of the

waterbodies stocked, the catches of stocked fish in the test fishing and in villagers catches (as seen from village records) were very low. Stocked fish returns by number from village records indicated a mean return (with 95% confidence limits) of 3.84% (0.55%, 7.13%). However, despite the low returns, management had still been seen as successful in terms of village income, village development (allied to income), management experience and other benefits such as fish for guests or for consumption

Given that there did not seem to be enough data about the stocked fish to make conclusions about the performance of the species mixes, attention turned to the question of where all the fish could have gone. Several factors that might affect the catches of stocked fish were explored during the analysis including the effects of fingerling source, flooding, predation and the transport time of the fingerlings. Of these, only the transport time had a significant negative correlation with $R^2 = -0.454$. It is certainly the case that in certain particular waterbodies predation or flooding could be considered as very strong factors causing losses of fish but overall the transport time appeared to have the greatest effect.

3.2. Results at the end of the second year

The information collected during the second year was combined with that from the first to provide a larger dataset. Results are described for both the stocking experiment (the active experimentation) and for the comparison of costs and benefits from management systems (the passive experimentation). These results can also be found in the MRAG/RDC District Analysis workshop reports for 2001 and 2002.

The catches of stocked fish had improved during the second year. Total recorded catches had increased from 18709 kg to 22143 kg, with yields ranging from 3 to 3700 kg/ha/year and an average of 230 kg/ha/year. The returns from stocking in the second year had improved on the first with the mean number of stocked fish caught from the village records (with 95% confidence limits), now representing 6.70% (0%, 13.95%) of those stocked. Even so, a lack of stocked fish in the catches was the most consistently reported problem from villages. This was not surprising, as recapture rates, whilst better than last year, were still low.

3.2.1. Results of the active experimentation.

Total yield from the waterbodies was strongly related to fishing effort (Figure 2). The relationship was well described with a power function with an exponent of 0.53, indicating diminishing returns to fishing effort.

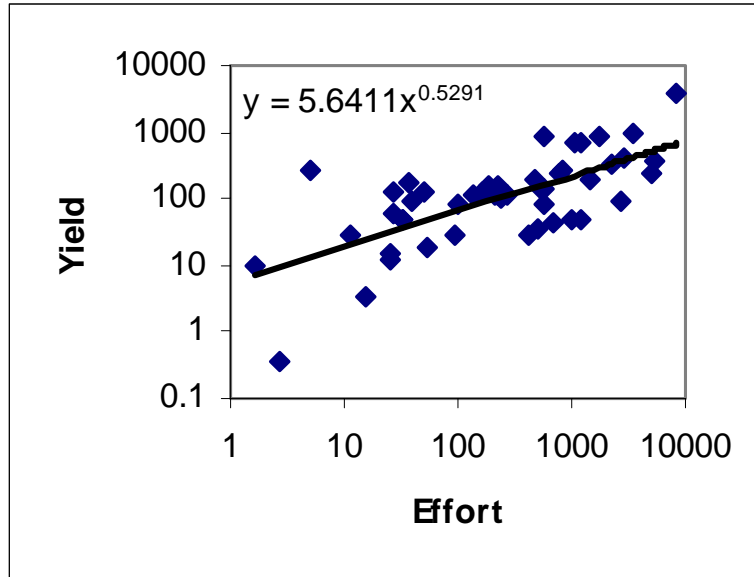


Figure 1. Relationship between total yield (kg/ha/year) and fishing effort (gear h/ha/year) in the project fisheries.

The diminishing returns to fishing effort are most obvious when plotting the relationship between catch per unit of effort (expressed in kg/gear h) against effort (Figure 3). Note differences in cpue of over two orders of magnitude over the effort range present in the project fisheries.

