SELF-RECRUITING SPECIES (SRS) IN AQUACULTURE: THEIR ROLE IN RURAL LIVELIHOODS IN TWO AREAS OF BANGLADESH

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ABSTRACT

Self-recruiting species (SRS) are the aquatic animals that do not require repeated stocking in farmer managed aquatic systems (FMAS) and can be of indigenous or exotic origin (Little, 2002). Current concept of conventional aquaculture greatly underestimated the contribution of SRS to the livelihoods and particularly nutritional security of the poor. The present study examines the role of SRS in poverty focused aquaculture. The role of SRS in aquaculture was evaluated from the perspective of people dependent on them in terms of well-being, gender, resource access and broader livelihoods in the northwest and south-central region of Bangladesh. SRS management practices, already an existing component of aquaculture in FMAS, were explored to define sustainable management strategies that benefited poor.

The thesis uses a livelihoods framework within a methodological context of participatory action research at household, community and national level. The process begins with a Participatory Community Appraisal (PCA) in 18 communities with 360 participants which then directs further investigation at household level through survey, longitudinal study farmer and farmer participatory action research over a systematic 4 year investigation from 2001 to 2004.

At the PCA stage, the context of livelihoods, importance of popular aquatic animals and their different sources were examined. The more frequently mentioned and higher scored SRS by the communities were *Clarias batrachus*, *Anabas testudineus*, *Macrobrachium* sp., *Puntius* sp., *Heteropneustes fossilis*, *Channa punctatus*, *Mystus vittatus*, *Amblypharyngodon mola*, *Channa striata*, *Macrognathus puncalus.* The sources of these aquatic animals provided a better understanding of the diverse typology of farmer managed aquatic systems (FMAS) and showed the importance of both FMAS and open systems to sustain a self-supporting population of aquatic animals for nutritional security of the poor. Rice and other crop farming, fish culture, livestock and poultry rearing, service and business were found to be common occupations among better off households where as share-cropping, petty trade, fishing, selling agricultural and non-agricultural labour were of greater importance to poorer households. Both gender and well-being affected livelihoods with significant differences in involvement of the better off and poorer. PCA findings were later

validated at a national level stakeholder workshop with 138 government, non-government officials, researchers and academics which established a broader understanding of the prospects and constraints of SRS culture and conservation.

The baseline survey with 119 households further examined the characteristics and access of key farmers to managed aquatic systems, livelihood assets, vulnerability and the behaviours of households managing SRS. Access to FMAS and SRS are of much greater importance to poorer than to the rich. Positive, negative and neutral attitudes towards managing SRS were not significantly affected by well-being. Access to appropriate types of FMAS, SRS management knowledge, traditional taste, greater involvement in non-farm activities, family need were all associated with the SRS positive attitude.

Results from the year round longitudinal study with 50 households focused on the seasonal dynamics of food consumption and its connection to livelihoods in terms of sources, income and expenditure. Aquatic animals are the 3rd most important contributor to the rural Bangladeshi diet after cereal and vegetables by weight and the 2nd most important contributor by price after cereal. FMASs are important source of aquatic animals compared to other sources such as open system, market and given sources (free from neighbours and relatives). SRS were accounts for 52% of the total aquatic animal consumption. Even among some very low income vulnerable groups such as day labourers and rickshaw pullers, SRS was found important in their diet. Poorer households rely significantly more on SRS than richer households. The total amount of SRS consumed by thenhosueholds over the year was strongly correlated with total number of SRS species consumed per year and further emphasised the significance of maintaining biodiversity. The pre monsoon dry period as April and May were low consumption periods in both zones. Rainy and post rainy season July to October were the peak consumption months in the northwest zone and June to November in south-central zone. The year round farmer participatory trial with 29 farmers confirmed the value of SRS within culture systems with lack of any major conflicts in the husbandry of non-stocked species with popular carps in the system which, in the past regarded as weed fish and have been generally excluded from formal aquaculture. The study found a range of species of both commercial and non-commercial SRS have greater significance to the poor than to the richer households particularly in terms of household consumption, income and social value. More deliberate attention towards avoidance of negative actions towards SRS in aquaculture in the lean season may also expand niche benefits for non-pond owners and vulnerable social groups such as fishers. Current investigations also revealed the complementarities of stocked fish particularly during dry months when SRS are less available.

In spite of the poor having limited access to ponds, the seasonal scarcity of water in dry seasons and habitat degradation, SRS remains an important and valuable food item for the poor in low income vegetable scarce months. The study recommends future emphasis on the management and conservation of both commercial and non-commercial (mainly for consumption) SRS in FMAS particularly during the lean season and also to maintain the integrity of the permeable nature of FMAS and its linkage with the broader open systems for the sustained availability of such self-recruiting population. Finally the study greatly influenced the perception of utilising both stocked and non-stocked species in formal aquaculture. It is necessary to take urgent steps to avoid negative actions to damage SRS and formulate an integrated approach to water, agriculture, environment and fisheries management to sustain them for current and future nutritional and livelihoods security of the poor.

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List of Abbreviations

AA	Aquatic animal
ADB	Asian Development Bank
AFGRP	Aquaculture and Fisheries Genetics Research Programme
BASC	Business Advisory Service Center
BBS	Bangladesh Burro of Statistics
FAO	Food and Agricultural Organisation of the United Nations
FAP	Flood Action Programme
FGD	Focus group discussion
FMAS	Farmer managed aquatic systems
FMSP	Fisheries and Management Science Programme
GDP	Gross development product
HYV	High yielding variety
IFAD	International Fund for Agricultural Development
ITDG	Intermediate Technology Development Group-Bangladesh
MoFL	Ministry of Fisheries and Livestock
NSP	Nutritional Surveillance Programme
PAR	Participatory Action Research
PCA	Participatory Community Appraisal
PRA	Participatory Rural Appraisal
RDRS	Rangpur Dinajpur Rural Development Services
SIS	Small Indigenous Species
SNS	Small Native Species
SRS	Business Advisory Service Canter
UNDP	United Nations Development Programme

Glossary of Terms

Amon	Rain fed rice cultivation season (July -November).
Aus	Dry season rice cultivation period (March- April)
Baor	Closed water body equivalent to an oxbow lake, up to several hundred hectares
Bazar/Hat	Village market
Beel	Seasonal open water bodies often containing low-lying agricultural land
Boro	Irrigated rice cultivation season (May – June)
Chotomach	Small fish mainly indigenous species
Eid	Muslim religious festival
Gher	An enclosure made for prawn cultivation by modifying rice fields through building higher dikes around the field and excavating a canal several feet deep inside the periphery of the dikes to retain water during the dry season.
Haor	Low lying areas that are seasonally flooded, normally for 5 to 6 months per year.
Hapa	Cloth made enclosure for fish seed nursing or used in fish seed business
Koom	Natural basins in flood pain areas occurred by the river current
Pen	Bamboo fence or net enclosure for fish culture in open water or in a lake
Puja	Hindu religious festival
Thana	An administrative unit in Bangladesh equivalent to a sub-district.
TK	Bangladesh unit of currency; US$ 1= Tk 58, 2002
Trap pond	Ditches to trap wild fishes usually not stocked

Glossary of Terms (contd.)

