ADAPTIVE LEARNING APROACHES TO FISHERIES ENHANCEMENT

FINAL TECHNICAL REPORT

Project R7335

Fisheries Management Science Programme
Managed by MRAG Ltd, under the DfID
Renewable Natural Resources Strategy

MRAG Ltd July 2002

Date Completed: Day/Month/Year : 30/06/02

Title of project

R7335 Adaptive learning approaches to fisheries enhancements

Programme Manager/Institution

Professor John Beddington
47 Prince's Gate
South Kensington
London SW7

Reporting period

FROM	TO
01/02/99	30/06/02

Authors of this report

Dr Caroline Garaway
Robert Arthur
Dr Kai Lorenzen

Table of Contents

Acknowledgements

This project was funded through the UK Department for International Development (DfID) as part of their Fisheries Management Science Programme (FMSP). The outputs are a result of close collaboration between MRAG Ltd (London, UK) and the RDC (Savannakhet, Lao PDR) and could not have been gained without the help and participation of a vast number of people. In particular, we give thanks to the Department of Livestock and Fisheries, (DLF), in Savannakhet and Khammouane provinces for making their staff, in particular Khamchanh Sidavong, Bounthong Saengvilaikham, Phansy Homekingkeo and Sonesai Kosy, available whenever possible, and to the district staff of eight districts in Savannakhet and four districts in Khammouane who worked with energy and enthusiasm throughout. Very little would have been achieved without the interest and effort of the 38 villages who are managing community fisheries and who shared their knowledge and experiences with us. We are extremely grateful to them.

Structure of report

This final technical report is a summary document laid out in the prescribed DfID format. The report provides statement of the purpose, activities and results of the project. Supporting documentation giving more details of the activities and results is provided in fourteen individual reports and academic papers, which have their own table of contents where appropriate. These supporting documents should be read in conjunction with this report and are referred to throughout.

Table of figures

1 Executive Summary

Enhanced fisheries can provide substantial benefits to the poor in developing countries, but past experiences show that benefits often fall short of expectations because advice is either non available or provided in a top-down manner without accounting for local ecological and institutional conditions and the uncertainties they create. Adaptive learning approaches, whereby external institutions can facilitate experimental learning by resource users were seen as a potential solution to this problem. The project purpose was therefore to develop and promote adaptive learning approaches to fisheries enhancements.

Activities included: Development of mathematical tools for supporting adaptive learning; and developing and implementing an adaptive learning approach to enhancements, using as a case study, small waterbody enhancements in Lao PDR. The project focused on management systems that are one of the principle, if not only ways that villages in Southern Lao PDR can generate income, enabling them to pursue their own development priorities (e.g. village school, local access roads). Key findings included:

- An experimental management simulation model was developed that was found to be a useful tool for assessing experimental options and quantifying the costs associated with each.
- Simple mathematical models that provide estimates of key biological parameters in culture-based fisheries have been tested and shown to have the potential to effectively reduce uncertainties associated with fisheries assessments.
- Frameworks, and associated methodologies, based on a broadened concept of adaptive learning, with the focus on participation and learning as a central theme, were found to be useful tools for guiding the implementation of an adaptive learning approach.
- Results from Lao PDR showed that an explicitly experimental approach can yield beneficial results with direct practical applications.
    - A stocking experiment investigating optimal combinations of species, dependant on waterbody productivity, showed that carp species are a better option for low productivity waterbodies, and tilapia for high.
    - Comparative analysis of management systems found that each management system had its own opportunities and constraints and therefore extension advice should be less prescriptive to take into account local conditions and objectives.
- Results from participant evaluations showed that methods for sharing information between stakeholders were effective and improved as a result of feedback and adaptation.
- Capacity of key stakeholders had increased as a result of taking an adaptive learning approach, according to their own evaluations. Whilst increases in knowledge were due to information gained during the project, skills were improved as a result of the *way* it was implemented. Adaptive learning approaches therefore have the potential to increase learning and build capacity at the same time.

- A quantitative analysis of the benefits of information gain revealed that the potential to generate significant benefits from the adaptive learning approach, in the Lao case, is high.
- Successful outcomes from implementing the approach were in part due to having time to develop effective relationships with and between the various stakeholders and it should be stressed that this aspect of the process cannot and should not be rushed.
- Several characteristics of the Lao resource systems facilitated implementation of the process and absence of these characteristics would bring additional complications to implementing adaptive learning that would need to be addressed on a case by case basis.

With its pro poor and inclusive approach to research in management, guidelines and associated outputs produced by the project are expected to contribute significantly to the development of tools and strategies to support improved livelihood outcomes of the poor.

2 Background

Throughout the developing world, inland fisheries enhancements are conducted by governments, local communities and individuals, often supported by international aid agencies. DfID have supported the development of enhanced fisheries through their country programmes (e.g. the Third Fisheries Project in Bangladesh) and through a series of RNRRS projects (e.g. R6338Cb, R5958, R5023).

Enhanced fisheries can provide substantial benefits due to both, (1) direct biological effects of stocking (increased recruitment of valuable species), and (2) indirect effects of institutional change resulting from the investment into common pool resources (e.g. incentives for sustainable use, reduced fishing pressure and higher returns to labour). However experience suggests that, while enhancements have the potential to yield substantial benefits, their actual outcomes (in terms of production, distribution of benefits, institutional sustainability etc.) are often different from those initially expected (Garaway 1995, Hartmann 1995, Garaway *et al*. 1997, Cowan *et al.* 1997; Lorenzen and Garaway 1998,Samina and Warby 1993).

The underlying reason for unexpected and sometimes undesirable outcomes is that there is still a great deal of uncertainty surrounding enhancement management. This uncertainty may be due to (a) limited prior knowledge of the physical, biological, technical and institutional characteristics of individual sites which can show great variability; and (b) the complex dynamic interactions that occur between the biological characteristics of the resource, the technical intervention of enhancement *and* the people who utilise or manage it.

Management advice for these new production systems is frequently not available and, when it is, often underestimates the uncertainties, adopting instead a "blueprint" approach. Such generalised solutions, by not accounting for the local ecological and institutional conditions that ultimately determine enhancement outcomes, lead to enhancement benefits that often fall short of their potential.

Adaptive learning approaches aim to overcome these problems by making uncertainties explicit and treating management as an experimental process, aimed at yielding crucial information for the improvement of management regimes as well as more immediate benefits. *Participatory* adaptive learning puts emphasis on facilitating communication and shared decision making between resource users, external analysts and other stakeholders, recognising the importance of such links for management in a development context. For example, external analysts such as fisheries departments often lack resources for widespread research at a local level. At the same time, the crucial importance of local people's expectations and understanding of resource dynamics in determining outcomes is often overlooked. On the other hand, resource users often have substantial knowledge of local dynamics but being isolated, and with little technical knowledge, their learning is slow. By involving all stakeholders in the adaptive learning process, the potential for more dynamic, relevant and location specific outcomes is expected to be greatly increased.

Explicit adaptive learning approaches have developed independently in different fields such as the (technical) management of renewable resources (Holling 1978, Walters 1986), economic policy and development administration (Berman 1980, Rondinelli 1993). Whilst emphases in the different fields are different they all have the same fundamental idea - management must proceed despite uncertainty and the reduction of this uncertainty becomes a central function of management itself. In such cases management becomes a structured learning process where management and reduction of uncertainties are occurring at the same time.

Preliminary studies indicate that adaptive approaches could yield substantial benefits within a short period of time and the need and potential for adaptive learning approaches was clearly identified in previous RNRRS projects and the FAO/DFID expert consultation on inland fisheries enhancements (Petr 1997).

The aim of the project was to facilitate the adoption of this approach by developing and testing a framework for the implementation of adaptive learning approaches to enhancements of small water body fisheries in a development context.

Small waterbody fisheries in Lao P.D.R were chosen as the test case study site. Stocked communal waterbodies in the Provinces of Southern Lao PDR bring vital income to villages enabling them to pursue their own development priorities as well as providing an important insurance device for the particularly vulnerable in times of need (Garaway *et al.* 1997). However, many villages lack experience and technical knowledge and benefits from waterbodies have not always been as great as anticipated. Adaptive learning approaches were identified as promising in this case for the following reasons.

- There is great variability within the region in terms of the biology of the resources and the institutions set up to govern use of small waterbodies. This means that much can be learnt from the careful selection and comparative study of existing resource systems as well as providing sufficient replicates for any active experimentation that might be carried out.
- Previous research showed that local communities have extensive time and place knowledge of their resource systems and the people who use them. This includes a far better understanding of local needs, desires and patterns of behaviour (Garaway *et al.* 1997). Communication between them and other stakeholders involved in enhancement management would enable their knowledge and skills to be combined with the wider reach and technical knowledge of external agencies thereby increasing the knowledge base and enhancing the learning capacity of all concerned.
- Cross-community communication was shown to be appreciated and to benefit greatly the communities concerned (Garaway 1999).
- Finally, it was known that communities already experimented with enhancement management through time, but given their relative seclusion this learning process was slow. Were their efforts to be incorporated in to a more structured process involving a larger number of villages with similar objectives, their learning would be greatly enhanced.

3 Project Purpose

The project purpose was to develop and promote adaptive learning approaches to fisheries enhancement. This was in turn achieved by developing the following:

a) Criteria for assessing the priority areas for adaptive learning established and applied.
b) Methods for appraising adaptive designs and analysing outcomes developed and applied.
c) Criteria for evaluation of adaptive learning process developed and applied.
d) Process framework for implementation of adaptive strategies developed.

4 Research Activities

Research activities can be split into two different, but complimentary components. The first was carried out throughout the project and was concerned with the development of mathematical tools for supporting adaptive learning approaches to enhancement. The second has been split into four broadly sequential stages that included:

- Developing an adaptive learning approach to enhancements for implementation in a development context;
- Implementing this approach, using as a case study small waterbody enhancements in Southern Lao PDR;
- Evaluating the approach;
- Promoting the approach.

In each section activities are described with reference to those set out in the project logical framework, with any changes or additions described.

4.1 Mathematical tools for supporting adaptive learning approaches to enhancement.

This section relates to item b) in Section 3. Tools developed that could support an adaptive learning approach included the following:

- Appraisal of experimental strategies for multi-species stocking programmes in replicated systems;
- Further development of population dynamics models for the assessment of management strategies.

4.1.1 Appraising experimental management strategies for multi-species enhancements in replicated systems

Enhancements in small water body fisheries are typically characterised by the following factors:

- Most are managed as polyculture, or multi-species stocking systems so quantifying inter-specific interactions is important to the optimisation of such systems;
- Small water bodies are replicated systems. Experiments can be carried out on a representative sample of water bodies with an appropriate degree of replication, and the knowledge gained can justifiably be generalised to the whole population of water bodies.

The implications of these characteristics for the design of experimental management strategies aimed at improving small water body enhancements were explored using a simulation model.

4.1.2 Further development of population dynamics models

While empirical models such as that developed under 4.1.2 are effective tools for technical assessment of fisheries in small-scale replicated systems, population dynamics models that incorporate biological understanding are more effective tools for assessment of larger fisheries enhancement systems (such as stocking programmes in large reservoirs) where replication is more difficult to achieve. The use of population models in adaptive management has been the subject of much research in capture (non-enhanced) fisheries, and no further research in this respect was deemed necessary here.

However, the assessment of enhanced fisheries requires specialised and more detailed population models than those used in capture fisheries. Previous DFID-FMSP projects (R5023, R5958) have developed population models and assessment tools specifically for culture-based fisheries. These models incorporate size and density dependent population processes that are commonly disregarded in capture fisheries but were deemed crucial to the assessment of culture-based fisheries. Within the current project, two studies were undertaken that both tested the generality of the processes, and led to simple but robust approaches to assessing culture-based fisheries.