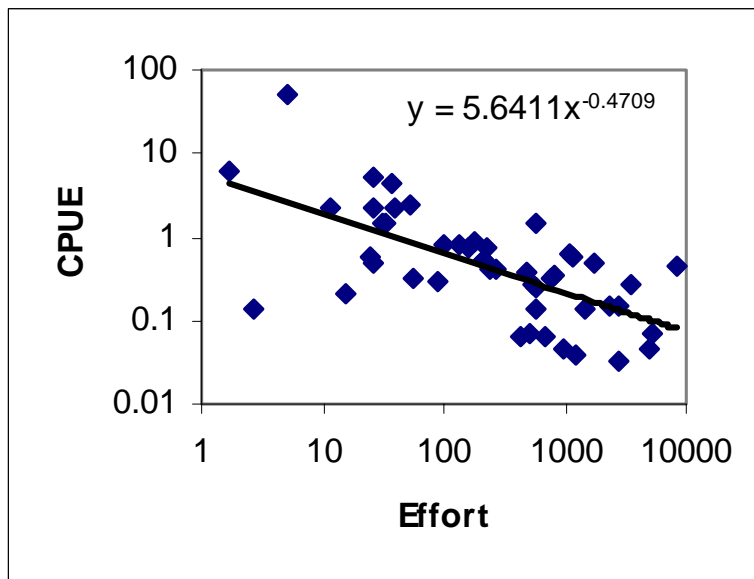


Figure 3. Relationship between catch per unit of effort (kg/gear h) and fishing effort (gear h/ha/year) in the project fisheries.

The contribution of stocked species to total yields ranged from 0 to 99%, with an average of 50%. On average, stocked species contributed most in fisheries

subject to low to intermediate levels of effort (up to about 500 h/ha/year). At higher levels of effort, the contribution of stocked fish was much lower (Figure 4). The likely explanation for this is the pattern of exploitation.

Waterbodies with the highest effort were those managed as fishing days. Fishing days are characterised by a day where several hundred fishers may be exploiting the waterbody with a wide range of gears with the intention of simply maximising their catches. Because a wide range of gears are used, including gears such as lift nets that are relatively unselective, a wide range of fish species and fish sizes are caught. The level of effort means that catches are also relatively high (see also figure 10). On the other hand, the waterbodies with lower effort levels are mainly managed as group fishing systems. In these fisheries the main gear types are cast nets and 4 to 10 cm gillnets and the fishers are targeting the stocked species.

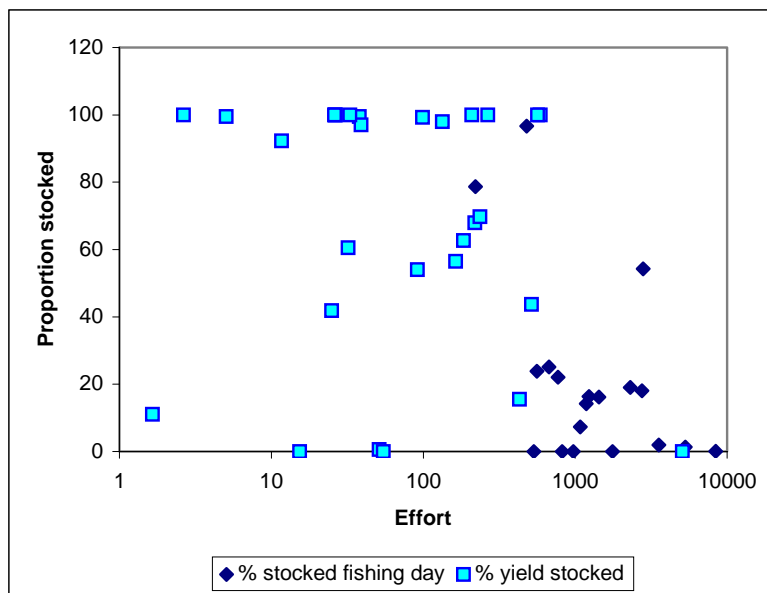


Figure 4. Contribution of stocked fish to total yield (%) as a function of fishing effort fishing effort (gear h/ha) in the project fisheries.

2.1.1.4 Interaction between species stocked and waterbody productivity

Total phosphorous was used as an indicator of the trophic status of the waterbody as it had been shown to be correlated with yield from these small waterbodies in the baseline study (Arthur and Garaway 2002). However in the results from the experiment total there was only a weak relationship between the yield of stocked fish and TP (Figure 5). The lack of a strong relationship between total yield and TP is likely due to the dominant effect of fishing effort on yield.