Local name	English name	Scientific name
Big head carp	Big head carp	*Aristichthys nobilies*
Boal	Cat fish	*Wallago attu*
Carpio	Common carp	*Cyprinus carpio*
Catla	Carp	*Catla catla*
Chingri/Icha	Small prawn	*Macrobrachium* sp.
Darika	Minnows	*Esomus danrika*
Gochi	Spiny eel	*Macrognathus puncalus*
Goinna	Carp	*Labeo gonius*
Grass carp	Grass carp	*Ctenopharyngodon idella*
Gutum	Loach	*Lepidocephalichthys guntea*
Kholisa	Perch	*Colisa fasciatus*
Koi	Climbing perch	*Anabus testudineus*
Magur	Walking catfish	*Clarias batrachus*
Mola	Mola carplet	*Amblypharyngodon mola*
Mrigel	Carp	*Chirrhinus mrigala*
Puti	Barb	*Puntius sophore*
Rui	Carp	*Labeo rohita*
Sharputi	Silver barb	*Barbas gonionotus*
Shing	Stinging catfish	*Heteropneustes fossilis*
Shol	Snakehead murrel	*Channa striatus*
Silver carp	Silver carp	*Hypophthalmichthys molitrix*
Taki	Spotted snakehead	*Channa punctatus*
Tengra	Small cat fish	*Mystus vittatus*
Tilapia	Tilapia	*Oriochromis niloiticus*

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Chapter 1
General Introduction

1.1 Introduction

This study is concerned about the roles of species of aquatic animals in aquaculture those that self-recruit, rather than require repeated stocking (‘self-recruiting species’; SRS), evaluated from the perspective of people dependent on them. The relationship between SRS and people is viewed in terms of well-being and gender, and related to geographic zone, resource access and broader livelihoods. Benefits of integrating SRS within formal aquaculture, management strategies and their impacts on the seasonal context of food consumption, vulnerability and income are investigated. The study focused on aquaculture and rural livelihoods, key species and aquatic systems that determine the role of SRS in rural livelihoods.

This chapter introduces the concept, rationale and scope of the investigation described sequentially as research background, context of food security and increasing human population, conventional approaches to aquaculture development, understanding poverty, livelihoods, global aquaculture and research approaches to aquaculture in development.

1.2 Background of the research

Fish provide the main source of animal protein to about one billion people globally. Per capita fish consumption has doubled over the past 50 years (Ahmed & Delgado, 2000; Delgado et al. 2002, 2003) and production would need to double again to meet the projected demand over the next 25 years. However, practical constraints to investment, profitability, resource access, system efficiency, competition for fresh water, make the integration of aquaculture within agriculture an important challenge for the future (Muir, 2005; Verdegem et al. 2006). Fish and fisheries are an important part of food security, particularly for poor people living in developing countries. In low income food deficit countries (LIFDC), they make up over 20% of animal protein consumption. Among Southeast Asian fish-dependent countries, fish provides around 45% of total protein consumption (Prein and Ahmed, 2000). One third of all fish now consumed globally is from aquaculture, and the majority is produced and consumed in developing countries of Asia (FAO, 2004). Sustainable management of the remaining wild stocks and continued growth in aquaculture require better understanding of key systems and use of a wider range of species. Consideration of the role of fish populations in diversified livelihoods, local and global demand for fish and substitutes and environmental degradation, particularly in developing countries are also critical.

Traditionally wild species of aquatic animals have been a component of farming systems as well as an important source of food and income for the poor in developing countries. Aquatic resources within farming systems, in which the household can manage all or part of the life cycle of aquatic animals, include ponds, ditches, rice field trap ponds, rice fields and small canals. Harvesting wild fish and prawns from flooded paddy fields is an ancient practice in Southeast Asia (Li, 1988; Fedoruk and Leelapatra, 1992). Some species are harvested both from such farmer managed aquatic systems and from open systems like rivers, large lakes etc, yields from which. are typically in decline. The definition of self-recruiting species (SRS) in aquaculture that do not require regular stocking (Little, 2002) focuses on domestication of wild species rather than the biological aspects such as size etc. SRS can include both indigenous and exotic species and non-fin fish.

Unmanaged aquatic species in common pool resources are in decline for a variety of reasons. A combination of siltation of floodplains, flood prevention controls, changing water management practices, competition of water use for agriculture and increased fishing effort has placed heavy pressure on aquatic resources. Land fragmentation at the household level, damaging harvest techniques and increased use of chemical pesticides has reduced the availability of wild fish in Bangladesh (Lewis, 1997). The continuous decline in previously common species and degradation of common-pool natural habitats has probably stimulated people to manage them within their own household managed aquatic systems and such species can no longer be considered as only ‘wild fish’.

Control and management of open aquatic resources requires a level of ‘enclosure’ (enclosed area) to ensure the benefits of management can be achieved. The level of physical ‘openness’ of any aquatic system is however affected by season. During periods of flood, household managed resources can become very inter-connected . An inundated low-lying area (part of a lake, low- land rice fields) in the rainy season may form a closed system at the time of draw-down during the dry season. The classification of ‘closed’ and ‘open’ systems can embrace both hydrological characteristics and access. Classification of water bodies (such as floodplains) is more complicated when they are hydrologically linked and highly dynamic (de Graaf et al., 2001). Water bodies can be classified by the extent of flood, depth and duration of flood, timing and connectivity within the water resource system (WARPO, 1999). The exchange of water, nutrients, biota that occurs during flooding events between closed and open systems affects both productivity and measures of efficiency. A range of indigenous and introduced fish species; as well as molluscs, crustaceans and amphibians are inevitably present in many rural aquaculture systems unless deliberately eradicated (Little et al. 2004). Such aquatic animals naturally or through active interventions gain access to, and thrive in, small-scale aquatic systems especially those under semi-intensive or extensive management. Sometimes they are considered by-catch and are under-reported or not reported at all, despite being an important part of harvested yield. Amechi (1995) found that by-catch in stocked, semi-intensively managed fish ponds varied from between 20 to over 40% of the total yields.

The concept of conventional culture in ‘ponds’ fails to capture the current realities of rural farmers in Bangladesh. Farmer managed aquatic systems (FMAS) refers to aquatic systems that are managed and controlled by households regardless of ownership of the resource. Management is not limited to activities like stocking and feeding, but covers a broader definition that includes any form of activity undertaken to enhance the productivity and harvest of aquatic organisms (plants and animals) in the area. Rice-fields, ponds isolated from, or integrated physically within, flooded rice fields, canals, parts of oxbow lakes, depressions in flood affected areas may be farmer managed systems. Both terms, SRS and FMAS, are interrelated and important in characterising the complexity of the aquaculture-fisheries continuum.

FMAS do not include large open water bodies such as ox-bow lakes, rivers, or semi closed lakes (*beels*). These systems however can be co-managed or community managed (Ahmed et al. 2004, Thompson et al.1999). Co-management implies the share of responsibility of the management of resources among governments, local communities, and various management authorities of concerned countries (Salequzzaman and Costa, 2004). Seasonal water bodies such as flooded crop fields, ponds and reservoirs within irrigation schemes can also be communally managed by stakeholders on an equitable basis. Aquatic resources may be FMAS on a temporal or seasonal basis. Recent experiences of the WorldFish Center in Bangladesh and Vietnam show that while fish can be cultured communally during the flood season, the same land is cultivated with rice during the dry season on a household basis (WorldFish Center, 2005) and managed as FMAS during that period. Ahmed et al. (2004) stated that fisheries are complex and interdependent ecological and social systems that can be managed under different types of property right arrangement such as private, state, community or co-managed, however all these types have their own limitations. They also pointed out that in some cases community control excludes the poorest people from access to common property resource, increasing inequality. Poor households may however retain access to FMAS through various mechanisms. Sole access to FMAS such as rice fields and ponds may be established through leasing arrangements or there may be opportunities for traditional/local access arrangements such as share cropping

