SELF-RECRUITING SPECIES IN AQUACULTURE – THEIR ROLE IN RURAL LIVELIHOODS

FINAL TECHNICAL REPORT

Project R7917

Aquaculture and Fish Genetics Research Programme
Fisheries Management Science Programme
DfID Renewable Natural Resources Research Strategy

Institute of Aquaculture
Imperial College London
Asian Institute of Technology

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Appendix 1 Dissemination outputs from the project.

Appendix 1 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.

Appendix 2 Lorenzen, K. (2004) Population dynamics and potential of fisheries stock enhancement: practical theory for assessment and policy analysis. Philosophical Transactions of the Royal Society of London, Series B. (in press).

Appendix 3 Lorenzen, K., Beveridge, M. & Mangel, M. Fish culture, domestication, and interactions between wild and cultured fish: the undiscovered country. Submitted to Fish and Fisheries

Appendix 4 Arthington A.H., Lorenzen K., Pusey B.J., Abell R., Halls, A., Winemiller K.O., Arrington D.A. & Baran E. (2004) River fisheries: ecological basis for management and conservation. In: Welcomme, R.L. (Ed.) Proceedings of the 2nd International Large Rivers Symposium. Vol. 1 pp. 31-60. Phnom Penh/Rome: Mekong River Commission/FAO.

Acknowledgements

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Very little would have been achieved without the interest and effort of the villagers 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 results of certain activities is provided in the appendix.

1 Executive Summary

(1) The purpose of the project was to characterise the role of self-recruiting species in different farmer managed aquatic systems, and to develop management approaches that enhance the production of, and access to, such resources by the poor.

(2) Self Recruiting Species (SRS) are aquatic animals that can be harvested sustainably from a farmer managed system without regular stocking. The definition of a 'farmer managed system' depends on the season, country and location.

(3) Research on SRS was carried out in five different countries: Thailand, Cambodia, Vietnam, Bangladesh and India. The project identified the socio-economic, technical and environmental factors that determine the role of SRS in farmer managed aquatic systems, and management strategies to enhance the production of, and access to, such resources for the poor where opportunities exists.

(4) SRS are critical for poor people, both for home consumption and sale. Seasonally they are especially important during the dry season when access to other water bodies becomes limited.

(5) In each country lists of species popular with poor producers/consumers have been developed, which can inform further work on the development of species of poverty-focused aquaculture.

(6) It is not just fish that have been rated as important; frogs, snails, crabs and shrimps are also valued

(7) SRS from farmer managed systems (ponds, ditches and rice fields) are most important in upland areas where other waterbodies are limited.

(8) Management techniques that have been effective include keeping of broodstock, re stocking of collected juveniles and the screening (or not) of pond entrances.

(9) Value addition (drying, fermenting) is an important activity resulting from increased seasonal availability of non-stocked aquatic animals from farmer managed systems.

(10) Farmers who previously excluded SRS have observed that having SRS in the system does not negatively affect the production of stocked fish

(11) Local resource group management of SRS in tracts of farm land can be effective in raising benefits to individual farmers from their SRS-based aquatic systems.

(12) Due to the strong linkages between large waterbodies and farmer managed systems, location specific group management shows promise in the maintenance and enhancement of SRS in poor communities.

(13) The population dynamics of SRS and systems that rely on mixed SRS/stocked fish have been investigated theoretically and in field studies and management principles derived.

2 Background

Research has highlighted the importance of wild fish and other aquatic animals in both natural and managed habitats to the livelihoods of the rural poor (Roos et al 1998, Mazumder 1998, ITB/BASC, 1998; Garaway 1999, Gregory and Guttman, 1999). Often these resources are actively managed by rural people in both public/communal and private water bodies. In particular, active management of wild aquatic animals in privately owned rice fields and ponds is widespread throughout the rice farming regions of Asia. Aquatic animals that can be harvested sustainably from a farmer managed system without regular stocking are referred to as self recruiting species (SRS). A range of indigenous and introduced fish species; as well as molluscs, crustacea and amphibians are inevitably present in many rural aquaculture systems even where deliberately eradicated. SRS resource systems operate at the interface of capture fisheries and aquaculture, involving active management and private ownership of animals during all or part of their life cycle, but remaining closely linked to the wider, natural aquatic ecosystem. As aquatic habitats are increasingly modified, active management of wild aquatic animals on farms serves not only to increase their availability for harvest, but to conserve the natural aquatic biodiversity of rice based farming landscapes.

A number of previous studies have indicated the importance of SRS to rural households in the Mekong region. The importance of carnivorous wild fish species that typically enter fishponds in floodplain areas in meeting farmers' needs has been documented by AIT Aqua Outreach (1992). Sengrut (1998) found that in the lower Chi Valley, northeast Thailand, wild fish caught from natural and modified ecosystems were more important to rural households than fish culture based on stocking of hatchery seed. The interest of farmers in intensification of household-managed aquatic systems is also linked to the relative abundance of wild fish and other aquatic organisms. Gregory and Guttman (1996) related interest in stocking fish to the proximity of farmer's aquatic systems to perennial water bodies that acted as refuges for wild fish. Extension of fish culture was best targeted to farmers living away from perennial water bodies, where wild fish was most limited (Guttman, 1999). Mixed stocked and self-recruiting systems are common in northeast Thailand. More than 20% of farmers were found to stock hatchery seed in trap ponds and associated rice fields, but yields remained dominated by wild aquatic animals. Most hatchery seed currently stocked into farmer systems is of exotic carp and tilapia species. However, transfers of wild fry from open water bodies are also practiced, and the current development of hatchery production for indigenous species implies that stocking of such species may become widespread.

Although SRS are likely to be of greatest importance in systems managed extensively, they can also be important in intensive aquaculture systems. Amechi (1995) found that by-catch in stocked, intensively managed fish ponds near Bangkok varied from between 20 to over 40% of total yields. Molluscs were the main contributors to this 'by-catch', rather than prawns or fish. The stocked species combination was found to affect the quantity of by-catch, especially if the benthic common carp were included. Provisional nutrient budgets also suggested the importance of by-catch to the availability of major nutrients. Lorenzen et al. (1998) found that in community fisheries with regular stocking of tilapia and carps, the

stocked species dominated catches but a high standing stock and diversity of wild, self-recruiting species was maintained.. Despite the high biomass of stocked fish, standing stocks of wild fish were similar to those from non-stocked waterbodies with fishing restrictions, indicating weak interactions and a potential to maintain wild stocks in culture situations. Recently, Roos et al (1999) have demonstrated the feasibility of managing the small indigenous fish *mola* in conventional polycultures. The high levels of micro-nutrients (eg vitamin A and calcium) contained in this species compared to commonly stocked fish such as silver carp, and a tendency to consume them in the household, has important impacts on household nutrition. Even under commercial culture conditions, small “trash” fish, which are available to workers as payment in kind or are sold at low price may contribute to the livelihoods of poor non-fish farmers in rural and urban areas (Little 1998, Cheftel & Lorenzen 1999). In some cases SRS are managed by farmers as an integral part of intensive aquaculture. Yoonpundh (1996) demonstrated that farmers raising the snakeskin gourami in Samut Prakarn, Thailand, use a variety of strategies based on natural and stocked recruitment to optimise their systems.

Aquatic resource systems based on a combination of natural recruitment and stocking of hatchery produced aquatic animals are increasingly common in inland waters. This may take the form of fisheries enhancement (where hatchery fish are stocked into open waters), or mixed SRS and stocked aquaculture in farmer managed systems. In many cases the stocked and self-recruiting populations are of different species and interact only through interspecific competition and sometimes, predation. In south and Southeast Asia for example, hatchery stocking is predominantly of exotic tilapia and carp species. However, populations maintained by both natural recruitment and stocking are becoming increasingly common as tilapias and common carp establish self-recruiting populations, and hatchery production and stocking programmes for native species are being developed. It is thus important to understand the dynamics of mixed, stocked and self-recruiting populations in order to assess the effects of stocking on yield and on the natural population, and to manage such populations effectively.

Existing information thus indicates that self-recruiting aquatic animals in farmer-managed systems such as ponds and rice fields may contribute substantially to rural livelihoods in the rice growing regions of Asia. However, these resource systems at the interface of aquaculture and capture fisheries have received very little attention in research, extension and policy. The current project was thus designed to document the extent and role in livelihoods of such systems, to analyse their ecology and to identify management strategies to increase, or at least maintain ,productivity of and access to such resources.

3 Project Purpose

The purpose of the project was to characterise the role of self-recruiting species in different aquaculture systems, and to develop management approaches that enhance the production of and access to such resources by the poor.

This purpose was achieved by delivering four distinct outputs:

1. Role of SRS in Asian farmer managed aquatic (aquaculture) systems understood.

2. Importance to livelihoods of SRS produced in aquaculture systems defined.

3. Management strategies defined to optimise production of and access to SRS within the livelihoods of the poor.

4. Dissemination of results and promotion of management and policy recommendations.

4 Research Activities

4.1 Overview

The project involved a wide range of field, laboratory and theoretical investigations carried out by a total of ten partner institutions based in six countries.

4.1.1 Research partners

The research partners and key staff were:

Institute of Aquaculture, University of Stirling
Dr Dave Little (co-PI)
Mr Anton Immink (Project RA)

Department of Environmental Science, Imperial College London
Dr Kai Lorenzen (co-PI)

Aquaculture and Aquatic Resource Management, Asian Institute of Technology
Dr Amararatne Yakupitiyage (co-PI)
Dr Harvey Demaine (co-PI)
Mr. Danai Turuongruang (co-ordinator)
Ms Elsa Amilhat (Project RA)
Mr Ernesto Morales (Project RA)

Department of Fisheries, Cambodia
Mr. Eric Meusch
Mr. Hav Viseth
Mr. Khong Sophoan (co-ordinator)
Department of Fisheries, Thailand
Mr. Somkiat Pongsirichan

Mr. Sangob Kamsaentae (Field co-ordinator)
Mr. Boonmee Maneerat

Research Institute for Aquaculture No. 1
Dr. Pham Anh Tuan

Mr. Kim Van Van (co-ordinator)

Intermediate Technology Development Group, Bangladesh
Faruk Ul Islam (co-ordinator)

Gramin Vikhas Trust, India
JS Gangwar (co-ordinator)

Other UK partners:

IACR Rothamstead
Dr Janet Riley (Biometrics advisor)

The Natural History Museum
Dr Darrell Siebert (Fish taxonomist)

4.1.2 Overview of activities

The project supported a broad range of field-based and theoretical activities. Field – based activities aimed to assess the ecology and role in livelihoods of SRS in different physical environments, agricultural systems and socio-economic conditions; and to assess experimentally potential measures for improving productivity of and access to SRS. Theoretical studies aimed to improve the scientific basis for management of fisheries based on a mixture of natural recruitment and stocking of hatchery fish. An overview of research activities is given in Table 4.1.

Table 4.1. Overview of research activities

<table>
<tr><th colspan="5">Field-based activities</th><th>Theoretical activities</th></tr>
<tr><th>Cambodia</th><th>Thailand</th><th>Vietnam</th><th>Bangladesh</th><th>India</th><th>UK</th></tr>
<tr><td colspan="5">Participatory Rural Appraisal</td><td rowspan="2">Development of population dynamics theory for mixed stocked-self recruiting populations</td></tr>
<tr><td colspan="5">Household background survey for system identification</td></tr>
<tr><td colspan="5">Baseline and Household monitoring survey</td><td rowspan="2">Review of fish domestication and interactions between cultured and wild fish</td></tr>
<tr><td colspan="3">Intervention: farmer group management</td><td>Intervention: farmer-lead trial</td><td></td></tr>
<tr><td></td><td>Snakehead population study</td><td></td><td>Assessment of gender issues</td><td></td><td></td></tr>
<tr><td></td><td>Lipid profile study</td><td></td><td></td><td></td><td></td></tr>
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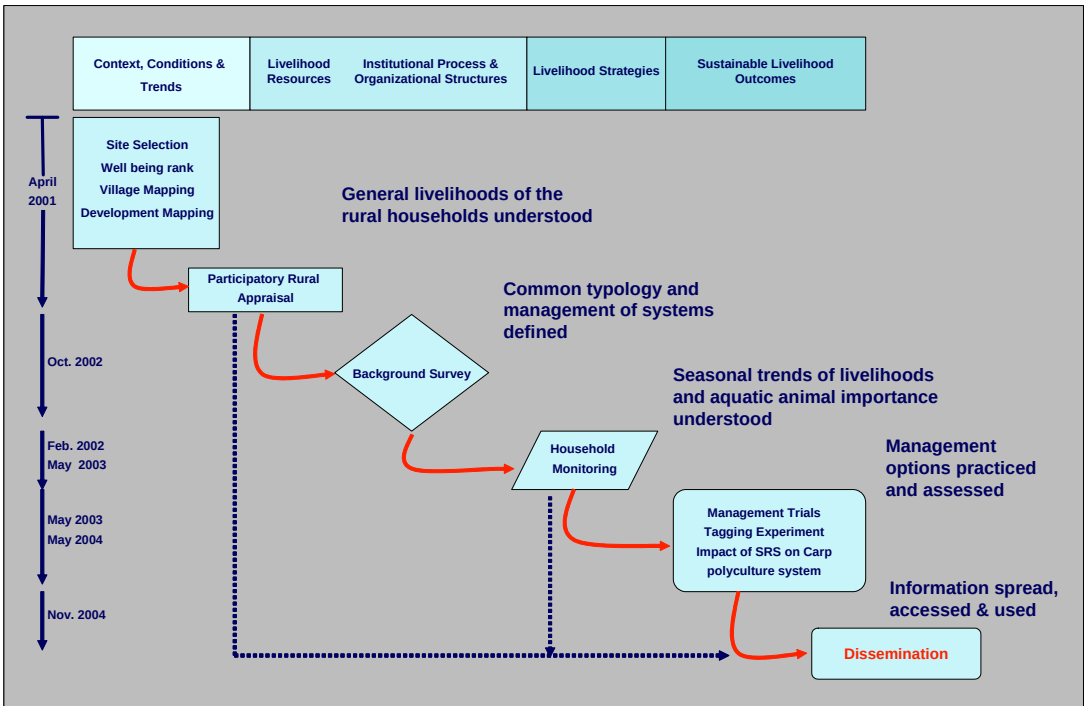

Figure 4.1a. Chronology of activities

4.1.3 Overview of countries and study areas

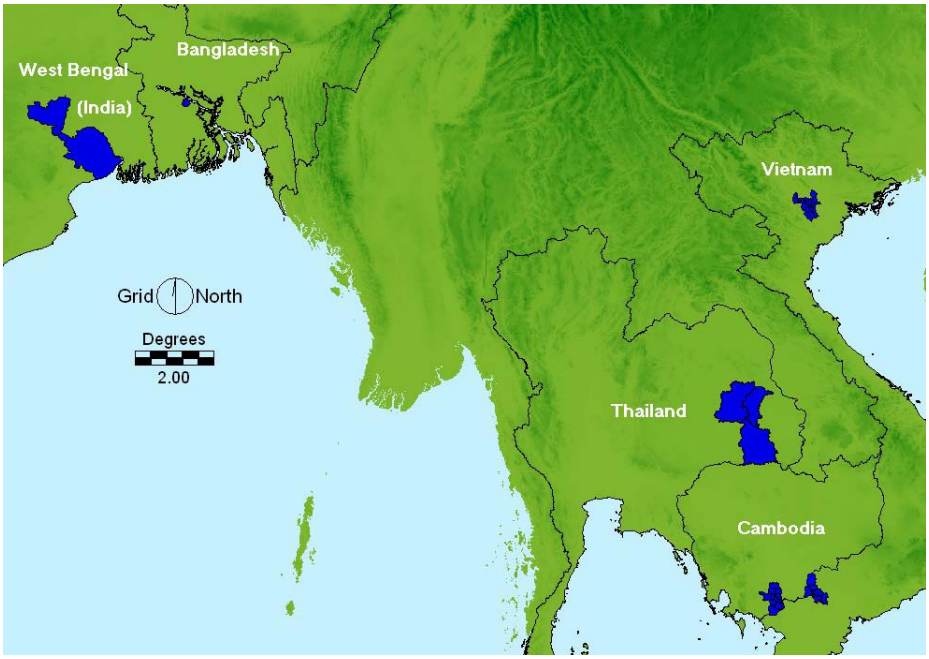

Figure 4.1b. Research sites (Source: Van Brakel, 2004)

Field activities were conducted in five countries: Cambodia, Thailand and Vietnam in SE Asia, and Bangladesh and West Bengal, India in S Asia. Aquatic resources are known to play a significant role in rural livelihoods in all five countries, which are therefore geographical foci for DFID aquatic resources research and development activities. The countries differ in physical, ecological and socio-economic characteristics, so that it was possible to gain insights into a broad range of factors

influencing the ecology and role in livelihoods of SRS. Brief country profiles are presented in Table 4.2.

Table 4.2 Country profiles (From Coates 2000 and others)

	Cambodia	Thailand	Vietnam	Bangladesh	W. Bengal, India
Area (km²)	181 035	514 000	331 000	144 000	88 800
Government	Constitutional Monarchy	Democratic constitutional monarchy	Communist people's republic	Parliamentary democracy	Federal state
Main religion	Buddhism	Buddhism	Buddhism	Islam	Hinduism
Population (million)	10.2	61.4	76.3	141.3	88.1
Rate of population increase (% per year)	2.5	1.5	2.3	2.1	2.1
Population density (no./km²)	55.25	117.3	228.2	981.3	992.2
% of the population living below the poverty line	36	13	32	35	24
GDP per capita (US$)	309	1,906	267	360	221

Thailand has by far the highest GDP per capita and the lowest levels of poverty and population growth among the study countries, and only a moderate population density. Other countries have low GDP per capita, greater incidence of poverty and the higher population density. The country profiles of course hide substantial heterogeneity within countries.

Sites within countries were selected to provide contrasting conditions for the study of factors affecting SRS. The three sites in SE Asia were selected based on a perception of differing levels of importance of conventional aquaculture and harvest of wild stocks; the Red River delta, Vietnam as a representative of a more aquaculture-dependent situation; lowland Cambodia where aquaculture among rural smallholders is undeveloped and there is greater dependence on capture fisheries and Sisaket, Northeast Thailand hypothesised to be intermediate. In Bangladesh one site was identified as being more drought prone and one as more flood prone by the local partner ITDG, and in West Bengal, India the sites were upland drier areas where farmer-managed aquatic resource management had been prioritised for development by GVT (Gramin Vikas Trust). Within-country sites and communities were identified based on the following criteria: zone (topography), proximity to perennial water and poverty level.

In Thailand, the project sites were located in the Northeastern region (Isan) which is considered the least developed region with the lowest per capita GDP. Northeast Thailand is largely flat and has considerable seasonal wetland areas; the region suffers from an extreme dry season and an infertile soil. Farming is the major occupation of 80% of the population and the region supplies 36% of the country's rice.

In Cambodia, the project focused on two very different provinces: the lowland province of Svay Rieng and the much dryer upland province of Takeo. The majority of Cambodian population (84%) lives in rural areas. Agriculture occupies a major place in the Cambodian economy and involve three-quarter of the labour force. Rice farming is largely rainfed and characterised by one harvest per year. Fishing and farming activities engaged nearly 75% of poor people (Khiang *et al.*, 2003).

In Vietnam, the project focused on an area with intensive, irrigated rice cultivation near the Capital Hanoi. Inland aquaculture is well developed and very productive with 727 000 tons in 2000 (Anh *et al.*, 2003). The agricultural sector (mainly rice production) represents about a quarter of the total GDP (Anh *et al.*, 2003).

In West Bengal, India the project worked within the area of the DFID-funded East India Rain-fed Farming Project, typically upland areas with limited flooding and poor lateritic soils. This area is not typical of the rest of West Bengal, being more strongly associated with the agro-ecological context of Jharkhand and Orissa. Agriculture is the main income source, although only one rice crop is grown each year. Wheat is often a second crop, although many fields are left fallow. Community forestry also offers significant labour opportunities and resources for the mainly indigenous population.

In Bangladesh the project worked within the field sites of ITDG in Faridpur. A low-lying district in south-central Bangladesh. Annual flooding events merge individual farmer resources into larger community waterbodies. In northwest Bangladesh the flood is short-lived and with poor, sandier soil drought is the main problem. Community resources have been privatised and the role of farmer-managed resources is of increasing significance. Irrigation from shallow tube wells is facilitating the production of two rice crops.

Overall Site Selection Criteria

Thailand

I. Upland and in between stream – Srisaket
II. Short-time flooded near urban – Ubol Ratchathani
III. Long time flooded near Chi River – Roi-et and Yasothon Province

Vietnam
Main Criteria:

Distance to urban areas
Midland, lowland and river side

I. Phu Xuyen - Lowland

II. Van Giang – intermediate and close to the Red River Delta
III. Socson – drier and near urban area

Cambodia

I. Southern Svay Rieng – abundant in aquatic resources, more water, close to market
    a. Romduol and Chantrea
II. Northern Svay Rieng – floodplain to drier area/ primarily rural
    a. Romeas Hek
III. Takeo – Drier area and limited in water resources / known for conventional aquaculture

India, West Bengal

I. Close to large-scale irrigation, uplands, little forestry, poor soils – Purulia
II. Lowerland, forested, poor soils, close to main transport links - Jhargram

Bangladesh

I. Upstream, poorer soils, limited flooding – Dinajpur
II. Downstream, longer deeper flooding – Faridpur

4.1.4 Aquatic resources in rice farming landscapes

All field research in the project was conducted within rice farming landscapes characterized by extensive, man-made wetlands in the form of rice fields and associated ponds and canals. In rainfed and flood recession farming systems, rice fields tend to hold substantial amounts of water for several months of the year and thus provide habitat very similar to that of natural floodplains. Fish and other aquatic animals enter and use these man-made habitats in a way broadly similar to their use of natural floodplains. Figure 4.2 illustrates typical migration patterns. At the start of the wet season (around May-June in the study area), fish migrate from permanent water bodies (Rivers, lakes, reservoirs, canals, or deep ponds) to the paddy fields to reproduce and feed (black arrows). This allows larvae and juveniles to disperse in the floodplain where food is abundant. When the dry season arrives, fish return to permanent water bodies (white arrows). Fish performing such lateral migrations often enter farmer-managed systems such as rice fields and pond, and thus form the main “SRS”.