One study tested the use of allometric mortality-weight relationships in the assessment of optimal release size of fish. Seven well-documented stocking experiments were analysed in a common framework to test whether the survival of stocked fish was subject to a consistent scaling with body size that would provide simple assessment rules for release size.

A second study investigated the role of density-dependent individuals growth in the regulation of fish population abundance. Density-dependent growth had been identified as a key process determining optimal stocking density in enhancements but the generality of the process had been controversial and no comparative information had been available to gauge the likely range of the crucial density-dependent growth parameter.

4.2 Developing an adaptive learning approach for implementation in a development context

Before implementing and testing an adaptive learning approach it was necessary to:

- Define its principles more clearly;
- Develop a framework and methodology for how it could be implemented in a real field setting.

These research activities corresponded to a number of activities in the project logical framework: Those relating to item d) in Section 3, which was 'to develop a process framework for the implementation of adaptive strategies'; those relating to the 'development of methodology' parts of items a) and b), which were to 'establish and apply criteria for assessing the priority areas for adaptive learning' and 'to develop and apply methods for appraising adaptive designs' respectively.

4.2.1 Defining adaptive learning

A literature review of adaptive learning was undertaken to clarify terms and summarise different theoretical approaches and practical experiences to date. While the potential for adaptive learning to improve management outcomes for small waterbody fisheries, and indeed many renewable resources, existed (Garaway *et al.* 2001, Walters 1997), there was a need to conceptualise how such an approach could be implemented. Information from the literature review indicated that, amongst other things, participation of all stakeholders involved in management would be fundamental to the success of any adaptive learning approach. This, in particular, influenced the subsequent development of the adaptive learning framework and associated methodologies.

4.2.2 Developing a framework and methodologies for implementation

The frameworks and associated methodologies were developed in the context of small waterbody enhancements in Lao PDR, but their applicability is wider; to adaptive learning approaches in a development context in general. There were two foci to the development of methodology:

- How to identify and implement management options that would generate information that could *potentially* improve management;
- How to ensure that relevant stakeholders wanted, received and understood that information in a way that it would be utilised and thereby *actually* improve management.

Outputs of this activity were developed through further reviews of literature, experimentation during implementation and consultation with stakeholders. This occurred throughout the project cycle, but particularly in the early stages.
All these activities resulted in:

- An adaptive learning framework;
- Frameworks and methodologies for each identified stage in the process.

4.3 Implementing an adaptive approach to enhancement management

This was a substantial component of the project and corresponds to implementation of activities associated with items a), b) and c) in Section 3.

Whilst the overall research exercise was to implement, test and refine the adaptive learning approach, by its very nature implementation would involve scientific research of enhancements resulting in, if successful, the generation and sharing of new knowledge, and improvement in enhancement management. Research activities were therefore nested and included:

- Developing, implementing and refining methodology;
- Collection and analysis of information regarding enhancement that resulted from the implementation of the cycle.

Key activities relating to implementation, which was carried out between Sept 1999 – July 2002, are presented in Table 1.

Table 1 Activities associated with implementation of the adaptive learning approach.

Activity	Date	Details
Creating an inventory of small waterbodies and management in the project area.	Sept 1999	Expanding on information collected in the previous project (R6338cb) inventorised small waterbodies (>1ha) that had been or were being stocked and/or managed by local villages in project area. Information collected included: • Size of waterbody; • Flooding/drying regime; • Stocking regime and type of management. Design was based on previous studies (e.g. Garaway 1999), the knowledge of district staff, available district and/or Provincial records. It was collected for eight districts in Savannakhet Province and four districts in Khammouane Province. Details are provided in Appendix 7.
Baseline survey to: • Identify current uncertainties in enhancement management; • Collect information to establish whether and how those uncertainties could be reduced; • Introduce the project to villagers; • Discuss their management priorities and problems; • Determine interest in joining with the project in the future.	October 1999 – December 1999	Conducted by an inter-disciplinary field team in 40 villages identified as being involved in some way in small waterbody management. Information collected included: • Physical and biological characteristics of the resource (from test fishing, water quality sampling and collection of other basic waterbody data); • Characteristics of the village communities; characteristics of the institutions set up for management and; • Perceptions of the outcomes of, and problems with, enhancement initiatives (from semi structured interviews with village leaders and/or committees). Further details are given in Section 5.3.1 and Appendix 7.

Activity	Date	Details
Identification, evaluation and selection of learning options.	January 2000 – May 2000	Sub activities included: • Analysing data from the baseline survey; • Applying a selection procedure developed in activity 4.2.2 to identify experimental and/or learning options for the next fishing year in workshops with Provincial and subsequently District staff; • Putting plan to village representatives and negotiating involvement, roles and responsibilities. Negotiations were held at 'village' workshops (four workshops in total were carried out, three in Savannakhet Province where the majority of sites were based, and one in Khammouane). These workshops were the first time that local communities managing community fisheries had ever got together and considerable workshop time was devoted to enabling them to share their experiences of waterbody management and learn from each other.
Implementation of options (generating new knowledge)	June 2000 – May 2001	Sub activities included: • Development of data collection methods with both government and local communities; For more information see Appendix 6; • A stocking experiment in all participating villages and monitoring activities carried out on a daily, (village catch and effort records), and once two-monthly, basis (test fishing, management questionnaire). For more details see Appendix 8; • Analysis of subsequent data by MRAG project staff.
Sharing/disseminating information.	May – June 2001	Workshops held with Provincial staff (1), then district staff (1), then village representatives (4) using methods developed to enhance understanding in activity 4.2.2. For more information see section 5, & Appendices 6 & 11. These workshops, as with all other activities were evaluated. For further methodological details see Appendix 9.

Activity	Date	Details
Repeating and improving the process	July 2001 – June 2002	Sub activities included: • Improving methods for collecting data & sharing data as a result of evaluations by both government staff and local communities as to their effectiveness in the previous year; • Planning learning options for the following year; • Implementing a stocking experiment for a second experimental cycle. Given that it was up to the communities to determine whether they wanted to be involved, two villages decided not to join with the experiment in the second year as it would not ft with their development objectives. However, district staff had spread the news of the project during their extension activities, and five more of the villages who asked, were able to join, leading to a net gain of villages in the second year; • Analysing, consolidating & sharing data; • Evaluating outcomes.

4.4 Evaluating an adaptive approach to enhancement management

Activities in this section relate to item c) in Section 3.

Monitoring and evaluation were a significant part of the adaptive learning process that was developed, so this activity had two functions, being both an evaluation of the approach and the final stage of the implementation of the process. Evaluation of the Lao case specifically led to identifying challenges and opportunities for the implementation of the approach in general.

There were three main activities regarding evaluation:

- Development of evaluative framework and associated methodologies (as part of activity 4.2.2);
- Evaluating the adaptive learning approach to small waterbody enhancements in Lao PDR;
- Drawing wider conclusions on the adaptive learning approach in general.

4.5 Promotion of approach

Activities in this section relate to item d) in Section 3.

Nine months before the project finished, 3 Provincial staff from Lao PDR came to London for a two-week workshop on development of the adaptive learning guidelines. Style, content and format were all discussed and a timetable for guidelines production developed. It was at this workshop that the need for an additional set of guidelines on community fisheries was recognised and an additional activity was added to the existing project activities. Both sets of guidelines (see Appendices 11 & 12) were then written over the final months of the project. A

Lao version of the community fisheries guidelines is currently being prepared. A project flyer (Appendix 10) was designed to promote both sets of guidelines and was available for the project final workshop. This workshop (Appendix 13) was attended by government departments and NGO's from all over Lao PDR. Besides activities set out in the logical framework, project activities have also been promoted through workshops, conferences and papers (for details see section 6).

5 Outputs

5.1 Mathematical tools for supporting adaptive learning approaches to enhancement

5.1.1 Appraising experimental management strategies for multi-species enhancements in replicated systems

An experimental management simulation model for multi-species enhancements in replicated small water body fisheries was developed and used to evaluate nine alternative management strategies, both experimental and non-experimental. These strategies are outlined in Table 2. Strategy A reflects a situation where species combinations are not actively controlled, for example because information is not available on suitable species combinations, or the availability of individual species is variable. Strategies B and C involve using information from an extension manual, or following traditional practice similar to past stocking patterns.

Table 2. Overview of management strategies simulated

Code	Management strategy
A	Random allocation of species densities subject to a constant total
B	Constant stocking regime based on a pond culture manual
C	Constant stocking regime based on average observed densities in Bangladesh oxbow lakes
D	Experiment without constant total constraint, no optimisation
E	Experiment without constant total constraint, optimisation after one cycle
F	Experiment without constant total constraint, optimisation after three cycles
G	Experiment with constant total constraint, no optimisation
H	Experiment with constant total constraint, optimisation after one cycle
I	Experiment with constant total constraint, optimisation after three cycles

Strategies D to I are experimental treatments, designed to provide contrast in treatments, while also incorporating some information from an extension manual. In treatments D, E, and F, total stocking densities were allowed to vary in order to provide the greatest possible contrast, while in treatments G, H, and I, total densities were kept constant. The latter strategy is of practical interest because constant

density strategies are more readily acceptable to communities than those that involve an unequal distribution of benefits.

Figure 1 shows the average yield per hectare for all the water bodies in the final year of the simulation. The experimental strategies (E, F, G and H) were able to produce substantially higher final yields than the strategies based on either extension advice or tradition. Strategies using variable stocking densities, but not using the information to improve management (A, D, and G), performed least well. The more powerful experimental strategies varied total density as well as species combinations (E, F) providing greater yield gains than those using constant total densities.

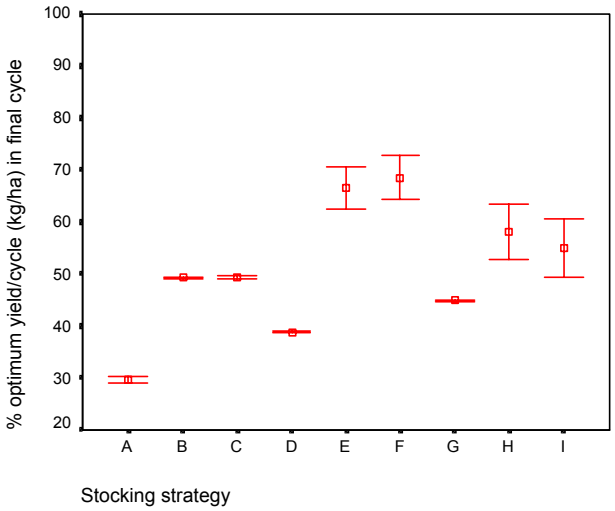

Figure 1 Average yield from the final (10th) production cycle for each management strategy, expressed as a proportion of the true optimum yield.

The costs associated with experimentation are clearly seen in Figure 2 where the Net Present Values (NPVs) of the different strategies are shown. The NPVs are highest for stocking strategies B and C (using existing knowledge). The experimental strategies resulting in the highest final yields (E, F) perform worse in NPV terms than the less informative strategies (H, I). This is because experimentation can impose costs in terms of lower yields during the experimental period. While experimental strategies can provide increased annual yields in the longer term, the short-term benefits may be affected. The importance of this and the magnitude of the effect will depend upon the discount rate used and this is also discussed in Appendix 9.

