

SELF-RECRUITING SPECIES (SRS) FROM FARMER MANAGED AQUATIC SYSTEMS: THEIR ROLE IN RURAL LIVELIHOODS



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.

Abstract

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Aquatic resources play an important role in rural livelihoods throughout the rice farming regions of Asia and are particularly critical for the poor. Aquatic resource use comprises rice farming, capture fisheries in open waters, conventional aquaculture in farmer's ponds and cages and the active management and harvesting of aquatic animals from farmer-managed aquatic systems (FMAS) such as rice fields and ponds. Whereas capture fisheries and aquaculture have received much attention in development and research, the role of these aquatic animals from FMAS (known as self-recruiting species or SRS) has long been overlooked. The present project aimed to characterise the role of SRS in rural livelihoods, understand their ecology, and identify management strategies to maintain or increase productivity of and access to such resources. Research was carried out in five countries: Thailand, Cambodia, Vietnam, Bangladesh and India, in different physical environments, agricultural systems and socio-economic conditions.

Characteristics of FMAS and important SRS were analysed in all project countries. Key SRS included several fish species as well as frogs, snails, crabs and shrimps. A wealth of indigenous management techniques have been documented, and several including brush parks and manuring have been shown to be effective in increasing SRS availability from FMAS.

Harvesting of aquatic animals was an important activity in all project sites, regardless of whether conventional aquaculture was developed or not. SRS from farmer managed systems often accounted for the major part of the total catch. Harvesting of SRS was also more efficient than harvesting in open waters: households catch more wild aquatic animals with less effort in FMAS compared to open water systems.

The SRS catch is used mainly for consumption within the household and often accounts for a large part of animal protein intake. About one third of households also sell SRS for cash. Overall SRS are most important to the poorer households. SRS are especially important during the dry season when access to other water bodies becomes limited.

Trials in Bangladesh show that incorporating SRS into conventional polyculture systems is beneficial overall and has no measurable negative effect on the production of stocked fish.

FMAS are closely linked to each other and to larger open waterbodies facilitating the migration of aquatic animals with flooding and receding waters. Coordinated management of FMAS and SRS through local resource user groups (LRUG) was identified as a promising management intervention that was tested in participatory experiments. The majority of LRUGs reported perceived overall benefits.

These findings indicate that SRS are a valuable resource for the rural poor, which can be maintained and enhanced through agricultural, aquaculture and environmental management programs.

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Introduction

Previous research has highlighted the importance of aquatic resources in both natural and managed habitats to the livelihoods of the rural poor particularly in rice farming landscapes (Mazumder and Lorenzen 1999; Gregory and Guttman, 2002; Meusch *et al.* 2003). 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.

Self-Recruiting Species (SRS):

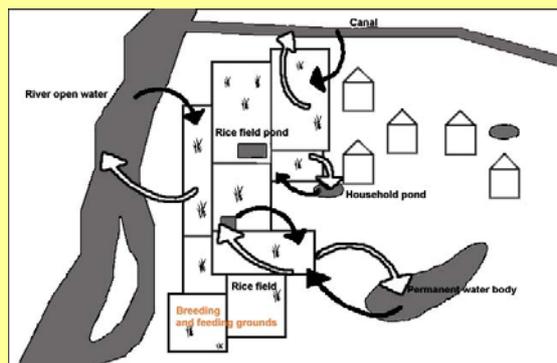
Are aquatic animals that can be harvested sustainably from a farmer managed system without regular stocking. They can be indigenous (fish and non-fish) or introduced species such as tilapia (Little, 2002)

Farmer managed aquatic system (FMAS):

Are systems managed by farmers, such as ponds or rice fields, that fill with water during at least one period of the year (rain-fed or irrigation) providing habitats for aquatic animals. Management includes any form of activity aiming to enhance the production of aquatic plants and animals.

Rice farming landscapes

Are characterised 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. The diagram below illustrates typical lateral migration patterns. At the start of the wet season (around May-June in the study area), Mobile aquatic animals 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 where food is abundant. When the dry season arrives, these aquatic animals return to permanent water bodies (white arrows). Aquatic animals performing such lateral migrations often enter farmer-managed systems such as rice fields and pond, and thus form the main "SRS".



Objectives

The purpose of the project was to characterise the role of self-recruiting species for rural livelihoods in different farmer managed aquatic systems, to analyse their ecology and to identify management strategies to increase, or at least maintain productivity of and access to such resources.

Please note that the majority of results presented in this report are for Southeast Asia as the greatest understanding of the data to date is for this area.