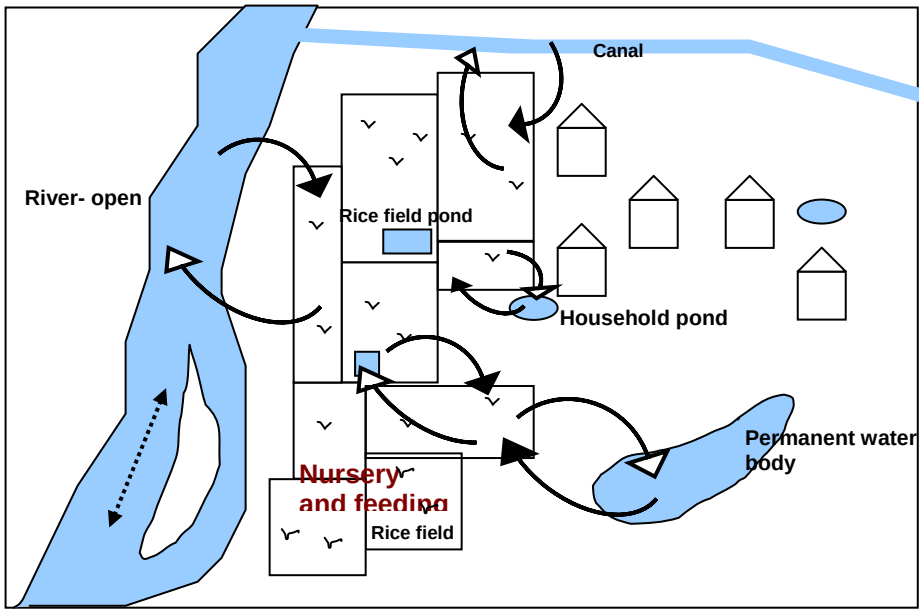

Figure 4.2. Fish migration patterns in the floodplain. Black arrows represent the lateral migration during the rainy season and the white ones the lateral migration when the dry season started. Dashed arrow represents the longitudinal migration in the main channel.

Irrigated rice systems can provide similar habitat for wild aquatic animals as long as a rainfed wet season crop is maintained along with an irrigated second crop (Lorenzen et al 2000). However, where rice fields are engineered for irrigated cropping and store only minimal amounts of water, they provide little habitat for aquatic animals.

4.2 Participatory Rural Appraisal

A series of participatory rural appraisal (PRA) activities were conducted in all countries. The main objectives of the appraisal were to assess the situation in these provinces in terms of aquatic resources and to understand the importance of self-recruiting species (SRS) in farmer-managed aquatic systems to the livelihoods of the villagers.

The PRA was conducted by a group of facilitators at nine sites in each country. An important feature of the approach used was that the researchers did not identify themselves in any initial contacts with a specific interest in aquatic resources or fisheries. The aim was to reduce the risk of information collected from local people being affected by our early expression of a particular interest or bias towards their development, and thus to obtain a more balanced picture of the role and importance of aquatic animals in their livelihoods. Initially a series of activities was conducted with a few key informants independently including a well-being ranking exercise of the community as whole. Participants for small focus groups to carry out other PRA activities were pre-selected from the poorer and better off groups within the community identified using this method. This approach also helped to understand

the communities own assessment of well being, as the criteria used for each key informant to place households in different wealth groups was also identified.

Three types of PRA tools were used, with four independent focus groups. Physical mapping by the different groups enabled researchers to understand the physical location of key features within the village and the importance attached to them by the different groups. Maps were also useful later in the process to identify specific resources and access issues. Scoring tools were used to assess the perceptions of farmers of the importance of different livelihood activities. Scoring was also used to determine the importance of aquatic animals to farmer's livelihoods. Seasonal calendars and timelines were exercises used to highlight seasonality and trends, helping both the research team and the farmers involved in understanding the different activities, and the resources, particularly aquatic resources, available in the area during the year. The timelines drew attention to the broader trends and led to discussion of their causes.

The exercise was conducted over an average total period of five days in each community. The first day allowed contact with village leaders/elders and some key informant exercises (wellbeing ranking, timelines and village mapping) to be conducted in addition to making arrangements for the later focus group work. On the first day of work with the four focus groups, activities were used to set the importance of aquatic animals and their management in a broader livelihood context. On a second day further knowledge and practice regarding their exploitation and value of aquatic animals was investigated. A full day was then required for preliminary analysis of the results, which were presented back to the community as a whole on day 5.

4.3 Baseline Survey

A baseline survey was conducted between September and November 2001 on 30 households per village. The purpose was to capture the general aquatic farmer-managed system characteristics of each village and their distribution among the villages. General information was collected on type and surface area of farmer-managed systems, on management practices and on the presence of self-recruiting species. Table 4.3 lists the topics covered in the baseline survey.

Table 4.3 Background survey questionnaire topics

1. Profile of the household members
2. Household assets
3. Land area
4. Livestock
5. Water resources
6. Physical characteristics of aquatic system (type, area, is stocked, depth)
7. Farming, number of crops per year
8. Farmers' managed aquatic system management (species stocked, source of seed, wild fish management: elimination, prevent, attract, do nothing)
9. Harvesting periodicity
10. Selling fish activity
11. List of the 6 most important SRS harvested in ponds and rice fields

To ensure coverage of all the types of farmer-managed aquatic systems, samples were stratified by whether or not farmers practiced 'conventional' aquaculture involving the stocking of hatchery fish. In villages where less than 50 % of households were engaged in 'conventional' aquaculture, 20 households were selected on random and 10 were targeted, randomly chosen from the pool of farmers doing aquaculture. If more than 50% of the households practiced 'conventional' aquaculture, all households were chosen randomly from the population. The baseline survey served as a basis for the selection of the households covered in the monitoring survey.

4.4 Monitoring survey

A household monitoring survey was conducted over a period of 13 months in each country between February 2002 and April 2003. The purpose of the survey was to gain quantitative information on FMAS management, SRS catches and their role in livelihoods. Data on farming, fishing, consumption, income and expenses activities and resource use were collected. The survey was based around the questions "who?" (household member), "what?" (activity done), "where?" (location), frequency?" (number of time during the last 7 days) and "time spent?" (in hours) for a range of topics summarized in Table 4.4.

Household monitoring was conducted to identify seasonal importance of SRS and aquatic resources in the livelihoods of rural farmers. Data on different livelihood resources, strategies as well as ecological information were collected. Monitoring questions focused on who (member of the family, gender); what (activity); where (location); how often or frequency of the events; how much time spent; and reasons for doing the event where also noted in some cases particularly on the reason of working in another farm.

Monitored households were selected based on a number of criteria. However the type of farming system was the main criteria used in this selection to ensure the representation of the different types. Aside from the farming system the household socio economic status and gender were also considered during the selection process of the target households.

Table 4.4 Monitoring survey topics

1. Agricultural activities on household's land
2. Agricultural activities on other people's land
3. Non-farm activities (both in the village and outside the village)
4. Aquatic animal management
5. Aquatic animals collected (species, size, number, weight, gear, use (sell, consume, give or process)
6. Life history information for the last month (observations of eggs, migration, juveniles, reproduction, diseases)
7. Food consumption (type, quantity, source, preparation)
8. Income and expenditure (source, amount)
9. Physical parameter record in the farmer ponds (every 2 months) about the depth, shade area, temperature, turbidity

Targeted selection was employed to identify households for the monitoring survey, to ensure representation of different system types, household socio-economic status, and leadership structures. Meanwhile and in the measure of the possible, the proportions of the different type of farmer-managed aquatic systems from the baseline survey were respected.

An important concern was the reliability of the recall. The larger the time between the event and the recall, the less accurate the recall is likely to be. Seven day recall was used as previously tested in a Lao survey (Garaway, 1999). To aid recall of quantities of aquatic animals harvested, a technique using sticks and bowls was used as designed and tested in Laos (Garaway, 1999).

4.4.1 Data analysis

Standard descriptive and inferential statistical methods were use to analyse baseline and monitoring survey data. This included Chi-square tests, analysis of variance and nested general linear models (GLM) to determine factors that influence SRS productivity and use (Sokal &Rohlf, 1995). Analyses were carried out in SPSS for Windows.

4.5 Life history study

A life biological sampling programme was implemented to elucidate the life histories of key SRS species as a basis for management. Study species were selected according to their importance for poor people, availability and limitations imposed by staff capacity. The species selected were: *Trichogaster trichopterus, Esomus longimanus, E. metallicus, Rasbora aurotaenia* and *Channa striata* in Thailand; *Macrobrachium nipponense* (prawn), *Somanniathelphusa pax* (rice field crab) and *Misgurnus mizolepis* in Vietnam; *Mystus mysticetus* in Cambodia; and *Channa striata* and *Puntius sophore* in Bangladesh and West Bengal. Samples were collected in the same study sites as used in the household surveys.

The specimens were collected from farmer managed systems (ponds and rice fields) and associated open systems such as rivers, canals and lakes. From November 2001 and June 2003, monthly samples of 30 specimens were collected for all species. In all samples it was aimed to cover as wide a range of sizes and life stages as possible using a variety of gear including small mesh nets, traps and hooks. The specimen were preserved in formalin solution and subsequently transferred to 70% ethanol for permanent storage. Parameters measured included: standard length and body weight; sex, gonad weight, maturity stage and number of eggs; and stomach contents.

Species identification was aided by two taxonomists: Dr. Darell Siebert from the Natural History Museum of London (fish species) and Dr. Peter Ng Kee Lin from the National University of Singapore (decapod crustaceans).

4.6 Local resource user groups

This experiment was designed to test the hypothesis that joint management of water and living aquatic resources within tracts of interconnected FMAS may allow for increased benefits over and above those achievable within each separate FMAS in the absence of cooperation. Figure 4.3 illustrate the processed applied in implementing the local resource users group (LRUG). LRUG were initiated in a total of 14 areas from the three countries in Southeast Asia. A standard protocol was used in setting up all trials. A consultation in each village identified potential areas and groups who would agree on management plans and assess their effectiveness. After the initial consultation, planning workshops were held with members of each group at which group activities were planned.

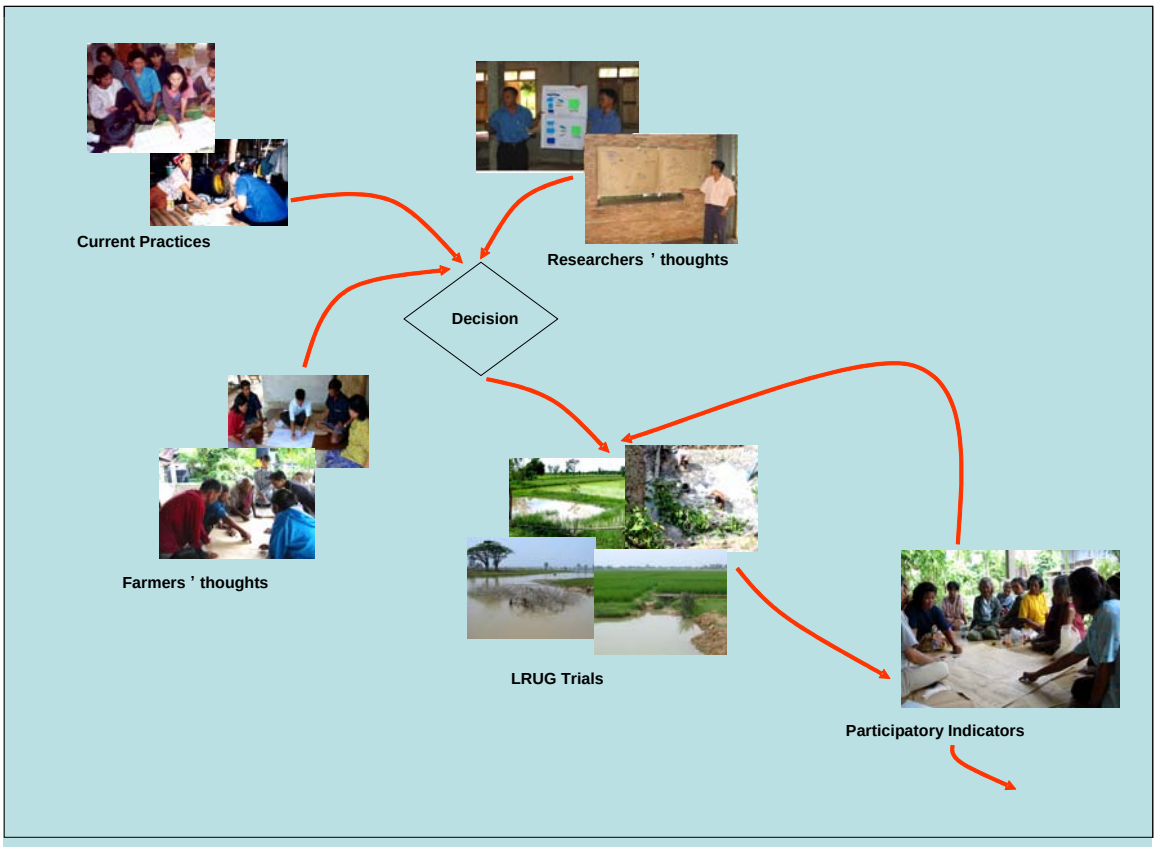

Figure 4.3 Process in implementing LRUG approach

Table 4.5 Summary of the different user groups in three countries.

Country	Local Groups	Total Farmers	FMAS
Cambodia	6	78	Trap ponds, Household ponds, Rice fields
Thailand	5	85	Trap ponds, Rice Fields, Culture ponds
Vietnam	3	29	Portion of Canal, Lake, Rice fields

A series of workshops was conducted seasonally (four workshops/group) that assessed the progress of the activities and also collected information on the following:

1. Importance of the systems (based on time spent)
2. Availability of the different resources in each system
3. Food collected in each system
4. Flow of resources
5. Labor distribution for managing the systems
6. Plan of activities for the next season

After a year of monitoring, a final evaluation of the group activities was carried out. Group discussion was carried out with all the 13 groups from the three countries following a checklist of information. Perceptions regarding Local Resource Groups were also assessed by household interviews based on semi-structured checklists with a total of 280 farmers. Table 4.6 summarized the number of respondents interviewed during the assessment interview.

Table 4.6 Summary table of respondents for the assessment survey.

Country	Member	Non Member	Total
Cambodia	55	60	115
Thailand	42	50	92
Vietnam	34	30	64

4.7 Impact of SRS management strategies on carp polyculture and rural livelihoods

The impacts of incorporating selected SRS into conventional carp polyculture systems was studied in farmer managed ponds in a drought- prone area of northwest Bangladesh. On the basis of farmers' attitudes, interest and resource type three categories of SRS management at the household level were identified as: SRS positive (POS), SRS negative (NEG) and SRS neutral (NEU). A total of 30 households from 3 villages were wealth ranked as poor (10), medium (15) and better-off (5). Farmers with a positive (POS) attitude towards SRS deliberately stocked *Clarius batrachus* and *Heteropneustes fossilis* broodfish and fingerlings of *Anabas testudineus, H. fossilis*, *C. batrachus* along with commonly stocked carps while also encouraging entry of selected wild fish from adjacent aquatic systems where possible. NEU households did not deliberately stock SRS or prevent their entry, nor eradicate them once in the system. In contrast NEG households actively excluded all SRS where possible. Household attitudes and activities regarding their managed aquatic systems were monitored monthly. System input/output and consumption data were recorded weekly. Total production was estimated after draining of ponds at final harvest. Estimates of consumption and sale were assessed from all farmers at the end of season.

4.8 Nutritional Value of SRS

To complement information on the role of SRS in livelihoods as obtained from the above surveys, a small study was conducted to assess lipid profiles and therefore an important aspect of the nutritional value of SRS. Aquatic animals were sampled in August 2002 in Sri Sa Ket Province, NE Thailand. A total of 30 individuals of six species were analysed for their total lipid and fatty acid profiles (Table 4.7). Fish were sampled in rice fields from a number of different localities. The fishing gear used was gillnets or fishing rods using small green frogs or worms as a bait. A number of fish were also bought from the district fish markets.

Table 4.7 SRS species sampled in this study and where obtained (RF=rice field).

Species	Location
Channa striata	RF Nongweng - Sri Sa ket, RF Lum Poo - Sri Sa ket
Clarias batrachus	Kantalalom fish market, Sri Sa Ket Fish market
Anabas testudineus	RF Nongweng - Sri Sa ket, RF Lum Poo - Sri Sa ket, Sri Sa ket fish market
Rasbora borapetensis	RF Nongweng - Sri Sa Ket
Puntius brevis	RF Nongweng - Sri Sa ket
FW prawns	RF Nongweng - Sri Sa ket

Lipid analysis was conducted on edible muscle tissue of fish and included lipid extraction FA analysis by gas liquid chromatography (GLC).

4.9 Snakehead population study

Snakehead (*Channa striata*) are the most valuable SRS resource in Thailand and Cambodia, and the main target of active management by farmers. A populations dynamics field study of snakehead was conduced in Sisaket (Northeast Thailand). The purpose of the study was gain information on migration patterns, growth and mortality rates of the species in a rainfed rice farming landscape, and to identify management approaches to increasing yields.

The experiment was carried out during one year from May 2003 to June 2004 in two adjacent villages (Lumpoo and Steng) in Northeast Thailand. Workshops were held in both villages to inform farmers about the experiment, raise their interest and promote ownership. An extensive information campaign using posters and audio messages was also conducted in both target villages and in all surrounding villages.

Tagging was carried out in three stages: during the dry season (tagging fish in farmer ponds within rice fields), at the start of the rainy season (tagging fish during their up-migration from deep water bodies to rice fields) and at the end of the rainy season (tagging fish during down-migration). Local fishermen caught the fish by

methods such as trapping and cast netting. Fish from at least 20 cm total length were tagged with T-bar anchor tags of 3cm length. Fish were released at the capture location.

In each village, one farmer was hired to record recaptures of tagged fish in the fishery and maintain interest within the village. Table 4.8 presents the overall events during this experiment. A small reward (a bag of MSG) was offered for reporting recaptures and allowing measurements to be taken of the recaptured fish. The weight (g), the total length (cm), the tag number and the location recaptured were recorded. Detailed village area maps were drawn using information from a variety of sources including aerial photographs and farmer mapping of rice fields. This allowed the recording of recapture locations with a high degree of precision. In addition, 30 randomly selected households in the two target villages recorded their total snakehead catches throughout the experimental period.

Table 4.8 Overview of tagging events and recapture

	Lumpoo	**Steng**	**Total 2 villages**
Overall numbers tagged and recovery			
Tot number of fish tagged	422	329	751
Tot number of tagged fish recovered	85	55	140
Proportion recovered	20%	17%	19%
Results per tagging event			
TAGGED			
First Event (7 May – 14 May 2003)	132	165	297
Second event (28 Aug. - 12 Sept 2003)	111	45	156
Third Event (30 Oct-14 Nov 2003)	146	152	298
RECOVERY			
From First Event	43%	16%	28%
From Second event)	14%	42%	17%
From Third Event	8%	13%	10%

4.10 Ecology of mixed stocked and self-recruiting systems

The ecology of populations subject to both natural recruitment and stocking was investigated theoretically using mathematical models, and through a review the development of a new conceptual model of the domestication process.

The role of population regulation in the adult phase of the fish life cycle was assessed through a comparative study of density-dependent growth. A mathematical model for hatchery-enhanced populations was developed and used to derive management principles for such populations. Cultured fish inevitably enter a process of domestication with consequences for their performance in the wild and interactions between wild and farmed fish. An extensive review was conducted of the process of domestication and its implications for wild-cultured fish interactions.

Full details of these studies are given in the manuscripts in the Appendix.

5 Outputs

5.1 Overview

There were significant differences in the total number of main activities among people in each country by zone, level of well-being and by gender interaction. The greater importance of fishing to poorer men than other groups found in this study suggest that harvest of aquatic animals from both managed and un-managed environments is most important to supporting livelihoods of poor households, particularly through provision of food.

5.2 Participatory Rural Appraisal (Background data on the role of aquatic resources)

Community level PRAs on aquatic resource use and its livelihoods context indicated that natural aquatic resources are important in rural livelihoods in all project countries. Unexpectedly, the perceived importance of aquatic resource use increased with distance from larger open water bodies, possibly indicating that people expend more time on meeting subsistence requirements when living at distance form perennial water. Importance of wild aquatic resources increased, while importance of aquaculture declined with distance from towns. Most respondents felt that the availability of natural aquatic resources had declined over time.

Rural people in Thailand depend on aquatic resources caught from the wild for food and income, and aquaculture is relatively unimportant as wild resources are still abundant. In Vietnam, aquaculture and wild fishing are both important for food and income. Aquaculture tends to be more important to the rich, and wild fishing to the poor.