Aquaculture in Bangladesh embraces a diverse range of aquatic resource management, many of which are location specific. A variety of types of fish culture both land and water based (Edwards, 2000) have been developed in Bangladesh over the past 20 years including pond aquaculture (mostly semi-intensive), rice-fish culture, pen culture, shrimp *gher* (enclosure) farming, community based fisheries, cage culture etc. However, rural aquaculture is characterized by marked inequalities among households reflecting differential access to land and other resources; about one half of the population is functionally landless, i.e. owning less than half of one acre of homestead and farm land (Wood, 1994). The unequal distribution of resources in Bangladesh and the unusually high prevalence of landlessness necessarily complicate attempts to develop the aquaculture sector in the interests of the rural poor (Lewis, 1997). Some aquatic systems in Bangladesh are well understood from a production perspective but not from a livelihoods or biodiversity perspective (biodiversity of SRS populations); such narrow technical and economic perspectives are no longer considered enough. In the last two decades, development specialists have widened their assessment of natural resource- based livelihoods from largely economic efficiency concerns to encompass equity and environmental objectives (Grimble and Wellard, 1997). In fisheries governance there has been a shift in objectives from maximizing production and employment to sustaining stocks and taking wider ecosystem aspects into account (FMSP-5, 2006). Such concepts applied to aquaculture and poverty reduction need a deeper understanding from livelihoods, equity and environmental perspectives.

World aquaculture production has grown at an average annual rate of 8.8 percent from 1950 to 2004 (FAO, 2006). Aquaculture is growing more rapidly than any other animal food producing sector. The annual growth rate in aquaculture between 1990 and 2000 was 11.4%, compared to 4.9% for poultry, 2.5% for pork and 0.5% for beef. Over the past two decades aquaculture has been one of the most rapid and technically innovative food production sectors globally with significant investment, scientific and technical development and production growth. Its great potential to enhance food security, alleviate poverty, contribute to rural development and improving livelihoods is well recognised and likely to continue (Muir, 2005; Edwards, 2000 & ADB, 2005).

Asia is the centre of the world’s fish production and consumption. It accounts for over 63 percent of total fish production, and as much as 90 percent of all aquaculture output. Low value fisheries and aquaculture, which contribute significantly to the livelihoods of poor households, make up an important part of this production. Fish is, furthermore, an important part of Asian diets. In Bangladesh, Indonesia and the Philippines, it comprises 50 percent of animal protein intake, while in Thailand and Vietnam its share is 40 percent. It is the major and often the only source of animal protein for the poor (Briones et al. 2004). The importance of fisheries including aquaculture in achieving the Millennium Development Goals (MGDs, 2006) is presented below (Table 1.1; FMSP-1, 2006).

Table 1.1: Some contribution of fisheries to the Millennium Development Goals

Millennium Development Goal	Some contributions of fisheries
Eradicate poverty and hunger	Food security and livelihood benefits for 200m people; food for 1 billion people
Universal primary education	Income from fisheries is used for a number of socially important activities. Nutritional benefits of fish contribute to a child's development and learning ability
Gender equality	Processing and trading fish are dominated by women, providing income and some control over household spending
Reduce child mortality; improve maternal health	Fish provide significant nutritional benefits to women and lactating mother and thus improve maternal health and reduce child mortality in developing countries.
Ensure environmental sustainability	Effective management of fisheries contributes to ensuring environmental sustainability
Global partnership for development	Fish are amongst the most widely traded goods, globally. Fisheries boundaries often international. Policies /governance promote management partnerships.

Source: (FMSP-1, 2006)

Although an increasing share of fish for consumption both now and in future will be supplied from conventional stocked aquaculture in Bangladesh, this trend in conventional production may actually worsen access to fish by the poor (Roos, 2001). There is an expectation that SRS are 'weeds' that through competing with, or predating on stocked species inevitably reduce yields and returns of stocked species. However, there is little evidence to support these views. Garaway (1999) found that despite the high biomass of stocked fish, standing stocks of wild fish were similar to those from non-stocked water bodies with fishing restrictions, indicating weak interactions and a potential to maintain wild stocks in culture situations. Yoonpundh (1997) observing commercial aquaculture of *Trichogaster pectoralis* in Thailand found that inclusion of other SRS was common as a strategy to optimize both yield and economic performance of the systems. Various strategies may be valid in improving compatibility of SRS within aquaculture including ensuring high quality of juveniles stocked, especially that the size of stocked seed is large (Little et al.1991). Gregory and Guttman (1996) related farmers' interest in stocking fish to the proximity of the household managed aquatic systems to common pool perennial water bodies that acted as refuges for wild fish. Intensification tends to lead towards management of less diverse crops of fish in which SRS are discouraged or eliminated. In semi-intensive aquaculture many species, not normally stocked by the farmer, gain access to the system. This natural recruitment of aquatic animals and/or deliberate inclusion of more diversified species by the household has been misunderstood and undervalued. Conventional aquaculture extension messages have so far not only over looked the importance of those species, but have often promoted management actions to control, reduce or eradicate them with unknown impacts on rural people. Observation of farmer behaviour (e.g. cutting pond dikes to facilitate entry of un-stocked organisms) suggests that many households typically ignore or subvert attempts to prevent such control of SRS. However, trends to intensification of conventional aquaculture in response to increasing demand for fish may tend to change this attitude. A recent comparative study between Vietnam, Thailand and Cambodia observed less interest and a greater likelihood to eliminate SRS among farmers intensifying their aquaculture (Morales et al. 2006).

The importance of SRS for household nutrition is likely to be great in Bangladesh, but there is currently a lack of data to support this perspective. Large cultured species are generally not used for home consumption, but rather cultured as a cash crop and as such have less impact on the nutritional status of poor (Thilsted et al.1997). Better understanding of extensive and semi-intensive aquaculture, natural recruitment and stocked recruitment of species in aquatic systems, and the management of natural habitats and man made aquatic habitats are important issues to explore benefits of aquaculture for the poor.

Therefore, the current study is motivated to define the importance of SRS to rural livelihoods and to develop management strategies of SRS within aquaculture.

1.3 Feeding people, population growth, relative importance of fish and fish culture

Bangladesh has a huge population of over 140 million people that is growing rapidly (2.09%, 2000-2005) with a high population density of 972 persons per km^2 (EC, 2002). Some 73% of the total land area (147,570 km^2) is used for arable cropping, 2% for permanent crops, 5% permanent pastures, 15% woodlands and 5% others (FAO, 1999). Although the country has achieved success at increasing food grain production, food security has yet to be achieved, and whatever progress has been made may be difficult to sustain in view of the growing pressure of population on extremely scarce natural resources. Nearly 40% of the population in Bangladesh live below the food consumption-based poverty line, lacking sufficient resources to afford a diet of 2,122 kilocalories (kcal) per person per day, along with other basic necessities (Hossain et al., 2004). The normal diet of Bangladeshi people is seriously unbalanced, with inadequate consumption of fat and protein, and with more than 80 per cent of calories derived from cereals. Women and children are especially vulnerable to malnutrition.

Fish plays a major role in human nutrition in Bangladesh by supplying around 63% of the total animal protein intake (Laureti, 1998). But the importance of cultured fish mainly major carps and smaller ‘collected species’, is different among richer and poorer categories of people (Lewis, 1997). Dey (2000) reported that poor households consume mainly small fish. Technological improvements in the culture of small fish might therefore be expected to increase the welfare of poor consumers more than that of the rich. Understanding the importance of fish in human nutrition is complicated by a lack of specificity in reporting. Fish tend to be reported without reference to species, size and source and the huge diversity of species make fish a very heterogeneous commodity (Westlund, 1995; Smith et al. 1998). Fish may be reported in the literature as - small fish, wild fish, collected fish, assorted fish etc. Access to, or importance of, various species to different social groups in rural areas remains largely guess-work.