Site selection

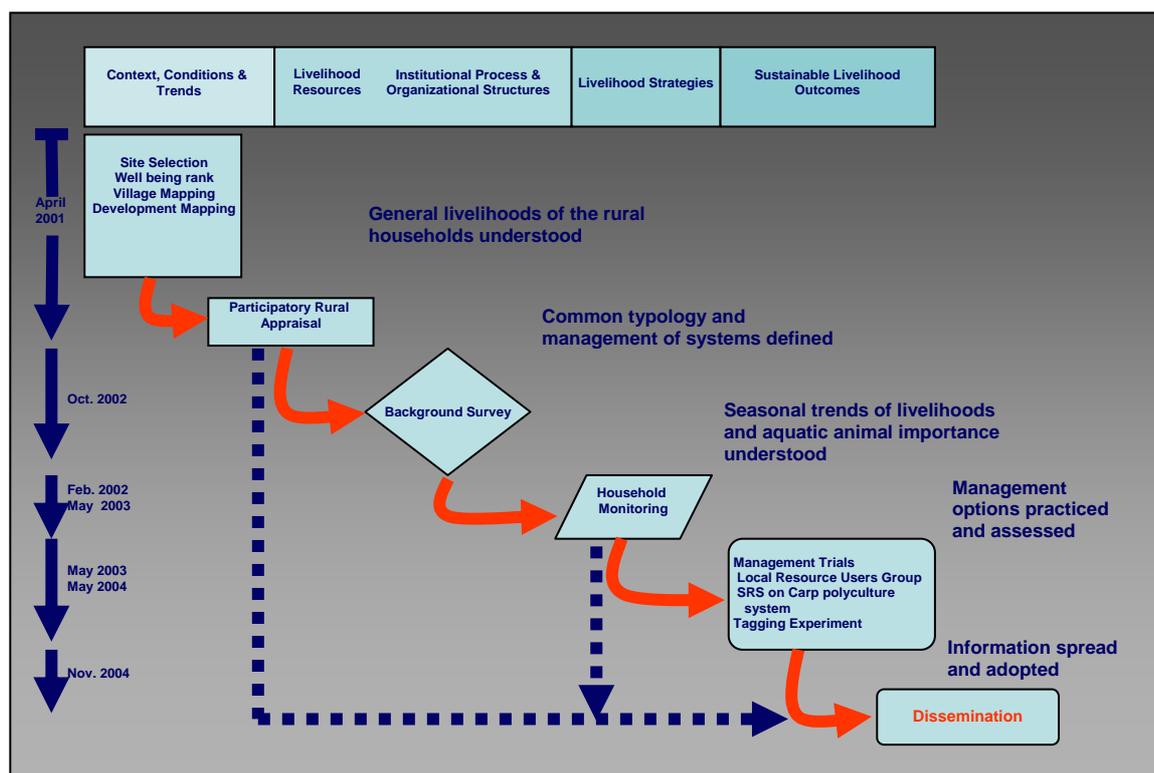
Field activities were conducted between April 2001 and November 2004 in five countries where aquatic resources are known to play a significant role in rural livelihoods: Cambodia, Thailand, Vietnam, Bangladesh and West Bengal in India.

Sites 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 representative of a more aquaculture-dependent situation; lowland Cambodia where aquaculture among rural smallholders is undeveloped and there is greater dependence on capture fisheries; Sisaket, Northeast Thailand hypothesised to be intermediate; Bangladesh with strong cultural dependence on wild fish, but with increasingly intensive agriculture and aquaculture and West Bengal, India with limited water availability and little dependence on fish. Within country, sites and communities were identified based on topography, proximity to perennial water and poverty level. A description of each study site is provided table 1.

Table 1. Description of the study sites

Country	Study sites	Characteristics
Thailand	Northeastern region (Isan) Provinces of Sisaket, Yasothon and RoiEt	-least developed region with the lowest per capita GDP -Farming is the major occupation of 80% of the population -the region supplies 36% of the country's rice -largely flat with considerable seasonal wetland areas -extreme dry season and an infertile soil -Only one rice crop is grown each year
Cambodia	lowland province of Svay Rieng and the much dryer upland province of Takeo	-The majority of Cambodian population (84%) lives in rural areas, agriculture involving 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 <i>et al.</i> , 2003).
Vietnam	Red River Delta region in northern part. Phu Xuyen and Soc Son Districts	-intensive, irrigated rice -Inland aquaculture is well developed and very productive with 727000 tons in 2000 (Anh <i>et al.</i> , 2003). -The agricultural sector (mainly rice production) represents about a quarter of the total GDP (Anh <i>et al.</i> , 2003) -Irrigation is facilitating the production of two rice crops.
India	Purulia and Midnapore districts of West Bengal	-typically upland areas with limited flooding and poor lateritic soils -Agriculture is the main income source although only one rice crop is grown each year -Community forestry offers significant labour opportunities and resources for the mainly indigenous population.
Bangladesh	Faridpur and Rajbari districts Dinajpur and Panchagarh districts	- Low-lying district in south-central Bangladesh: annual flooding events merge individual farmer resources into larger community waterbodies -Northwest Bangladesh: 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.