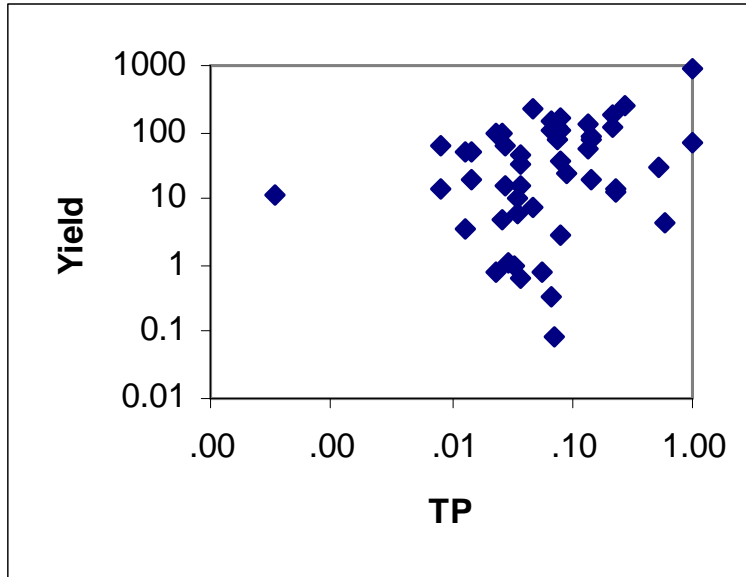


Figure 5. Relationship between the yield of stocked fish and the level of total phosphorus (TP), an indicator of trophic status.

A central question to be answered by active experimentation was whether the performance of tilapias and carps was dependent on the trophic status of the water body (as measured by TP), and whether any effect was due to independent responses of the species concerned, or due to an interaction between tilapia and carp performance and trophic status. As shown in Figure 6, catches of both carp and tilapia were higher in the more productive waterbodies, in the case of tilapia significantly so. Overall, the result is consistent with the hypothesis that there might be advantages in stocking low productivity waterbodies with carp and more productive waterbodies with tilapia. Indeed, as the graph shows, tilapia catches in low productivity waterbodies were extremely low

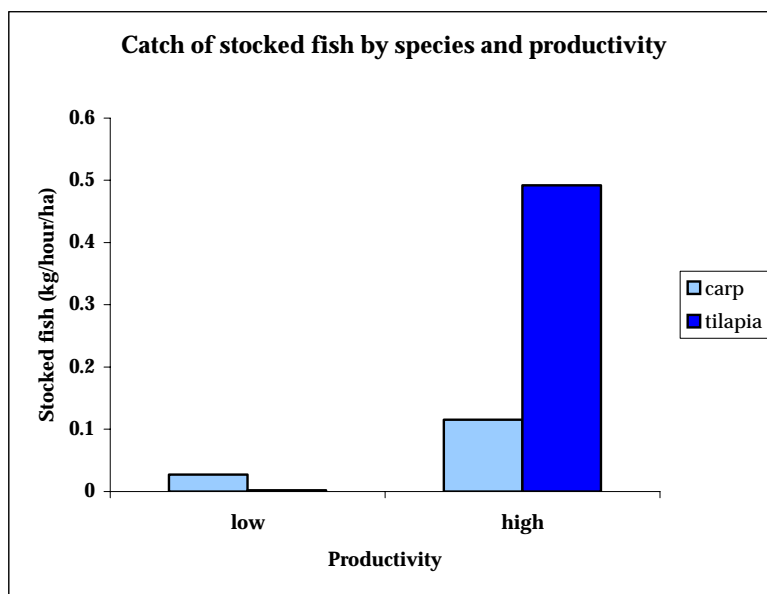


Figure 6. The catch of stocked fish by species and waterbody productivity

The mean yields per seed fish of tilapias and carps achieved in high and low TP water bodies are shown in Figure 7. While carp yields per seed fish are similar in both types of water bodies, tilapia yields per seed fish, as with the catches, are significantly higher (by more than an order of magnitude) in high TP waterbodies. Returns to tilapia stocking exceed those to carp stocking in high TP water bodies, but are much lower than carp returns in low TP water bodies. This suggests that tilapias should be the preferred species for stocking in high TP water bodies, while carps would be preferable in low TP water bodies. In either case, not stocking the worse performing species will lead to substantial savings.