Ricefield associated aquatic systems (including trap ponds, rice-fish culture systems, fish culture ponds in ricefields etc.) and household ponds (ponds in the immediate vicinity of dwellings) were identified as foci for further research.

5.3 Background (Physical and ecological characteristics of SRS systems)

This section describes key characteristics of the FMAS, importance of stocked fish, participation in self-recruiting species collection, diversity of species collected , and indigenous management measures and their effectiveness.

5.2.1 Physical typology of SRS systems

Figure 5.1. Example of a trap pond in Northeast Thailand

The household baseline survey confirmed the existence of several broad categories of farmer-managed systems throughout the project area. The main components of the FMAS are rice fields (RF) and three different types of ponds. Household ponds (HP) are located near the farmer's house, tend to be closed towards the surrounding aquatic environment, and are used mainly for water storage and/or 'conventional' stocked aquaculture. Ponds in rice fields (PRF) tend to be open to other water bodies during the wet season, are usually located away from the farmer's house, and are used mainly to attract and trap wild fish (SRS). Other ponds (OP) is a category used only in Cambodia, where it refers mainly to ponds located within natural lakes and wetlands to trap wild fish (SRS). The main differences between these pond types thus arise from their location, morphology and primary intended use.

Overall farmer systems fell into five categories, comprising:
1: rice field(s) only: RF
2: rice field(s) and household pond(s): RF+HP
3: rice field(s) and household pond(s): RF+ PRF
4: rice field(s) and other pond(s): RF+OP
5: rice field(s), household pond(s) and other pond(s): RF+HP+OP

The distribution of systems varied greatly between the study sites (Table 5.1). In Thailand and Vietnam, farmers tend to have only one type of pond: pond in the rice fields in Thailand and pond near the house in Vietnam. In Cambodia there are 3 possible types: pond in rice field, pond near the house and also pond in the lake. In India very few people had ponds in rice fields and these are usually the property of the better-off. There was a strong reliance on community waterbodies. In Bangladesh main ownership was of ponds in ricefields. The results are therefore complex in terms of system-associations as almost all the possibilities exist.

Table 5.1 Proportional representation (%) of different FMAS in each study village. (RF= rice field, HP= household pond, PRF=pond in the rice field, OP=other pond)

Country	Province	Description	Village	Total number of households	RF	RF+ HP	RF+ PRF	RF+O P	RF+H P+OP
Cambodia	Takeo	Drier area, water is limited	Angtason	28	54	7	11	25	4
			Prey Tadok	25	48	24	0	28	0
	Svay Rieng	Lowland with abundant perennial water	Prey Sokrum	29	3	7	14	0	76
			Sv Cheak	21	0	33	0	10	57
			Thom	25	4	32	0	8	56
			Trapieng D	27	4	33	0	0	63
Vietnam	Hanoi	Drier, near urban area	Cong Hoa	20	65	35	0	0	0
			Phu Cuong	20	65	35	0	0	0
			Yen Tang	21	81	19	0	0	0
	Hatay	Lowland area	Hoang Nguyen	20	100	0	0	0	0
			Trai	18	89	11	0	0	0
			Cham Ha	20	65	35	0	0	0
Thailand	Sisaket	Upland between streams	Samoe chai	21	33	0	67	0	0
			Lumpoo	20	25	0	75	0	0
			Nong Weang	18	44	0	56	0	0
	Yasothon/ Roi Et	Long time flooded near Chi River	Kudlod	20	20	0	80	0	0
			Siangam	19	53	0	47	0	0
			Yang Noi	16	0	0	100	0	0
West Bengal	Purulia	Upland, little forestry	Adabona	26	100	16	3	2	0
			Berada	30	96	20	5	10	0
	Jhargram	Lowland, poor soils, forestry	Narda	31	96	18	14	25	2
			Banstala	31	96	18	10	6	0
Bangladesh	Dinajpur	Upstream, poor soil	Panchagor	31	96	35	30	5	2
			Dinajpur	28	100	33	26	2	0
	Faridpur	Downstrea m long flood	Faridpur	28	100	20	40	10	4
			Rajbari	32	100	28	38	20	0

Farmers in Vietnam are significantly less likely to have ponds compared to those in Cambodia and Thailand. Ponds are common systems in Thailand and Svay Rieng Province in Cambodia whereas less than 50% of the households have one in Takeo Province in Cambodia and in Vietnam.

In Cambodia there are significant differences between the provinces, with FMAS dominated by RF+HP systems in the lowland province of Svay Rieng, and RF only in the upland province of Takeo. In Thailand the majority of households had combined RF+PRF systems regardless of whether they were located in upland or lowland areas. In Vietnam, the majority of farmers had rice fields only, and some had rice fields as well as household ponds use for 'conventional' aquaculture.

There were significant differences in the overall size of FMAS between the countries, the provinces within countries and the villages. In general, household rice field areas were significantly larger in lowland areas than in upland areas.

Households in Vietnam had significantly smaller rice fields than those in Thailand and Cambodia (Figure 1).

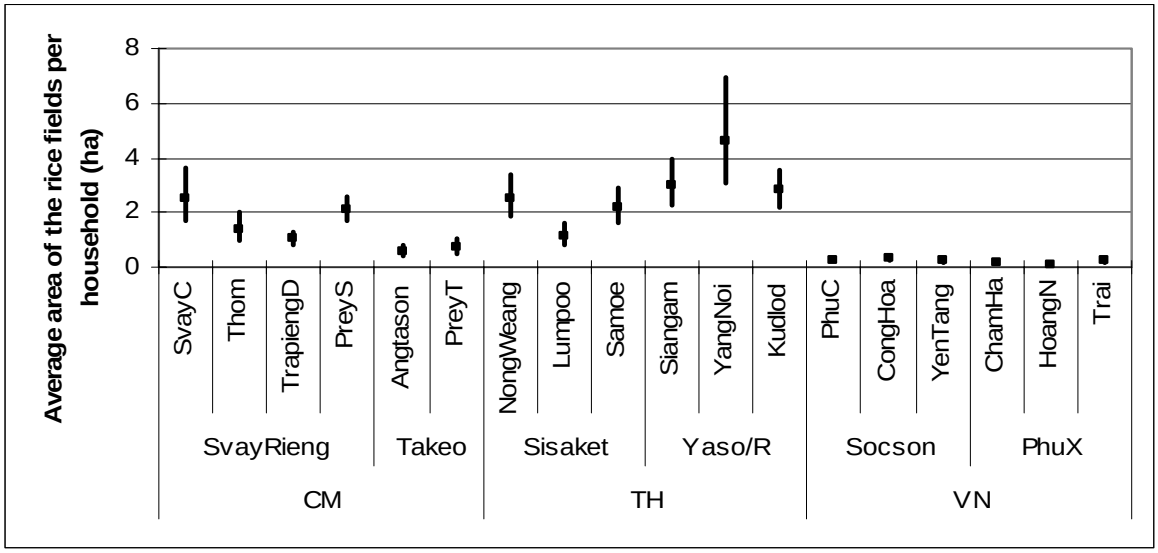

Figure 5.2 Average area of rice fields (95% CI of mean) in the three SE Asian countries studied.

Seasonal flooding of FMAS is a major factor determining both the availability of SRS (which often enter the FMAS from outside during times of flood) and the incentive for stocking hatchery fish (which may disperse from the FMAS during flooding). Most FMAS are prone to flooding, with the exception of those in Vietnam and in the Cambodian upland province of Takeo.

Table 5.2 Proportion of FMAS that are flooded during the year

Country	Province	Total FMAS	FMAS flooded	% FMAS flooded
Cambodia	Svay Rieng	102	101	99
	Takeo	53	5	9
Vietnam	Hanoi	61	23	38[1)]
	Hatay	58	2	3
Thailand	Yasothon	55	40	73
	Sisaket	59	22	37

[1)] Limited to near-river locations

5.2.2 Collection of SRS

Information on the participation of households in the collection of the SRS from their FMAS is summarized in Table 5.3. Over 50% of farmers are involved in SRS collection in all countries. Participation is near universal Thailand and the lowland province (Svay Rieng) in Cambodia, but much lower in Vietnam and upland Cambodia.

Table 5.3 Frequency table of the number of households collecting SRS in each village for the three countries

Country	Province	Village	Random HH	HH harvest SRS	%HH harvest SRS
Cambodia	Takeo	Angtason	28	14	50
		Prey Tadok	25	18	72
	Svay Rieng	Prey Sokrum	29	26	90
		Sv Cheak	21	21	100
		Thom	25	24	96
		Trapieng D	27	26	96
Vietnam	Hanoi	Cong Hoa	20	9	45
		Phu Cuong	20	10	50
		Yen Tang	21	14	67
	Hatay	Hoang Nguyen	20	1	5
		Trai	18	10	56
		Cham Ha	20	6	30
Thailand	Sisaket	Samoe chai	20	20	100
		Lumpoo	21	19	90
		Nong W	18	18	100
	Yasothon/ Roi Et	Kud Lod	20	19	95
		Siangam	17	14	82
		Yang Noi	14	14	100

5.4 Baseline and Monitoring

5.4.1 Role of SRS in livelihoods

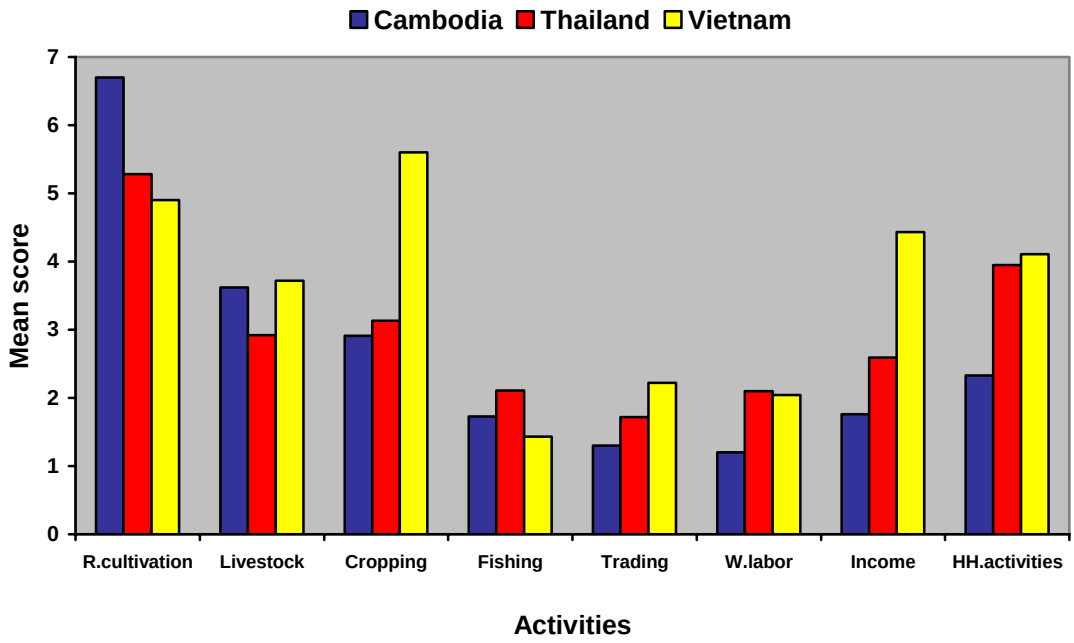

Figure 5.3 Overall importance of different major activities to livelihoods

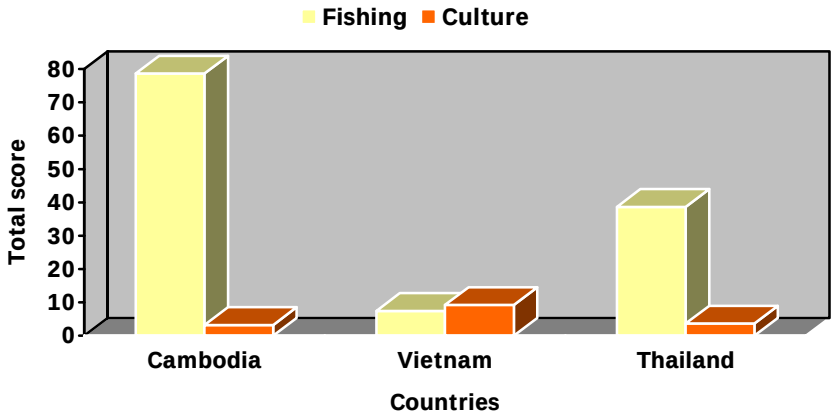

Figure 5.4 Comparison on the importance of fishing as oppose to fish culture in three countries of SE Asia

Contribution to financial capital

The harvest of aquatic animals was a source of income in less than 50% of households assessed in Cambodia and Vietnam but more than 60% in Thailand (Figure 5.5a). But as a proportion of total household income (Figure 5.5b), aquatic animals contributed most in Vietnam (>10%) and least in Thailand (<3%). In Vietnam only livestock contributed more to annual household income (>$250/HH) among the major components of the livelihood than aquatic animals (>$150/HH) reflecting the well developed and commercial nature of aquaculture at this site compared to Thailand and Cambodia (Figure 5.5c). Incomes were much lower in Cambodia but the limited proceeds from sale of aquatic animals produced more cash than sale of crops other than paddy or small business activities. Income flows in Thai households were higher (especially from paddy rice) and more diversified than the other two sites making the sale of aquatic animals relatively unimportant.

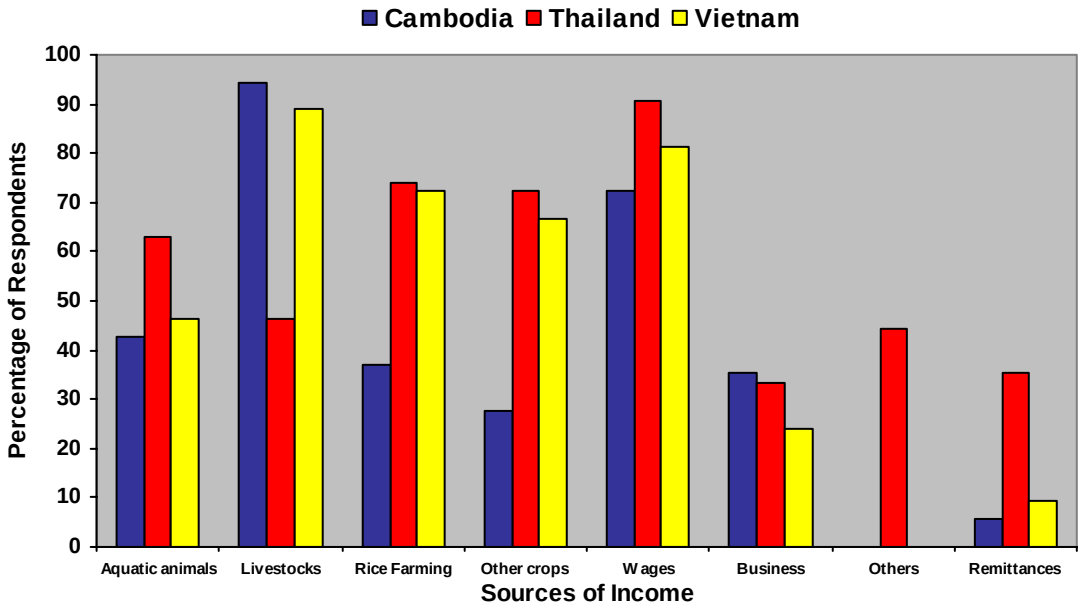

Figure 5.5a Distribution of sources of income from respondents in 3 countries of SE Asia

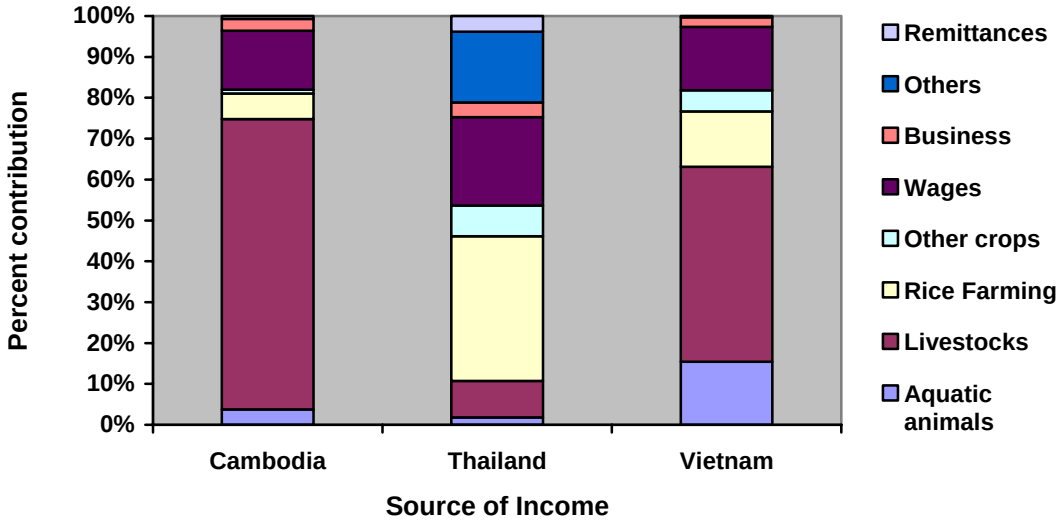

Figure 5.5b Percent contribution of the different sources of income to total household's income in rural areas of the three countries of SE Asia

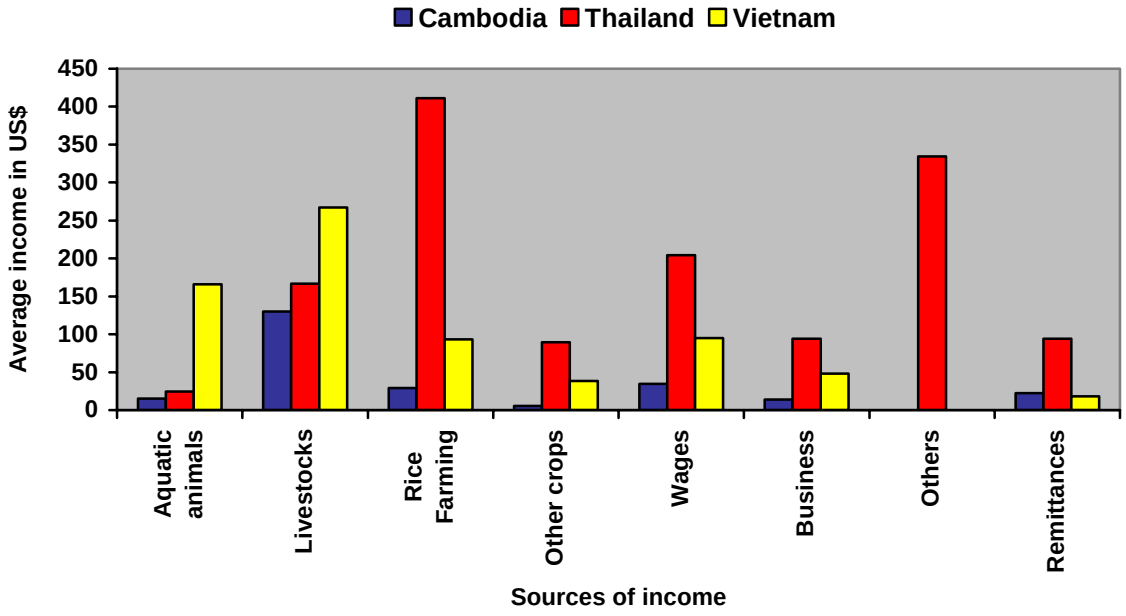

Figure 5.5c Average income from the different sources of income in rural areas of the three countries of SE Asia

Role in Food Consumption – Human Capital

Major differences existed in the nature of diets within the three countries and the contribution of aquatic animals (Figure 5.6). Rice was relatively more important in Cambodia than Thailand and Vietnam, reflecting the greater overall poverty. In addition to vegetables, meat and processed food were relatively more important in Vietnam, reflecting the greater role of pork and tofu in diets respectively. The high

contribution of aquatic animals in Thailand suggests better availability and access at this site; more fish and other aquatic products were retained for use by the household rather than sold. AA makes up a similar percentage and overall amount in diets of people in Vietnam and Cambodia but are relatively far more important in the latter. In Vietnam meat, poultry vegetables and processed food all contribute much more to the rice-based diet than in Cambodia where diets are less varied.