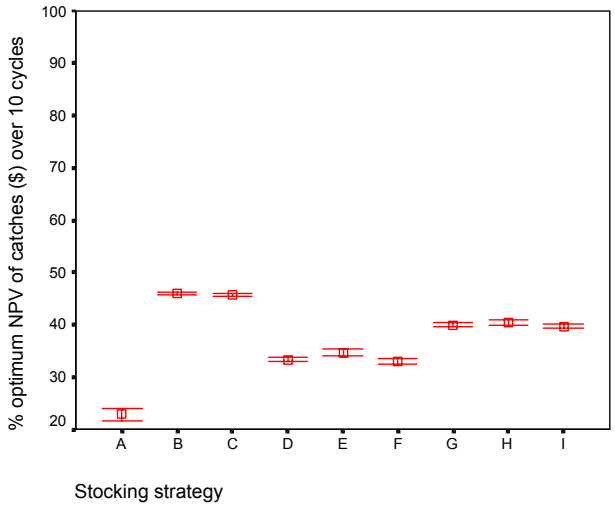

Figure 2. NPV of management strategies over ten production cycles.

Conclusions

- Experimental strategies were effective at increasing yields over and above levels achieved when stocking regimes were determined *ad hoc*, or based on recommendations from a pond culture manual.
- Experimentation requires contrasting treatments and sufficient replication to provide adequate statistical power for analysis. Hence stocking regimes that are known to be sub-optimal may have to be adopted experimentally, incurring short-term losses for the long-term benefit of optimising stocking regimes.
- When accounting for this trade-off by comparing the discounted NPV of alternative strategies, experimental strategies performed less well than those simply implementing recommendations from a pond culture manual, even where experimental strategies led to significant long-term improvements.
- When designing experimental strategies, a delicate balance has to be struck between statistical power and cost. Because of the strong effect of short-term costs, more attractive strategies in terms of NPV tend to be only moderately informative and lead to moderate long-term benefit. Similarly, short experiments leading to the identification of moderate improvements may be more valuable in terms of NPV than longer experiments leading to greater improvements.
- Where experiments involve a sample of a larger set of similar systems that will benefit from application of the results, more informative and therefore costly strategies may become feasible, provided that ways can be found to share costs.
- Where experimental management is being considered as an option for the optimisation of extensive polyculture systems, costs and benefits and the resulting NPV of different strategies should be assessed carefully. This criterion is likely to favour designs of relatively low statistical power.

Full details of this study are provided in Appendix 1.

5.1.2 Further development of population dynamics models for adaptive learning

Two separate studies have been carried out to provide simple models for the assessment of release size and stocking density in enhanced fisheries.

5.1.2.1 An allometric mortality model for the assessment of optimal release size

This study evaluated the use of general mortality-size relationships for the assessment of fish release size in stocked fisheries and the results support the existence of a consistent allometry that applies independent of the overall level of mortality. The best performing model was one where the length exponent of mortality is set to –1 *a priori* while mortality at reference length is allowed to vary between experiments. An example of observed and predicted survival is shown in Figure 3.

Using this length exponent, survival models have been derived for the linear, exponential and von Bertalanffy growth equations. The models can be used to assess alternative release sizes given a mortality estimate for one particular release size. This implies a substantial reduction in experimental requirements for the assessment of optimal release size, thereby allowing experiments to focus on other areas where greater uncertainties remain, such as the interactions between species.

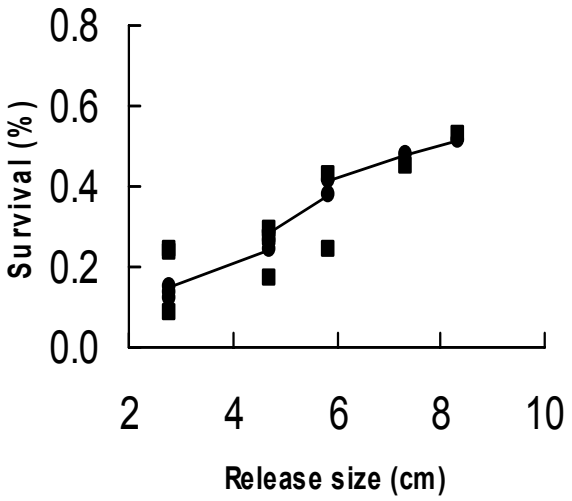

Figure 3. Observed (■) and predicted (●) survival of *Oncorhynchus mykiss* in a stocking experiment. Predictions were obtained using a simple survival model developed in the study. Note that because periods-at-large t varied between stocking events, data and model predictions do not form a smooth curve.

A comparison of mortality rates between stocked and wild fish using the model showed that mortality rates of hatchery-released fish were on average about ten times higher than those of the same sized wild fish size and can be substantially

higher as well as lower than expected for natural fish populations. Again, this information is highly valuable for the appraisal of stocking regimes where no specific data exists, and may be used to gauge uncertainty in the evaluation of experimental management strategies. Full this study - Allometry of natural mortality as a basis for assessing optimal release size in fish stocking programmes - are provided in Appendix 2).

5.1.2.2 Density-dependent growth

Density-dependent growth has been identified as a key process determining optimal stocking density in enhancements. However most fisheries assessment models assume density dependence only in the survival of pre-recruit fish. The analysis aimed to demonstrate that density-dependent growth is a key process in the regulation of fish populations (either self-recruiting or stocked), and to provide information that will help managers estimate the likely range of the density-dependent growth parameter. This parameter is crucial to the assessment of optimal stocking density and harvesting rate in enhanced fisheries.

Density-dependence in growth (g) was found to be significantly higher than 0 in nine out of the 16 populations studied. Comparisons among the nine populations where significant density-dependence in growth had been detected showed a close inverse relationship between the competition coefficient g and average population biomass density $\overline{B}$ (Figure 4). Regression analysis demonstrated a highly significant (P<0.001) relationship of the form $g = 3.3\ \overline{B}^{-1.0}$, indicated by a solid line in Figure 4.

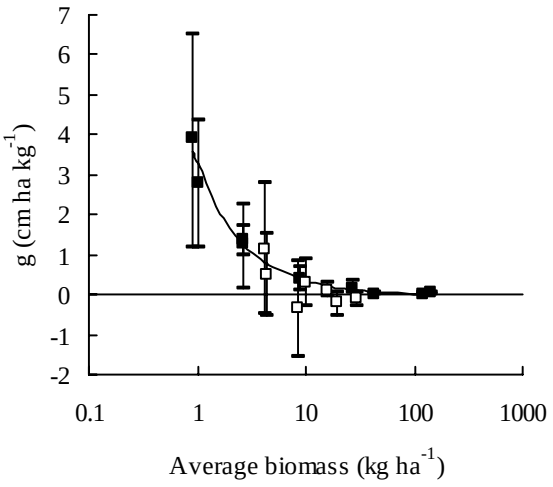

Figure 4 Relationship between the competition coefficient g (estimates shown with 95% CI) and average population biomass density $\overline{B}$. The solid line indicates the relationship $g = 3.3\,\overline{B}^{-1.0}$ estimated for populations with significant density-dependence in growth (solid squares).

Finally, a simple population model was used to show that this pattern is consistent with the hypothesis that these populations are regulated primarily by density-dependent growth, and that the value of g determines the carrying capacity. Explicit consideration of density-dependent growth is crucial in aquaculture-based and enhanced fisheries where population densities are manipulated directly by stocking, and relevant assessment models are available (Lorenzen 1995; Lorenzen *et al.*, 1997).

The compensatory nature of density-dependent growth implies that where the process is significant, yield and biomass responses to changes in exploitation are less pronounced than would be predicted from conventional dynamic pool models. Disregarding density-dependent growth would lead to conservative reference points for underexploited stocks, but over-optimistic assessments of the effectiveness of conservation measures for overexploited stocks. The present study identifies a first empirical relationship that may be used to obtain indicative information on the degree of density-dependence in growth for populations where specific data are not available. Comparative analyses of larger data sets may lead to relationships of greater predictive power. Full details of this study - Density-dependent growth as a key mechanism in the regulation of fish populations: evidence from among-population comparisons - are given in Appendix 3.

Conclusions

- Allometric mortality models can be used to assess alternative release sizes given an estimate of mortality for one particular release size. This implies a substantial reduction in experimental requirements for the assessment of optimal release size.
- The allometric mortality model also provides a tool for comparing mortality rates between stocking experiments, and between stocked and wild fish. Mortality rates of hatchery-released fish were on average about ten times higher than those suffered by wild fish of the same size. This information is highly valuable for the appraisal of stocking regimes where no specific data exists.
- Density-dependent growth has been demonstrated to play a key role in the regulation of wild as well as stocked fish populations.
- A first empirical relationship has been identified that may be used to obtain indicative information on the degree of density-dependence in growth for populations where specific data are not available.
- Together, these advances in the understanding and quantitative description of the population dynamics of enhanced fisheries imply substantial reductions in the uncertainties faced in the assessment of individual fisheries. Applying these methods and results will reduce the costs of experimentation, and allow the design of more efficient adaptive learning strategies.
- The results also have important implications for the assessment of capture fisheries, which are discussed further in the respective papers.

5.2 Development of the adaptive learning approach

5.2.1 Broadening the concept of adaptive learning

The literature review found that adaptive approaches were most successful in situations where there was control over resource use and the aim of the approach was the reduction of technical uncertainties (e.g. Sainsbury 1988, Walters 1986). However, natural resources management in developing countries generally occurs in a much more complex institutional environment where managers have much less control and outcomes of technical interventions are not always as expected as a result (e.g. Lorenzen and Garaway 1998, Garaway *et al*. 2001, Cowan *et al*. 1997). This meant that there was a need to develop an adaptive learning framework and mode of working that could address the institutional uncertainties associated with management as well as the technical.

In order to develop this initial framework, there was a need to broaden the primarily technical focus of adaptive management by including aspects of the wider social, economic and institutional environment in which management operates (Rondinelli 1993, Dovers and Mobbs 1997, Lorenzen and Garaway 1998). This shift towards a broader definition of adaptive learning had implications for the implementation of the approach. It indicated that external agencies and communities should combine their strengths in a participatory adaptive learning process. Participation of all stakeholders was deemed crucial because:

- Firstly it would enhance the quality and relevance of any learning produced from the approach. Many uncertainties can be reduced and information generated through local knowledge, user monitoring of responses and the enhanced understanding of the institutional environment that becomes possible. In addition, management can result in more relevant and sustainable outcomes if users have been involved (Röling 1989, Lorenzen and Garaway 1998).
- Secondly, adaptive approaches require flexibility and the possible changing of management actions and regulations. This would be difficult, if not impossible, to implement without the co-operation of resource users and other stakeholders.

Full details of this review are provided in Appendix 4. The initial framework was further developed as experience was gained during the early phases of the implementation phase. The broader scope of the approach remained but the focus on ‘learning by all’ was strengthened.

5.2.2 The adaptive learning cycle

The final conceptualisation of the adaptive learning framework developed during the project is presented in Figure 5. Emphasis was given to different stages of learning, not seeing it as *just* the generation of new information as is common in other adaptive management approaches. Literature on organisational learning helped to develop ideas and in particular Nevis *et al.* (1998) helped to conceptualise learning as a 3 stage process involving:

- Knowledge generation;
- Knowledge sharing and;
- Knowledge utilisation.

With the requirement for a learning partnership between government, local users and researchers, there came the challenge of combining the perspectives, skills, and ways of doing and thinking of each. The emphasis on sharing knowledge in the cycle gave recognition to this challenge, whilst including utilisation as a final stage emphasised the need for application of knowledge and adaptation of current practices if learning is to be complete.