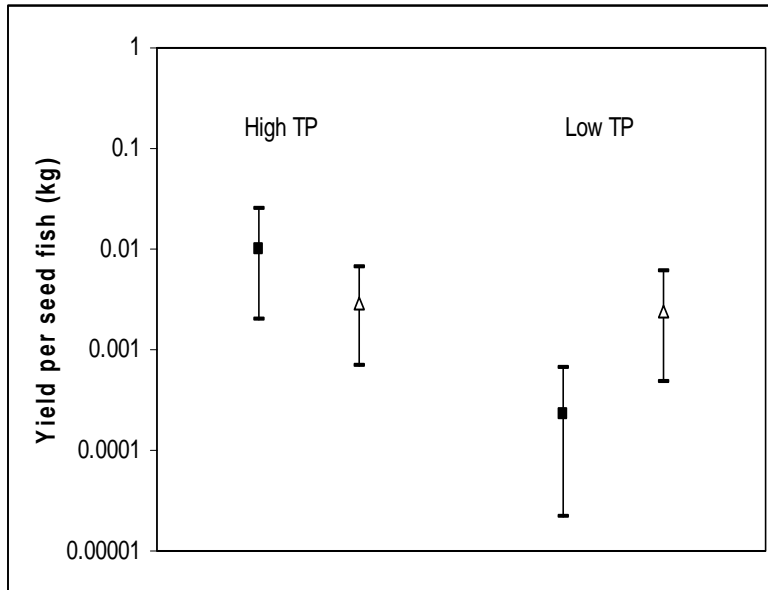


Figure 7. Yield of stocked tilapias (solid squares) and carps (open triangles) in high TP and low TP water bodies. Means with 90% CI.

Finally, a comparison of tilapia and carp performance in single or mixed stocking answers the question whether the effect of trophic status as measured by TP on tilapia and carp performance is due to independent responses of the species concerned, or due to an interaction between tilapia and carp that is influenced by and trophic status (Figure 8). Carp and tilapia performance were similar in single and mixed stocking configurations, which suggests that the effect of trophic status on their relative performance is solely due to the strong effect of TP on tilapia performance, and not due to interactions with carp.

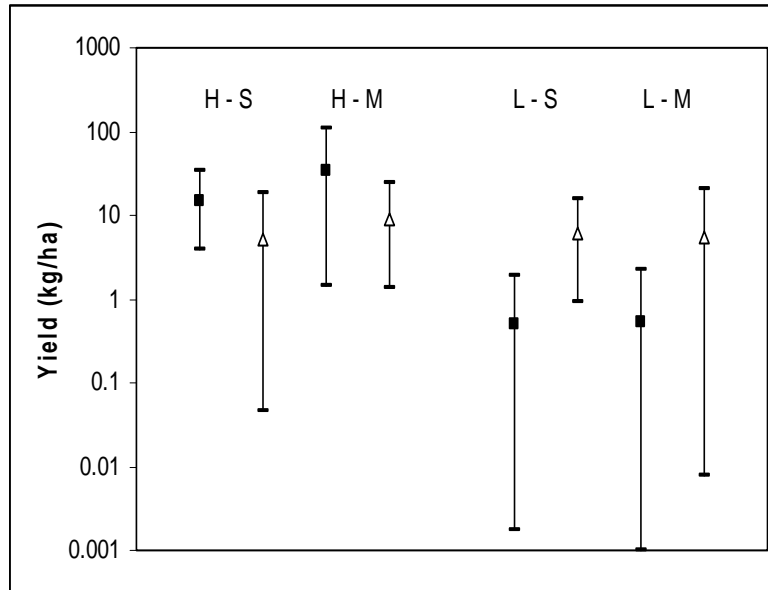


Figure 8. Yield of stocked tilapias (solid squares) and carps (open triangles) under different conditions: high TP, single group (H-S); high TP, mixed group (H-M); low TP, single group (L-S); low TP, mixed group (L-M). Means with 90% CI.

In the high productivity waterbodies however, stocking with tilapia appears to provide higher yields. This is probably due to the ability of tilapia to establish self-sustaining populations in these conditions that results can increase the potential yields from these waterbodies.

2.1.1.5 Effect of transport time on fingerling mortality

Looking at the results for both years combined, fingerling mortality at the time of stocking as a percentage of those stocked was higher in those waterbodies where transport time was highest. It was found that fingerling mortality at stocking increased with increasing transport time ($R^2=0.211$). Figure 9 shows the effect of transport time on fingerling mortality, as shown at the district analysis workshop, where the transport time has been divided into quartiles. Cpue of stocked fish was found to decrease with increasing transport time ($R^2=-0.216$), which also suggests increased mortality. These results are believed to confirm what had already been suspected last year and described in section 3.1. This result remains important because of the effect on mortality and because it should also be borne in mind that higher transport times may affect the condition of surviving fingerlings and further losses may occur because of this