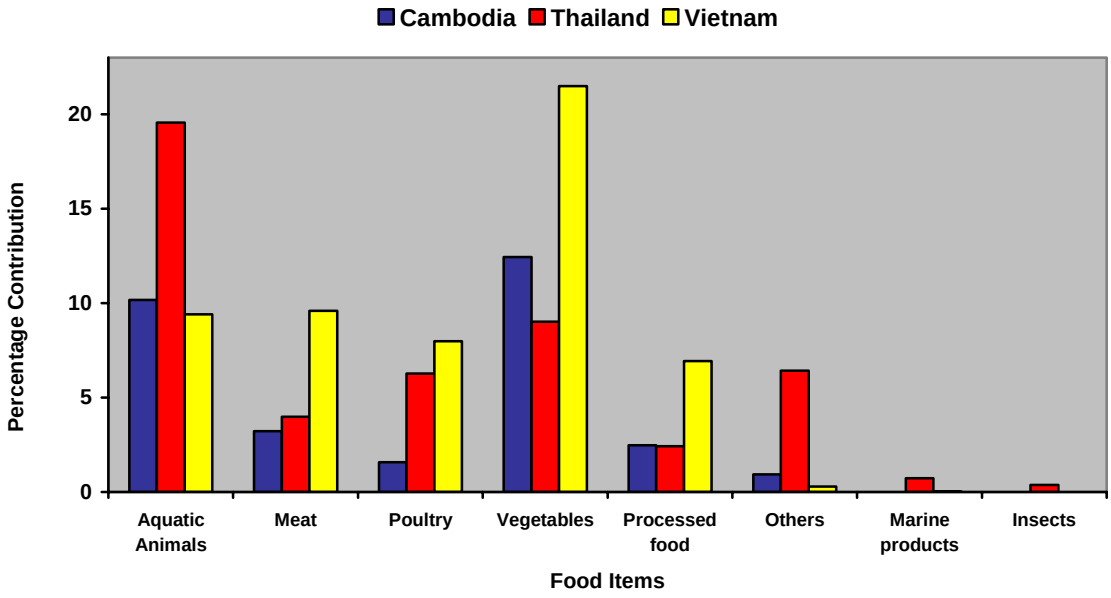

Figure 5.6 Percentage contributions of aquatic animals to overall food consumption (excluding rice)

The source of AA consumed was also very different. AA from farmer-managed aquatic systems (FMAS) dominated consumption in Thailand and Cambodia but were far less important in Vietnam. The much higher amounts of AA consumed in total at the research sites in Thailand than Cambodia, and specifically from FMAS, indicates very different levels of relative poverty. AA are relatively easily accessed by Thai households to meet subsistence needs in well diversified diets compared to those observed in Cambodia. AA harvested off-farm, from open access sources, are also much more important in Thailand than in Cambodia and Vietnam suggesting lower population pressure and more intact aquatic ecosystems. Similar levels of AA are purchased at all three sites. The importance of SRS to poorer households is thus likely to be greater in Cambodia than at the other sites investigated. A comparison of the importance of stocked AA and fish within each country by well-being level also revealed interesting differences. Whilst there was little difference between consumption of SRS by better-off and poorer households in Cambodia, poorer people in Thailand were far more dependent on SRS than the better-off. In Vietnam, stocked fish and SRS were consumed at similar levels by richer and poorer.

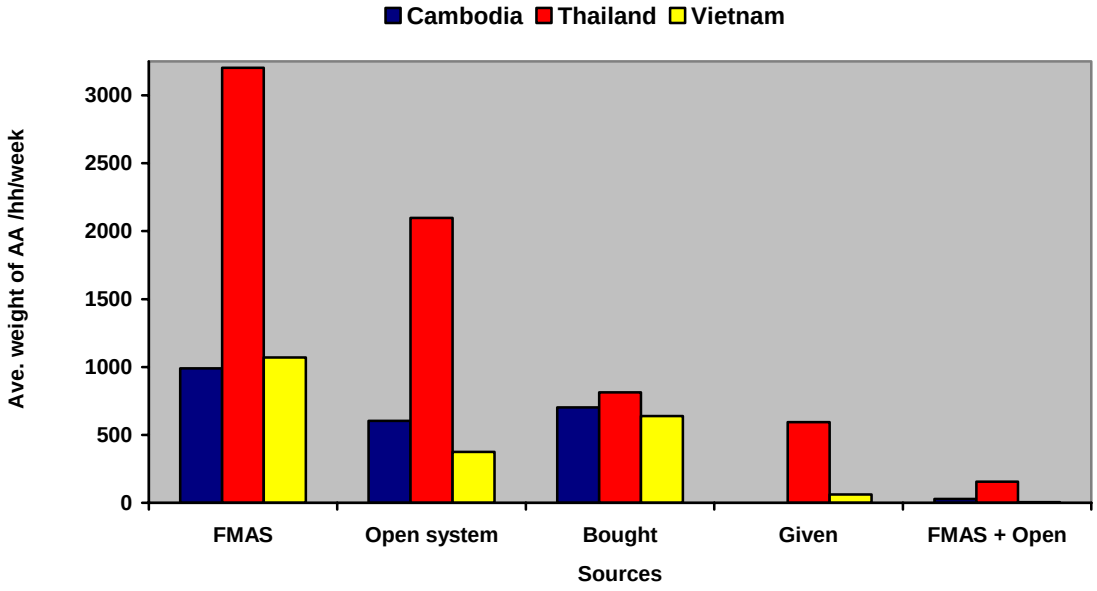

Figure 5.7a Average quantity of aquatic animals eaten from main sources.

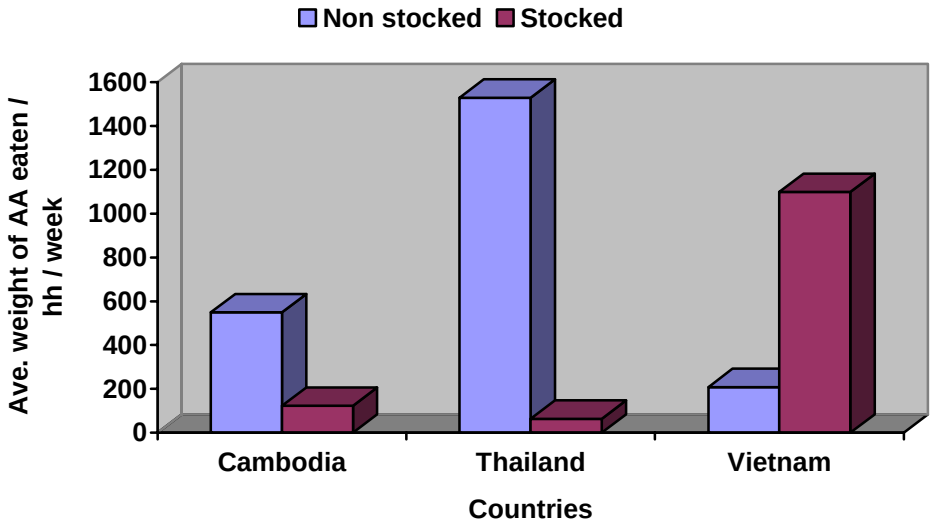

Figure 5.7b Average consumption of SRS and stocked aquatic animals by households in Cambodia, Thailand and Vietnam.

Fresh AA were more important than preserved forms by weight consumed and frequency of consumption in all three countries (Figure 5.7c). Preserved, especially fermented fish were relatively more important in Cambodia than in Thailand and Vietnam. Within country, site (lowland/upland) and level of well-being (better-off, worse-off) had little effect on the proportions of fresh to preserved AA consumed.

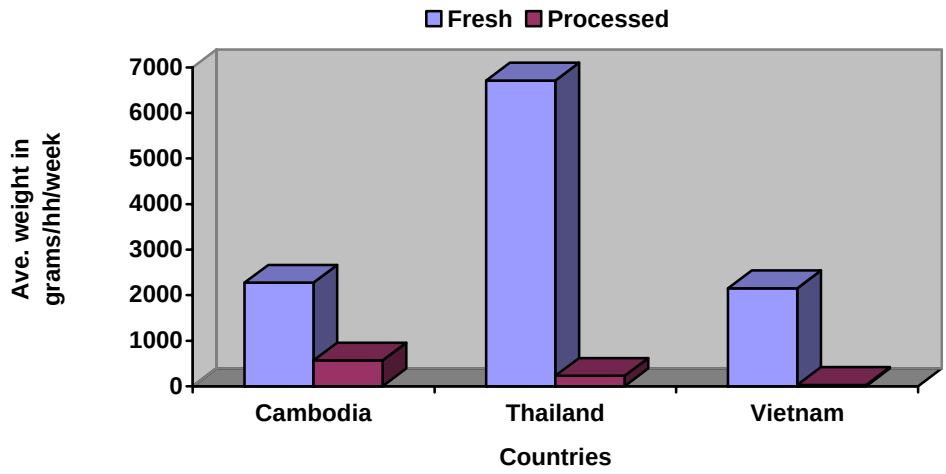

Figure 5.7c Comparison of the average weight eating fresh and processed aquatic animals eaten

Role in Social Capital

Relatively little informal exchange of AA appears to occur between households; such practice is most important in Thailand. Sharing of aquatic animals was probably underestimated during monitoring as it was clear that the practice was quite common, especially of low market value AA species, among relatives and neighbors, whenever amounts in excess of meeting immediate needs were obtained. More formal gifting of fish and other aquatic products within communities is not so important however.

5.3.4 Overall economic value of SRS catch

From the average catch per household and per year in each country, it is possible to compare the market value of this catch with the value of the rice harvest. The average net income from rice cultivation was estimated by the farmers monitored (project data) at 660 USD1 in Thailand, 260 USD2 in Vietnam, and 88USD3 and 194 USD respectively in the Cambodian provinces of Takeo and Svay Rieng. The average price of selling aquatic animals is 0.6 USD/kg in Thailand, 0.4 USD/kg in Vietnam and 0.7 USD/kg Cambodia (project data). Table 13 summarizes the relative importance of the SRS value to the value of the rice. SRS represent less than one fifth of the total revenue of the rice crop. SRS represent a more important income source in Svay Rieng (23%) and Thailand (7-10 %) and a minimal income in Vietnam (<4%). In Svay Rieng Province the wild fish value is particularly important as it represent more than a third of the rice crop value. Garaway (1999) reported similar results in Southern Lao PDR with wild fish value representing almost half of the value of the rice crop.

[1] Exchange rate is 1 USD = 42 Bahts

[2] Exchange rate is 1 USD = 15 300 Dongs

[3] Exchange rate is 1 USD = 3990 Riels

Table 5.4 Market value of the SRS and all wild aquatic organisms relative to the value of the rice harvest.

Countries	Provinces	Average SRS catch (kg/house hold/year)	95% confidence limit of the SRS catch	Value of the SRS catch in USD	Relative value of the SRS compared to rice crop value (%)	Relative value of the wild fish compared to rice crop value (%)
Cambodia	Takeo	3.1	1.0 - 7.2	2.17	2	9
	Svay Rieng	64.7	46.2 - 90.5	45.29	23	35
Thailand	Yaso	80.1	43.7 - 146.4	48.06	7	17
	Sisaket	114.5	71.9 - 182.0	68.7	10	
Vietnam	Soc Son	14.2	5.4 - 35.6	5.68	2	2
	Phu Xuyen	28.4	7.9 - 95.7	11.36	4	4
	Trai	17.6	2.1 - 110.6	7.04	3	46

5.3.4 Seasonality of aquatic animal consumption

Consumption of SRS (non-stocked aquatic animals from FMAS) was highly seasonal in Cambodia and Thailand but less so in Vietnam (Figure 5.8a). Seasonal variation was greater for the poor than for the population as a whole (Figure 5.8b). In Cambodia and Thailand, SRS consumption was low during the wet season when fishing is concentrated in open waters, and high throughout the late wet and dry seasons. The consumption of processed aquatic animals was highest in Cambodia where it followed an opposite seasonal trend from that of fresh aquatic animal consumption (Figure 5.8c).

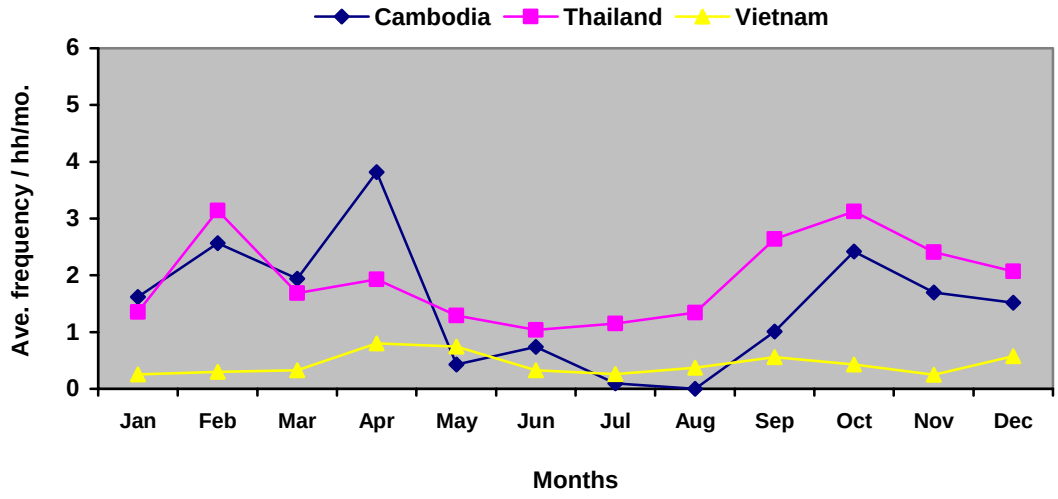

Figure 5.8a Comparison on the monthly trend of frequency of eating SRS

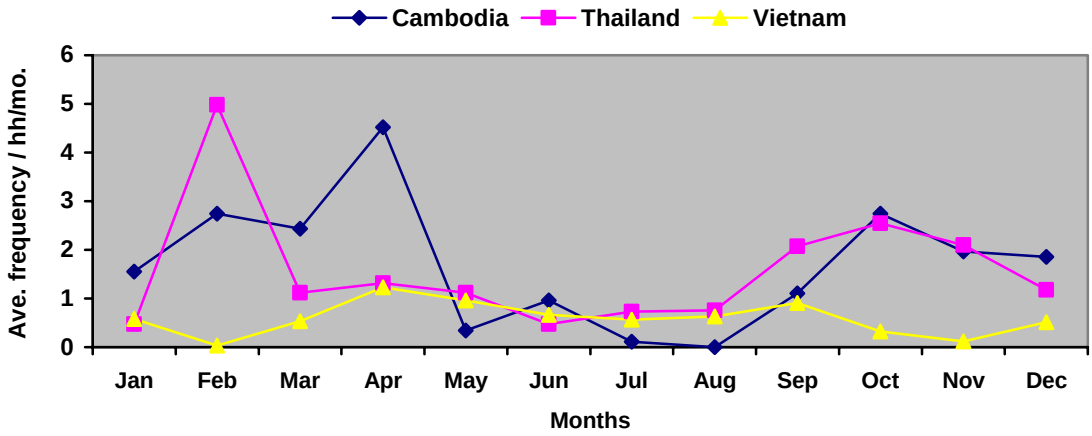

Figure 5.8b Comparison on the monthly trend of frequency of eating SRS by the poor

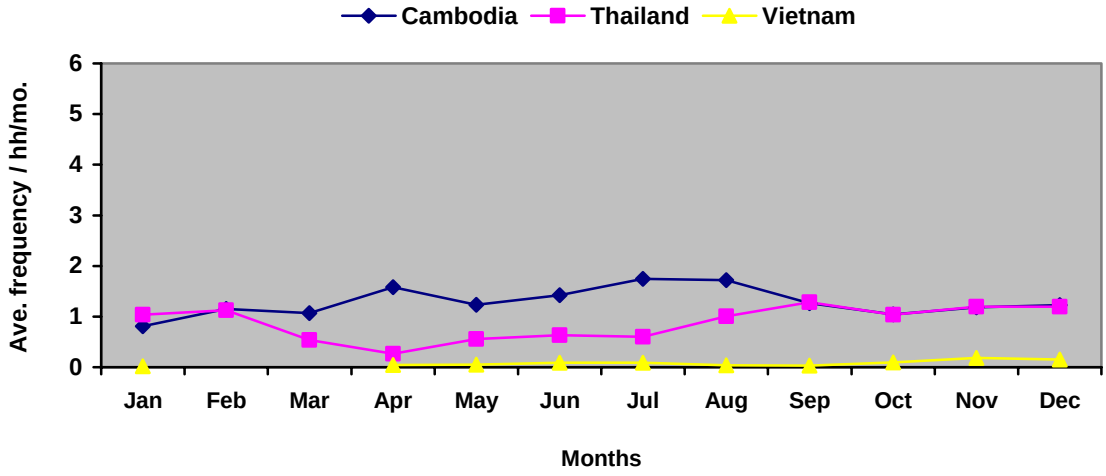

Figure 5.8c Comparison on monthly trend of frequency of eating Processed AA

5.3.1 Quantities of aquatic animals caught per household

The total catches of aquatic animals obtained by individual households were highly skewed (Figure 5.9). All further analysis were thus carried out on logarithmically transformed catch data and results back-transformed as appropriate.

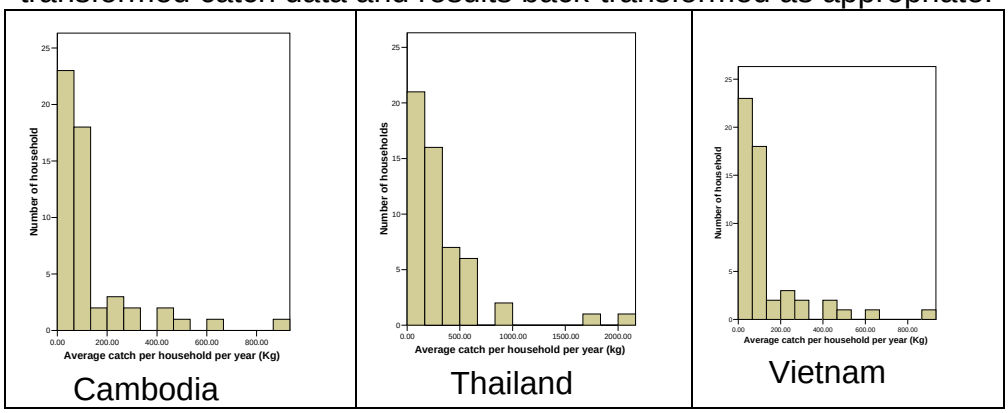

Figure 5.9 Frequency distributions of the average catch per week end per household.

Figure 5.10 shows the variation in average household catches between study villages.

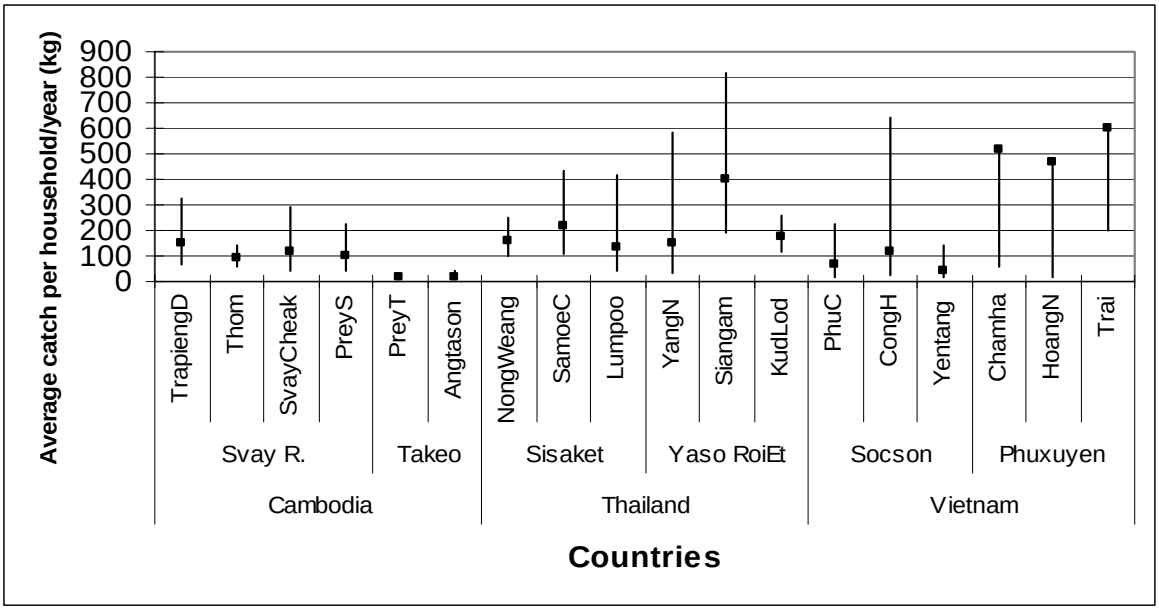

Figure 5.10 Difference in yearly catch per household per village in each country.

In Thailand, there was no significant difference in catches either between provinces or between villages. However, catches recorded for Cambodia and Vietnam are significantly different between provinces. Catches in Svay Rieng are higher compared to Takeo and catch in Phuxuyen is higher compared to Socson. Country averages, disaggregated by province as appropriate, are given in Table 5.5.

Table 5.5: Average annual catches of aquatic animals

Country	Provinces	N	Mean	Minimum	Maximum	95% Confidence Interval	Monitoring period
Thailand		54	189.7	2.7	2109.3	139.0 - 258.8	Feb. 02-Feb. 03
Cambodia	Svay Rieng	36	112.0	8.7	870.5	81.1 – 154.7	Apr. 02-Apr. 03
	Takeo	17	13.4	0.8	67.4	7.5 – 23.9	
Vietnam	Soc Son	24	70.1	8.3	969.9	35.2 – 139.4	Apr. 02-Apr. 03
	Phuxuyen	22	532.8	4.2	10166.1	213.0 - 1333.0	

5.3.2 Importance of SRS and stocked species

Total catch figures reported above include all wild and stocked aquatic organisms. Our primary interest however is focused on self-recruiting species, i.e. the proportion of the catch taken from wild aquatic animals in farmer-managed systems. We therefore explored the importance of wild versus stocked aquatic animals, and FMAS versus open systems.

Figure 5.11 shows the catch of wild and stocked species in the household catch in the three SE Asian countries. As expected, stocked species represent most of the catch in Vietnam whereas in Cambodia and Thailand, wild fish dominate. It is however important to note that a significantly larger catch of wild species is obtained in Trai village in Vietnam. Trai, located in the vicinity of a river and low land areas provides more opportunity to collect wild fish. Table 5.6 summarizes the average catch of wild fish per household and per year.