The cycle is split into three parts: Preparing for learning; learning; and evaluating learning. Within each are several sub activities, some fairly common to research in a development context and some more particular to the adaptive learning approach. Methods for the latter were developed both before and during implementation. All stages of this cycle were completed in the Lao case and a summary of key results is presented in later sections.

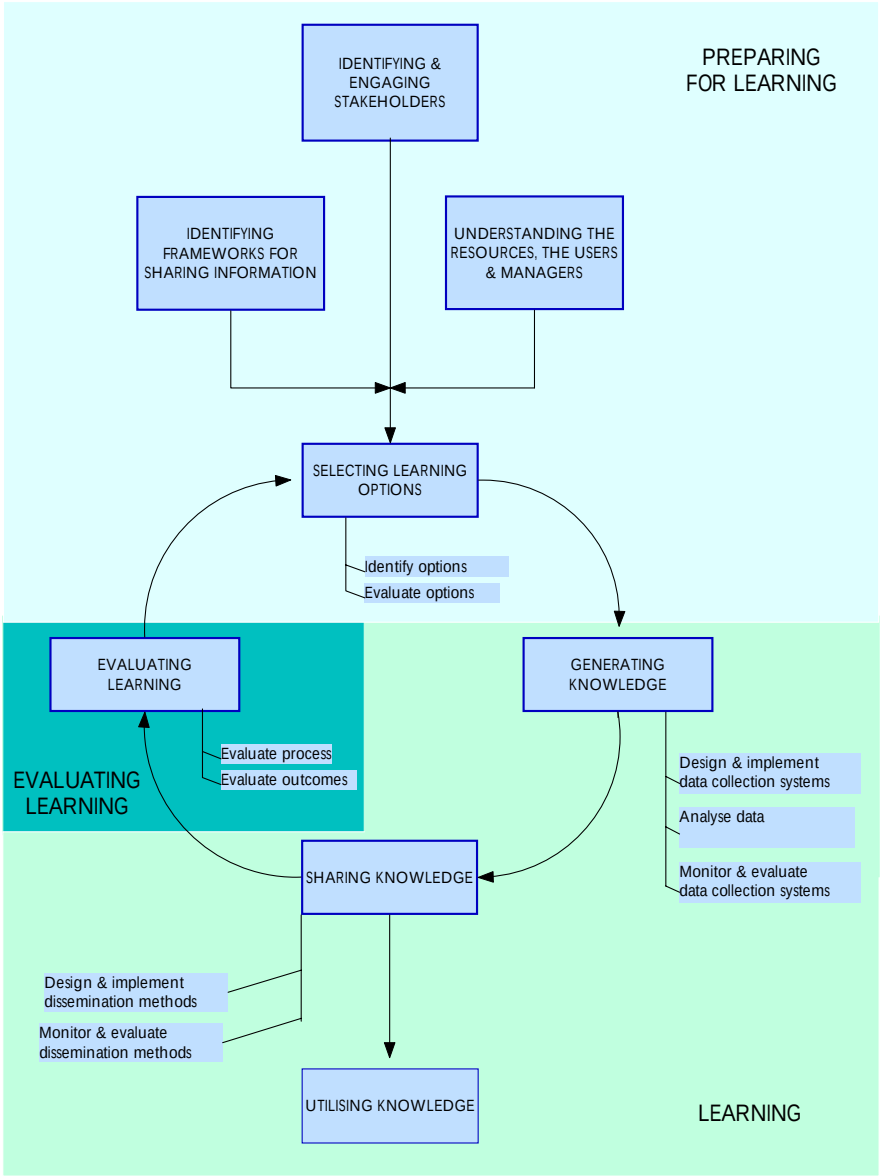

Figure 5 The stages of adaptive learning

5.2.3 Methodologies to support the implementation of the adaptive learning cycle

Methodologies in support of this cycle are synthesised in the Adaptive Learning Guidelines (Appendix 11) and more detail can be found in the Appendices detailing different parts of the cycle (6, 7, 8 & 9). Two additional frameworks were designed, one for selecting learning options and one for evaluating learning. These are presented in 5.3 and 5.4 respectively; in conjunction will actual results arising from them in the Lao case.

Table 3 summarises the core workshops that brought the different groups of stakeholders together, addressing each of the four stages within the cyclical part of the framework. As can be seen, workshops were important fora for communication within and between different stakeholder groups. A significant amount of time during the project was spent designing workshop methods for effective information share and training staff, as necessary, in training and facilitation skills. More details about why workshops were used, how they were organised and specific methods within them can be found in Appendix 6.

Table 3 Core workshops addressing the major stages of the adaptive learning cycle

Title & number of workshops	Stage in cycle workshop addressed	Participants (& Facilitators)	Workshop objectives	Key Activities/methods used	Further information
1. District Analysis Workshops (1 three day workshop per year)	• Selecting learning options • Sharing knowledge • Evaluating learning	District staff (Provincial staff & MRAG staff)	• Analyse information from previous year • Evaluation of workshops and learning process in previous year • Preliminary plan for coming year	• Preparation of summary data sheets for participants to analyse during workshop • Participants analyse, evaluate and present results to each other Other activities through: • Small group discussions & participant presentations; • Whole group discussions; • Evaluation questionnaires.	RDC 'District Analysis Workshop' reports. Section 5.3.2 Appendix 6
2. Village Discussion meetings (2 one day workshops per year)	• Selecting learning options (presentation of possible options) • Sharing Knowledge • Evaluating learning	Village representatives (Provincial staff & district staff)	• Present results from previous year and share experiences between villagers • Presentations of potential experimental options for following year • Individual negotiations with villages on precise strategies for them to take back to their villages for discussion • Evaluation of workshop and learning process in previous year	• Preparation of key results generated in 'District Analysis' workshop by district staff • Presentations by Provincial staff and question and answer sessions • Small group discussions and presentations • Evaluation questionnaires	RDC 'Village Discussion meetings' reports Some methods in Appendix 6
Village Planning Workshops (4 one day workshops per year)	• Finalise selection of learning options • Generating Knowledge	Village representatives (Provincial staff & district staff)	• Finalise which villages wish to be involved in experimental management • Develop individual village action plans • Evaluate data collection from previous years & design data collection methods • Any necessary training in data collection methods	• Design 'Practicals' • Small group discussions & presentations • Evaluation questionnaires and group discussions	RDC 'Village Discussion meetings' reports Some methods in Appendix 6
District Staff Monitoring Workshops (1 two day workshop per year)	• Generating Knowledge	District staff (Provincial staff & MRAG staff)	• Design data collection systems • Evaluate previous data collection systems • Training in new methods	• Practical training sessions • Role plays • Small group discussions and presentations • Evaluation questionnaires and group discussions	RDC 'District Monitoring' workshop reports Some methods in Appendix 6

5.3 Results of experimental approaches to management in Lao PDR

Whilst results of the scientific investigation into enhancements were a secondary outcome in terms of the objectives of this research, they were the principle means by which the adaptive learning could be evaluated and hence their inclusion as a major section of this report is justified.

The experimental management involved four stages:

- Collection and analysis of baseline information;
- Design and implementation of a management experiment;
- Analysis of data relating to the technical aspects of management;
- Analysis of data relating to the costs and benefits of different management systems.

5.3.1 Collection and analysis of baseline information

Results of the inventory showed that there was an abundance of small waterbodies and a range of management systems, some newly developed and some traditional. This suggested that, as anticipated, the learning potential of comparative analysis could be high.

In the subsequent baseline survey, a total of 67 waterbodies were surveyed, ranging in size from 0.1 to 200 hectares. Key characteristics of the resource systems, their management and the needs and priorities of resource users were identified.

- The biological sampling indicated that in waterbodies that were subject to some form of management there was a significant positive correlation between total phosphorous and the yields from the test fishing.
- Analysis of test yields and water quality data suggested that tilapia were more likely to be caught in waterbodies with higher natural productivity while carp were more likely to be caught in lower productivity waterbodies, suggesting that there might be an advantage in stocking tilapia in high productivity waterbodies and carp in low productivity waterbodies.
- Analysis of the species caught in the test fishing indicated that there was no significant difference in either the composition of the catches or the species diversity of wild fish between the stocked and non-stocked waterbodies.
- Six priority objectives were identified for managed waterbodies including: income for community development; fish for guests/community work; water for household use; preservation of a sacred place; conservation of fish stocks and preserving fish for harvesting at specific times of year. Income generation was by far the most common cited.
- The management of waterbodies managed for community income could be classified as either group fishing, renting or fishing days. These systems are discussed in more detail in Appendix 7.
- Based on limited information for group fishing and fishing days, yield/hectare values are fairly similar but income/hectare was much higher for group fishing.

Full details of the baseline survey are provided in Appendix 7. Information from the survey was used to identify and categorise uncertainties and select the learning option using the procedure outlined in Figure 6. Details of this procedure are presented in Appendix 8. A summary is given below.

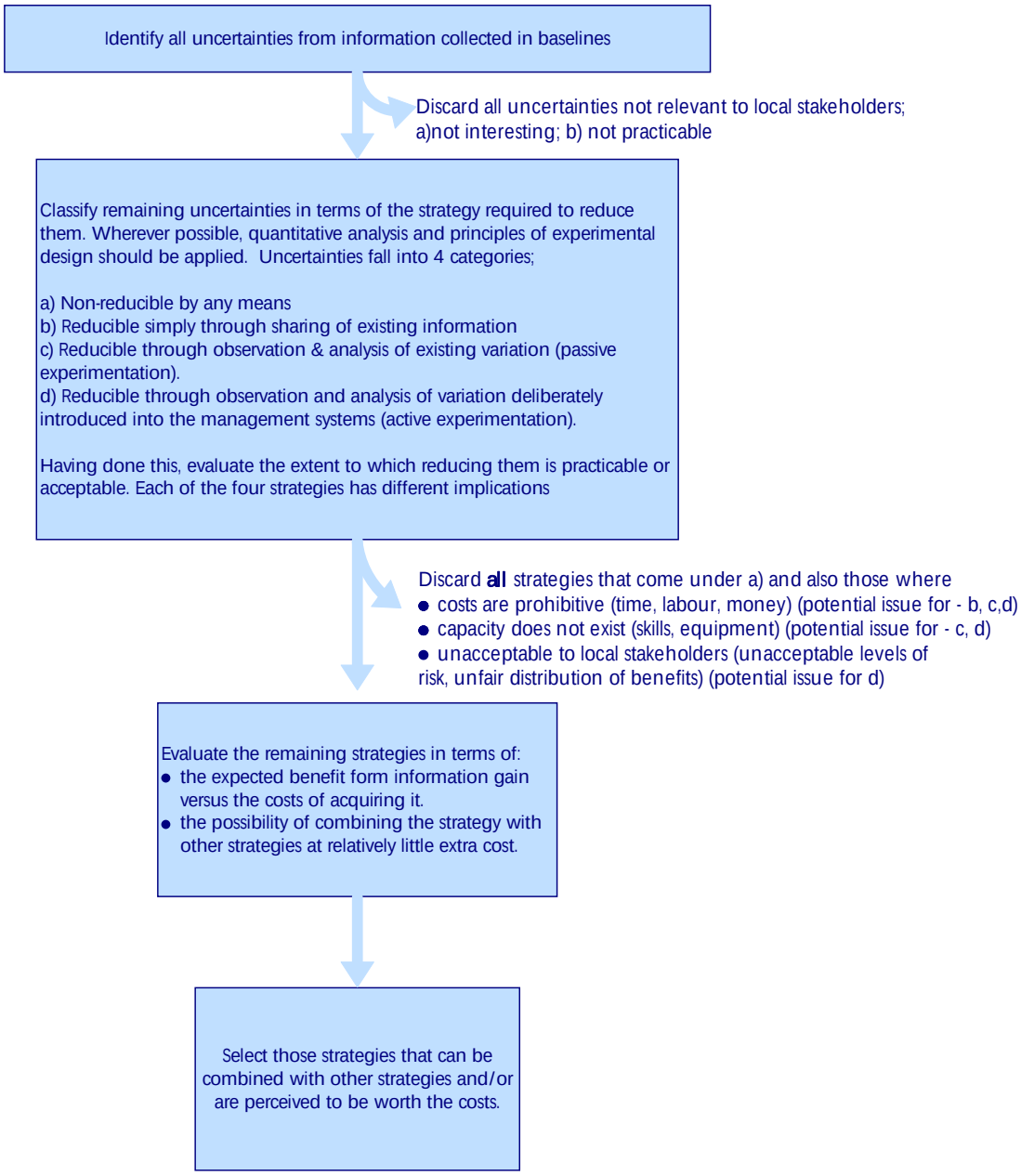

Figure 6 Framework to guide selection of experimental options

5.3.2 Design and implementation of a management experiment.

The uncertainties identified from the baseline survey are summarised in Table 4. Using the procedure in Figure 6, firstly uncertainties classified as irrelevant were rejected (column 2). Criteria described in the Figure were then used to assess and

reject those options (classified as categories a-d) also considered unviable. 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)

Having rejected options that were clearly unviable, the remainder were carefully evaluated in terms of what the costs would be and how useful the information gained would be. The result of the procedure is the strategies remaining in Column 6. Column 7 shows those areas where it was felt some uncertainties could be reduced by villages sharing experiences with each other. On the basis of this, an experiment was designed that combined:

- active experimentation to generate information about which species to stock;
- passive experimentation to generate information concerning the best management system.