Research schedule



Findings

Importance of fishing and aquaculture in livelihood

Community level appraisals indicated that fishing in natural aquatic resources is important in rural livelihoods in all project countries (Figure 1). 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 the livelihoods of poor households, particularly through provision of food. Unexpectedly, the perceived importance of aquatic resource use increased with distance from larger open water

An output of the project – Self-recruiting species in farmer managed aquatic systems: importance to rural livelihoods

bodies, possibly indicating that people expend more time on meeting subsistence requirements when living at distance from perennial water. The importance of wild aquatic resources increased with distance from towns, whilst the importance of aquaculture declined. Most respondents felt that the availability of natural aquatic resources had declined over time.

Rural people in Cambodia and Thailand depend on aquatic resources caught from the wild for food and income, and aquaculture is relatively unimportant as wild resources are still abundant (Figure 2). In Vietnam and Bangladesh, aquaculture and wild fishing are both important for food and income. Aquaculture tends to be more important to the better off and fishing to the poor.



Photo: Rice fields, Vietnam

Household ponds are located near the farmer's house, tend to be closed off from the surrounding aquatic environment, and are used mainly for water storage and/or 'conventional' stocked aquaculture. These systems were present for around 25% of households in Cambodia and Vietnam.

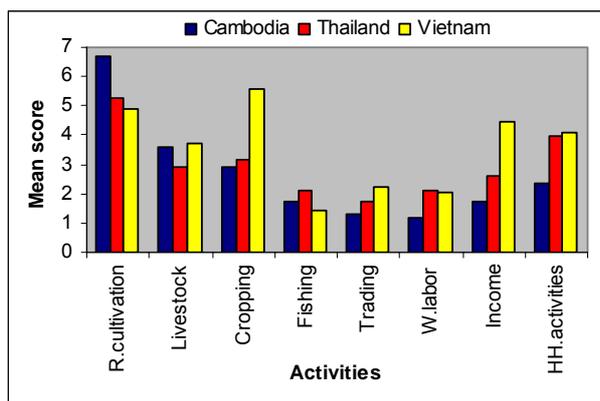


Figure 1. Importance of fishing to livelihoods compared with different major activities (maximum score is 10)

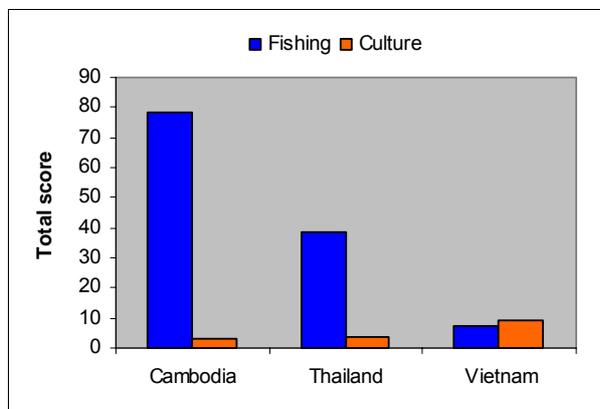


Figure 2. Comparison on the importance of fishing as opposed to fish culture in three countries of SE Asia (maximum score is 100)



Photo: Household pond, Vietnam



Photo: Household pond, Cambodia

Ponds in rice fields 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). This was the most common type of pond in Bangladesh and over 70% of households in Thailand had a pond in their rice field. In India these were only accessible to the better off households.

Farmer managed aquatic systems (FMAS) characteristics and management

FMAS characteristics

The main components of the FMAS are **rice fields**, almost universally, and 4 different types of ponds. The main differences between these pond types arise from their location, morphology and primary intended use.



Photo: pond in rice field

Ponds located within natural lakes used to trap wild fish (SRS), were only present in Cambodia.



Photo: pond in the lake, Cambodia

Bid rent ponds are present only in Vietnam, they are large ponds that households can rent from the government for a limited period of time mainly to culture hatchery fish.



Photo: bid rent pond, Vietnam

Overall, farmers in Cambodia, Thailand and Bangladesh are more likely to have their own ponds than farmers in Vietnam or India. In general, the area of rice fields owned per household was significantly larger in lowland areas than in upland areas. Rice fields area owned per household in Vietnam is significantly smaller than those in Thailand and Cambodia, probably due to the higher population density. A large proportion of surveyed households from the 2 districts of Red river Delta, Vietnam had no pond (80%) and in the drier province of Takeo in Cambodia where 50% of the surveyed households do not have pond. However FMAS in Cambodia is more diverse in types than anywhere else which shows a larger dependence on aquatic resources.

Most FMAS, are prone to flooding, with the exception of those in Vietnam, India and in the Cambodian upland province of Takeo. 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). Irrigation canals were only developed in Vietnam; Cambodian, Bangladeshi and Thai study sites rely mostly on rain and floods from larger water bodies.

Management activities in FMAS and effect on total yield

Farmers' attitudes to SRS and their consequent management actions varied widely between countries (Figure 3). 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, 40% 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. In India and Bangladesh most farmers allowed SRS as they were seen as 'free food'.