Fisheries management in Bangladesh includes marine fisheries, coastal aquaculture, open water inland fisheries and closed water inland aquaculture. Inland waters are characterised by immense diversity with 260 indigenous fish, 12 exotic fish and 24 freshwater prawn species. In marine waters, there are 475 fish and 36 marine shrimp species and a wide range of turtles, crabs, molluscs and seaweeds (DoF, 2005). Bangladesh has 2,832,792 ha (MPO, 1989 ;DoF 2002; DoF, 2005) of floodplain area which is inundated at various depths ranging from very shallow (0-30cm) to deeply flooded (more than 1.8 meter) during monsoon season are a potential area for aquaculture and culture based fisheries. Under closed inland waters, there are 1.47 million ha of pond area of which nearly half is cultured ponds, usually stocked with fingerlings and managed. A further 30% are ponds having potential for culture without any structural improvement but not currently stocked and the remaining 20% are derelict ponds, which are not suitable for fish culture without improvement (Alam, 2001; FAO, 1999). There are 12 million ha of rice fields, of which 2.5 million ha are lowland rice-fields prone to uncontrolled flood, hundreds of thousands of shallow seasonal ponds, ditches, road side canals and irrigation canals (DoF, 2002). Additionally, trap ponds in flooded areas which retain water for only a part of the year (mostly 4–7 months) have also been identified as a potential resource for culturing fish at least up to a semi-intensive level (Gupta and Rab, 1994). The fisheries sector is important for Bangladesh economy as it accounts for some 5.71 % of total export earnings and 4.92 percent of GDP and more than 12 million people are directly or indirectly involved (BBS, 2004).

During the last decade the agriculture sector grew at an overall rate of 3.2% per annum. The crop sector grew at the rate of 2.1%, forestry by 4%, livestock by 7.6% and fisheries by 7.8% per annum. Poverty in rural areas declined by 1 percentage point per annum in the last decade (BBS, 2003; Toufique, 2003). UNDP (2000) reported that Bangladesh is considered one of the most suitable countries in the world for aquaculture, due to its favourable agro-climatic conditions and because it has one of the highest man-water ratios in the world, at 20 persons per ha of water area (Task Force, 1991). A greater understanding of rural aquatic systems and their seasonal complexity and the importance of different species to people, will enhance the role of the fisheries sector contributing towards rural development and poverty alleviation.

1.4 Conventional aquaculture definitions and its limitations

In Asia the evolutionary process leading to modern forms of aquaculture is thought to have started with storing wild caught fish in baskets submerged in water (Ling, 1977). It is believed that this practice gradually developed into the rearing of caught fingerlings in nets and eventually earthen ponds (ibid.).

The Chinese simple form of traditional aquaculture (do not exist now) was very different from modern systems such as the culture of Atlantic salmon that began only three decades ago. Although aquaculture is the world's fastest growing food production sector and promises to meet the growing shortfall in world's wild fisheries this success has attracted much criticism. Fish farming is a potential source of food for the world's rich and poor alike although there is concern about its environmental and health hazard. Modern aquaculture is at an early stage of development and is highly heterogeneous. While the commercial agriculture has developed over centuries; large-scale commercial aquaculture is little more than 30 years old. New technologies, new breeds and newly domesticated species of fish offer great hope for the future (Economist, 2003).

Early definitions of aquaculture focused mainly on biological management perspectives and typically lacked social context. An early definition states that aquaculture is man's attempt, through inputs of labour and energy, to improve the yield of useful aquatic organisms by deliberate manipulation of their rates of growth, mortality and reproduction (Reay, 1979). A revised definition of aquaculture used by the United Nations Food and Agricultural Organisation states that aquaculture is: ' the farming of aquatic organisms including crocodiles, amphibians, finfish, molluscs, crustaceans and plants, where farming refers to their rearing to their juveniles and/or adult phase under captive conditions'. Aquaculture also encompasses individual, corporate or state ownership of the organism being reared and harvested.'(Rana, 1998). According to Beveridge and Little (2002) this definition omits common forms of access and exploitation rights and suggested two key criteria 1) some form of intervention to increase yields, and 2) there is either ownership of stock or controls on access to and benefits accruing from, interventions.

Fish consumption trends are very heterogeneous globally, regionally and within countries (Kent, 1997). Current policy to advance fisheries lacks attention to equity issues and needs a balance between social, economic and environmental goals (Campbell and Salagrama, 2000). Consumer demand for organic aquaculture, issues of animal welfare, environmental concerns including a need for more water efficient aquaculture production systems, human and social goals of aquaculture are current concerns. Brown (2001) states that around 2 kg of grain concentrate is needed to produce 1 kg of live fish, where roughly 1000 litres of water are used to produce 1 kg of grain (Brown, 1999). Furthermore some of the major species of fish intensified are carnivorous requiring feeds based on, or including high level of fishmeal and oil. As animal production including aquaculture is a major water consumer. Verdegem et al. (2006) emphasised water efficient pond aquaculture and enhancement of feed production within the system. More reliance on natural feeds and fertilization to increase pond productivity will reduce water use in aquaculture, but not enough to make production as efficient as most terrestrial animal production systems. Viewing pond-based production from a broader whole farm perspective in which the pond supplies irrigation water for associated horticulture increases efficiency substantially however (Karim, 2006).

Aquatic systems supporting the active rearing of privately owned fish stocks and the harvesting of wild fish held in common ownership is well understood. But many livelihoods are linked to ‘halfway’ systems between conventional ‘aquaculture’ and ‘fisheries’ and there is a large knowledge gap in this area. Approaches towards commercialization and intensification of aquaculture without neglecting the needs of poorer people who produce fish only for local market and home consumption need to be developed (Lorenzen, 2000). Little (2002) also emphasized a need to understand how the poor benefit from the SRS in farmer managed systems. In assessing the consequences of decreasing fish supply for human food security, it is important to distinguish between effects on the population as a whole and effects on the poor, those most vulnerable to malnutrition (Kent, 1997). Lewis et al. (1996) reported that development agencies in Bangladesh are mainly prioritising increases in production and income with a lack of understanding about access and equity for low income households. Such approaches lay behind the expansion of production of relatively expensive Indian Major Carp species consumed mainly by rich households rather than smaller, more accessible, 'collected' species upon which lower income people mostly depend.

The introduction of species or strains into productive habitats for aquaculture, stock enhancement, or for culture based fisheries can have significant implications for biodiversity (Beveridge et al, 1994; Leach, 1994; Myrick, 2002). Hence, it is necessary to understand the constraints of aquaculture, including culture-based fisheries, from a biodiversity and environmental perspective (Minkin and Boyce, 1994). A major advantage of aquaculture is the higher productivity per unit of land and water compared to more extensive production systems but this can result in loss of common pool resources that are unmanaged and biologically diverse (Thompson et al. 1999; Prager and Thompson, 2005). Aquaculture has been interpreted as a mechanism for resource capture by the better off at the expense of poorer people and the wider environment. Such 'elite capture' (Gregory et al. 2007, Plateau and Gaspart, 2003) might result in both less water available for, and a diminished fauna in, natural habitats.

Limited access to natural resources, inefficient land use and poor social equity currently undermine the benefits of aquaculture. Disparity in per capita aquatic food supply, low system efficiency and a lack of appropriate market interventions are also the areas of limitation in aquaculture (Muir, 2005; Beveridge and Little, 2002). In the light of the critique to which the Green Revolution of the major food grain crops has been subjected, a balanced approach of both commercial scale industrial production and less intensive, environmentally sound production system needs to evolve. Specifically aquaculture and capture fisheries need to be complementary rather than competing with each other (Bush, 2004).