Table 4. Applying the selection process to the identified uncertainties

Strategy	Relevant ?	Available sites?	Can use active strategy?	1st cut – accept or reject	2nd 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 administration?	✓*	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

Specifically, active experimentation investigated the optimal combination of species dependent upon waterbody productivity. Production from an extensive culture-based fishery is dependent on the efficient use of natural pond productivity. Understanding fish/fish and fish/environment interactions is therefore crucial for the effective management of such systems. A stocking experiment was designed to investigate how carp and tilapia respond to productivity and whether there was an interaction between these species that depended on productivity. A passive experiment was also selected that investigated the costs and benefits associated with the three management systems used to generate community income.

The stocking experiment involved stocking waterbodies, categorised as high or low productivity based on the total phosphorous concentration in the waterbody, with carp, tilapia or a mix of carp and tilapia at a density of 3500 fingerlings/ha. The passive experiment involved collecting and comparing information relating to the costs and benefits of the three existing management systems – group fishing, fishing days and renting. Full details of the selection and implementation process are provided in Appendix 8.

5.3.3 Analysis of data relating to the technical aspects of management.

The results from the test fishing and village records at the end of first the year showed that catches of stocked fish were poor (mean return from village records = 3.84%) and the result of the stocking experiment was inconclusive. Given insufficient data, making conclusions about the stocking experiment was not possible. Attention turned to the question of where all the fish could have gone. Several factors that might have affected the catches of stocked fish were explored during the analysis including fingerling source, flooding, predation and the transport time of the fingerlings. Of these, only the transport time had a significant negative correlation with stocked fish catches (R^2 =-0.454).

It was felt that the original question the stocking experiment had sought to address was still relevant so the stocking experiment was repeated for a second year. To improve recapture rates, a number of measures to improve fingerling survival were put in place, including efforts to reduce transport times, to procure larger fingerlings and to introduce nursing, with training and hapas provided to those villages that wished to take it up.

Returns from stocking in the second year of the experiment were an improvement on the first and Figure 7 shows results from both years. 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 are advantages in stocking low productivity waterbodies with carp and more productive waterbodies with tilapia. Indeed, tilapia catches in low productivity waterbodies were extremely low and in these waterbodies carp species would be a better stocking option. In the high productivity waterbodies, stocking with tilapia appears to provide substantially higher yields. This is possibly due to tilapia establishing self-sustaining populations in these conditions that increases the potential yields from these waterbodies.

Furthermore, carp and tilapia performance were similar in single and mixed stocking configurations (see
Figure 8), which suggests that the effect of trophic status on their relative performance is solely due to the strong effect of productivity on tilapia performance, and not due to interactions with carp.

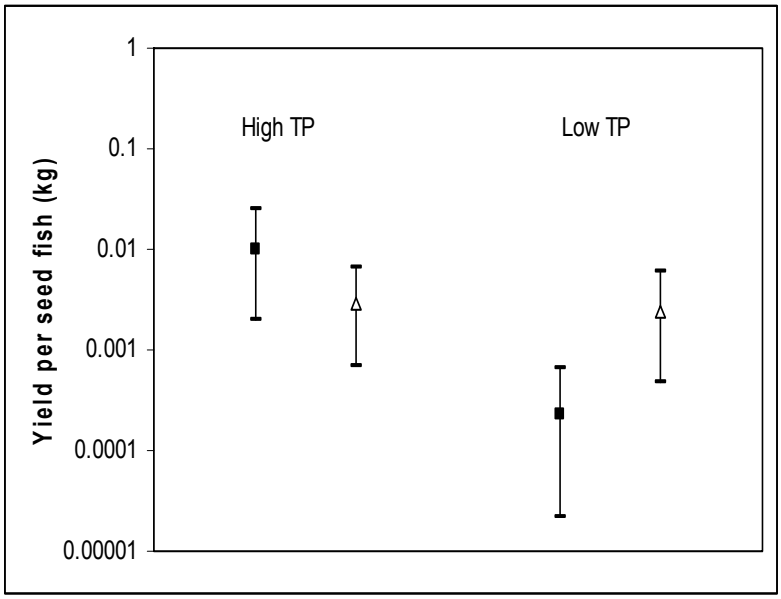

Figure 7 Yield of stocked tilapias (solid squares) and carps (open triangles) in high TP and low TP water bodies. Means with 90% CI.

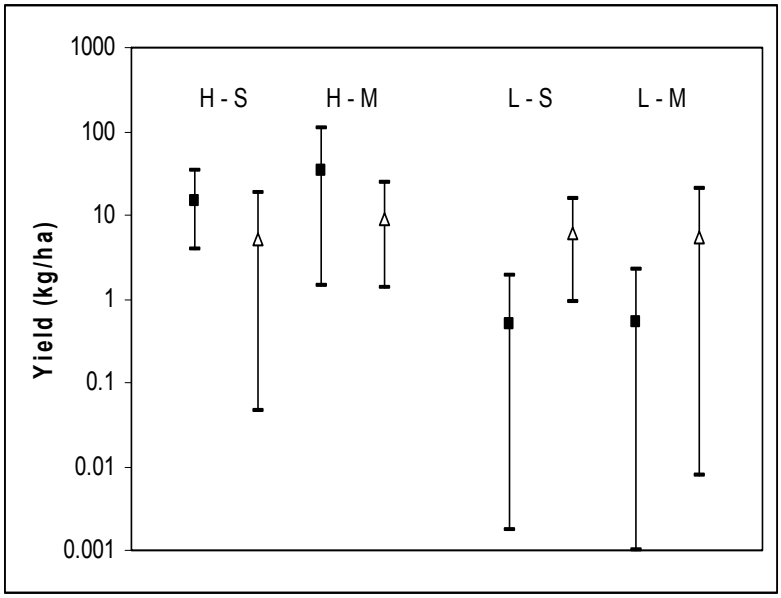

Figure 8 Yield of stocked tilapias (solid squares) and carps (open triangles) under different conditions: high TP, single group (H-S); high TP, mixed group (H-M); low TP, single group (L-S); low TP, mixed group (L-M). Means with 90% CI.

Results from the two years combined indicated that fingerling mortalities were positively correlated with transport times and catches of stocked fish were negatively correlated. Figure 9 shows the effect of transport time on fingerling mortality where the transport time has been divided into quartiles. These results confirmed the result obtained in the first year.

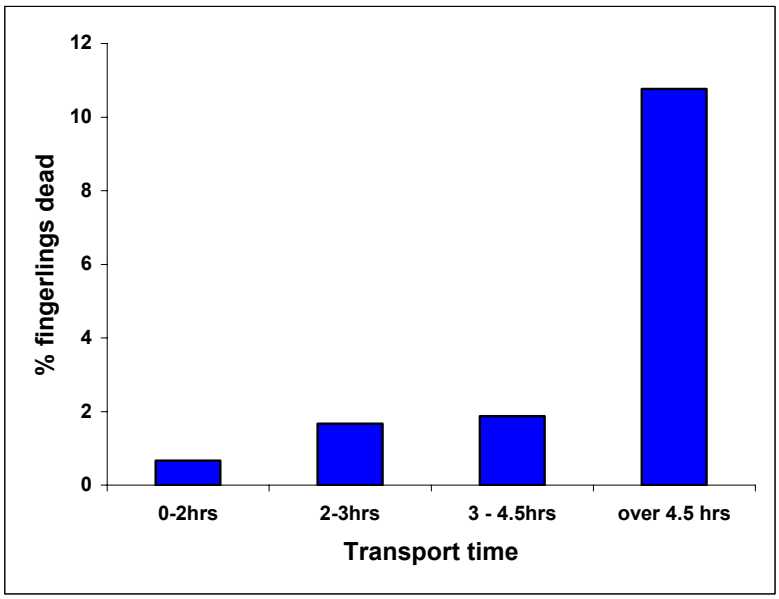

Figure 9. Effect of transport time on fingerling mortality at stocking.

Results from this experiment have a direct practical application and can go some way towards improving the utilisation of natural productivity. They have been summarised in an accessible manner in the community fisheries guidelines (see Appendix 12)

5.3.4 Analysis of data relating to the costs and benefits of different management systems.

The results of the passive experimentation over the two years are presented in Figure 10. Group fishing villages have been separated into villages with high fishing effort (>100 hours fished in the year) and those with low effort (<100 hours fished in the year). Benefits have been converted to an equivalent weight of fish for comparison.

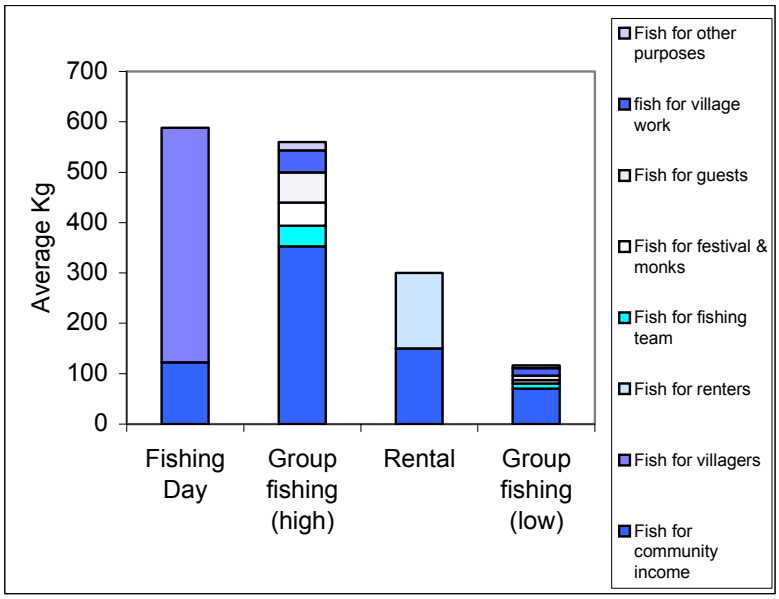

Figure 10 The benefits from different management systems.