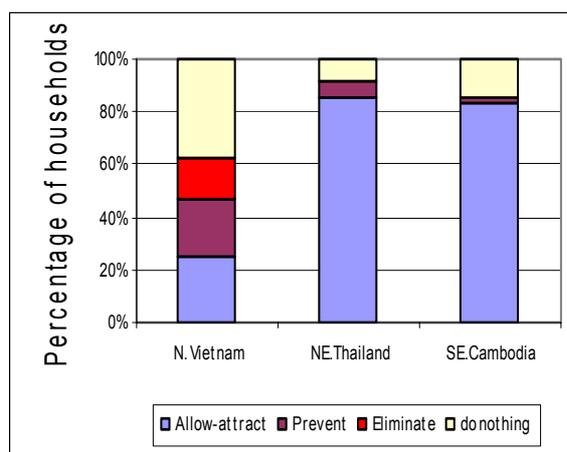


Figure 3. Attitude and management actions towards SRS of farmers with ponds

A range of indigenous management activities aimed at SRS were practiced by farmers (Figure 4). The most common activities aimed at allowing or attracting SRS into the pond were building brush parks and deepening ponds as well as feeding and retaining water during the dry season. The most common measures used to exclude or eliminate SRS were screening of the pond and liming and to a lesser extent the use of pond drying and pesticide applications.

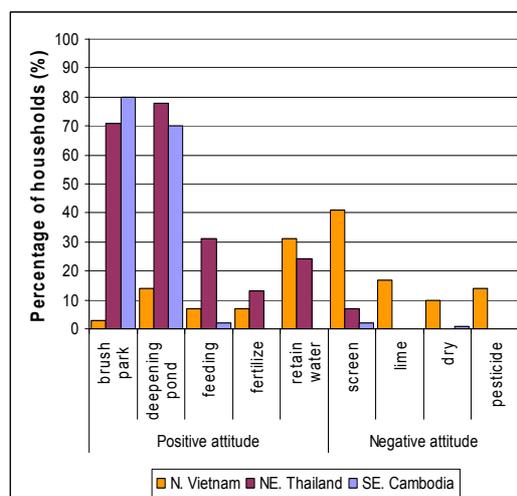


Figure 4. Percentage of household involved in different SRS management activities from the baseline survey.

Farmers may adopt different 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.

Catch per unit effort (CPUE) has been measured for particular management activities and 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. Pond preparation, stocking, feeding and water management activities provided significantly higher CPUE. 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.

Diversity and important SRS

The determination of the important SRS derives from the triangulation of the PRA results, the baseline survey and the household monitoring survey. Farmers were always asked for the local name and depending of the location and the household, this name corresponded to a particular species or a group of species that comprise similar looking species. In the household monitoring survey, farmers distinguished 66, 24 and 17 types of aquatic animals in Thailand, Cambodia and Vietnam respectively. Cambodia is well known for its species diversity and the small number of aquatic organism types here reflects farmer habits to give only general group names and not specific name for each species. In Vietnam, the low diversity of SRS may be due to the fact that wild fish were rarer and farmers with ponds were more focused on cultured species and often perceived wild fish as pests. Non-fish species were also important and accounted for 8, 4 and 5 types in Thailand, Cambodia and Vietnam respectively.

Figure 5 shows the importance of the high value predator fish climbing perch (*Anabas testudineus*), snakehead (*Channa striata*) and catfish (*Clarias batrachus*) in the three countries, especially in Thailand and Cambodia where they make up more than 40% of the total catch by weight. Non-fish species were also important, shrimps and snails in Cambodia and Vietnam. Small fish species such as *Esomus spp.* and *Rasbora spp.* were also important in all five countries, especially for home consumption for the poorest households.

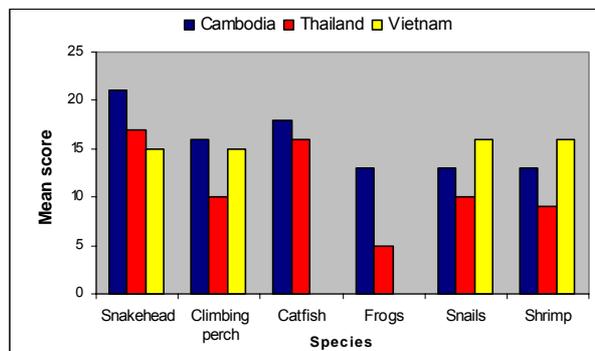


Figure 5. Important self-recruiting species in the three countries of SE Asia based on PRA results

SRS importance in the catch

Fishing and foraging for aquatic animal is almost universal with more than 85% of the household involved in all countries. The average total catch per household per year in Thailand was 182kg, in Cambodia 108kg in Svay Rieng and 12kg in Takeo, and in Vietnam 418kg in Phu Xuyen compared to 60kg for Soc Son. Significant differences between provinces in Vietnam and Cambodia come from the higher aquaculture development in Phu Xuyen province and a particularly dry year in Takeo.