Roos (2001) carried out a study in central Bangladesh and found that the supply of fish from aquaculture had partially filled the gap created by the loss of fish supplied from capture fisheries, but the main beneficiaries of aquaculture were better-off households. Aquaculture production is currently dominated by a small number of fast-growing carp species and this may be reducing diversity in the Bangladeshi diet (Roos 2001). Benefits from aquaculture may therefore be more biased to richer than poorer people, limiting the role of aquaculture in poverty reduction.

The convention of managing mostly stocked Indian Major Carp and some Chinese carps apart from reducing local biodiversity also places dependence on purchased inputs. The most common management activities in aquaculture are the stocking of hatchery produced seed and external feeding. According to Mazid (2002), poor access and cost of quality seed is the single greatest limitation to the expansion of aquaculture. Hambrey et al. (2001) also suggested that one of the main factors limiting the access to aquaculture by the poorer sectors of society remained a requirement for seed and feed. But, in the field most farmers continue to rely to some extent on SRS. Barman (2000) working in northwest Bangladesh stated that farmers managing aquatic systems had greater reliance on natural seed in areas distant from seed markets. Observation of farmer practice in flood affected areas suggested that they managed SRS during times of flood and start to stock large seed (over wintered) during the post flood period. In drought-prone areas they may prefer to manage SRS concurrently with a low density of carps where both hatchery seed and wild seed is less accessible to poor (Barman et al. 2002). A conceptual idea (personal communication with Dave Little) of different seed sources based on different management options in different systems is presented below:

Table 1.2: Relationship of fish seed source and aquatic system type and management

Seed source	**Type of aquatic systems and management**	
	Farmer managed aquatic systems (FMAS)	**Open aquatic systems**
Only Hatchery	Conventional Aquaculture of only carps in ponds, cages, pen/enclosures	Only possible by setting cages (FMAS) in a open system
Hatchery + Non-hatchery	SRS + carp management in ponds, rice fields, closed canals	Stocking/Conserving of wild broods & seeds in lakes
Only Non-hatchery (Only natural recruitment)	Only SRS in trap ponds (sustain a natural recruitment process, linking systems)	Wild stock harvest and management without stocking seed.

This indicates that the aquatic system management options involving SRS depend on the 1) value, availability and status of wild stocks, 2) seasonal and other types of risk of stock loss from flood or drought, and 3) presence or absence of hatchery in the seed distribution network. Therefore, reliance on SRS is likely to be highly context specific.

The extent to which conventional aquaculture can help in poverty reduction is a major policy question (Edwards, 2000). To promote poverty focused aquaculture and fisheries, credit was introduced in Bangladesh. However, credit to fisheries and aquaculture accounts for only 1.5 – 4.5 % of the agricultural sector (World Bank, 1991) in Bangladesh and rich farmers and affluent people have enjoyed most of the benefits of easy credit. No effective model of credit has been evolved specially to benefit the landless (Alam, 2001). IFAD's (International Foundation for Agricultural Development) experience with rural credit in Bangladesh suggests that reaching the very poor is remaining a challenge (Mallorie, 2002). However, though a large number of ponds have entered into the lease market, potentially increasing the access to ponds benefits are mostly accessed by better off farmers (Toufique, 2003). This is explained partly by lower resistance to risk situations such as flood, drought, seed unavailability etc. of poorer people. "Credit has been seen as a resource to borrower households, but credit is also debt and is a risky strategy for the poorest and most vulnerable to economic stress" (Rahman, 1999).

In a land-scarce country like Bangladesh a decrease in farm size is linked to intensification of farming but opportunities for intensification in smallholder farming systems are limited as most farmers are not able to pay for the necessary external inputs (Peters et al. 2001). A tendency for poorer households with access to seasonal or perennial water bodies to reduce investment cost and rely more on the natural asset base is understandable. A greater reliance on SRS in aquaculture which require less external inputs and might reduce dependency on credit for seed and other inputs might be expected to be greater among the resource-poor. A challenge is to assess the impact of non-stocked species and their management practices in conventional aquaculture. Polyculture of mixed Indian and Chinese carps along with SRS appears to have great potential and might allow aquaculture diversification that benefits the poor. But management of such wild species in aquaculture has received very little attention among policy makers, researchers and grass-root promoters. In order to develop management strategies for self-recruiting species in aquaculture, research is required in areas that bridge social and natural sciences. The dynamics of the self-recruiting populations at the local and meta population levels, interactions between stocked and self-recruiting populations need to be assessed together with an analysis of the roles and impacts of such species within culture systems. Moreover the impacts of conventional aquaculture management practices on self-recruiting species require analysis (Little et al. 2000).

The genetic profile of SRS are inevitably congruent with populations in the vicinity given the 'porous' nature of FMAS. The wild populations and those occurring in aquatic systems managed by households are linked within a larger integrated and complex aquatic system that typically comprise rivers, canals, rice fields, ponds, large perennial water bodies, trap ponds etc (Little et al. 2004). FMAS might play a role in sustaining wider biodiversity in seasonally flooded agro environments by acting as refuges for adults in dry season and breeding places in the rainy season. Therefore, holistic thinking that considers both biodiversity and production of aquatic systems like - low land rice fields, 'derelict' ponds, road side canals is required. Such systems have been identified as being 'under-managed' (Gupta and Rab, 1994) but an issue is if their roles as refuges for un-stocked aquatic animals can be maintained whilst production is intensified using stocked seed and additional inputs.

The evolution from "capture" to "culture-based fishery'' has a long history. Instead of being complementary components of an over all living aquatic resource agenda, a tendency is for both aquaculture and capture fisheries to become competing areas of development (Bush, 2004). A location specific understanding on the aquaculture and fisheries continuum is also important for future aquaculture (Figure 1.1). An improved distinction between the different degrees of semi-intensive and extensive culture systems (Muir, 2005) might help to define the role of non-stocked aquatic animals or more specifically SRS in broad or more complex aquatic systems. Figure 1.1 illustrates the aquaculture and fisheries continuum explaining various steps of evolution and suggests the major areas of interest for SRS. To a background of continuous decline in capture fishery habitat, steps to maintaining biodiversity not only of open water extensive systems but also under large and small scale aquaculture and culture based fisheries is essential.

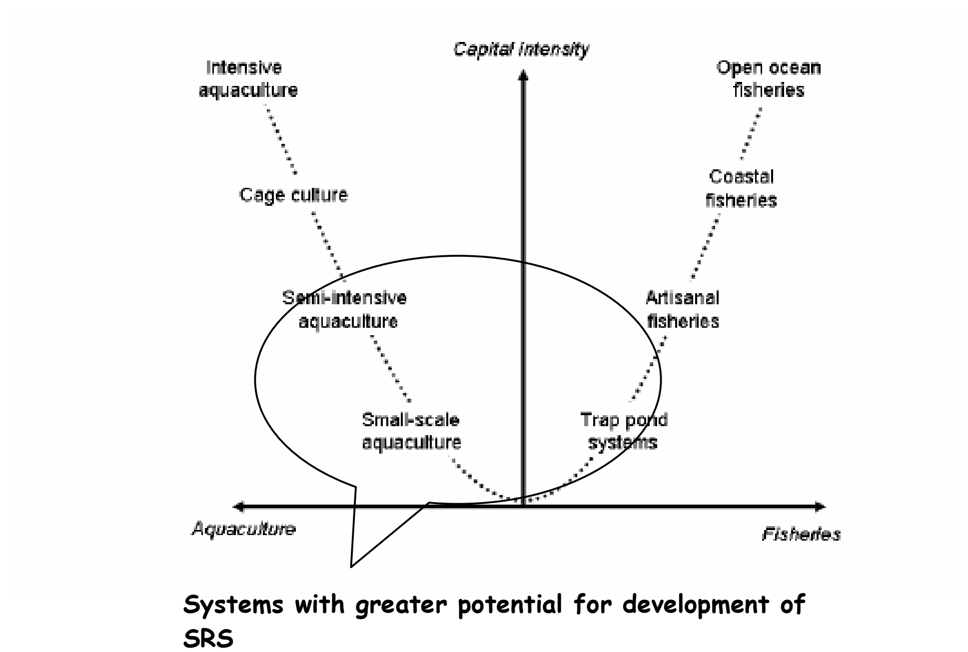


Figure 1.1: Aquaculture and fisheries continuum (modified after: Guttman, 1996).