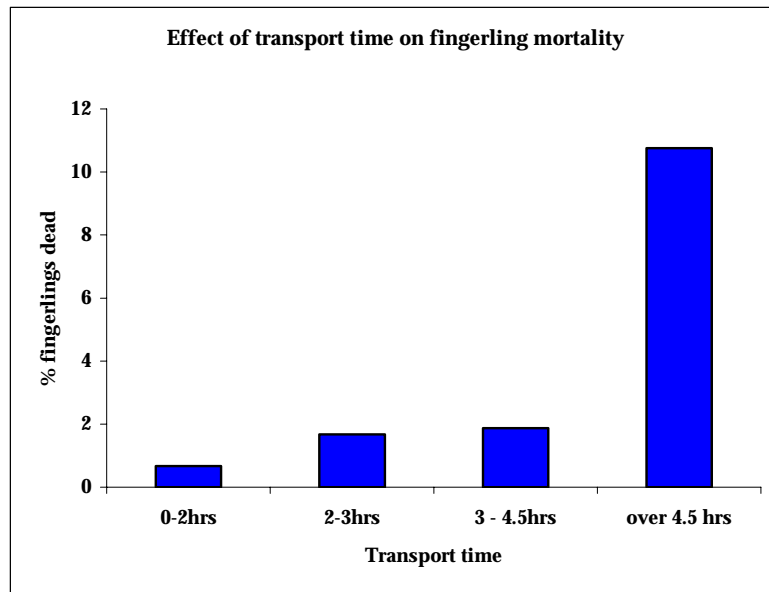


Figure 9. Effect of transport time on fingerling mortality.

3.2.2. Results from the passive experimentation.

This section focuses on the management systems found in villages involved in the project. In contrast to the technical experiment being carried out on stocking regimes, there was no *active* experimentation being carried out with management practices.

2.1.1.6 Benefits of different management systems

It was instructive to examine the benefits and types of benefit that each system provided (Figure 10). In this graph the group fishing villages have been separated into villages that fished a lot (high effort – over 100 hours fished in the year) and those that fished less (low effort – less than 100 hours fished). The benefits have been converted to an equivalent weight of fish for comparison. In the case of fishing days, the village income is the kilograms of fish caught in these systems that could have been purchased with the income from ticket sales. For group fishing the values are all simply the yield as distributed by the communities while for renting, a similar method was used as for fishing days in that the community income represents the kilograms of fish that could have been bought with the income.

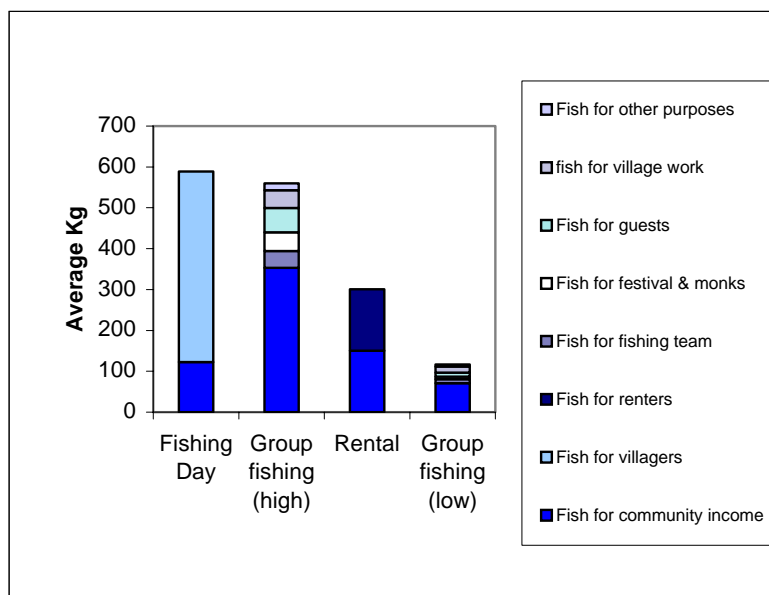


Figure 10. The benefits from different management systems.

From this we see that the total benefit from the waterbodies is highest for fishing day and high effort group fishing. The reason for this is that these two systems were subject to the highest fishing effort. The benefit in terms of village income however is a bit different with the greatest being for high effort group fishing and all the other types making a similar amount (group fishing being the only system where community income is directly related to yields). This might appear to make fishing days seem a less attractive option until the question of who benefits from the fish that does not count as community income is considered. In the case of renting, this fish goes to the renters but in the fishing day systems, this fish is taken by those who have purchased tickets (usually members of the community or a nearby village). Thus fishing days benefit the community in addition to the income the community receive from ticket sales. It is worth noting at this point that the fishing days are thought to provide a benefit in terms of a sense of village solidarity and community that the fish for households can only partly value.