The total catch includes wild aquatic animals caught in FMAS (SRS), wild aquatic animals caught in open water bodies (such as swamps, reservoirs and rivers), and stocked species collected in FMAS. SRS dominate the catch in Thailand and Cambodia (figure 6) whereas stocked species dominate the catch in Vietnam. Harvesting of SRS was also more efficient than harvesting in open waters: households catch more wild aquatic animals with less effort in FMAS compared to open water systems.

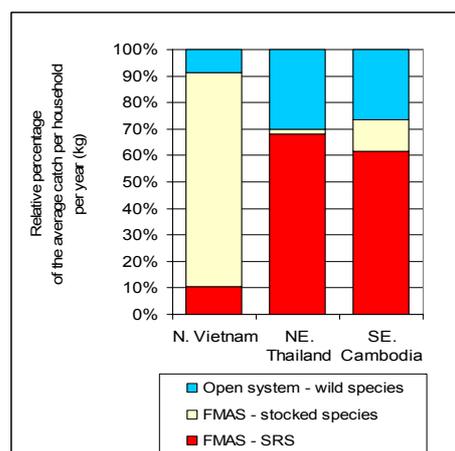


Figure 6. Average catch per household per year showing proportions of SRS, wild catch from open systems and stocked species.

In Cambodia and Thailand, rice fields are the main SRS fishing location during the rainy season and when the water recedes (Sept-Nov). During the dry season most of the catch is made from the ponds. Non-fish species catch was important almost all year round and particularly during the rainy season when they are more available. In Vietnam the trend is more complex due to the well developed irrigation system that makes 2 periods particularly favourable for the

catch during rice culture from March to May and from August to October.

Most of the households in the three countries retain the catch for home consumption although there is difference between countries. In Vietnam selling stocked and wild species was important for households having a pond. In Cambodia some households sell a small part of the catch (<30%, including stocked species and SRS), but consume most of it. In Thailand, farmers rarely sell their catch, process and gift are more important.

Important role of SRS in the diet

Major differences existed in the nature of diets within the three countries and the contribution of aquatic animals (AA) (Figure 7). In Cambodia the diet is not very diversified, with major reliance on AA and vegetables to supplement the major consumption of rice, all indicative of greater poverty. In the villages studied in Thailand AA feature significantly and indicate the good availability of AA at these sites. In addition to vegetables, meat and processed food were relatively more important in Vietnam, reflecting the greater role of pork and tofu in diets. The percentage of AA consumed in Vietnam is similar to Cambodia, but has greater significance in Cambodia, where the diet is less diversified.

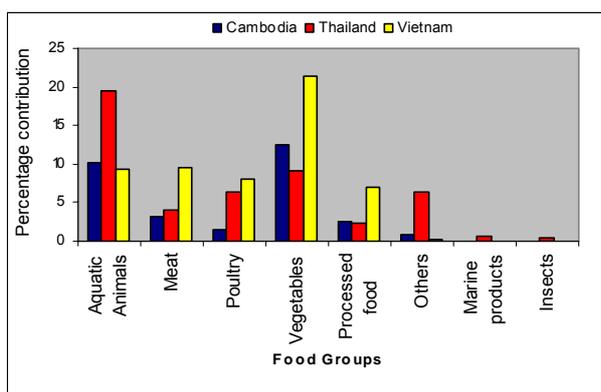


Figure 7. Percentage contributions of aquatic animals to overall food consumption by weight (excluding rice, which is over 70% in all cases)

AA from farmer-managed aquatic systems (SRS) dominated consumption in Thailand and Cambodia but were far less important in Vietnam (figure 8). Other research has shown that more AA from open access sources were consumed in Thailand than in Cambodia and Vietnam. 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 better-off and poorer. Fresh AA were more important than preserved forms by weight consumed and frequency of consumption in all three countries. Preserved, especially fermented fish were relatively more important in Cambodia than in Thailand and Vietnam.

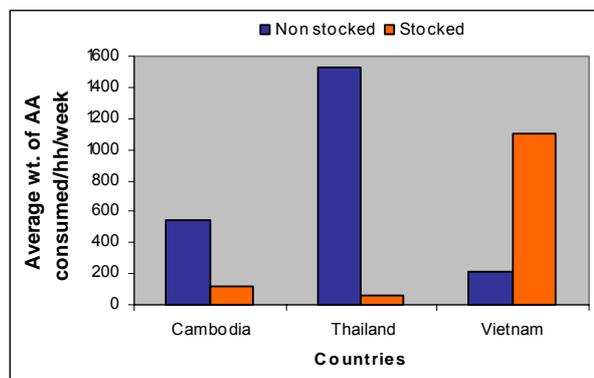


Figure 8. Average consumption of SRS and stocked aquatic animals by households in Cambodia, Thailand and Vietnam.

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 9). Seasonal variation was greater for the poor than for the population as a whole. 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, especially during the wet season during the rice cultivation period when households have no time for collecting fish.