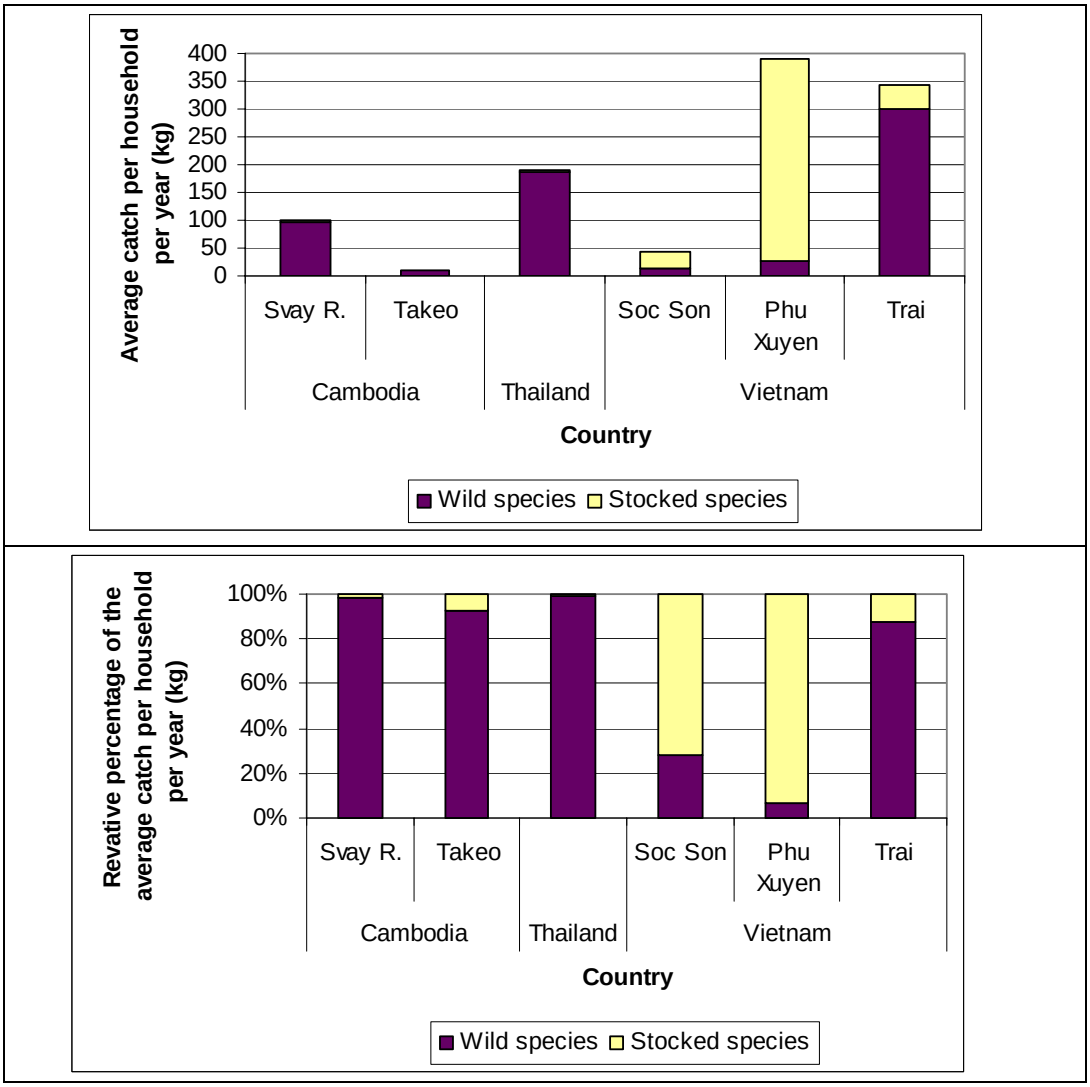

Figure 5.11 Distribution of the total catch between wild species and stocked species

Table 5.6 Average catch of wild aquatic species per household and per year (Phu Xuyen results excluding Trai)

Country	locations	N	Average catch (kg)	Minimum	Maximum	95% Confidence Interval for Mean
Cambodia	Svay R.	36	96.91	8.69	609.28	71.98 - 130.36
	Takeo	17	10.75	0.00	50.36	5.41 - 20.54
Thailand		54	187.91	2.70	2109.34	138.57 - 254.71
Vietnam	Soc Son	24	12.08	0.00	918.00	4.83 - 28.31
	Phu Xuyen	13	26.69	0.00	506.77	8.21 - 82.26
	Trai	9	300.99	49.85	3921.23	90.96 - 990.69

Aquatic animals are obtained from both FMAS and open systems. FMAS are the aquatic systems owned and managed by the farmers, often with restricted access and de facto ownership of the resource by the farmer. Access to ponds in the three countries is usually restricted whereas access to rice fields depends of the season. Open systems are larger natural or man-made water bodies where fish stocks are common or communal property

Figure 5.12 shows the annual amount of aquatic animals collected from the FMAS and from open areas in the three SE Asian countries. For the three countries, the average catch in FMAS is significantly higher than in the open system, representing more than two thirds of the total except for Takeo (32%) and Trai (17%). In Vietnam, farmers in Trai village collect significantly more wild fish in open systems compared to owned systems.

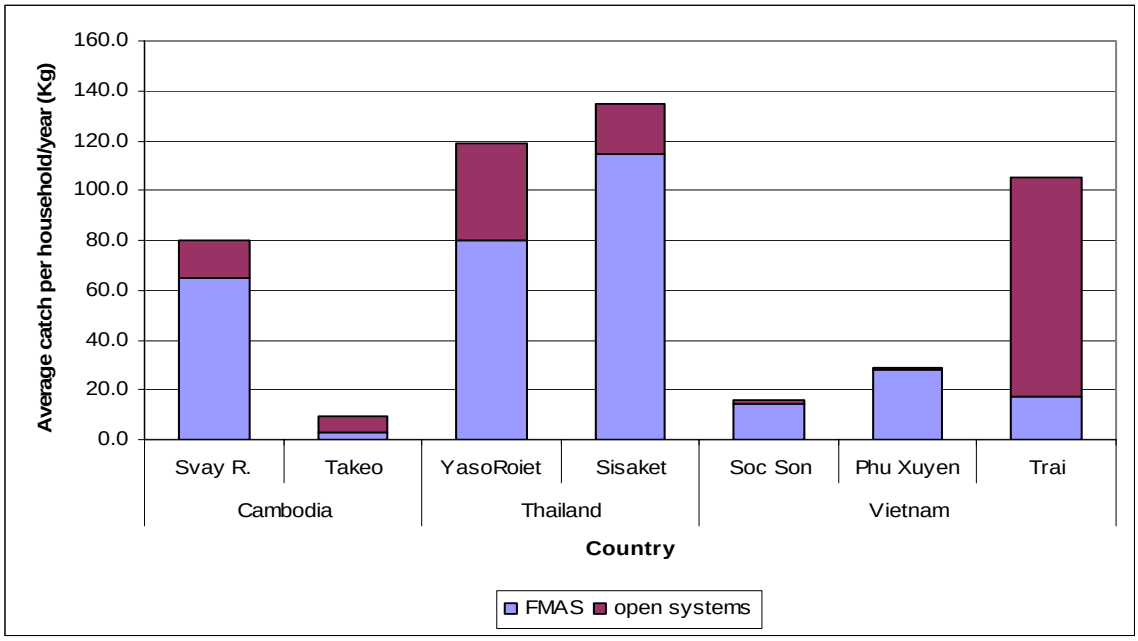

Figure 5.12. Average catch of wild fish in FMAS and open systems

By contrast, more fishing effort was expended in open systems than in FMAS in most locations (Figure 5.13). Only in Vietnam and in Sisaket provinces in Thailand are farmers fishing significantly more often in the FMAS than in open systems. As expected in Cambodia, Takeo shows significant lower number of trips per months compared to Svay Rieng Province. In Vietnam, in line with the previous results on catches in open systems, farmers in Trai are fishing more frequently in open systems than any other village. Farmers in Vietnam collect SRS less frequently than those in Cambodia and Thailand.

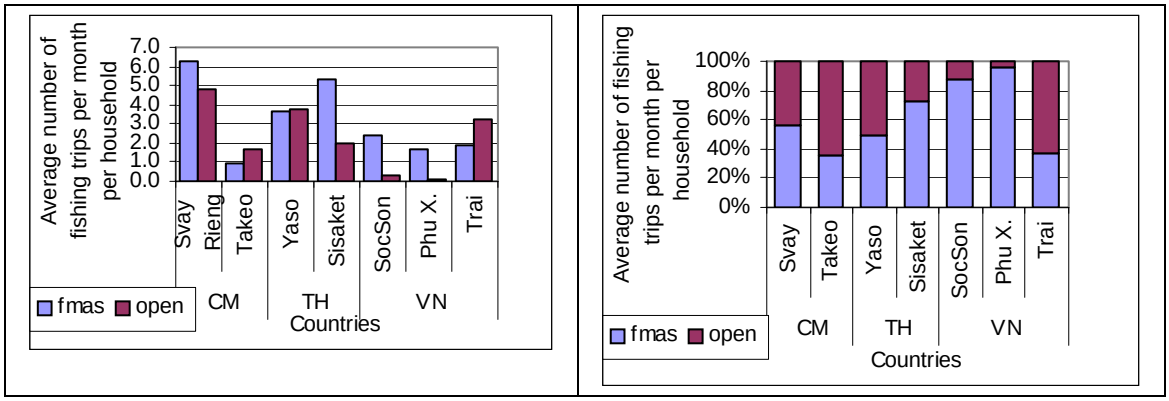

Figure 5.13 Average number of fishing trips per month per household and associated proportions.

As expected from the differences in the levels of catch obtained and effort expended in FMAS and open systems, catch per unit of effort was found to be substantially higher in FMAS than in open systems in all countries (Fig. 5.14)

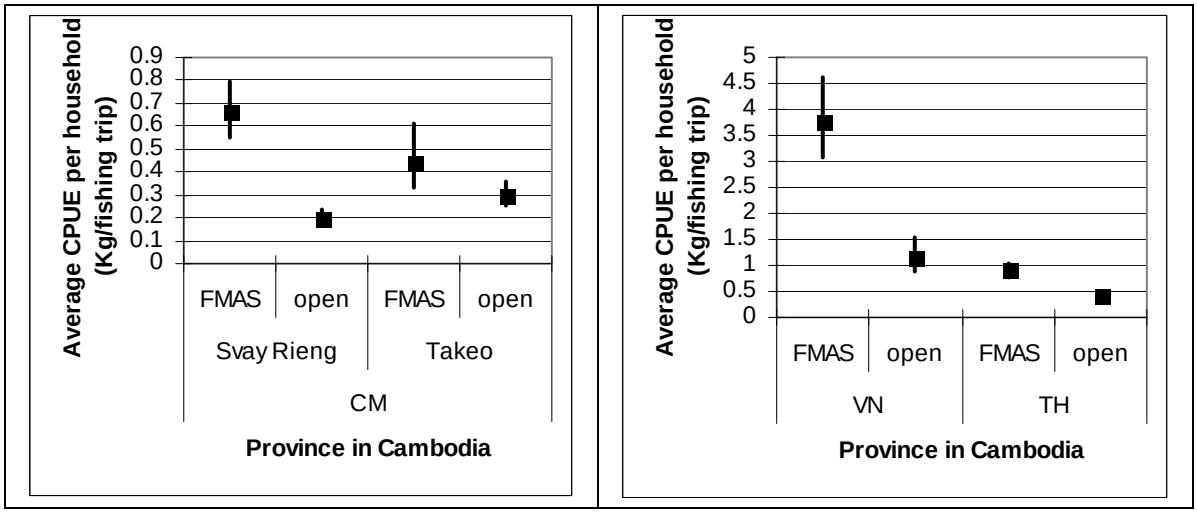

Figure 5.14. Average Catch Per Unit of Effort CPUE) in FMAS and open systems. CPUE is expressed as catch per trip in Cambodia, and as catch per hour in Thailand and Vietnam.

5.2.3 Diversity of SRS collected

Data on the diversity of SRS collected was derived from the household survey, and thus used farmer definitions of SRS types rather than biological species. Many farmer-recognized types nonetheless corresponded to particular dominant species, wile others comprised several similar looking species. A total of 29 types as recognised by farmers were collected in Thailand, 14 in Cambodia, and 9 in Vietnam. In each country 3 types collected were non-fish species.

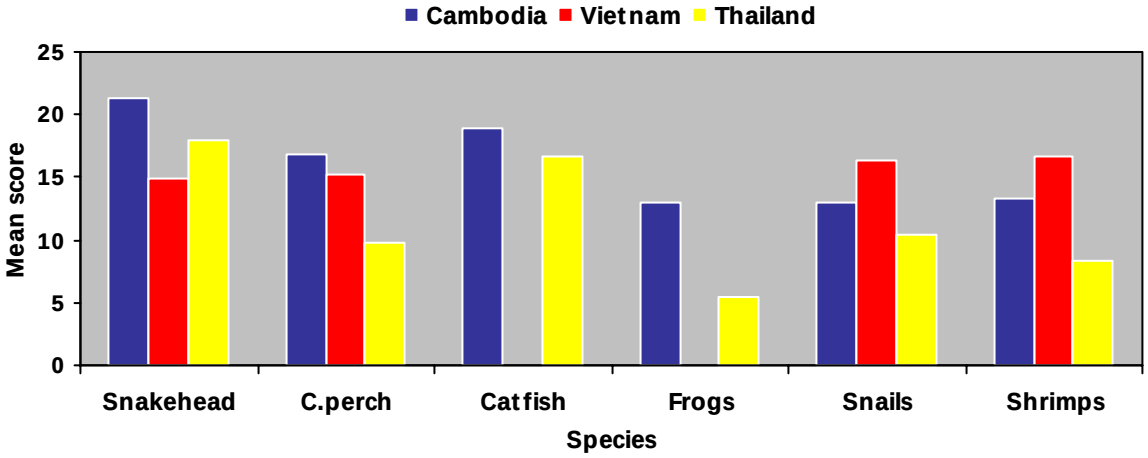

Figure 5.15. Important self-recruiting species in the three countries of SE Asia

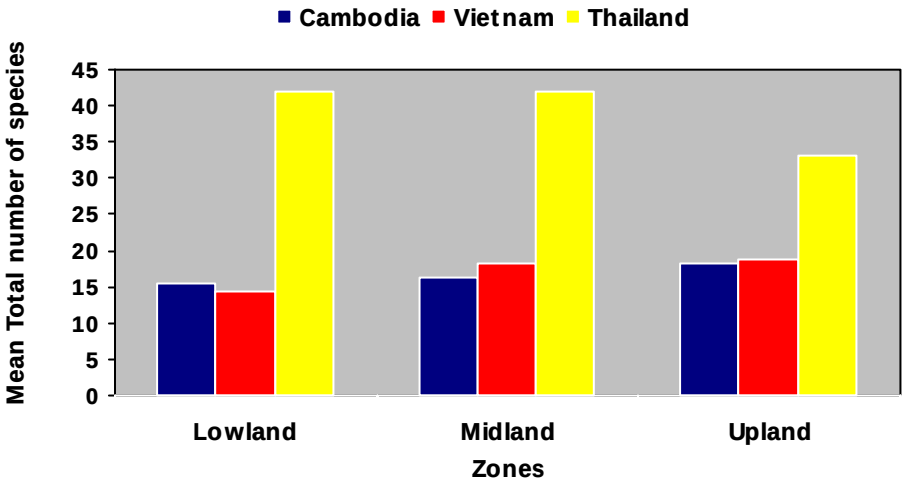

Figure 5.16. Average number of species of aquatic animals in the three countries of SE Asia

Table 5.7 summarizes the most important types of SRS, considering only those collected by more than 50 farmers (30 in Vietnam because fewer farmers collect SRS). The climbing perch *Anabas testudineus* is the most harvested species in al;l countries, followed closely by the snakehead *Channa striata* in Cambodia and Thailand. In Vietnam, the low diversity of SRS may be due to the fact that wild fish are more rare and difficult to catch. Farmers with ponds are more focused on

cultured species and wild fish are perceived as pests. The shrimps hold an important place in Cambodia and Vietnam. The low number of 'major' types in Thailand reflects the high diversity of species collected.

Table 5.7: Types of SRS most collected in each country. The number in brackets indicates the number of households that have collected each type.

Cambodia	Thailand	Vietnam
Anabas testudineus (121)	*Anabas testudineus (97)*	*Anabas testudineus (49)*
Channa striata (118)	*Channa striata (99)*	*Carassius spp (41)*
Clarias spp (119)	*Clarias spp (97)*	*Small Shrimp (38)*
Esomus-Rasbora spp (101)	*Esomus-Rasbora spp (56)*	
Small shrimp (109)		
Spiny eels (76)		
Frog (55)		
Three spot gourami (52)		

5.2.6 Stocked species in FMAS

The proportion of households stocking hatchery fish in their ponds is shown in Figure 5.17. Stocked species are most important in Vietnam, where all households with at least one pond stock hatchery seed. On the other hand, very few households with ponds stock hatchery seed in Cambodia (less than 10%), and less than 50% do so in Thailand. The main species stocked are: the major carps in Vietnam (Grass, Indian, Silver and Common carp); *Barbodes gonionotus*, Nile tilapia and African catfish in Thailand; and Nile tilapia and *Pangasius* spp. in Cambodia.

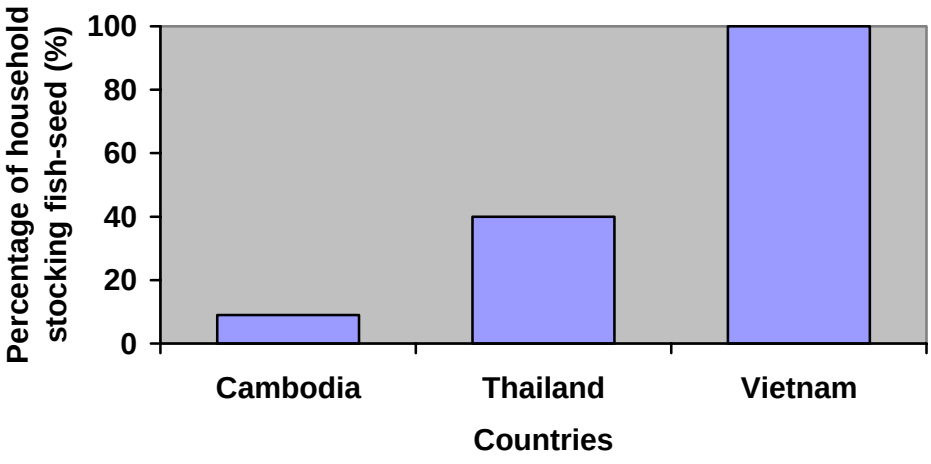

Figure 5.17. Proportion of households stocking hatchery fish in their ponds.

Systems involving a combination of SRS and stocked hatchery fish were thus relatively uncommon, with farmers focusing their management mostly at either SRS only or stocked fish only. Of the stocked fish, only the native *Barbodes gonionotus* and the exotic Nile tilapia and African catfish are likely to recruit naturally into or

within farmer systems as well and thus form mixed self-recruiting and stocked populations.

5.2.7 SRS management activities in FMAS

Attitudes to SRS of farmers with ponds and their consequent management actions varied widely between countries (Figure 5.18). In Cambodia and Thailand the vast majority of farmers actively allowed and attracted SRS into their ponds, with the remainder either preventing entry or doing nothing. In Vietnam, only about 20% of farmers allowed or attracted SRS, 20-50% prevented entry or actively eliminated SRS and the remainder did nothing. The higher proportion of households preventing and eliminating SRS in Vietnam is linked to the fact that aquaculture of hatchery fish is more developed.

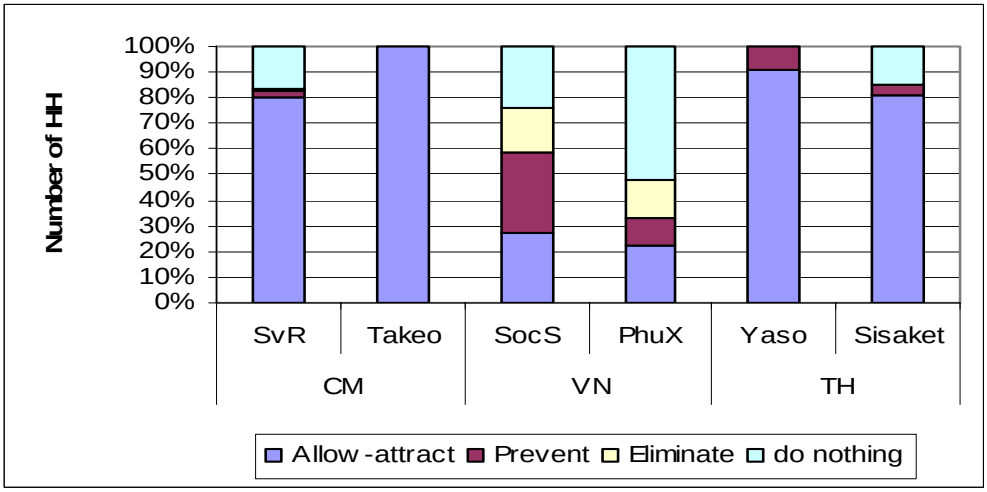

Figure 5.18. Attitude and management actions towards SRS of farmers with ponds (farmers without ponds not included).

A range of indigenous management activities aimed at SRS were practiced by farmers (Table 5.8). The most common activities aimed at allowing or attracting SRS into the pond were building brush parks and deepening ponds in Cambodia and Thailand, as well as feeding and retaining water during the dry season in Thailand only. The most common measures used to exclude or eliminate SRS in Vietnam were screening of the pond, and to a lesser extent the use of pond drying and pesticide applications.