In Figure 10 it can also be seen that the villages who managed as a group fishing system but did not fish much (low effort) got less benefit than villages using other systems and in particular got less benefits than villages that fished a lot using the group fishing system. Because group fishing, either high or low effort, takes a lot more time to organize or manage than either fishing days or renting it may be that these villages could benefit more from their waterbody by considering an alternative type of management

Results from the district monitoring forms and discussions with District staff based on Figure 10 were very interesting (see Table 4). There was a belief that while a community fishery operating a group fishing system might make the most income and also have other benefits (such as fish for guests and income for fishers), it was also the system that required the most effort in terms of time for fishing and organizing. Fishing days, as with renting, both had the advantage of providing the income all at once with renting seen as being the system that required the least effort. Fishing days were perceived as having benefits other than income in the form of providing a social occasion that enhanced village harmony and supplied fish for consumption. Renting was seen as the least beneficial in these respects.

The experimental process appears to have increased understanding about all systems of management, in particular that each have their own benefits and costs and that what is right for one village may not be right for another. What works will be dependant on the objectives of the village undertaking management and the conditions of the village and its waterbodies

Table 4. Summary of the advantages and disadvantages of community fishery management systems identified by district officers.

Management type	Advantages	Disadvantages
Group fishing	More income than other systems	Can be difficult to organize fishing teams
	Village manage themselves	Takes time and expense
	Village make regulations themselves	Price of fish not constant
	Good for taking care of brood fish and young fish. Good for self-recruiting species.	Can be difficult to control
	Fishers get income	Fish consumed/lost (fishermen, village work, meetings)
	Fishing and income daily	
	Fish provided for benefits other than just providing income	
	Easy to control the income	
Fishing Day	Selling tickets easier & less time consuming than group fishing	Difficult to monitor who has & hasn't got tickets on the day
	Lower than group fishing but reasonable income	Makes the water turbid (on fishing day) which may affect the young fish
	Income all at once	Difficult to monitor and record catches
	Fish for consumption	Get less income
	Villagers catch fish, everybody joins together	Difficult to sell tickets in some cases
	Easy to control waterbody	Can destroy brood fish
	Village harmony	
Renting	Income all at once	No fish for consumption
	Easy to manage	Difficult to monitor catches
		Villagers not participants
	Villagers have time to do other work	Difficult to define reasonable rental price
		Destroys brood fish
		Get less income
		May not follow contracts

4. Discussion

Some local communities perceive enhancement of small perennial waterbodies through stocking as a way of providing income for community development and by government as a means of increasing fish production and improving rural livelihoods. Such enhancement is an idea gaining in popularity with the Lao government (and local communities) and is seen as

one means of addressing their development wider objectives. Thus research that can increase understanding of these complex and dynamic resource systems is both timely and welcome.

Overall, the results of showed that a management experiment could be implemented and produce information that was relevant to the needs of local stakeholders. Importantly, the process was able to yield information that addressed not only technical uncertainties associated with management, but also some of the important institutional issues.

It was found that fish yield was closely correlated with fishing effort and also that the proportion of stocked fish in the catch was lowest at high effort. The reason given for this is that the lower effort fisheries are managed as group fishing fisheries and the gears used target the stocked species. This effectively reduces the fishing pressure on the smaller wild species. It was found in the baseline survey (Arthur and Garaway 2002) that stocked species did not have any significant effect on the abundance or diversity of wild species. This suggests that these fisheries have, as Lorenzen et al. (1997) have suggested, the potential to act effectively as a refuge for the wild fish. Further evidence for this comes from the results in Table 4 where the district staff indicated that group fishing systems are good for protecting brood fish and self replicating systems while both renting and fishing days – where effort is high and the aim is to remove the greatest quantity of fish – are not.

The species combinations used for stocking small waterbodies in the study area, including those in the survey, tended to depend upon what is available at the time and was often a combination of species. Likewise, the stocking densities depend upon fingerling supply and available resources. Uncertainty existed concerning what would be the optimal species combination to stock in these small waterbodies and this was certainly an issue that was of interest to those managing the waterbodies. Selecting an appropriate species combination is widely acknowledged to be a way of increasing the yields from a waterbody (e.g. Rothuis et al. 1998, Lorenzen, et al. 1998 and Nguyen et al. 2001).