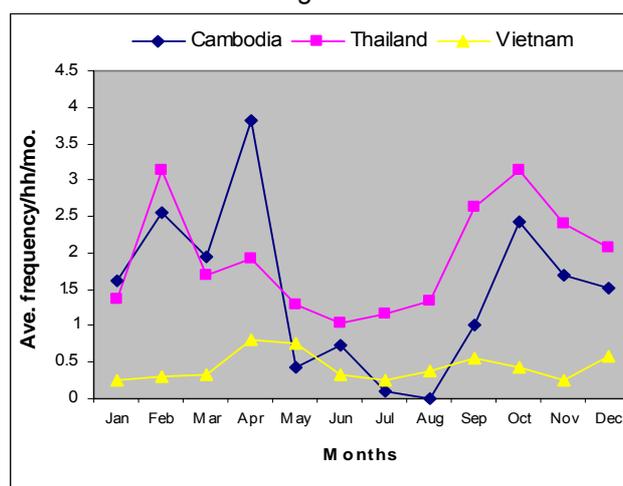


Figure 9. Comparison on the monthly trend of frequency of eating SRS.

SRS contribution to the household capital

Financial capital. The harvest of aquatic animals was a source of income for more than 40% of the households assessed in each country. But as a proportion of total household income (Figure 10), aquatic animals contributed most in Vietnam (>10%) and least in Thailand (<3%), reflecting the well developed and commercial nature of aquaculture in Vietnam. 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 (figure 11). 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.

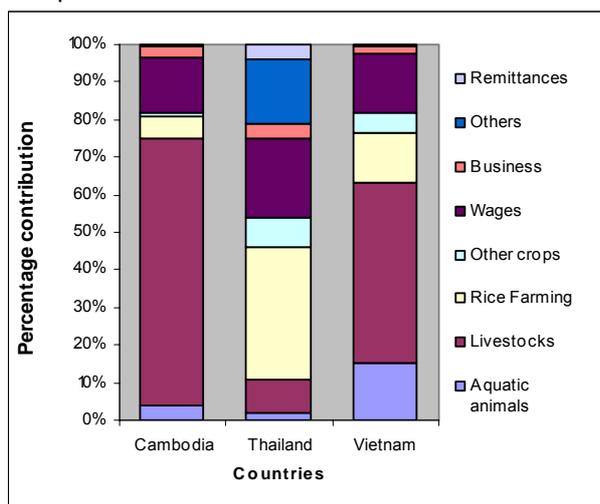


Figure 10. Percent contribution of the different sources of income to total household's income in rural areas of the three countries of SE Asia

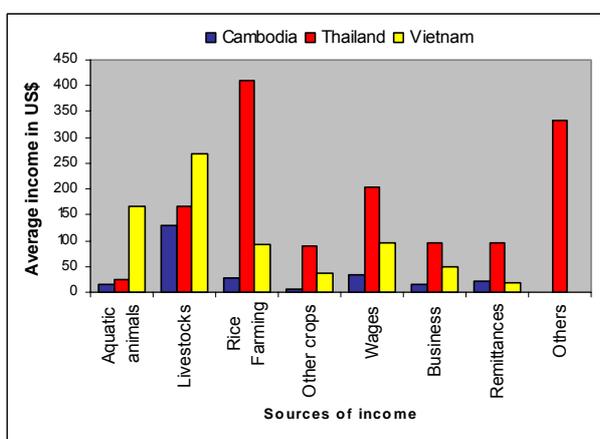


Figure 11. Average income from the different sources of income in rural areas of the three countries of SE Asia (13 weeks data)

Overall economic value of SRS catch. 25% of households in Thailand and 40% in Cambodia and in Vietnam sold SRS. The average price of selling aquatic animals was 0.6 USD/kg in Thailand, 0.4 USD/kg in Vietnam and 0.7 USD/kg in Cambodia. The corresponding value of the SRS catch was 58 USD in Thailand, 7 USD in Vietnam and 2 and 45 USD in Takeo and Svay Rieng respectively per year per household. SRS catch is potentially important for producing cash income, especially in Svay Rieng, Cambodia where it accounted for a quarter of the estimated income from rice harvest. Prices of wild aquatic animals varied with the season, and get higher when the resource is less available during the dry season. In all study sites, wild fish generally reach higher prices than culture fish and also SRS get higher market price when less available during the dry season.

Social Capital. Sharing of aquatic animals was probably underestimated during monitoring as it was clear that the practice was quite common, notably in Thailand and especially of low market value AA species among relatives and neighbours, whenever

amounts in excess of meeting immediate needs were obtained.

Nutritional Value of SRS

A small study was conducted to assess lipid profiles and therefore an important aspect of the nutritional value of SRS. A total of 30 individuals of six species, including *Channa striata*, *Clarias batrachus*, *Anabas testudineus*, *Rasbora borapetensis*, *Puntius brevis* and *Macrognathus sp.* were analysed for their total lipid and fatty acid profiles. The specimens were sampled in rice fields in August 2002 in NE Thailand field sites. A number of fish were also bought from the district fish markets. Lipid analysis was conducted on edible muscle tissue and included lipid extraction fatty acids (FA) analysis by gas liquid chromatography.