Total benefit is highest for fishing days and high effort group fishing. The reason for this is that these two systems were subject to the highest fishing effort. Benefits in terms of village income however are a bit different with high effort group fishing making more than the rest. This might appear to make fishing days a less attractive option until the question of who benefits from the fish not contributing to community income is considered. In the case of renting, this fish goes directly to individuals who have rented the waterbody. Fishing days on the other hand are social occasions, and are valued by communities for promoting village solidarity and harmony. In the case of fishing days, fish not contributing to community income is taken by community members themselves.

Figure 10 was used as the basis for discussion with District staff about the benefits and costs associated with management types. The results of this discussion are shown in Table 5 below. Again, as with the results of the active experiment, the information is not only directly useful to the communities managing the waterbodies, but was extremely relevant to the Provincial government staff. They have been keen to promote community fisheries but have previously done so based on the group fishing model, believing that this type of management yielded the greatest benefits. However, the results indicated that management advice should not be so prescriptive but rather take into account much more the objectives and constraints of the communities wishing to manage. These results have also been synthesised in the community fisheries guidelines (Appendix 12).

Table 5 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

Conclusions

- An explicitly experimental approach to the management of community fisheries can yield information that is relevant to the management of the resources.
- Carp species are a better option for low productivity waterbodies whereas in high productivity waterbodies tilapia can provide higher yields.
- Carp and tilapia performance were similar in single and mixed stocking configurations, suggesting that the effect of trophic status on performance is due to the strong effect of productivity on tilapia performance, and not due to any interactions with carp.
- Efforts should be made to source fingerlings from nearby as higher transport times lead to higher fingerling mortalities.

- Each management system presents its own opportunities and constraints Advice on the type of management communities should adopt depends upon these together with the objectives and constraints of the communities wishing to manage.

5.4 Evaluation of the adaptive learning approach

Evaluation was a key aspect of the adaptive learning approach. Not only was each step of the process evaluated but also the entire process. Figure 11 shows the evaluation framework developed to guide evaluation both during the experimental cycle and at the end of it (the last stage of the cycle). It combines evaluation of process with evaluation of outcomes and is organised as a diagnostic tree to enable identification of areas where problems lie. The sections below use the framework to evaluate results from implementing the approach in the Lao context.

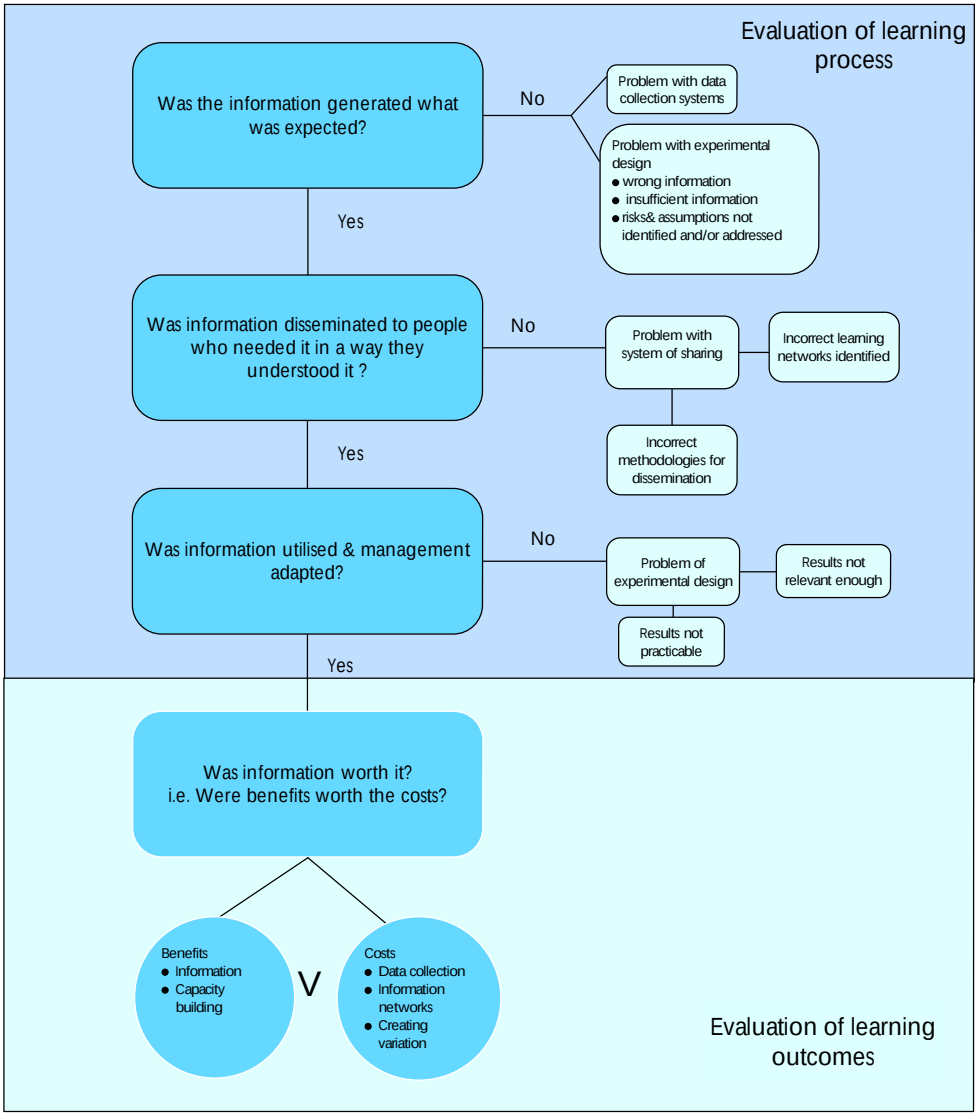

Figure 11 The evaluation framework

5.4.1 Evaluation of the project process

At the end of the first year, the information generated was not what was expected. Analysis indicated that the fault lay not with the data collection systems but with the experimental design itself. Uncertainties had not been reduced because the risks and assumptions associated with the stocking experiment had not been adequately addressed.

While the initial results were disappointing in terms of the original experimental aims, they did provide an opportunity to learn and to improve the approach for the next year. Information regarding management was successfully collected and it was all shared with stakeholders during workshops. As a result, stakeholders were able to begin to compare different management approaches, the first time this had been systematically done in the region. Participant evaluations indicated that methods for sharing information had been successful, as shown in Figure 12. In this graph, each of the questions on the evaluation questionnaire could be ranked between 0-5, 0 being 'poor' and 5 being 'excellent'.

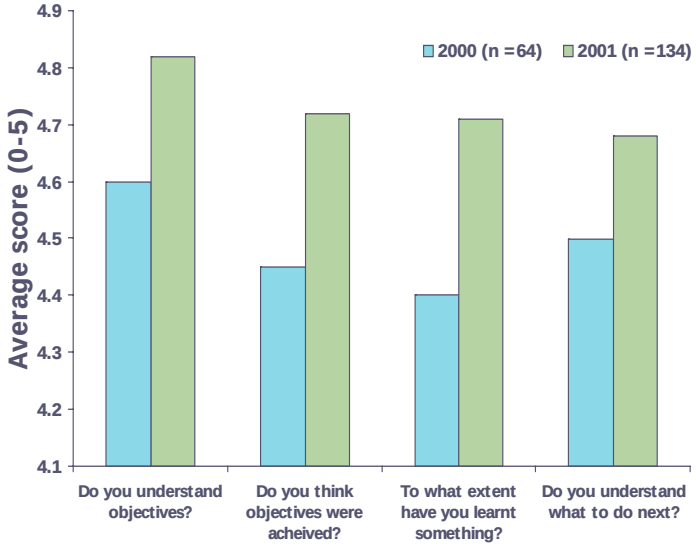

Figure 12 Comparison of the results of participant evaluations in workshops in 2000 & 2001

Sample size was greater in the second year due to the fact that an extra set of village workshops were undertaken – a direct result of comments on the evaluation form in the first. Based on evaluations in the first year, the methods for sharing information were improved and, as can be seen in the graph, average scores from first year to second increased in all cases. Activities had been monitored and evaluated, adaptations in the light of new information made and learning increased.

Results in this first year were therefore mixed. While the information generated was shared successfully and, in some cases, management adapted, problems with experimental design had meant results of the active experiment were inconclusive.

The same experiment was implemented again in the second year (July 2001 – June 2002) and further information on the different management systems collected. Evaluation this time revealed the approach was successful in reducing the uncertainties that had been identified and selected. Both the active and passive experiments had produced positive results, were shared with key stakeholders and resulted in a clear set of recommendations. It is too early to say if stocking strategies have been adapted in the light of this new information (stocking won't occur until end July 2002), but given that evaluations suggested that comprehension was high (see Figure 12), it is anticipated that they will be.

Given that the information generated had reduced the uncertainties expected, had been shared effectively with stakeholders and is expected to be utilised the question remaining was whether it had been worth it.

5.4.2 Evaluation of the project outcomes

Quantitative analysis of the benefits and costs focussed on the value of information gained only from the active experiment (carp/tilapia stocking). This revealed that if the villages involved in the project utilised the results, leading to changes in their stocking policy, yields with a value equivalent to the local project costs (funded by DfID) could potentially be produced within five years. With the potential for results being spread elsewhere (high, given the levels of comprehension of Provincial staff and extension staff) and with all the other benefits of the approach that it was not possible to quantify, the potential to produce yields from all waterbodies equivalent to the total project costs, including overseas costs, relatively quickly is certainly obtainable.

As an example of this last point, simulated increases in total yields as a result of changing stocking strategy based on the results were 7141 kg. Given the total of waterbodies (who fished at all) being 113.2 hectares, this gives an average yield of 111 kg/ha (equivalent to £109/ha). If further waterbodies were stocked at similar densities and subject to the same fishing effort, the number of hectares required to produce yields with a total value equivalent for following costs are:

- Stocking costs – 31ha
- Field costs - 193ha
- Local costs – 275ha
- Project core costs – 1360ha
- Total project costs – 1905ha

In addition to the knowledge gained and the value of this knowledge, results indicated that capacity had also been built as a result of the approach (see Figure 13 and Figure 14).

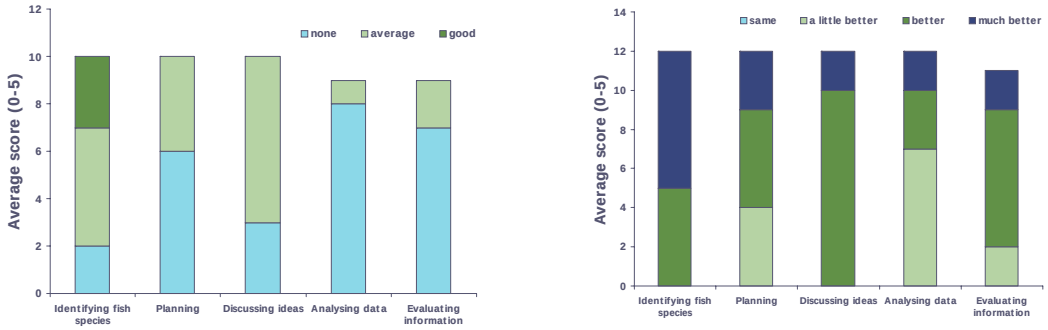

Figure 13 a & b. Skills of district staff pre and post implementation of the adaptive learning approach.