Table 5.8. Frequency of specific management activities aimed at SRS.

Action	Management activities	CM	VN	TH
Allow-attract	add bone	0	0	3
	brush park	80	3	71
	link with canal	0	3	0
	dig hole	2	0	0
	deepening pond	70	14	78
	Feeding	2	7	31
	Fertilization	0	7	13
	Flood	0	7	0
	add mud	0	0	3
	screen once entered	0	0	1
	retain water	0	31	24
	Other	1	14	0
Prevent	Screen	2	41	7
Eliminate	Lime	0	17	0
	Dry	1	10	0
	Pesticide	0	14	0
Total number HH		90	29	72

5.2.8 Effects of SRS management activities on yield and abundance

Assessment of the effectiveness of indigenous management measures on yield and abundance of SRS prior to active experimentation was based on an observational study, i.e. the comparison of yield and abundance indicators between systems where a particular management measure was practiced with controls where this was not the case. While these data are analyzed in a way analogous to the treatment of data obtained from designed experiments, it must be borne on mind that treatments (management activities) were not allocated at random to the experimental units (individual FMAS). In particular it must be appreciated that farmers may adopt management measures in response to the perceived status of their FMAS, i.e. they may chose to stock in systems of below-average SRS production, or build brush parks to restrict fishing by others in systems that are particularly productive. Hence the apparent effectiveness of management measures as deducted from observational comparisons may be greater or less than the true effectiveness.

The effects of all common management measures on catch per unit of effort (CPUE), a measure of abundance, are shown in Table 5.9. CPUE has been measured for all species combined, i.e. SRS as well as stocked species. Strong effects are apparent for a range of management measures in Vietnam, where FMAS are dominated by ‘conventional’ aquaculture based on hatchery seed. In the Cambodian FMAS which are dominated by SRS, building brush parks and feeding had a positive effect. In the Thai FMAS which are equally dominated by SRS, only manuring was associated with a positive effect on CPUE. The results suggest that SRS production is less influenced by management inputs than ‘conventional’

aquaculture, which may reflect both the greater reliance of SRS on natural processes and generally lower levels of inputs. Nonetheless, certain indigenous management measures such as brush parks and manuring can increase SRS abundance (CPUE) by about a factor of two.

Table 5.9 Effects of various management measures on the total catch per unit of effort (CPUE) from FMAS in the three Southeast Asian countries.

Activity	Country	N non-managed	N managed	P	Effect (%)	95% LCL (%)	95% UCL (%)
Brush parks	CM	33	15	**0.010**	127	22	322
Brush parks	TH	30	23	0.677	10	-30	74
Clean pond	CM	42	6	0.311	-37	-75	57
Clean pond	VN	34	9	0.275	74	-36	384
Deepen pond	CM	24	21	0.289	41	-26	170
Dike	VN	33	10	0.894	-6	-65	153
Dry pond	CM	26	22	0.701	-11	-52	64
Dry pond	VN	29	14	**0.081**	115	-9	411
Feeding	CM	31	17	**0.096**	70	-9	217
Feeding	TH	33	20	0.994	0	-37	60
Feeding	VN	8	35	**0.001**	437	109	1280
Fertilization	VN	23	20	0.157	80	-20	310
Own pond	TH	7	46	0.545	22	-37	139
Own pond	VN	7	36	**0.002**	415	86	1324
Manure	TH	46	7	**0.051**	90	-0	264
Manure	VN	32	11	0.576	30	-50	241
Pond preparation	VN	19	24	**0.035**	138	6	430
Stocking	CM	32	16	0.209	50	-21	185
Stocking	TH	33	20	0.948	1	-36	62
Stocking	VN	8	35	**0.039**	194	5	722
Water management	CM	34	14	0.785	9	-44	116
Water management	TH	46	7	0.202	53	-20	196
Water management	VN	23	20	**0.069**	111	-5	375

5.5 Life histories of key SRS species

Life history information on key species was available from both the biological life history study, and from the monitoring survey which recorded farmer observations on the biology of key species. On the whole the information obtained from scientific sampling and farmer observations was consistent and/or complementary, as shown in an example in Table 5.10.

Table 5.10 Life history information on the snakehead (*Channa striata*) obtained from the biological sampling programme, recording of farmer observations, and the existing literature.

Results	(1)Sampling	(2)Farmers observations	(3)Literature
1. Size and weight	$W(g)=0.0162\ SL(cm)^{2.94}$ Max SL=28.4 (male)		To 90 cm but usually smaller.
2. Reproduction	Minimal size with mature gonads: 17-22 cmTL From May to August Fecundity: 9805 oocytes in average (8181-11428) positive	Oocytes are observed in the fish from March to July. Matting behaviour from June to December Observations of offsprings from April to October All activities observed in all kind of water bodies: TP, CP, PF, stream, oxbow, swamp.	Build nest in aquatic vegetation but able also to spawn in ponds without vegetation. Eggs are released and fertilized Parents vigorously guard their young Fecundity: 2300-26000 oocytes increasing in number with increasing body length. Newly hatched fry are about 3 – 3.5 mm Breed year round (Okada,1960) Sexually mature at 30 cm when 2 years old (Talwar and Jhingran, 1992).
3. Diet	More frequently observed: insects and insect larvae, shrimp, fish, snail. But also tadpole, clam, crab, frog	Predator of all kind of smaller fish (tilapia, anabas, puntius spp…)	All snakeheads are predators. Adults: fish, crustaceans, frogs, small reptiles
4. Habitat	Collected mainly in Ponds. During rainy season, collected with fish-rod in the river and in the rice fields.	From June to Sept (beginning rainy season): move from ponds to paddy fields. And from Oct to Dec (end rainy season): move from paddy fields to deeper water bodies (TP, cabal, PP)	Capable of overland migrations to escape drying habitats.
5. Population dynamics	K=0.103 ; SLinf=100cm K=0.24 ; SL inf=96cm		Most large snakeheads are reported to reach sexual maturity within 2 years, after which growth slows but fecundity increases with increasing size. Can attain a length of 30-36 cm in one year (Bhatt,197025-27cm in 13.5 months and 23.4-31.7 cm in 9.5 months. K=0.44 (based on SL) Linf=36.8cm K= 0.210 (based on TL) Linf=52cm

The survey confirmed that on the whole SRS systems are maintained by the seasonal spawning and feeding migration of key species from open water bodies into FMAS. Maintenance within FMAS however is possible for many species if a deep perennial pond is maintained within them.

5.6 Local resource management interventions in Thailand, Cambodia and Vietnam

Different management activities were practiced by local resource user groups (LRUGs) in the three SE Asian countries. The rank of management activities (Figure 5.19) practiced by LRUGs varied between sites and reflected both the nature of the FMAS and local conditions. Trapping, for example, was not scored at all in Cambodia as trap ponds were usually located away from, and not considered an

intrinsic part of, FMAS. In contrast trapping in ponds and partial harvesting were important in Thailand and Vietnam. Creating habitats and improving the physical nature of the system were not prioritized in Thailand, but considered important in both Cambodia and Vietnam. Catch rules were only instigated in Thailand and broodfish only maintained in Thailand and Cambodia. The lack of interest in broodfish retention in Vietnam perhaps reflected the focus on improved tilapias and common carp.

The priorities of LRUGs were similar to control groups although the concept of maintaining juveniles in Vietnam and improving the physical system in Thailand were scored higher (Figure 5.20).

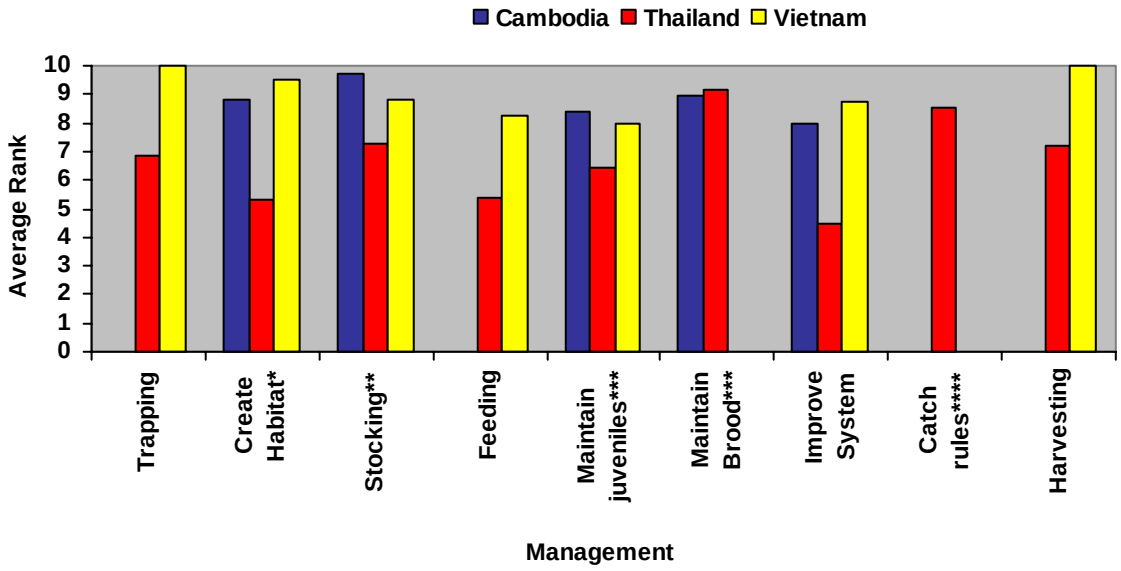

Figure 5.19. Average ranking of management activities practiced by members of Local Resource Users Groups. (Rank 10 is the highest and most important)

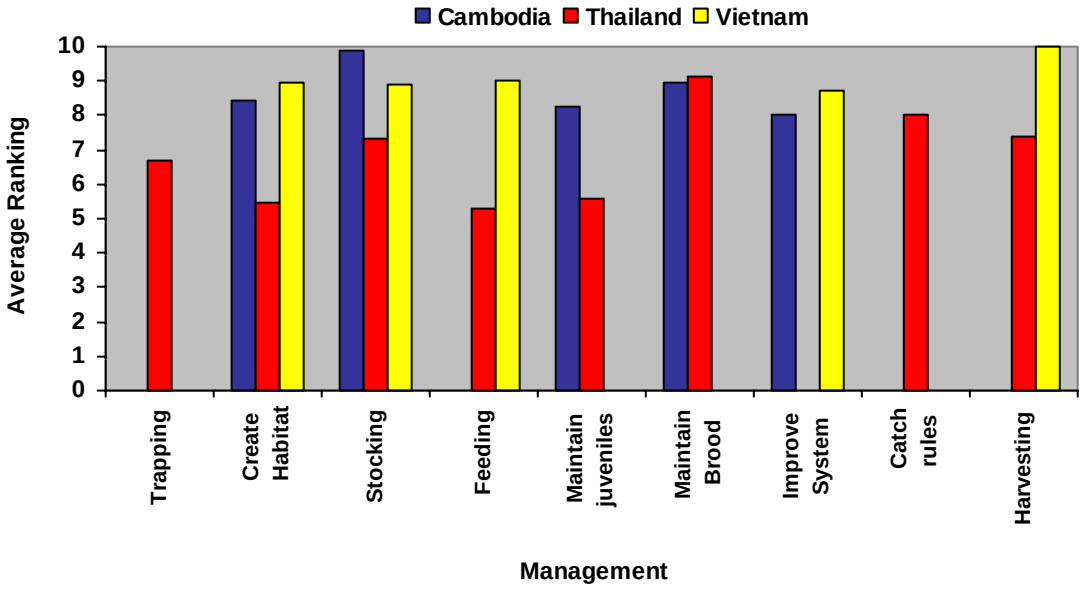

Figure 5.20 Average ranking of management activities practiced by non-members of Local Resource Users Groups.

The ranking of some management activities differed between zones in all countries (Figure 5.21).

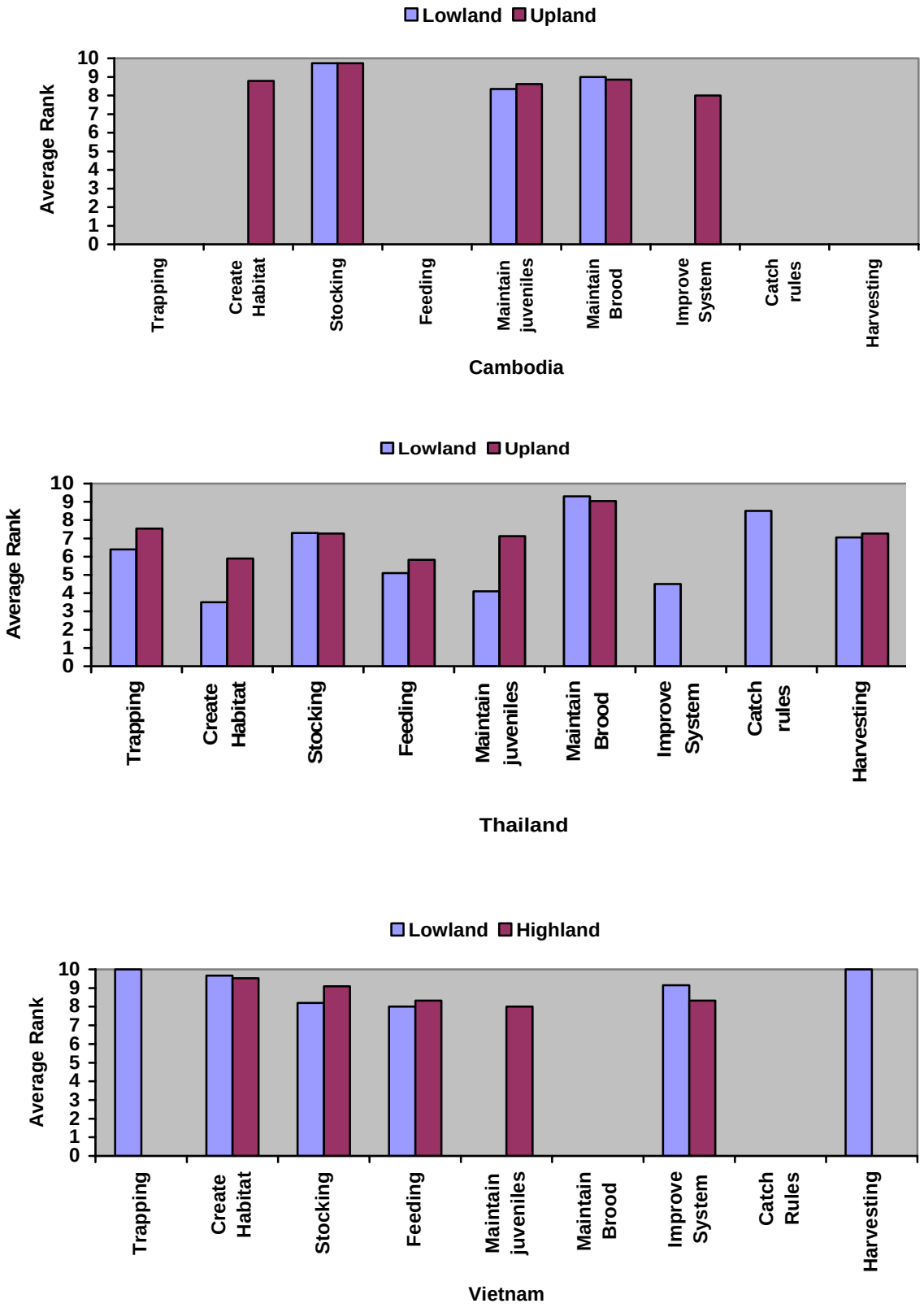

Figure 5.21. Differences between upland and lowland areas in Cambodia (top), Thailand (middle) and Vietnam (bottom) in the average ranking of management activities

5.5.2 Perceptions of benefits of LRUGs

The impacts of LRUGs on the group members as individuals, as a group and the wider community were evaluated at the end of the trial. The ability for people to work together and to realize increased benefits was clearly expressed by the majority of groups in each country. An important reservation of members about LRUGs was the impact of exclusion on those outside the group but within the wider community and the potential for conflicts that this might cause. Interest in forming a group appeared high among non-members, however, and it was only in Thailand that theft was considered an important constraint to LRUG activity. The importance attached to continuing the LRUG activities by non-members in both Cambodia and Thailand because it increased the quantity of aquatic animals (Table 5.11) suggests the value of a group-based approach can have on enhancing benefits for the wider community. Overall the high interest in sustaining LRUG, among both members and non-members, was perhaps best evidence for their value.

Table 5.11 Advantages of local resource users group.

Country	Advantage	Disadvantage
Cambodia	Less financial investment needed Community interest developed During rainy seasons linkages of FMAS are strengthened Farmers without ponds benefit	Reduced access to non-village members
Thailand	During rainy seasons linkages of FMAS are strengthened Farmers without ponds benefit	Reduced access to non-village members
Vietnam	Community interest developed Local government would help and adjust rules – taxation	Not all will benefit Conflict over water use with non-group members

Table 5.12 Livelihoods Assets.

Assets	Country		
	Cambodia	Thailand	Vietnam
Natural	Aquatic animals increased Collect more Aquatic animals improved	Aquatic animals increased	Aquatic animals increased
Financial	Earned more income	Earned income Reduced food expenses	Increased income Earned income
Physical	System improved Better use of water Multiple use of water Better conservation of water	Better use of water Multiple use of water Better conservation of water Easy to collect	System improved Multiple use of water Better conservation of water
Human	Learn how to culture AA Consume more AA Learn group management Learn how to manage wild AA Prevent sickness	Learn how to culture AA Consume more AA Learn group management	Learn how to culture AA Consume more AA Learn how to manage wild AA
Social	Share info with others Improved relationship Share AA	Share info with others Learn from others Exchange info Share fish	Share info with others Improve relationship Learn from others

Importance of Benefits

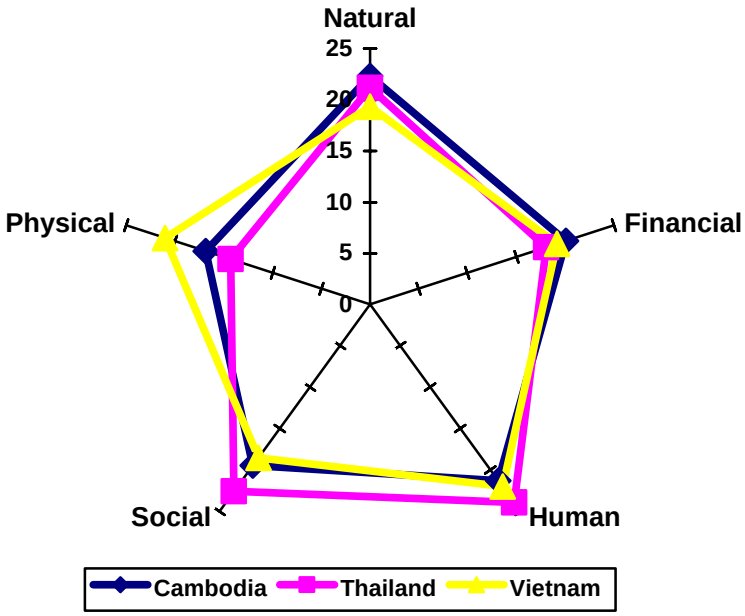

Figure 5.22 Individual perception of members of the local resource users group on the benefits of group management.

In general the major benefits to livelihoods were felt through improvements to human and social assets and least to physical and financial. Thailand was most extreme in this respect, Vietnam most balanced and Cambodia intermediate with respect to benefits to the five types of asset.

Farmers' perception on who is benefiting from the three most highly ranked management activities of Local User Groups

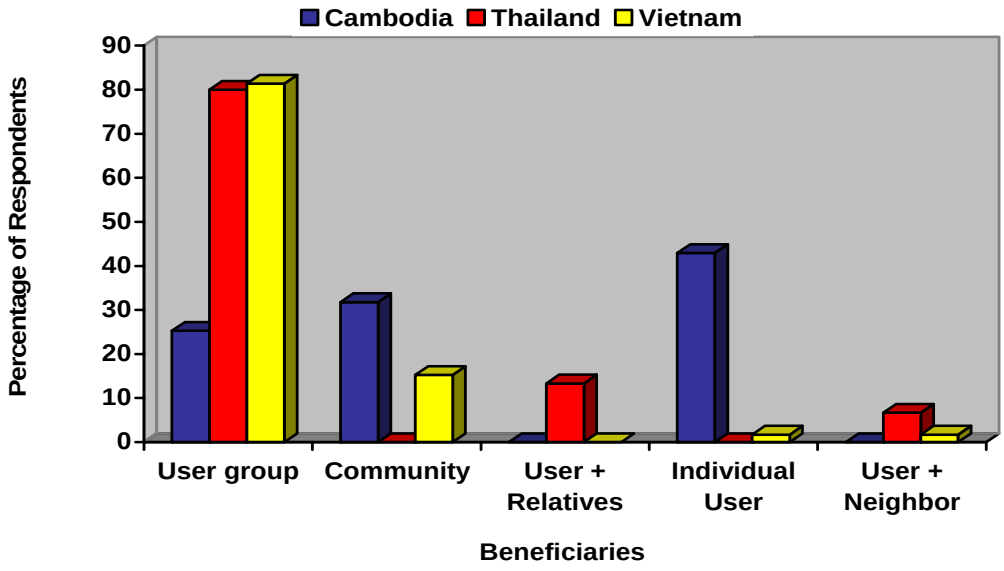

Figure 5.23 Individual perceptions of members of Local Resource Users' group on who is benefiting from the three most highly ranked management activities practiced.