In terms of human nutrition, these species are a rich source of essential polyunsaturated fatty acids (PUFA), though their edible muscle fat is low (<5%). There were no great differences in the FA profiles among the different species. SRS are a good source of the health-related $\Omega 3$ PUFA, with *Rasbora borapetensis* displaying the highest $\Omega 3$ content and $\Omega 3/\Omega 6$ ratio. Snakehead (*Channa striata*) also contained high levels of $\Omega 3$ PUFA and specifically of 22:6 $\Omega 3$ (DHA), which is an essential FA for the brain and eye development during early natal life. All fish species were also a good source of arachidonic acid, essential in human nutrition for normal immune function and reproduction.

Local resource user groups (LRUGs)

LRUGs allow joint management of water and living aquatic resources within tracts of interconnected FMAS, allowing for increased benefits over and above those achievable within each separate FMAS in the absence of cooperation. LRUGs were initiated in a total of 14 areas with 78, 85 and 29 households respectively in Cambodia, Thailand and Vietnam. LRUGs included rice fields in each country and other FMAS characteristic of each country: Trap ponds and household ponds in Cambodia, Trap ponds and culture ponds in Thailand and Portion of canal and lake in Vietnam. A consultation in each village identified potential areas and groups who would agree on management plans and assess their effectiveness. A series of workshops was conducted seasonally (four workshops/groups) to assess progress of activities and collect information on the following:

1. Importance of the rice fields and ponds in each tract (based on time spent)
2. Availability of the different resources in each pond or field
3. Food collected in each tract
4. Flow of resources
5. Labour distribution for managing the tracts
6. Plan of activities for the next season

After a year of monitoring, a final evaluation of the group activities was carried out. Group discussions were carried out with all the 14 groups

following a checklist of information. Perceptions regarding LRUGs were also gathered from non-member farmers, with 280 farmers responding in total.

The rank of management activities (Figure 12) 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 the tract. Creating habitats and improving the physical nature of the system were not prioritized in Thailand, but considered important in both Cambodia and Vietnam. The lack of interest in broodfish retention in Vietnam perhaps reflected the focus on improved tilapias and common carp.

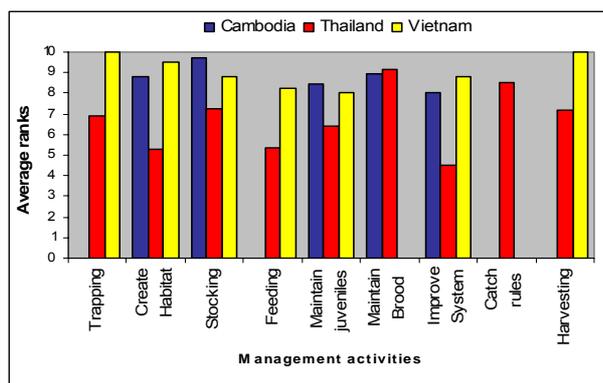


Figure 12. Average ranking of management activities practiced by members of Local Resource Users Groups. (Rank 10 is the highest and most important).

Perceptions of benefits of LRUGs.

At the end of the one year trial, the ability for people to work together and to realise 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 suggests the value this 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.

Incorporation of SRS into carp polyculture

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.

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 the three 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. 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. 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 for poorer farmers who do sell more SRS than they consume, there is potential for growing SRS for income generation.

Snakehead population study highlighted the importance of perennial water bodies to sustain SRS populations

Snakehead (*Channa striata*) are the most valuable SRS resource in Thailand and Cambodia, and the main target of active management by farmers. A population dynamics field study of snakehead was carried out during one year from May 2003 to June 2004 in two adjacent villages (Lumpoo and Steng) in Northeast Thailand, where farmer managed systems dominate seasonal aquatic habitats. An extensive information campaign using posters and audio messages along with workshops were conducted in both target villages and in all surrounding villages.

Tagging was carried out on fish of at least 20cm using a 3cm T-bar anchor tag. Fish were tagged 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)

(results table 2). The weight, total length and recapture location were recorded by one farmer in each village and reward given to those reporting a capture. The information was mapped using aerial photographs and farmers' maps (figure 13). 30 randomly selected households in the two target villages recorded their total snakehead catches throughout the experimental period.

Movements of snakehead were localised with the majority of fish (75%) being recaptured within 500m of their release site (figure 13 and 14). Natural and fishing mortality rates were estimated by fitting a simple population model to tag-recapture data. Natural mortality rates suffered by snakehead were extremely high at 3.0-3.6 y^{-1} , and about 20% of recovered tags were returned from fish that had died naturally as seasonal habitats dried out. Fishing mortality, albeit high in absolute terms (0.7-1.7 y^{-1}), makes only a minor contribution to total mortality and may well be at least partly compensatory. This indicates that while farmer managed systems support very high production in the wet season, only a very small proportion of fish from these systems will survive the dry season, and recruitment originates largely from larger perennial water bodies. This illustrates the importance of natural aquatic habitat in sustaining SRS production in farmer managed systems. Perennial aquatic habitats within farmer managed systems may be more important in areas where natural water resources are scarce.