In Bangladesh, it is recently realized that promotion of aquaculture has not considered the balance between the fish produced being a “cash crop” and that as a “subsistence” food crop. Normally large carps (Indian major carps) are considered as a cash crop and small indigenous species of fish (SIS) and SRS are typically used as food fish by the poorer households. It is clear that the culture of only large carps can have negative impacts on the family nutrition in rural areas (Wahab, 2003), which demands a shift in promoting small indigenous fish or SRS species for aquaculture. Deliberate exclusion of SRS in semi-intensive aquaculture may not only be ill-advised in terms of broader biodiversity and local benefits to the poor but in a highly flood affected country like Bangladesh it appears important to assess the trade-offs in managing SRS in aquaculture systems of variable intensity.

Another important issue is to understand the relative advantages of different socio-institutional approaches to aquaculture and culture based fisheries. Community based approaches may have a clearer pro-poor agenda but are inherently constrained by social factors and require years of capacity building before they are effective (FAO, 2002, Lovett et al. 2006). In such a context household managed approaches also need to be further refined as a pro-poor approach.

If growth in aquaculture is primarily linked with more commercialised production, options for resource-poor producers may be limited although niche opportunities may expand (Muir, 2003).This context raises the question to what extent and how aquaculture should be intensified or diversified and for whom? It might be also important to understand the seasonal role of aquaculture in terms of benefits for the poor.

Therefore, there is a growing need to redefine the appropriate nature of aquaculture interventions appropriate for the poor addressing issues of access, equitable consumption of fish and other aquatic animals, environmental concern and social benefits.

1.5 Importance and role of SRS

Research in Bangladesh and other south-Asian countries has highlighted the importance of SRS in managed systems and the same species from natural habitats to the livelihoods of the rural poor (Roos, 2001; Mazumder and Lorenzen, 1999, ITDG-B and BASC, 1998; Garaway, 1999; Gregory and Guttman, 1999; Amilhat et al., 2005). Terms such as native fish, small fish, trash fish, undesirable or weed fish, small indigenous species (SIS), small native species (SNS), black fish, white fish are familiar in Bangladesh among scientists, development practitioners and even farmers. These terms reflect the traditional characteristics and importance of different types of fish. Species that naturally breed in ponds and rice field systems or gain access to the aquatic systems themselves, or by farmers' actions, are very important to consider in a pro-poor and pro-environment type of culture pattern. The concept of SRS has a user perspective and is more about how farmers try to utilize the commodity rather than being solely a biological perspective. Nor is the definition limited to fin fish, delimited by size or exclusive to indigenous species. The term "SIS" (small indigenous species) is a re-interpretation of Bengali word "*Chotomash*" (literally meaning small fish) which have been defined as species which grow to a maximum length of about 25 cm (Felts et al. 1996). If such species are managed and harvested in farmer managed systems, these can also be defined as SRS. Studies have shown that the numerous "miscellaneous" small fish caught from floodplains and lakes by poor people, which have been neglected in official statistics and policies, provide relatively more essential nutrients than the large fish species favoured by fish culture programs (FAP-16, 1995 ; Thompson et al. 1999). Only recently SIS species have been considered as an important source of essential macro and micro nutrients, which play an important role in maintaining nutrition levels in the country (Thilsted et al, 1997). However, the culture of such species has not yet been attempted on a large scale in Bangladesh (Wahab, 2003). Fish biologists have also classified fish into black and white species based on their migration pattern and breeding grounds (Payne, 1997). Species belonging to the black fish category, include the great majority of small fishes and larger fishes such as *Wallago attu* and *Labio gonius* that breed on the floodplain. "Black fish" start breeding with the arrival of water on the floodplain, whereas "white fish"- breed in rivers. The term 'wild fish' refers to species that are un managed by farmers and occur in open systems such as rivers and large lakes. As these systems often physically, although temporally, connect with FMAS, such species may also be SRS although if their reproduction cycle needs access to specialized hydrological or physical environments they may not be self-sustaining within the FMAS. The term self-recruiting species (SRS), however, adds a livelihoods perspective to emphasize the importance of those species that do not require regular stocking, as costs and benefit are likely to be different to those inherent with stocked species. Most of the SRS known to be important in aquaculture (e.g. tilapias, small cyprinids, snakehead, catfish and invertebrates) are capable of carrying out their life-cycle either within the aquaculture systems or at least within the local area.

The current study aims to quantify and define the role of SRS from farmer managed systems, the seasonal dimension of their contribution to rural livelihoods and identify sustainable management approaches. The importance of SRS in the context of overall diets to rural households compared to other aquatic animals (both wild and stocked species) will also be assessed.

1.6 Poverty, livelihoods and aquaculture in Bangladesh

Poverty has many faces, changing from place to place and across time, and has been described in many ways. Poverty is hunger, poverty is powerlessness, lack of representation and freedom. Although the absolute numbers of very poor continues to increase, the proportion of the developing world's population living in extreme economic poverty, defined as living on less than $1 per day, has fallen from 28 percent in 1990 to 21 percent in 2001 (World Bank, 2002).

In Bangladesh, about 70 percent of the country's population are rural, of which 50 percent live in poverty and more than one in five live in extreme poverty (FAO, 1999). Aquaculture contributes to the livelihoods of the poor through improved food supply, employment and income (Edwards, 2000). Recently, viewing aquaculture as a component of development rather than aquaculture development has become more accepted. Muir (1999) illustrated the features of aquaculture and poverty as below (Table 1.3):

Table: 1.3 Primary features of aquaculture and poverty sourced from Muir (1999)

Positive opportunities	Potential constraints
• use otherwise underused resources • potential access for landless poor • possible options for artisanal fishing groups • opportunities for home food supply and inputs to local markets • involvement of women and children • may encourage better water management, with other benefits • range of secondary opportunities	• may give rise to resource access conflicts • possible market limitations-seasonal gluts/high prices in other circumstances • wealth creation dynamics may disadvantage poorest sectors • may depend on expensive seed, feed inputs • technical skills may be too complex • may add to production risks • may increase exploitation of vulnerable groups