Results from this investigation, like the baseline survey and the work of Lorenzen et al. (1998), indicated that tilapia dominated the catches in the more productive waterbodies and carp in the less productive waterbodies. Likewise, it was also found that the yields were highest in the high productivity waterbodies stocked with tilapia. The results of the experiment indicated that there was no benefit in stocking tilapia in waterbodies of low productivity. It also showed however, that in high productivity waterbodies tilapia could produce higher yields than could be obtained from stocking carp species. It is that this may be due to the ability of tilapia to establish self-recruiting populations in these waterbodies that are themselves highly productive.

It is believed that the experiment that was implemented, because it has sought to quantify the interactions between productivity and species, and between species, has yielded useful results that will assist in the management of the culture based fisheries in the study area. Because the community

fisheries in the study, and indeed the area, are extensively managed, yields depend upon the effective use of the natural production in the waterbodies. Results from this study can go some way towards improving the utilisation of this productivity. The results of this experience have been summarised in an accessible manner and are presented in the community fisheries guidelines that were produced in 2002 (see Garaway and Arthur 2002b).

An additional benefit of the experiment is that it has provided some useful information, also presented in the community fisheries guidelines as practical advice, concerning transport times. Other studies, such as Nguyen et al. (2001), have also suggested that shorter transport distances, resulting in better condition fingerlings at stocking can be beneficial.

While nursing was attempted by a number of villages in the second year, uptake was lower than had been anticipated, possibly due to the costs to the communities in terms of time and the difficulty in allocating responsibility. This was unfortunate, as greater uptake might have allowed a better evaluation of the value of nursing, which despite the inconclusive result, is still supported.

The results of the experiment regarding management costs and benefits were of great practical value. Not only was this information directly useful to the communities managing the waterbodies and who may not have had much experience of alternative systems but also it was also of extremely relevant to the Provincial government staff. The government in the study area have been keen to promote community fisheries but have done so based on the group fishing model, believing that this type of management yielded the greatest benefits. However, the results have clearly indicated that management advice should take into account much more the objectives and constraints of the communities wishing to manage. The results from this aspect of the management experiment have been written up in an accessible way in the community fisheries guidelines (see Garaway and Arthur 2002b).

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6. Appendix A. Stocking form

Stocking form

Village name	
District	
Waterbody name	
Date	
Monitoring period	
Enumerator	
Fingerling source	
Fingerling supplier	

1. Stocking

What time did fish leave hatchery?	
What time did stocking happen?	

species	no of fish	number dead
TOTAL		

Enumerator signature

Provincial staff signature

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9. Appendix D. District monitoring form

District Monitoring Form - Form 1 (Management information)

COMPLETE 1 FORM FOR EACH WATERBODY IN OUR STUDY

Section A - DETAILS OF INTERVIEW

Date	<input type="text"/>	Enumerator's name	<input type="text"/>
Monitoring period	<input type="text"/>	Respondent's name	<input type="text"/>
Village	<input type="text"/>	Respondents's position	<input type="text"/>
Waterbody name	<input type="text"/>		

Section B - MAIN MANAGEMENT SYSTEM

- B1. Do you plan to have, (or have you already started) group fishing ?
- B2. Do you plan to (or have you already) rented the waterbody ?
- B3. Do you plan to (or have you already) have a fishing day ?
- B4. Do you plan to (or already have) another system of management, e.g. for water only

Yes/No?
<input type="text"/>
<input type="text"/>
<input type="text"/>
<input type="text"/>

District staff guidelines

If answer to B1 is "yes"	Fill in	Section C (page 2)
If answer to B2 is "yes"	Fill in	Section D (page 2)
If answer to B3 is "yes"	Fill in	Section E (page 3)
If answer to B4 is "yes"	Fill in	Section F (page 3)
If there is more than 1 "yes" answer (e.g - If B1 is "yes" & B2 is yes)	Fill in	both sections C & D

Section C - GROUP FISHING

C1. Have they started fishing for selling yet ? (Y/N)

	If "yes" Go to C2
	If "no" Go to Form 2

Fishing & selling

C2. How many people are there each time ?

C3. Is it the same people each time ? (Y/N)

C4. How do they select the people ? (code)

C5. Do they get paid (code)

Fishers	Sellers

Marketing

C6 Does the village take the fish to the market to sell (Y/N)

C7 Do fishermen wait for buyers before they fish (Y/N)

C8 Do fishermen catch fish first & then wait for buyers (Y/N)

C9 If traders come, where do they sell the fish

SECTION D - RENTING

D1. Have they rented yet ? (Y/N)

If "yes"	Go to D2
If "no"	Go to Form 2

Renters

D2. How many people rented

D3. What is/was rental price (Kip)

Marketing

D4. Have the renters started fishing for selling yet ? (Y/N)

D5. Do the renters take the fish to the market to sell (Y/N)

D6. Do renters wait for buyers before they fish (Y/N)

D7. Do renters catch fish first & then wait for buyers (Y/N)

D8. If traders come, where do they sell the fish

SECTION E - FISHING DAY

E1. Have you had a fishing day yet ? (Y/N)

	if " yes" answer E2
	If "no" answer E3

E2. What was the income

Gear	Ticket Price	Number of people	Total income (Kip)

E3. When do you plan to have a fishing day ?