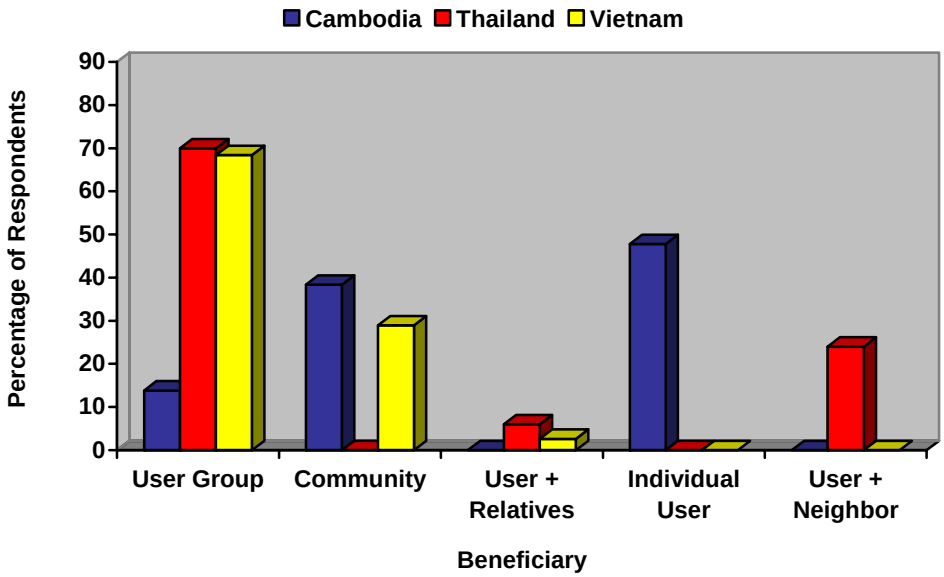

Figure 5.24 Individual perceptions of non-members of Local Resource Users' group on who is benefiting from the three most highly ranked management activities practiced

Perceptions of who gained in each country showed some interesting differences between countries and members and non-members of LRUGs. These differences perhaps reflected variations in norms relating to access to AA and the spatial nature of land holdings of group members. The perceptions on who benefited of both member and non-members was similar except in Thailand where non-members scored the benefits from group activities to neighbours outwith the LRUG was higher than members. This suggested that the likelihood of group formation causing conflicts was less of a risk as those surrounding the users groups also received benefits. The greater benefits felt by both members and non-members to the wider community than the user group itself in Cambodia would also support this.

The balance of benefits between the user group and other beneficiaries was perceived quite differently in Thailand and Vietnam compared to Cambodia however. In Cambodia the individual user was also believed to benefit more than the User group. In Thailand the user and relatives was perceived to gain relatively more and wider community less than in Cambodia and Vietnam; this may reflect the relatively more abundant choices of AA source in Thailand and the greater significance of the FMAS as household AA food source than the other two sites.

5.5.3 Indicators of LRUGs sustainability

On the whole, members as well a non-mebers of LRUGs expressed the intention of continuing LRUGs (Figure 5.25), for a variety of reasons (Table 5.13). There were, however, a range of issues arising (Table 5.14).

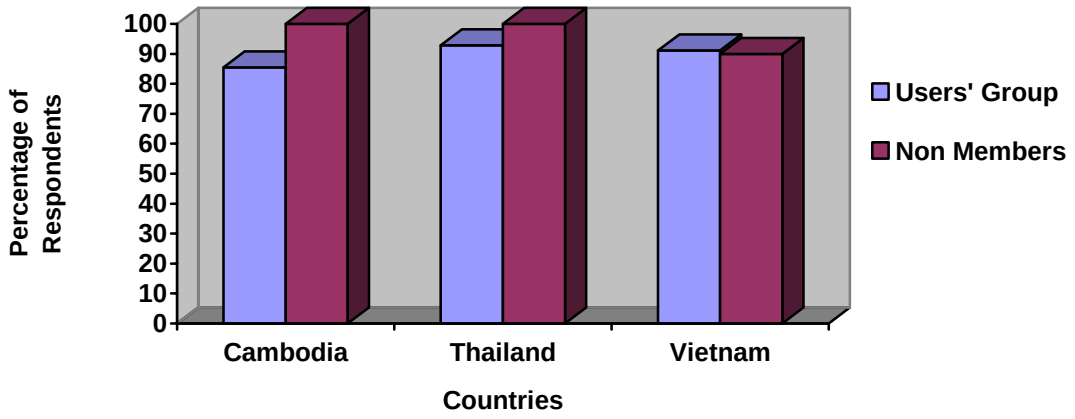

Figure 5.25. Percentage of farmers who want to continue the local resource user group management activities.

Table 5.13 Reasons for continuing LRUG approach of management (Values in percentage of total score)

Reasons	Country					
	Cambodia		Thailand		Vietnam	
	Member	Non member	Member	Non member	Member	Non member
Effective	18.2	1.7	23.1	12	6.9	51.8
Convenient					6.9	7.4
Increased income		1.7			17.2	3.7
More Aquatic animals	9.1	53.3		52	6.9	
More broodstock	38.6	30				
More knowledge			7.7			14.8
Increased AA + income					10.3	
Area improved		3.3			24.1	
Beneficial			2.6	36	24.1	3.7
Share knowledge	34.1		66.7			
Set Example						14.8
No reason		10			3.4	3.7

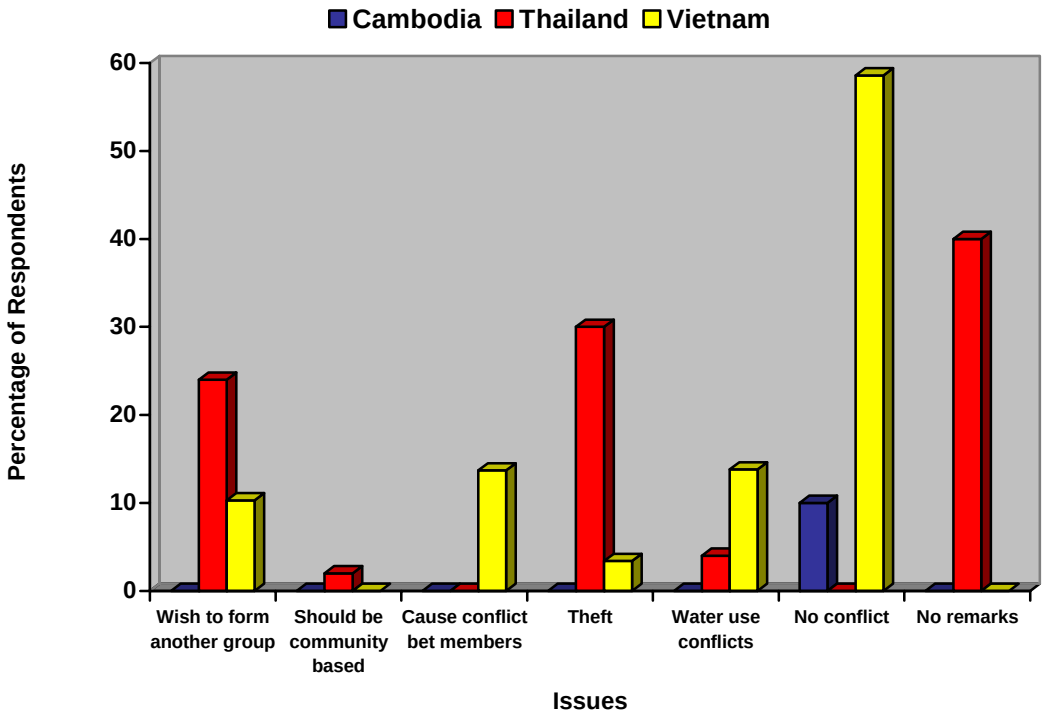

Figure 5.26 Individual perceptions of issues arising from local resource users' group management

5.7 Impact of SRS management strategies on carp polyculture and rural livelihoods

On the basis of farmers' attitudes, interest and resource type three categories of SRS management at the household level were identified as SRS positive (POS), SRS negative (NEG) and SRS neutral (NEU). Total production of carp and SRS in POS, NEG and NEU was 2472.47kg/ha, 1788.28 kg/ha and 2230.41kg/ha respectively. There was a significant difference of total production between 3 categories, but no significant difference in carp production. POS households which deliberately included SRS, achieved 1.38 times higher production than NEG which discouraged SRS and 1.11 times higher than NEU which accessed SRS without any deliberate effort. SRS production in POS was 2.14 times higher than NEG and 1.52 times higher than NEU where carp production was 1753.7, 1452.36 and 1765.17 kg/ha in POS, NEG and NEU respectively. Cost benefit ratio of POS, NEG, NEU was 2.62, 2.07 and 2.61 respectively suggesting that culturing some SRS with carps provides more income than excluding them. There was no significant difference in cost-benefit ratio among treatments. But total consumption of SRS per household in SRS positive group was higher than SRS negative and neutral households.

The study revealed that both better-off and poorer farmers tended to consume more SRS than they sell, but 30% of the poorer farmers do sell more SRS than they consume, which suggests the potential of SRS for income generation among poor farmers.

5.8 Nutritional value of SRS

The muscle total lipid of all SRS tested was characterised by high levels of PUFA, which was the predominant FA series, followed by saturated (SFA) and lower levels of monounsaturated (MUFA). In terms of human nutrition, these species are a rich source of essential PUFA, though their edible muscle fat is low (<5%). There were no great differences in the FA profiles among the different species.

All fish species showed low n-3/n-6 PUFA ratios (Figure 2), ranging from 0.6-1.1 that are typical of tropical freshwater fish. However, they are a good source of the health-related n-3 PUFA, with *Rasbora borapetensis* displaying the highest n-3 content and n-3/n-6 ratio. Snakehead (*Channa striata*) also contained high levels of n-3 PUFA and specifically of 22:6n-3 (DHA), which is an essential FA for the brain and eye development during early natal life. The high content of DHA in snakehead originates from its carnivorous feeding behaviour.

All fish species were also a good source of arachidonic acid (20:4n-6). Although an overproduction of the metabolic derivatives from this FA is undesirable and associated with health disorders, this FA is essential in human nutrition for normal immune function and reproduction. In general tropical fish are known to contain high levels of arachidonic acid.

5.9 Population ecology of snakehead

The snakehead population study provided crucial quantitative information on key information on the migrations, mortality and growth rates of this key SRS. About 20% of tagged fish were recovered within one year of catch monitoring, 60 % of these within 2 months of release. The majority of fish (75%) were recaptured within 500m of their release site, but some moved for distances of up to 3 kilometres.

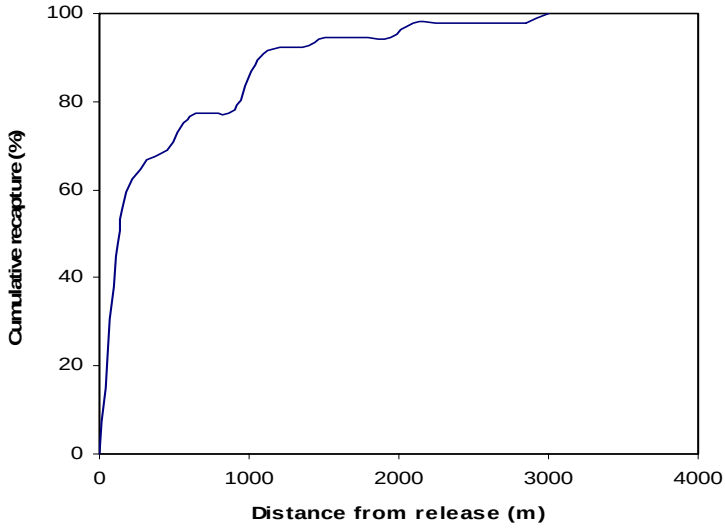

Figure 5.27 Cumulative recapture of marked snakehead as a function of distance from the release site.

Natural and fishing mortality rates were estimated by fitting a simple population model to tag-recapture data. Preliminary estimates of natural mortality M=5.4 y^{-1} and fishing mortality F=2.3 y^{-1} suggest that snakehead in rice farming landscapes are subject to extremely high rates of mortality overall. Fishing mortality, albeit high in absolute terms, is only moderate when compared to natural mortality. Very high rates of natural mortality are not unusual in natural river-floodplain systems, where the bulk of biomass production occurs on the floodplain but a significant share of fish become trapped on the floodplain as waters recede. Interestingly, a number of tags were returned from fish that had been found dead on dry land at the end of the wet season.

Overall these results suggest that despite intensive harvesting by the local population, the snakehead resource is not overexploited. Availability of dry season refuges is likely to be a key limiting factor as (a) most fish no not migrate for more than a few 100m, and (b) the very high natural mortality rate is likely attributable to fish becoming trapped in unsuitable habitat as water levels decline. Construction of deep ponds in FMAS and maintenance of some stock within them (rather than complete harvesting) is likely to be beneficial in areas that are more than a few hundred meters away from open water bodies.

5.10 Ecology of mixed stocked and self-recruiting systems

Studies on the ecology and management of populations maintained by a mixture of stocking and natural recruitment has focused on developing a theory of the dynamics of such populations, and on the process of domestication and its role in shaping interactions between wild and cultured fish.

5.4.1 Population dynamics of stock enhancement

While it has genarlly been assumed that fish populations are regulated primarily in the juvenile (pre-recruit) phase of the lifecycle, evidence for regulation in the adult phase has accumulated in recent years. Clearly, the extent of regulation in this phase where abundance is heavily influenced by stocking and harvesting has major implications for the outcome of stocking programmes. In an analysis of 16 fish populations with long-term records of size-at-age and biomass data, we detected significant density-dependent growth in nine. Among-population comparisons showed a close, inverse relationship between the estimated decline in asymptotic length per unit biomass density, and the long-term average biomass density of populations. A simple population model demonstrates that regulation by density-dependent growth alone is sufficient to generate the observed relationship. This study has identified density-dependent growth as a key mechanism of population regulation. Full details are given in Appendix 1.

The population dynamics of fisheries stock enhancement, and its potential for generating benefits over and above those obtainable from optimal exploitation of wild stocks alone are poorly understood and highly controversial. The study reviews

pertinent knowledge of fish population biology, and extends the dynamic pool theory of fishing to stock enhancement by unpacking recruitment, incorporating regulation in the recruited stock, and accounting for biological differences between wild and hatchery fish. The dynamics of stock enhancement and its potential role in fisheries management are analysed, considering economic as well as biological criteria. Enhancement through release of recruits or advanced juveniles is predicted to increase total yield and stock abundance, but reduce abundance of the naturally recruited stock component through compensatory responses or overfishing. Economic feasibility of enhancement is subject to strong constraints, including tradeoffs between the costs of fishing and hatchery releases. Costs of hatchery fish strongly influence optimal policy, which may range from no enhancement at high cost to high levels of stocking and fishing effort at low cost. Release of genetically maladapted fish reduces the effectiveness of enhancement, and is most detrimental overall if fitness of hatchery fish is only moderately compromised. As a temporary measure for rebuilding of depleted stocks, enhancement can not substitute for effort limitation, and is advantageous as an auxiliary measure only if the population has been reduced to a very low proportion of its unexploited biomass. This study has provided a population dynamics theory of, and practical tools for the assessment of fish populations enhanced with hatchery fish. Full details are given in Appendix 2.

5.4.2 Domestication and interactions between wild and cultured fish

Cultured fish inevitably enter a process of domestication with consequences for their morphology, physiology, ecology and evolution. Domestication involves plastic developmental responses as well as natural and artificial selection, and may occur in three alternative but related modes: (1) adaptation of the culture environment to the organism and consequent responses of the latter; (2) targeted promotion of desirable traits in the organism through developmental manipulations and genetic selection and engineering; and (3) targeted promotion of “wild” traits in cultured organisms. Controlled domestication can yield benefits for all forms of aquaculture, but inadvertent or poorly managed domestication can be detrimental to aquaculture as well as to wild stocks with which the cultured fish may interact. Accidental and intentional releases of cultured fish are widespread in the inland areas of Asia, and interactions between cultured and wild fish pose new challenges as well as opportunities for the conservation of wild stocks. Ecological and genetic interactions of cultured and wild fish can be significant and are closely linked. On the whole, cultured fish perform less well in natural ecosystems than their wild conspecifics. Nonetheless ecological and genetic interactions between the two groups can be significant, particularly where wild populations are small and/or declining. Such effects tend to be negative for the wild populations involved and often result in displacement and/or reduced fitness and biocomplexity of wild populations. Captive breeding and supplementation can play a positive role in restoring threatened populations, but the biology of threatened populations and the potential of culture approaches for conserving them remain poorly understood. Further details of this review are provided in Appendix 3.

5.4.3 Implications for stocking in FMAS

Currently, stocking is of minor importance in FMAS where wild fish (SRS) are abundant, and where stocking is practiced this involves predominantly exotic species. However, development of aquaculture of indigenous species has been widely promoted and it is likely that hatchery seed of such species will become increasingly available for stocking in FMAS. The studies reported above suggest that ecological and genetic interactions between cultured and wild components of indigenous fish species are all but inevitable where stocking is practised on a large enough scale in environmentally open FMAS. This will imply partial replacement of wild by cultured stocks, and partial loss of wild population genetic resources through ecological replacement and/or genetic introgression. Domestication effects are all but inevitable. Stocking of indigenous species into existing wild populations is likely to be less effective than stocking of the commonly used exotic tilapias and carps as significant compensatory effects on the wild stocks must be expected. Moreover, stocking of indigenous species should not *a priori* be regarded as posing a lower risk to wild populations than stocking of exotics. Extensive field experiments with tilapia and carp stocking in Laos have revealed little impact on wild populations (Lorenzen et al. 1998; Arthur 2004). Impacts of releasing cultured indigenous fish should be similarly assessed (with additional attention to genetic effects) before and large scale distribution or release of these organisms.

5.11 Summary of key results and recommendations

5.11.1 Key results

The project identified the socio-economic, technical and environmental factors that determine the role of SRS in farmer managed aquatic systems, and management strategies to enhance the production of, and access to, such resources for the poor where opportunities exists.

SRS are critical for poor people, both for home consumption and sale. Seasonally they are especially important during the dry season when access to other water bodies becomes limited.

In each country lists of species popular with poor producers/consumers have been developed, which can inform further work on the development of species of poverty-focused aquaculture.

SRS from farmer managed systems (ponds, ditches and rice fields) are most important in upland areas where other waterbodies are limited.

Management techniques that have been effective include keeping of broodstock, re-stocking of collected juveniles and the screening (or not) of pond entrances.

Value addition (drying, fermenting) is an important activity resulting from increased seasonal availability of non-stocked aquatic animals from farmer managed systems, both in rural, urban and peri-urban situations.

The population dynamics of SRS and systems that rely on mixed SRS/stocked fish have been investigated theoretically and in field studies and management principles derived.

5.11.2 Recommendations

Local resource group management of SRS in tracts of farm land can be effective in raising benefits to individual farmers from their SRS-based aquatic systems.

Due to the strong linkages between large waterbodies and farmer managed systems, location specific group management shows promise in the maintenance and enhancement of SRS in poor communities.

6 Contribution of Outputs

6.1 Contribution of outputs towards DFID's development goals

Outputs from this project address Output 3 of the AFGRP logframe; "improved culture and enhancement systems based on natural and human resource relationships, and their effective use of productive inputs (broodstock, seed, nutrients) in target regions" and Output 2 of the FMSP logframe; "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"

- The substantial and long-overlooked role of farmer managed aquatic systems in sustaining wild fish stocks and fisheries has been documented.
- Management strategies for aquatic resources in farmer managed systems have been developed.
- A theoretical underpinning and practical assessment tools for the management of stock enhancements has been developed.

6.2 Promotion of outputs

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

6.2.1 Direct dissemination during research

Several approaches pioneered during this project have subsequently been used in the following projects:

The research approach to identify and understand complex field situations has been used in several other research and development projects in the countries where the project was located. The rapid participatory situation appraisal has been used in a modified form by the SIDA-funded DOF Village fish pond and Community Fisheries projects in Thailand. The five day process was also used in the preliminary range-finding stage of several EC-funded research projects in the Region (MAMAS, PONDLIVE and PAPUSSA)

6.2.2 Presentations at workshops/seminars/conferences (see table at end of section for further details)

<u>Workshops</u>

FAO Technical Expert Meeting on Aquatic Biodiversity, it's nutritional composition, and human consumption in rice-based systems, December 8 – 10, 2004. FAO Regional Office for Asia-Pacific (RAP) in Bangkok, Thailand

> Morales, E.J., Little, D.C., Immink, A., Amilhat, E., Demaine, H., Yakupitayage, A., Lorenzen, K. (December 2004). Contribution of self-recruiting species (SRS) produced in farmer-managed aquatic systems (FMAS) in rural areas of Southeast Asia to food consumption

Dhaka Workshop (August 2001). Primary analysis of data from the 5 countries, including systems and important species. Proceedings reported in Aquaculture News article.

Roi Et workshop, Thailand, July 2004. Presentations to Department of Fisheries, Thailand on research process.

SIS Workshop at BAU (October 2002). Paper presentations and proceedings of BAU-ENRECA.DANIDA Workshop. In: Small Indigenous Species of Fish in Bangladesh: Culture Potentials for Improved Nutrition and Livelihood. Eds. Md. A. Wahab, S.H. Thilsted and Md. E. Hoq.

> Islam F, Immink A, Shaha KC, Islam S, Masud A and Little DC (2003). Self-recruiting species in aquaculture – their role in rural livelihood: A case study from South-Central and North-West Bangladesh.