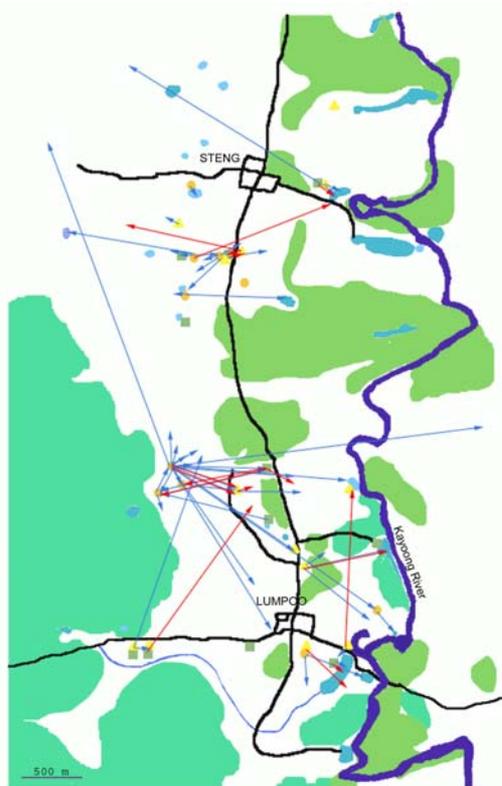


Figure 13. Recaptures of the tagged fish at the study site. Blue arrows represent the up-migration (May – Oct.) and red arrows the down-migration (Nov. - April). (migrations <50m are not indicated on the map)

Table 2. Percentage of marked fish recaptured (%rec) per tagging events NbR =number released, NbRec=number recaptured

Tagging events:	NbR	NbRec	%rec
1. Up migration from the ponds (10 locations) (7 May - 14 May 2003)	297	83	28%
2. Up migration from the rice fields (13 locations) (28 Aug. - 12 Sept 2003)	156	26	17%
3. Down migration from the rice fields (11 locations) (30 Oct-14 Nov 2003)	298	31	10%

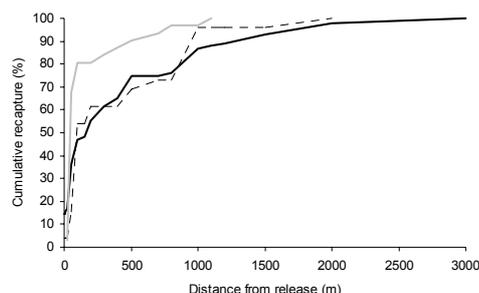


Figure 14. Cumulative recapture of marked snakehead as a function of distance from the release site. Lines represent the three tagging events: up migration from trap ponds (black), from rice fields (dashed) and the down migration (grey).

Biological sampling programme - 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 field limitations. 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. During one year, monthly samples of 30 specimens were collected for all species from farmer managed aquatic systems (ponds and rice fields) and associated open systems such as rivers, canals and lakes. In all samples the aim was to cover as wide a range of sizes and life stages as possible using a variety of gears. Parameters measured included: standard length and body weight; sex, gonad weight, maturity stage and number of eggs; and stomach contents.

Life history information on key SRS was then gathered from both the biological sampling programme and from the households monitoring survey which recorded farmer observations on the biology of SRS. On the whole the information obtained was consistent and/or complementary. 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 perennial pond is maintained within them.

Summary of key results

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, FMAS characteristics and 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.

Harvesting of wild aquatic animals was an important activity in all project sites, regardless of whether conventional aquaculture was developed or not. SRS from farmer managed systems often accounted for the major part of the total catch. Harvesting of SRS was also more efficient than harvesting in open waters: households catch more wild aquatic animals with less effort in FMAS compared to open water systems.

Trials in Bangladesh show that incorporating SRS into conventional polyculture systems is beneficial overall, and has no measurable negative effect on the production of stocked fish.

FMAS are closely linked to each other and to larger open waterbodies through migrations of SRS. Coordinated management of FMAS and SRS through local resource user groups (LRUG) was identified as a promising management intervention and tested in participatory experiments. The majority of LRUGs reported a range of perceived benefits. Management techniques that have been effective include keeping of broodstock, re-stocking of collected juveniles and the screening (or not) of pond entrances.

Recommendations

Consider SRS in agricultural, aquaculture and environmental management

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 and shows promise in the maintenance and enhancement of SRS in poor communities.

Investigation should be done to evaluate the trade-offs of intensifying aquaculture production against loss of traditional system. This should lead to a balance promotion of aquaculture and biodiversity protection.

Identify ecosystems that are important for SRS and develop strategy to protect these environment and make it more accessible to resource poor households.

Perennial water bodies are essential for SRS population sustainability and should be preserved from urban development and agricultural/aquaculture intensification.

Focusing on understanding the biology of some important SRS species to enable us to manage and protect them properly.

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Project partners

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. See table below:

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