The dimensions of poverty have been understood and described in many ways. Analysis of poverty requires disaggregating the poor and examining the many factors and combinations of factors that cause the poverty of different poor people. Hulme and Shepherd (2003) suggested a five tier categorization of poverty considering the extended duration of poverty as – 1) *Always poor* **:** whose poverty score (income, consumption, nutritional status, human deprivation index etc.) in each period (five years) is below a defined poverty line. 2) *Usually poor***:** whose mean poverty score over all periods is less than poverty line but are not poor every period. 3) *Churning poor***:** *whose* mean poverty score is around the poverty line but who are poor in some periods but not in others. 4) *Occasionally poor*: whose mean poverty score is above the poverty line but have experienced at least one period in poverty. 5) *Never poor:* whose poverty scores in all periods are above the poverty line. However, there are other classifications used in Bangladesh for poverty analysis such as destitute, ultra-hardcore poor, hardcore poor, moderate poor and neo poor (Mallorie, 2002) which are context specific but may also consider the duration of poverty. Hulme and Shepherd (2003) also noted that in any analysis of chronic poverty and livelihoods, it is important to differentiate whether one is referring to an individual, a household, a social group, a geographical area, or a country. The 'household' usually defined as a group of people who 'eat from the same pot' and live in the same residential unit has been the commonest unit of analysis for studies of chronic poverty to date. Critics of both neo-classical and Marxist approaches have rejected the characterisation of households as 'natural units' (Harris, 1981) and have theorised households as social units in which social and particularly gender relations need to be examined (Beall and Kanji, 1999). Critiques of the 'homogeneous' household mean that some research will have to focus on the 'individual level' or intra-household level and some poverty or livelihoods analysis can be focused on specific groups of people. Sometimes these are 'real' groups and have a common social identity such as fishers, pond owners, pastoralist communities etc. It may also necessary to focus on inhabitants of specific regions – such as remote rural areas, urban slums, low land areas, high land areas etc. Another important aspect of livelihoods, poverty and aquaculture analysis are broader macro-level trends occurring in Bangladesh. Toufique (2003) reported that many changes have recently occurred to livelihoods in Bangladesh which vary from place to place and region to region. Firstly, the gap between rural and urban has been declining fast. Secondly, markets have developed and inter-linkages intensified at various levels. Markets are increasingly playing an important role (Faruque, 2007). The forces of globalization are taking industrial commodities into village markets. Thirdly, there have been changes in allocation of labour force. Labour is moving out of agriculture-based livelihoods and entering into non-agricultural livelihoods. Karim (2006) again described in the context of peri-urban and rural locations in the north-central Bangladesh the importance of non-agricultural activities within livelihood portfolios.

Faruque (2007) reported on the importance of market dynamics to the development of aquaculture in three regions of Bangladesh (south-central, northwest & north-central). In particular he found that the number and type of market channels from rural producers to urban markets had significantly increased. Haque (2007) observed that farmers' involvement with non-farm activities can cause rejection of rice field based fish seed production technology in the northwest Bangladesh. The struggle of rural survival in many low income countries is increasingly linked to diversification of livelihoods of which the key determinants can be identified as seasonality, risk, labour markets, credits markets, asset strategies and coping strategies (Ellis, 2000). Rural livelihoods in Bangladesh have been diversified both in the agricultural and non-agricultural sector but are likely to retain a strong seasonal pattern. As diversification of livelihoods has been identified as an important strategy reducing poverty through alleviating vulnerability (Frankenburger et al. 2000; Allison & Ellis, 2001; Ellis, 2001), livelihood priorities and preferred outcomes should be understood before aquaculture is identified as a potential form of diversification

In Bangladesh, poverty dynamics need to be understood in terms of linkages between adverse shocks (such as massive floods and droughts), rural income, credit markets and nutrition (Hossain et al. 2002). Moreover, to capture the multidimensional features of poverty, any situation has to be viewed through a variety of indicators - levels of income and consumption, social indicators, and indicators of vulnerability to risks and of socio/political access (World Bank, 2002). Any change in the pattern of livelihoods needs to be fully understood to inform appropriate interventions.

Associations between aquaculture and broader livelihoods are complex (Muir, 2003) and include assessment of many factors apart from income. These include gaining and retaining access to resources and opportunities, dealing with risk, negotiating social relationships and managing social networks and institutions within households, and the wider communities (Beall and Kanji, 1999). Carney (1998) explained that an assessment of livelihoods assets should include both material and social resources. Ellis's (2000) approach is widely utilised and at its core proposes that the way in which a household meets its present and future needs, and pursues its aspirations, must be seen holistically and dynamically. By examining the full set of 'assets' at the disposal of any households the factors that shape the well-being or ill-being of its members can be understood at the micro-level in great detail (Murray, 2000) or at a meso-level through sample surveys of settlements and comparative aggregate analysis (Ellis, 2000). This can shed light on the ways in which household members, businesses, ‘civil society’, and the State interact to create, maintain or reduce poverty and vulnerability.

A **Livelihood platform**	B **Access modified by**	C **In context of**	D **Resulting in**	E **Composed of**	F **With effects on**
	Social relations	*Trends*		*Natural resource (NR) - based activities*	*Livelihood security*
	Gender	Population			Income level
	Class	Migration		Collection	Income stability
	Age	Technological change		Cultivation (food)	Seasonality
	Ethnicity	Relative prices		Cultivation (non food)	Degrees of risk
		Macro policy		Livestock	
		National economic trends		Non-farm NR	
Assets	*Institutions*	World economic trends	*Livelihood strategies*		
Natural capital					
Physical capital	Rules and customs				
Human capital	Land tenure				
Financial capital	Markets in practice				
Social capital					
		Shocks		*Non-NR-based*	*Environmental sustainability*
	Organisations	Drought		Rural trade	
		Floods		Other services	
	Associations	Pests		Rural manufacture	Soils and land quality
	NGOs	Diseases		Remittances	Water
	Local admin	Civil war		Other transfers	Rangeland
	State agencies				Forests
					Biodiversity

Source: Ellis (2000b:30).

Figure 1.2: Livelihoods framework for micro policy analysis (Ellis, 2000).

Livelihoods research needs to be carried out at both ‘household’ and ‘community’ level and involve empirical investigation of the various combinations of modes of livelihood and, above all, of the relationships between them (Murray, 2001). Additionally understanding changing livelihoods requires a defining of the structural, historical and institutional elements of what may for convenience be called its macro-context. A time-frame must be specified, key variables identified, important trends of change discerned. If livelihoods research is directed to the diagnosis of the causes of chronic poverty, the circumstances of poverty and the reasons for poverty should be understood through a detailed analysis of social relations informed by the particular historical context. This implies a structural or relational view of poverty, and, in turn, that understanding of its ‘persistence’ or its intractability or its ‘deepening’ should be driven by questions about inequalities of power (Murray, 2001). The implications for ‘policy-making’ from such research should contain explicit reflection on the particular, relevant, contexts in which ‘policy’ is made, with reference to the key questions; Who makes policy? How is it made? For what purposes? For whose benefit? With what outcomes?’’ (Murray, 2001).

In a livelihoods focused study, developing an understanding of vulnerability is one of the important challenges linked with all steps of analysis. Vulnerability has many dimensions including environmental, physical and social features and combinations of these. Floods and droughts are common phenomena in Bangladesh and cause fluctuations in food availability, employment and prices and affect land and water based food production systems increasing vulnerability. However, the “risk-centric view” of vulnerability is typically defined as variability in living standards caused by consumption or income shocks. The “rights-centric view” is that a lack of social and political rights causes vulnerability. Both the views are important in considering the implications of vulnerability for poverty reduction (Sen, 2006). The specific vulnerability context of aquaculture as an activity has many features such as - limited access to ponds and lands, poor productivity due to water scarcity and prolonged winter, acute and large-scale food shortages due to natural disasters like flood and drought. Gender and well-being disparities in access to, or consumption of, aquatic animals are important aspects. Poorly diversified production systems and poor access to inputs and markets and high levels of indebtedness etc. might also be expected to increase vulnerability. Haque (2007) found in a recent study in northwest Bangladesh that changes in land tenure increase vulnerability among rice field based fish seed producing households is also a factor of rejection of such seed technologies. The vulnerability of the poor who are most dependent on open access resources has increased as access to open fisheries resources becomes more controlled than in the past (Roos, 2001). Increased access to financial capital has created more access to ponds and other aquatic resources (Toufique, 2003; O’ Riordan, 1992) but the better off have gained more than very poor. Multi-ownership of ponds may impede management decisions and lead to conflicts in their use for aquaculture. Karim (2006) found that active integration of household ponds (*i.e.* fish & associated horticulture) were more frequent in those systems managed by single households. There have been various attempts to improve or maintain access of the poor to aquatic resources. Impacts of NGO group based larger ponds with landless, marginal farmer has shown mixed success and failure although Grameen Bank has successfully worked with landless groups to access public ponds for fish culture (O'Riordan, 1992). Community based fisheries initiatives were in many cases, found to be controlled by political interests or influential people rather than the poor. Possibly poorer people and share-croppers who do not own ponds may get the chance to do some sort of aquaculture or deliberate management activities with fish in rice fields they own, lease or sharecropped (Thompson et al. 1997). Garaway (1999) found that stocking in small community water bodies reduced regular access to fish for the poor in Lao PDR.