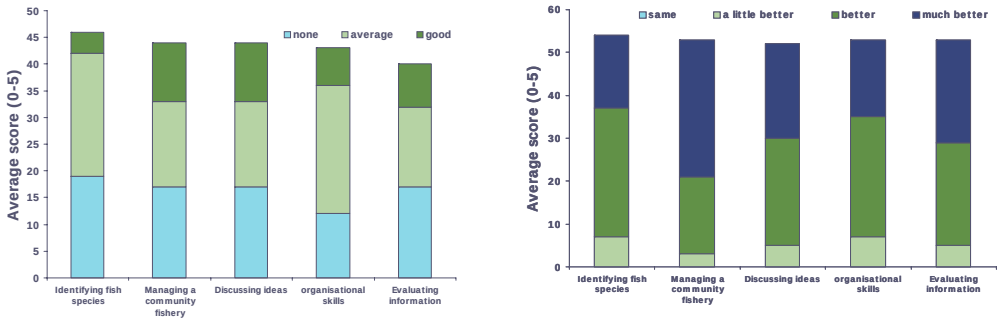

Figure 14 a & b skills of village representatives pre and post implementation of the approach

Skills are an interesting aspect of learning to consider. The increased skills, with the exception of managing a community fishery, were not gained as a direct result of the information generated. Rather skills would have been developed from *how* the activities throughout the adaptive learning cycle had been carried out *i.e*. with a focus on active participation, capacity building and communication. These results we believe illustrate how a *participatory* adaptive learning approach can produce benefits far greater than can be achieved by focusing on experimentation and/or information gain alone.

5.4.3 Conclusions

Results show that the adaptive learning approach can be a very successful way of reducing management uncertainties, increasing benefits from a resource system and building capacity. The results have shown how beneficial it is in terms of disseminating information to integrate the learning of *all* into the approach. More specifically,

The process:

- After two years, longer than anticipated, the information generated from the approach reduced the uncertainties expected, was shared effectively with stakeholders and is expected to be utilised. Evaluations during workshops showed comprehension was high and adaptations to management from information collected in the first year had already occurred in some villages.

- Stakeholder evaluations of the whole process showed that they thought levels of participation satisfactory and methods appropriate and also showed that they believed both their skills and knowledge had been increased as a result of their involvement.
- From the point of view of the learning process, the approach was successful.
- The evaluation framework proved a useful tool for coping with the multi-tiered nature of evaluation. Monitoring of activities such as data collection and information sharing enabled us to monitor our progress and, crucially, adapt and improve. Both data collection methods and training methods were improved as a result of evaluation and the latter showed statistically significant improvements.

The outcomes:

- Quantitative analysis of the benefits and costs of the information gained, revealed that, even if only results of the carp/tilapia experiment were implemented in only those villages involved in the experiment, yields equivalent in value to local project costs could potentially be generated within five years. With the potential for results being spread elsewhere and all the other benefits of the approach that haven't been quantified, the potential to generate significant benefits is high.
- With the spread of information being fundamental to its usefulness, the results show how important it is to integrate the learning of all into the approach. Results indicating increases in skills show the feasibility of building capacity *at the same time* as generating information.

Further information can be found in Appendix 9.

5.4.4 Lessons from Lao PDR: issues concerning wider applications of the approach

Results show that an adaptive learning approach can be a very successful way of reducing management uncertainties and building capacity. However, evaluation can only specifically relate to the Lao case and it cannot be assumed that similar results would occur in all circumstances. Implementation of the approach would have to be assessed on a case by case basis, demonstrating again the fundamental need for constant evaluation.

Whilst implementing the approach was challenging, there were a number of characteristics about the resources and management that we believe facilitated implementation:

- The ubiquitous nature of the resources in question within the study area meant the potential for finding adequate replicates for experimentation was high.
- Management objectives were similar enough in sites chosen that it was easier to find experimental strategies that would be relevant to all.
- Management in the villages was quite advanced in some cases with, for example, pre-existing systems for monitoring and enforcing compliance and recognised management committees to act as representatives of 'community' interests.

- Management systems already in place did not allow individual harvesting, with all fishing being carried out under the direction of the collective. Co-ordinating the activities of individual harvesters was therefore not the problem that it could be in other circumstances.
- The nature of the stocking and harvesting regimes meant that experiments could be conducted on an annual basis making the turnover of information high. This maintained interest in the approach, despite problems in the first year and also enabled costs of information gain to be recouped more quickly.
- The capacity to stock waterbodies also enabled us to develop experimental strategies where no one was likely to be worse of than they would have been, as a result of involvement in the experiment. This we have identified as one of the potential constraints of implementing the approach in a development context elsewhere. Given frequently high discount rates and levels of vulnerability, local communities may not be in a position to suffer even small short-term costs and this can drastically reduce learning options. It must be remembered that it is not only total costs against benefits that should be evaluated but also whom the approach is costing and whether they can afford it. The capacity to stock certainly helped in the planning phases and enabled us to reach consensus more easily than might otherwise have been the case (and even then this was a non-trivial matter).

We believe that these characteristics made the approach easier to implement than otherwise would have been the case. This is not to say that the approach cannot be implemented in other circumstances, only that the absence of them will have implications for implementation that will need to be addressed on a case-by-case basis.

5.5 Promotion of the approach

5.5.1 The guidelines

As a result of discussions with target organisations, the decision was taken to write the guidelines in a non-technical, easily accessible manner so as to be of interest to as wide a range of organisations/individuals as possible. In the past, guidelines written as a result of research, whilst often containing many valuable insights, were felt to have often failed to have much development impact due to being overly long or technical. Instead, advice was to produce a highly visual set of guidelines, professionally printed, with pictures and diagrams to break up sections of text. A4 versions of the guidelines (which have been printed as A5 booklets) are presented in Appendices 11 & 12. A flyer was also produced to advertise the guidelines (see Appendix 10). The flyer was available for the project final workshop (appendix 13) and generated interest. It is also being sent out as a mail shot to relevant organisations/individuals in the South East Asian region.

5.5.1.1 Community fisheries guidelines

The index for the community fisheries guidelines is shown in Table 6. The guidelines, an additional output of the project, synthesise, in an accessible manner, the experiences gained about ‘community fisheries’ in Southern Lao PDR. The publication describes what community fisheries are, what they require and what

benefits they can bring. It details where and how these systems can be promoted and what options would be preferable in which circumstances. Technical advice (such as when and what to stock) is provided alongside ideas such as how to increase stakeholder participation. Importantly, advice is also given on circumstances under which such initiatives would not be appropriate. The guidelines are aimed at any organisation whose remit is to promote rural development in a way that enables villagers to develop their own capacity and set and realise their own development priorities.

Table 6 Index for the Community Fisheries Guidelines

5.5.1.2 Adaptive learning guidelines

The index for the adaptive learning guidelines is shown in Table 7. The adaptive learning guidelines aimed to synthesise the knowledge gained from this project's experience with the approach and hence is the most significant output of the project. It is a non-technical guide aimed at organisations involved in natural resource management who wish to learn more about their resources at the same time as managing them. The guide explains the principles of adaptive learning and how these principles were executed in a real field setting. Amongst other things, it discusses; when it is appropriate, potential problems, and what skills and/or resources are required. It also outlines how the full participation of all stakeholders can be encouraged by facilitating and enhancing communication at all levels and increasing the learning of all involved.

Table 7 Index for the Adaptive Learning Guidelines

5.5.2 Final workshop

The final project workshop was facilitated by a member of the RDC and was attended by interested parties from across Lao PDR (for details see Appendix 13). The workshops aims were to;

- Present, discus and evaluate what the project had learnt about community fisheries management and the adaptive learning approach and compare with the experiences of other organisations, and
- Identify ways in which the adaptive learning approach could be used in the future.

Evaluation of the workshop revealed that there was greater than 77% satisfaction that the objectives were met in the opinion of the attendees. Similarly, the workshop was seen as relevant to the participants work; definitely interesting and with a great majority of those attending wishing to know more about the subject.

6 Contribution of Outputs

6.1 Contribution of outputs towards DfID's development goals

The project began in 1999 and relates to DfID goals defined in the original RNRSS and FMSP log frames with the specific project goal being; "yields from enhanced fisheries increased by optimising strategies for stocking & harvesting."

However the outputs from this project are also directly relevant to Output 2 of the recently modified FMSP log frame; "management tools and strategies for marine and freshwater capture and enhancement fisheries that are most likely to support improved livelihood outcomes of the poor developed and promoted"

This project has contributed to both outputs on several levels, both directly and indirectly and these are discussed in turn.

Firstly, the project has had a direct and positive impact on the performance of small waterbody enhancements in 38 villages in Southern Lao PDR. The project focused on the development of management systems (known locally as "community fisheries") that are one of the principle, if not only ways that villages in Southern Lao can generate community income, enabling them to pursue their own village development priorities such as improving the village school, health centre, access roads or temple. As well as generating community income, these systems also provide an important insurance device for particularly vulnerable households, providing cheap or free fish at times of household emergency.

The most immediate result of the project has been increased fish yields and community income from these systems, due to both initial stocking, and adaptations of stocking and harvesting regimes in the light of new information generated during the project. Additional technical, socio-economic and institutional information generated during the last experimental cycle is expected to improve further performance in these villages in the next years.

Partly as a result of this project, these systems of management have attracted a lot of interest in Lao PDR, and the region, as a means of enhancing the livelihoods of rural poor through their own village-led development. Guidelines produced by the project, on community fisheries, how they can be promoted and how stocking and harvesting regimes can be adapted to local circumstance, will ensure that all the results and experience gained from this project are available to Governments and NGO's promoting community fisheries elsewhere.

Many of the technical results resulting from the test implementation of the adaptive learning approach have a wider relevance and application than to just 'community fisheries' management systems. In particular, information regarding the performance of different stocked species combinations could improve the yields and/or performance of enhanced fisheries in the region generally.

The results mentioned above are an indirect benefit of the main purpose of this project, which was to develop and promote an adaptive learning approach to enhancement management. The scale and nature of direct benefits that came from implementing the approach is already evidence of how useful it can be to support improved livelihood outcomes of the poor.

The approach, as implemented in this project, has been shown to produce benefits to the poor via improved enhancement management, but its application is expected to be much wider. With a focus on developing widely applicable methodologies that enabled poorer communities to be partners in an adaptive learning process as opposed to just end users of research products, research outputs have the potential to improve performance in any renewable resource management system where management occurs in conditions of uncertainty.

Co-management of natural resources is now seen as a crucial factor in improving the livelihoods of those who depend on them, and has been the subject, or principle output, of several FMSP projects to date (e.g. R6436, R7043). As suggested above, its' importance was also recognised in this project and adaptive learning methodologies were specifically developed to facilitate the full involvement of local communities and other stakeholders in management research, ensuring that their needs and priorities were being met, and their skills and capacity to manage increased. Again, results from implementation of this approach in the Lao setting already suggest that this can be achieved - with another direct benefit of this project being the increased capacity of government staff and local communities alike, as measured by themselves.

With its pro-poor and inclusive approach to research in management, guidelines and associated outputs produced as a result of this project's experience are expected to contribute significantly to the development of tools and strategies to support improved livelihood outcomes of the poor.

6.2 Promotion of outputs

Project outputs have been promoted in a number of ways as discussed below.

6.2.1 Guidelines

As discussed earlier in this report one of the major activities to promote project outputs was the production of two sets of guidelines, one on the process of adaptive learning and an additional one on community fisheries, which together, synthesised project experiences. The guidelines are;

Garaway, C.J & Arthur, R.I (2002) Adaptive Learning. Lessons Learned from Southern Lao PDR
Garaway, C.J & Arthur, R.I (2002) Community Fisheries. Lessons Learned from Southern Lao PDR

Two hundred copies of each have been printed and promotion of these guidelines is already underway. A flyer advertising both productions has been printed and will be

sent by the collaborating organisation, RDC, to all organisations/ individuals in the Mekong region with an interest in natural resource management. The flyer was also available at the project Final Workshop and has been taken to a series of meetings on aquatic resources management within the region. Interest has been significant with multiple requests for copies. It is also anticipated that the guidelines will be available on the MRAG Ltd and FMSP websites, a fact also advertised in the guidelines themselves.