	Ask them to please tell us before
--	-----------------------------------



SECTION F - OTHER TYPE OF MANAGEMENT

F1. What do you use the waterbody for ?

Enumerator signature

Provincial staff signature

District Monitoring Form - Form 2 (General information)

COMPLETE 1 FORM FOR EACH WATERBODY IN OUR STUDY

Section A - DETAILS OF INTERVIEW

Date	<input type="text"/>	Enumerator's name	<input type="text"/>
Monitoring period	<input type="text"/>	Respondent's name	<input type="text"/>
Village	<input type="text"/>	Respondents's position	<input type="text"/>
Waterbody name	<input type="text"/>		

Section G - MONITORING AND MANAGEMENT COSTS

Monitoring

G1. Who monitors the waterbody (code)

G2. How do they monitor

G3. Do they get paid ? (code)

Sanctions

G4. What are the regulations for illegal fishing?

Since the last interview

G5. Has illegal fishing occurred (code)

G6. Was anybody caught (no of people)

G7. What sanction was given ?

Costs of management since last interview

G8. Have you used pumps? (Y/N)	<input type="text"/>	If "yes" G16 If "no" G19	
G9. How many pumps?	<input type="text"/>	Cost (kip)	<input type="text"/>
G10. How many days	<input type="text"/>		
G11. How much gasoline	<input type="text"/>	Cost (kip)	<input type="text"/>
G12. Any other costs for management ?(Y/N)	<input type="text"/>		
What for ?	<input type="text"/>	Cost (kip)	<input type="text"/>

SECTION H PROBLEMS & SATISFACTION

IN THE LAST TWO MONTHS, SINCE THE LAST INTERVIEW

Have villagers had problems with any of the following?

Write down what the problem is

H1. Monitoring the waterbody in the last 2 months?

H2. Villager disagreement in the last 2 months?

H3. Fish disease in the last 2 months?

H4. Flooding in the last 2 months?

H5. Waterbody drying up in the last 2 months?

H6. Finding people to do group fishing in the last 2 months?

H7. Catching fish in the last 2 months?

H8. Selling the fish in the last 2 months?

H9. Renting the waterbody in the last 2 months?

H10. Finding time to manage waterbody in the last 2 months?

H11. Other in the last 2 months?

Evaluation of management system over the last 2 months

H12. Are the village satisfied with catch ? (Y/N)

H13. Are village satisfied with income (Y/N)

H14. Are village satisfied with management system?(Y/N)

For H12 - H14 Why / Why not ?

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SECTION I - VILLAGE RECORDS

Ask to see the village records & check the village records

	Yes/no	Remark
I1. Did you see the records ?		
I2. Were there any problems with the records ?		

If the answer to I2 is "no" please explain to the villagers how to do and ask them to do in the future

After looking at the records ask the villager

I3. Has any fish (stocked or wild) come out of the waterbody that is NOT written in these records

If yes, what

SECTION J - DISTRICT STAFF EVALUATION

THIS SECTION IS VERY IMPORTANT AND IS YOUR OPINION

J1. Do you think the village is managing its waterbody well (why/why not?)

J2. Are the villagers keeping records well?

J3. Other remarks. Is there any other information from this interview that you think is interesting for our study?

Enumerator signature

Provincial staff signature

CODES

QUESTION	ANSWER	CODE
C3	fixed team all the time	F
	household rotation	HR
	other	O

QUESTION	ANSWER	CODE
C4	fish	F
	money	M
	fish & money	F & M
	nothing	O

QUESTION	ANSWER	CODE
C9, D9, E4, F2	village police	VP
	renters	R
	village soldiers	VS
	administration	A
	other	O

QUESTION	ANSWER	CODE
C11, E6, F4	fish	F
	money	M
	fish & money	F & M
	nothing	O

QUESTION	ANSWER	CODE
C13, D12, E8, F6	yes	Y
	no	N
	maybe	M