Immink A, Farooqui R, Rahman M, Mishra S and Little DC (2003). Self-recruiting species in aquaculture – their role in rural livelihood: A case study from rain-fed West Bengal, India.

Morales EJ, Little DC and Demaine H (2003). Participatory approaches to define the role of self-recruiting species in aquaculture on rural livelihoods.

Conferences

Morales, E, Little DC, Demaine H, Yakupitayage A, Sophoan K, Turuongruang D, Kamsaentae S, Maneerat B, Phanny M, Houn C, Chantoun H, Wongpen S, Choorerd P, Viriyaphap T, Huu Hoa N, Chien Van N and Tat Hao N (2004). Local Resource Users Groups – An Approach of Improving Farmer-Managed Aquatic Systems. Proceedings of the 7th Asian Fisheries Forum, December 2004.

Morales, E, Little DC, Amihat E, Lorenzen K, Demaine H, Yakupitayage A, Huu Hoa N, Chein Van N and Van Van K (2004) Contribution of Self Recruiting Species of Aquatic Animals Produced in Farmer-Managed systems to Urban Food Supplies in Northern Vietnam. Proceedings of the 7th Asian Fisheries Forum, December 2004.

2nd international large rivers symposium, Phnom Penh – 'Aquaculture in a fisheries environment' – importance of systems at the aquaculture-fisheries interface, incl. active management of 'wild' aquatic animals in rice fields. Presentation. Feb 2003

National symposium of aquaculture 40th anniversary, RIA No. 1 Vietmam – oral and poster presentations.

Research on Water in Agriculture production in Asia for the 21st century' CARDI conference Cambodia, Nov 2003. Oral presentation.

6.2.3 Publications

Refereed

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.

Lorenzen, K. (in press) Population dynamics of fisheries stock enhancement: practical theory for policy analysis and management. Philosophical Transactions of the Royal Society of London.

Arthington A.H., Lorenzen K., Pusey B.J., Abell R., Halls, A., Winemiller K.O., Arrington D.A. & Baran E. (2003) River fisheries: ecological basis for management

and conservation. In: Welcomme, R.L. (Ed.) Proceedings of the 2nd International Large Rivers Symposium. Pnom Penh/Rome: Mekong River Commission/FAO.

Hartmann,

Lorenzen, K., Beveridge, M. & Mangel, M. Fish culture, domestication, and interactions between wild and cultured fish: the undiscovered country. Submitted to Fish and Fisheries

Other

Bangladesh Journal of Fisheries Special Issue – June 2004 – The potential of SRS in aquaculture for sustaining the livelihoods of rural poor in Bangladesh.

Amilhat, E. (2002) Life History Workshop. Aquaculture News 28; 15. Institute of Aquaculture, University of Stirling http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.15.pdf

Demaine, H., Van, K. V. (2002) Yes, Dr Luu, SRS are important - especially to the rural poor! Aquaculture News 28; 14. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.14.pdf)

Immink, A. (2002) Unusual SRS in South Asia. Aquaculture News 28; 16. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.18.pdf)

Little, D. (2002) Self-recruiting species - a new approach in aquaculture. Aquaculture News 28; 10-11. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.10.pdf)

Lorenzen, K. (2002) A scientist in no-man's land: bridging the gap between fisheries and aquaculture. Aquaculture News 28; 12. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.12.pdf)

Morales, E.J. (2002) Challenges in doing research in a rural area: experiences in Cambodia. Aquaculture News 28; 15. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.15.pdf)

Riley, J. (2002) A biometrical View. Aquaculture News 28; 13. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.13.pdf)

Ul-Islam, F. (2002) Stakeholder views from the workshop in Dhaka- how can poor people's access to self-recruiting species in aquaculture be improved? Aquaculture News 28; 13. Institute of Aquaculture, University of Stirling (http://www.dfid.stir.ac.uk/Afgrp/greylit/AN28.13.pdf)

Similar articles appeared in the AIT/AARM Newsletter – Jan 2002.

6.2.4 Internal reports

Livesey, S. (2000) Importance of self-recruiting species to rural livelihoods in South and Southeast Asia: a review. Internal report. 76 pp.

6.2.5 Theses

Beaton, P. (2002) M.Sc thesis. Aquatic self-recruiting species in rural livelihoods, Cambodia. University of Stirling, Scotland 70 pp.
http://www.dfid.stir.ac.uk/Afgrp/greylit/TH017.pdf

Soubry, S. (2001) M.Sc. Thesis. Factors affecting the role of self-recruiting species in Asian aquaculture. Imperial College London.

Livesey, S. (2000). M.Sc. thesis. Livelihood analysis of the importance of self recruiting species in northwest Bangladesh, and the additional effects of 'Rotenone' usage on this. University of Stirling, Scotland. 97 pp.
(http://www.dfid.stir.ac.uk/Afgrp/greylit/TH015.pdf)

6.2.6 Other activities

Fields of Fish at the Eden Project, UK (August 2004). Posters, stalls and drama were presented to the general UK public based around basic finding and facts about wild fish in rice fields.

<u>Bangladesh</u>

National Level Wetland Network (2002-2003). ITDG/Stirling promotion of wild fish/ non-stocked fish management. Participants included NGOs, INGOs and donors (DANIDA, DfID); these met 3 to 4 time per year.

Feedback workshops held in the field at 3 locations (January 2003).

Farmer meetings (with 30 farmers from 2 sites) to devise intervention research design from the farmers views on research processes (March 2003).

Poster distribution in districts of Bangladesh (May-June 2003). ‘New options for farming awareness to promote new species and conservation of broods in dry season’.

Monthly workshops were held during the intervention phase with all project farmers (March to December 2003)

Linking results with other projects involved disseminating the relevant finding from SRS to 3 other ITDG and DANIDA projects (May 2003 to June 2004).

Fish Fortnight (National Programme, Bangladesh, August 2003). Included high level DoF officials, Faridpur District, 30 farmers and 6 DoF, NGO staff.

Training and Sharing Workshop (June 2004). Participants included all 33 project farmers and 7 local women.

District level sharing workshop (June 2004). Participants included members of the Department of Youth, DoF, NGO's (RDRS and Hunger Free World) and farmer leaders.

Fisheries education and research fair (June 2004). Stall, posters, leaflets, presentation, CDROM, TV broadcast.

Thailand, Vietnam and Cambodia

PRA reports, Vietnam (Aug 2001).

Provincial workshop, Thailand (September 2001). Dissemination of PRA results to farmers, DoF staff, Tambon members, village headmen approx 30.

PRA reports, Cambodia (September 2002). Reports to DoF and provincial officers.

PRA reports Thailand (September 2002). Reports to AOP and DoF in 4 provinces.

1st farmer workshop (March 2003). Introducing intervention and tagging to farmers and AOP staff.

2nd farmer workshop (April 2003). Farmers helped to design the intervention trial.

AIT/AOP steering committee meeting, Thailand (May 2003). Project progress presented to steering committee.

Local authority announcements, Cambodia and Thailand (September to December 2003). Activities of the SRS project were announced.

National TV broadcast, VTV, Vietnam, May 2004. Description of project and MoF involvement.

Farmer workshops in Sisaket, Thailand (August 2004). Validated and explained some results, discussed future management plan.

6.2.5 Evidence of uptake

ITDG, AIT (and Outreach partners) and GVT have all included SRS in their aquaculture strategies for poorer households managing individual aquatic resources. More specific evidence will be collected during the next dissemination phase (see below in section 6.3).

The methodologies used for the research process in this project have been taken up in EU funded projects in which Stirling is also a partner. The Department of Fisheries, Thailand have also taken up the processes in a project they are funding in other provinces of Thailand. Wider promotion of the research processes will take place at workshops and conferences in the coming year.

6.3 Future activities towards development and promotion of outputs

A dissemination phase has now been funded by AFGRP to ensure wider promotion in the five target countries and awareness across the region of the potential role for SRS in farmer managed aquatic systems, especially for the benefit of the poor. Working with partners specialising in the promotion of findings as well as some of the original research partners the aim is raise awareness of the idea amongst farmers and increase connections between farmers and service providers. Information on SRS will be incorporated into extension materials from service providers, e.g. Department of Fisheries, rather than being delivered as a special message. There is evidence already that SRS are being incorporated into these messages already with partners, including the ITDG-Bangladesh in their field extension and AIT in its extension materials.

This new project will also attempt to assess the impact of this wider dissemination (and the original research) on the livelihoods of the poor.

Summary table - dissemination so far

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
1st Phase Aug 2001	Dhaka Workshop	Primary analysis of the data from the 5 countries, including systems and important species. Highlighted SRS importance in food security, and difference from SIS.	Presentations, working groups	Teachers and students from 5 universities of Bangladesh, Fisheries Development Projects, DoF, research institutes, AIT staff, SUFER-DFID. 120 delegates.	Audience asked for suggestions on future direction of project	Report of proceedings of workshop produced. Aquaculture News article with comments from participants Wide coverage of event in Bangladeshi newspapers. *Awareness on broader dimension of aquaculture for future, Priority of species and systems understood by researchers and development experts.*
1st Phase Aug 2001	Dhaka Workshop	Primary analysis of the data from the 5 countries, including systems and important species. Highlighted SRS importance in food security, and PRA findings.	Presentations, working groups	Teachers and students from 5 universities of Bangladesh, Fisheries Development Projects, DoF, research institutes, AIT staff. 120 delegates.	Audience asked for suggestions on future direction of project	Report of proceedings of workshop produced. Aquaculture News article with comments from participants. Wide coverage of event in Bangladeshi newspapers.
1st Phase Aug 2001	PRA reports, Vietnam	PRA findings	Reports in English and Vietnamese	Village Headman, RIA no. 1		
1st Phase Sept 2001	Provincial Workshop, Thailand	PRA findings	Presentations, working groups	Farmers, DoF staff, Tambon members, village headmen. >30 (5 per village in 6 villages + DoF)	Feedback on research so far – relevance, problems/issues in aquatic systems	Summary of workshop

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
2nd Phase 2002 - 2003	National Level Wetland Network	ITDG /Stirling promoting wild fish/non stocked fish management	Presence at the meetings, discussions	NGOs, INGOs & Donors (DANIDA, DFID). 20-25 participants, 3-4 times a year		They expect final outputs of SRS project to be disseminated to them. *NGOs, and related experts will put priority for the management issues of non stocked fishes and other wild aquatic animals*
2nd Phase Apr 2002	Articles in Aquaculture News	SRS and aquaculture, stakeholder views, unusual SRS in South Asia	Newsletter	Institute of Aquaculture staff, researchers and government staff around the world		
2nd Phase Oct 2002	SIS Workshop at Bangladesh Agricultural University	Livelihood issues, gender issues, species priorities, SRS availability and seasonality	Presentation of paper	University teachers, Researchers , DOF Officials, Fisheries Project Staff, Students. 30 people		Report of workshop proceedings produced, including paper, 'SRS in aquaculture – their role in rural livelihoods: a case study from rain-fed West Bengal'. *Advocate key issues of SRS Project to University teachers, Research Organisations, Department Of Fisheries*
2nd Phase Jan 2003	Feedback workshops in the field, at 3 locations	Results so far, and rough data from baseline monitoring and PRA	Presentation, handmade poster, discussions	Farmers who had been involved in project so far and a few interested local institutional players. > 70 farmers in upland and lowland site	Farmers approached to get agreement for involvement in intervention trials	Some farmers adopted practices from Cambodia and Thailand to encourage SRS *Share information from elsewhere and better understand their livelihoods and farming context*
2nd Phase March 2003	Farmer meetings	Intervention research design	Discussion	30 farmers from 2 sites	Farmer views of the design before implementation	*Farmers view on research process valued, farmer feel more ownership*

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
2nd Phase Jan 2002	Articles in AARM Newsletter	SRS in Aquaculture – intro, description of project, findings so far	Newsletter	Distribution by AARM in Thailand, Cambodia, Laos, Vietnam		
2nd Phase Apr 2002	Articles in Aquaculture News	Working with farmers, research in rural areas, SRS and aquaculture, stakeholder views	Newsletter	Institute of Aquaculture staff, researchers and government staff around the world		
2nd Phase Sept 2002	PRA reports, Cambodia	PRA findings	Reports in English and Cambodia	DoF and provincial officers		
2nd Phase Sept 2002	PRA reports, Thailand	PRA findings	Reports in English and Thai	AOP and DoF involved (4 provinces)		
2nd Phase Oct 2002	SIS Workshop at Bangladesh Agricultural University	Livelihood issues, gender issues, species priorities, SRS availability and seasonality	Presentation of paper	University teachers, Researchers , DOF Official, Fisheries Project Staff, Students. 30 participants		Report of workshop proceedings produced, including paper 'Participatory approaches to define the role of SRS in aquaculture on rural livelihoods'.
2nd Phase Feb 2003	2nd International Large Rivers Symposium, Phnom Penh	'Aquaculture in a fisheries environment', importance of systems at the aquaculture-fisheries interface, incl. active management of 'wild' aquatic animals in rice fields	Verbal presentation	Researchers, policy-makers, government officials		
2nd Phase Mar 2003	1st Farmer workshop	Introducing intervention and tagging	Meetings	Farmers and AOP staff. >30 people from 8 villages	Validated info from monitoring, discussed future project plans	Decided location of experiments and management strategies
3rd Phase March - Dec 2003	Workshops monthly during intervention phase	What had been learned during previous month	Discussion	All project farmers. 33 farmers, 2 meetings in 2 sites	Shared fears and hopes. Made plans for the next month	*Use of collective wisdom ,farmers coping mechanism understood, emphasize farmer to farmer sharing*

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
3rd Phase May 2003 - May 2004	Project briefing paper for more information	Project briefing, updated over time, including 'Future Direction & DoF/NGO role in dissemination' section	Report	Anyone who asked for more information on the SRS project		*Inform NGOs and other projects on the project activities.*
3rd Phase May 2003 - June 2004	Linking results with other projects	Relevant SRS findings	ITDG-B's dissemination strategy, through private village extensionists	3 other ITDG projects, DANIDA projects.		*Expect to reach at least another 600 households. Replicate and adapt SRS Project key messages/interventions.*
3rd Phase Aug 2003	Fish Fortnight (National Programme)	Farmers initiatives/on going activities on SRS management	Farmers talked about their experiences and showed visitors around ponds/fields	High level DoF officials, Faridpur District. 30 farmers and 4-6 DOF, NGO staff		Best of Exhibition Award. Increased local public awareness *Inform Govt. high officials at district level, feel ownership with the SRS project*
3rd Phase May - June 2004	Poster distribution	Title : New options for farming, awareness to promote new species and conservation of broods in dry season	Posters	Distributed in 4 districts: Panchaghar, Gaibandha, Jamalpur, Faridpur. 700 copies distributed (2000 printed)		Many farmers liked the poster and its issue, some village leaders suggests to broad cast the message in television. *Awareness among villagers/farmers and Govt. and NGOs*
3rd Phase June 2004	Training & Sharing Workshop	Results, lessons, criticisms	Discussions, exercises, posters, leaflets, packages of related materials	All project farmers, some local women. 33 farmers, 7 women, 2-3 day workshop	Made individual and village plans for activities after project finishes	Exercise outputs. *Customise key messages for farmers, help to initiate a individual and villager level plan*

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
3rd Phase June 2004	District level sharing workshop	Results, benefits and prospects of SRS management in ponds and rice fields	Presentation, discussion, posters, leaflets	Dept of Youth, DoF, NGOs (RDRS & Hunger Free World), farmer leaders. ~15 people		Dept of Youth asked for a curriculum and training. DoF high level decision-makers need to be informed. *Local (district level) level institutional players informed on the research results, and share their needs related to the project*
3rd Phase June 2004	Fisheries Education & Research Fair	Technical project report, abstract, policy & livelihood implications report	Stall, posters, leaflets, presentation, CDROM, TV broadcast	Researchers, DoF, policy-makers e.g. ministers, students, development projects, donors, entrepreneurs with commercial farms. Many visitors to stall over 2 day fair		*Reach large number of audience at national and regional level.*
3rd Phase June 2004	Bangladesh Journal of Fisheries Special Issue	'The potential of SRS in aquaculture for sustaining the livelihoods of rural poor in Bangladesh'	Extended abstract	University teachers, researchers, DOF, NGOs, private sector. 200 copies		*Inform Researchers, Scientists and University teachers*
3rd Phase Aug 2004	'Fields of Fish' at the Eden Project, Cornwall, UK	Basic findings and facts about wild fish in rice fields	Poster, stall, play	General UK public visiting Eden Project over 3 day bank holiday weekend		*Raise awareness of the general public about rice and fish issues in developing countries.*
3rd Phase Nov 2004	Asian Fisheries Forum	SRS project findings	Poster, booth, presentation	Policy-makers, government officials, researchers, private companies	Networking and making contacts for similar events in 5 target countries	Abstract accepted. *Expect many visitors and significant exposure*
3rd Phase Apr 2003	2nd Farmer workshop	Ideas on intervention trial	Discussions	Farmers involved in intervention trials. 10-20 people in each of 14 groups from 3 countries	Farmers help design intervention trial	Intervention trial designed and set up

Date and phase	Dissemination event	Material/info disseminated	Media used	Audience	Other activities	Results (*expected results*)
3rd Phase May 2003	AIT/AOP steering committee meeting, Thailand	Progress of project so far	Presentation, group discussion	DoF, AOP, Deputy of MoF, provincial heads and biologists of all provinces in NE. ~30 people	Discussion whether to continue to support the project	Decided to continue supporting project
3rd Phase Sept – Dec 2003	Local authority announcements, Cambodia and Thailand	Activities of the SRS project	Announcements	Villages involved in project		
3rd Phase Nov 2003	National Symposium of Aquaculture 40th Anniversary, RIA No.1 Vietnam	Processes, outputs and findings of project so far	Oral and poster presentations	Researchers, university teachers, Ministry of Fisheries officials. >50 people		
3rd Phase Nov 2003	'Research on Water in Agriculture Production in Asia for the 21st Century' CARDI conference, Cambodia	'Livelihood improving functions of pond based integrated agriculture aquaculture systems'	Oral presentation	50 people		
3rd Phase May 2004	National TV broadcast, VTV Vietnam	Description of project and MoF involvement in it	TV	Nationwide. Large number of viewers.		
3rd Phase July 2004	Roi Et workshop, Thailand	Project processes, findings and outputs	Presentations	DoF, Fisheries Colleges, AOP. >30 people	Discussion groups on relevance of project and methods for dissemination	Report from workshop, including translation of group discussions. DoF are planning to use the processes in their own project in 5 provinces of NE Thailand.

Date and phase	**Dissemination event**	**Material/info disseminated**	**Media used**	**Audience**	**Other activities**	**Results (*expected results*)**
3rd Phase Aug 2004	Farmer workshops in Sisaket, Thailand	Presented results from tagging and discussed ideas for improving management and working in groups	Presentation and discussions	Farmers involved in tagging, and other interested parties. 25-38 participants per village, in 2 villages.	Validated and explained some results, discussed future management plan	Willing to work in groups to design suitable conservation zones regarding results of study. Expressed need to carry results to Orbotor to spread information in the area.
3rd Phase Aug 2004	'Fields of Fish' at the Eden Project, Cornwall, UK	Basic findings and facts about wild fish in rice fields	Poster, stall, play	General UK public visiting Eden Project over 3 day bank holiday weekend		*Raise awareness of the general public about rice and fish issues in developing countries.*
3rd Phase Nov 2004	Asian Fisheries Forum	SRS project findings	Poster, booth, presentation	Policy-makers, government officials, researchers, private companies	Networking and making contacts for similar events in 5 target countries	Abstract accepted. *Expect many visitors from across Asia and significant exposure.*

Summary table of the activities and people that were involved in specific activities of the research

Actors	Project Planning	Proposal Writing	PRA	Data analysis	PRA Report Writing	Background Survey	Analysis / Report Writing	Monitoring	Data analysis / Report writing	Experiments (Life history/ Tagging/ other UK expt.)	Analysis / Report writing	Interventions (LRUG Approach/Carp polyculture)	Analysis Report writing	Final Report
Institute of Aquaculture, Stirling														
Dave Little	X	X	X			X		X	X	X	X	X		X
Anton Immink			X	X	X	X	X	X	X					X
Ernesto Morales*			X	X	X	X	X	X	X			X	X	X
Faruk Ul Islam*			X	X	X	X	X	X	X			X	X	X
Iaonnis Karapanagiotidis										X	X			
Penny Beaton				X	X									
Imperial College, London														
Kai Lorenzen	X	X				X		X		X	X			X
Caroline Soubry			X	X	X									
Elsa Amilhat*						X	X	X	X	X	X			X
Asian Institute of Technology														
Dr. Harvey Demaine	X	X	X			X		X				X		
Dr. Amara Yakupitayage	X	X				X		X		X	X	X		

Actors	Project Planning	Proposal Writing	PRA	Data analysis	PRA Report Writing	Background Survey	Analysis / Report Writing	Monitoring	Data analysis / Report writing	Experiments	Analysis / Report writing	Interventions	Analysis Report writing	Final Report
Mr. Danai Turongruang			X			X		X		X		X		
Mr. Eric Meusch	X		X			X		X				X		
Bangladesh														
ITDG														
Mohammed Ali			X			X		X						
Kingkar Chandra Saha			X			X		X						
Al Masud			X			X		X						
Shams			X			X		X				X		
Shafiq														
India														
Gramin Vikhas Trust														
JS Gangwar			X			X								
Mahfoozur Rahman			X			X								
Rashid Farooqui			X			X								
Snehasish Mishra			X			X								

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