Besides the production and promotion of guidelines, project outputs have also been promoted through seminars and workshops, internal reports and scientific papers. A list of these is given below.

6.2.2 Presentations at workshops/seminars/conferences

Developing fisheries enhancements in small water bodies: lessons from Lao PDR and Northeast Thailand. ACIAR and MRC Reservoir & Culture Based Fisheries Workshop. Bangkok, 14-18th February 2000 (presented by Caroline Garaway).

Population dynamics models as practical tools for the assessment of culture-based reservoir fisheries. ACIAR and MRC Reservoir & Culture Based Fisheries Workshop. Bangkok, 14-18th February 2000 (presented by Kai Lorenzen).

Enhancements & Culture Based Fisheries. NACA/FAO Aquaculture in the 3rd Millenium Conference. Bangkok February 20th –25th 2000 (presented by Kai Lorenzen).

Participatory Adaptive Learning for Community Fisheries in Lao PDR. MRC Co-management Workshop, RDC, Savannakhet, Lao PDR & Mugdahan, Thailand. May 14th –25th 2001 (presented by Caroline Garaway).

Performance of alternative experimental strategies for optimising multi-species fish stocking programmes. EU FISHSTRAT end of project workshop, Bangkok, February 23rd –24th 2002 (presented by Robert Arthur).

Adaptive Learning. Experiences from Savannakhet & Khammouane Provinces Lao PDR. MRAG/RDC Adaptive Learning Final Workshop Savannakhet, Lao PDR 2nd-3rd July 2002 (presented by Robert Arthur).

An evaluation of the Adaptive Learning Approach. MRAG/RDC Adaptive Learning Final Workshop Savannakhet, Lao PDR 2nd-3rd July 2002 (presented by Caroline Garaway).

A full list of participants and activities at the project final workshop, another means of promoting project outputs, is given in the Final Workshop Report document supporting this FTR.

6.2.3 Internal reports

RDC policy was to write a report in both English and Lao after every significant project activity thereby ensuring that experiences weren't lost and anyone visiting

the RDC could be brought up to date quickly with the project's progress. A large number of internal reports have therefore been written as listed below.

1. (2000, 2001, 2002) Summary reports of the district staff data analysis workshops on adaptive learning and community fisheries in Savannakhet (English & Lao versions)
2. (2001, 2002) Summary reports of the village level discussion workshops on adaptive learning and community fisheries in Southern Laos (English & Lao version)
3. (2000, 2001) Summary reports of the village level planning workshops on adaptive learning and community fisheries in Southern Laos (English & Lao version)
4. (2000, 2001) Reports of the district monitoring training workshop on adaptive learning and community fisheries in Southern Laos (English & Lao version)
5. (2001) Summary report of the stocking for adaptive learning and community fisheries in Southern Laos (English & Lao version)
6. (2000) Community Fisheries Theme Sheet (English), RDC Report, Savannakhet, Lao PDR

6.2.4 Publications

Lorenzen, K. (2000) Allometry of natural mortality as a basis for assessing optimal release size in fish stocking programmes. Canadian Journal of Fisheries and Aquatic Sciences 57: 2374-2381

Garaway, C., Lorenzen, K. & Chamsingh, B. (2001) Developing fisheries enhancements in small waterbodies: lessons from Lao PDR and Northeast Thailand. In: Reservoir and Culture-Based Fisheries: Biology and Management. Edited by S.S. de Silva. ACIAR Proceedings 98. Canberra: ACIAR. pp. 227-234.

Lorenzen, K. (2001) Using population models to assess culture-based fisheries: a brief review with an application to the analysis of stocking experiments. In: Reservoir and Culture-Based Fisheries: Biology and Management. Edited by S.S. de Silva. ACIAR Proceedings 98. Canberra: ACIAR. pp. 257-265.

Lorenzen, K. & Welcomme, R.L. (2001) Stocking. In: Inland Fisheries: Ecology and Management. Compiled by R.L. Welcomme for the UN Food and Agriculture Organisation. Oxford: Blackwell Science. pp. 241-253.

Lorenzen, K., Amarasinghe, U.S., Bartley, D.M., Bell, J.D., Bilio, M., de Silva, S.S., Garaway, C.J., Hartmann, W.D., Kapetsky, J.M., Laleye, P., Moreau, J., Sugunan, V.V. & Swar, D.B (2001) Strategic review of enhancements and culture-based fisheries. In: Aquaculture in the Third Millennium. Rome: FAO. pp. 221-237. (Also online: http://www.fao.org/DOCREP/003/AB412E/AB412E00.HTM)

Lorenzen, K. & Enberg, K. (2002) Density-dependent growth as a key mechanism in the regulation of fish populations: evidence from among-population comparisons. Proceedings of the Royal Society of London Series B - Biological Sciences 269: 49-54.

Papers to be edited and re-submitted:

Garaway, CJ, Lorenzen K., Chamsingh, B. (to be submitted to the Journal of Aquatic Living Resources) Effect of stocking on small waterbody production and the role of institutional factors in determining the outcomes of community-led enhancement. Case Studies from Lao PDR.

Arthur, R.I, Garaway, C.J, Lorenzen, K Adaptive Learning: A broadening of the concept of adaptive management and implications for its implementation.

6.2.5 Other activities

Posters

Garaway *et al.* (2000) An adaptive learning approach for fisheries enhancement in small waterbodies.

Garaway *et al.* (2000) 'Community fisheries' in Savannakhet Province Lao PDR – an aquatic resource system that benefits the poor.

Both written for the DfID E-mail conference on Aquatic Resources Management for Sustainable Livelihoods of Poor People.

Government Fairs

A stall showing the work of the project has been presented at a Government Fair by members of the Provincial Staff. This initiative was completely government-led.

TV

As mentioned previously, one of the major methods of communicating with local communities was through holding workshops out in th edistricts where they lived, often bringing together representatives from 20 villages at a time. Local TV were always invited to these workshops and more often than not came. Our project therefore had frequent coverage on local TV.

T-shirts

T-shirts advertising the project were distributed to all district staff working on the project.

6.2.6 Evidence of uptake

RDC, target organisation have already shown some signs of uptake of project results. Even during the project some of the systems set up to monitor and evaluate the process of implementing an adaptive learning approach have been used in other parts of their work. An RDC member facilitated the final workshop and, along with other project staff was promoting the benefits of the approach. During the workshop

areas were identified, by RDC and other organisations, where an adaptive learning approach might prove useful.

The community fisheries guidelines, an output not originally planned, were specifically requested by the RDC who wish to use them to expand community fisheries in the Southern Provinces. They are currently translating them into Lao to make them accessible to a larger number of people.

Finally, RDC are currently writing a proposal for funds to expand their work, and in particular develop their relationship with neighbouring countries such as Cambodia. Adaptive learning has been identified as one of the methodologies that they wish to develop further.

6.3 Future activities towards development and promotion of outputs

The guidelines are the principle means by which the project outputs will be disseminated and every effort is being and will be made to ensure they reach as wide a target audience as possible. The next step is to ensure that they are posted on the FMSP and MRAG websites.

Robert Arthur, research assistant on this project is expected to finish his PhD on Adaptive Learning in December of this year and further publications may arise from this and from further research of project data from other members of the project team.

Finally, in addition to concept notes being put in by RDC (see above), the guidelines produced by this project are the subject of a new DfID FMSP Call which hopes to establish whether they can indeed be adapted to different physical and institutional evironments. Such a project should further develop and promote this very promising approach.

7 References

Berman, P. (1980) Thinking about programmed and adaptive implementation: matching strategies to situations. In: Why Policies Succeed or Fail. (Ingram, H.M. & Mann, D.E. eds.). pp 205-227. Sage, Beverly Hills.

Cowan, V., M. Aeron-Thomas, Payne, A.I. (1997). An evaluation of floodplain stock enhancement. London, MRAG Ltd.

Dovers, S. and C. Mobbs 1997. An alluring prospect? Ecology, and the requirements of adaptive management. In: Klomp & Lunt. (eds). Frontiers in ecology. Elsevier.

Garaway, C (1999) Community management of enhanced fisheries in Lao P.D.R , PhD dissertation. Imperial College of Science, Technology & Medicine, London, UK

Garaway, C. (1995). Communal Ponds in NE Thailand under different us-rights systems: a participatory rural appraisal of their differing roles in peoples' livelihoods. London, MRAG /AIT / Imperial College of Science & Technology.

Garaway, C. J., K. Lorenzen, Chamsingh, B. (1997). Reservoir fisheries management in Savannakhet Province, Laos. Final report. London, DfID Fisheries Management Science Programme. MRAG Ltd.

Garaway, C.J., K. Lorenzen and B. Chamsingh (2001). Developing fisheries enhancements in small waterbodies: lessons from Lao PDR and Northeast Thailand. In S.S. De Silva (ed) Reservoir and culture-based fisheries: biology and management ACIAR Proceedings 98 Canberra.

Hartmann, W. (1995). “Institutional Development for common -pool Resources Management: A task in technical Cooperation. The case of Kerala Reservoir Fisheries.”.

Holling, C.S. (1978) Adaptive Environmental Assessment and Management. Wiley, Chichester

Lorenzen, K. (1995) Population dynamics and management of culture-based fisheries. *Fisheries Management and Ecology* 2: 61-73.

Lorenzen, K., Xu, G., Cao, F., Ye, J. & Hu, T. (1997) Analysing extensive fish culture systems by transparent population modelling: bighead carp culture in a Chinese reservoir. *Aquaculture Research* 28: 867-880.

Lorenzen, K. & Garaway C.J. (1998) How predictable is the outcome of stocking? In: *Inland Fisheries Enhancements*. FAO Fisheries Technical Paper 374, pp. 133-152. Rome: FAO.

Lorenzen, K., Garaway, C.J., Chamsingh, B. & Warren, T.J. (1998) Effects of access restrictions and stocking on small water body fisheries in Laos. *Journal of Fish Biology* **53** (Supplement 1).

Nevis, E.C., A.J. DiBella and Gould, J.M. (1998) Understanding organisations as learning systems. Available from the Internet. URL: http://www.solonline.org/solonline/res/wp/learning_sys.html

Röling, N.G. (1989). Why farmers matter: the role of user participation in technology development and delivery. Paper at International Workshop Making the Link Between Agricultural Research and Technology Users, ISNAR, November 20-25 1989.

Rondinelli, D.A. (1993) Development Projects as Policy Experiments: An Adaptive Approach to Development Administration. Routledge, London.

Petr,T (ed) (1997) Inland Fisheries Enhancements. FAO Fisheries Technical Paper 374, pp. 133-152. Rome: FAO.

Samina, Z. and E. Warby (1993). "Nagashini Beel:A case study of the transformation of a common property Aquatic Resource." *NAGA* April/July 1993.

Sainsbury, K.J. 1988. The ecological basis of multispecies fisheries, and management of a demersal fishery in tropical Australia. In J.A. Gulland (Ed.) Fish population dynamics (second edition). John Wiley and Sons Ltd.

Walters, C.J. (1986) Adaptive Management of Renewable Resources. Macmillan, New York.

Walters, C.J. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online] 1(2): 4. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1http://www.consecol.org/vol1/iss2/art4