Harvest of aquatic animals is associated with the seasonal features of the flood cycle and fisheries biology may be associated with vulnerability as shown in the seasonal fishing cycle by Craig et al. (2001) modified from Hoggarth et al. (1999) (Figure 1.3) The harvest from FMAS and open systems are related to income and consumption vulnerability.

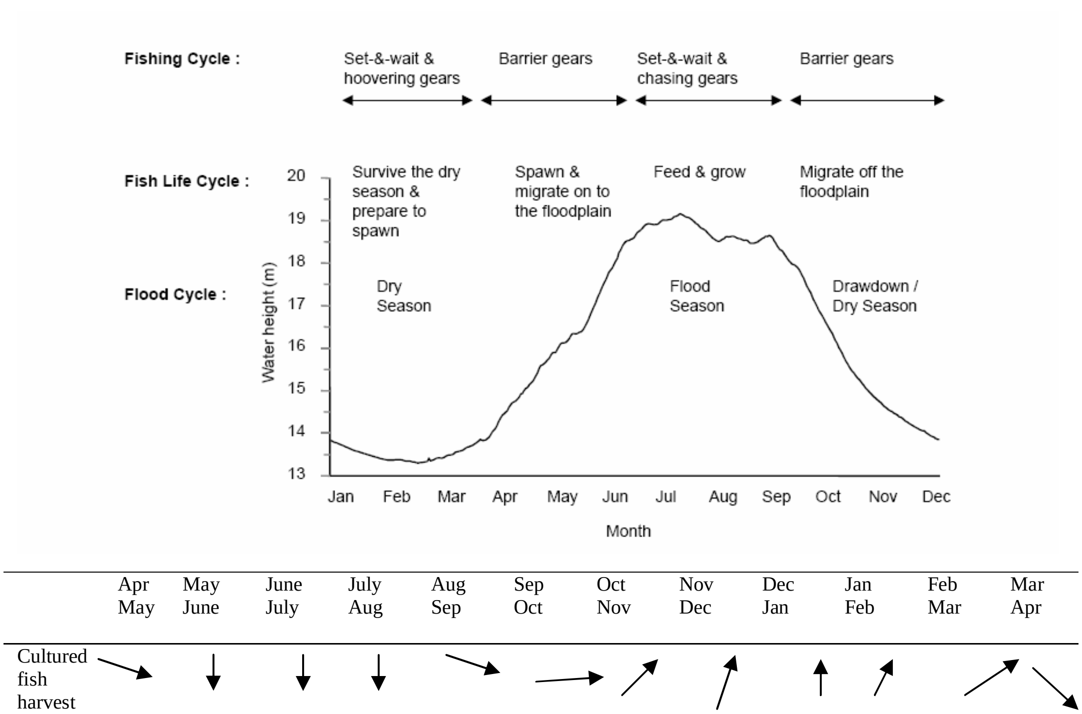


Figure 1.3: Fishing, fishing biology, flooding and aquaculture (source: modified after Hoggarth et al.1999, Craig et al., 2001)

A Fisheries Sector Review study of Bangladesh (2003) suggested that with the right mix of policy and investment the potential for the fisheries sector is potentially high in spite of increasing constraints over the coming decade (Muir, 2003). Therefore, continuous improved understanding on the role of aquaculture to reduce poverty is very important. The above discussion on poverty, vulnerability, aquaculture, livelihoods and its analytical frame work provides methodological and contextual insights which applied in the current study to examine the role of aquaculture and aquatic animal and SRS.

1.7 Research approaches to aquaculture in development

In 1980s and 1990s there was a shift from so called 'blueprint' or top-down approaches to bottom up rural development and which emphasised development as a process (Ellis and Biggs, 2001; Mosse et al., 1998). Participatory approaches tend to be less extractive than top down approaches and more empowering of those involved (FAO, 2000). The development of rapid rural appraisal (RRA) techniques in the last two decades was stimulated largely from the limitations and cost of traditional structured survey approaches (Chambers, 1994). Participatory techniques, in which the researcher plays more of a role of catalyst and facilitator for the farmer (Scoones and Thompson, 1994) uses tools such as poverty ranking, resource mapping (Lightfoot et al., 1992; Townsley, 1996) and seasonal calendars. Participatory approaches evolved from RRA and are used in many forms such as -active participatory research, agro-ecosystem analysis and applied anthropology (Pretty et al. 1995). PRA tools are being applied to the design of farmer-managed research, monitoring and evaluation (Lawrence et al., 1997) and institutional analysis (Crowley and Appendini, 1999) though the use of some RRA/PRA techniques have been questioned, both for their growing 'rigidity' and for becoming an 'end in itself' (Edwards and Demaine, 1997). However, well planned applications of PRA techniques such as ranking are now commonly used. More recently participation is being reviewed in a broader context, as to where it fits in relationship to broader development trends especially the promotion of decentralisation and other forms of participative governance (Hickey and Mohan, 2005). Research methods have gradually become more participatory, creative, flexible and diverse in nature. What is distinctive about participatory research is not the methods, but the methodological contexts of their application, differentiating it from conventional research in the alignment of power within the research process (Cornwall and Jewkes, 1995). It emphasizes action rather than only understanding alone with perhaps action later. Participatory approaches towards a more collaborative or collegiate research process include Participatory Rural Appraisal (PRA), Participatory Action Research (PAR), Participatory Research (PR) etc. PAR and PRA have particularly important roles in planning and implementation of activities within a development cycle. There has been growing concern that approaches of fisheries research need to change but this process is however, at a very early stage (Campbell & Salagrama, 2000).

In demand-led participatory action research it is important to link research with innovation. Deeper understanding of interactive and cross-disciplinary science, innovation and research is important to apply to the participatory process. Many scientists believe, innovation is not primarily about 'doing scientific research' (Leeuwis, 2004, Leeuwis and Remmers, 1999). Science can be rather strong at analysing what happened in the past, but is weak in composing, or synthesising, the future (Remmers, 1998). Whereas innovation is essentially synthesis, research is essentially analysis, but doing research and gathering data can include interactions between researchers and stakeholders that imply learning moments for both. Thus scientific insight and investigation can play an important role in social learning process and joint fact finding within a context of negotiation (Van Meegeren and Leeuwis, 1999). But innovation processes are not likely to be successful if they are owned and /or initiated by scientists alone (Broerse and Bunders, 1999; Leeuwis, 1999). For 'interactive' and 'cross-disciplinary' science (Röling, 1996) it requires a different modes of operation by scientists as - (a) intensive cooperation between stakeholders, change agents and researchers (b) cross-disciplinary cooperation among scientists (c) greater emphasize on-farm experimentation and (d) new procedures for setting research agendas etc. (Leeuwis, 2004; Vereijken, 1997; Bouma, 1999). These are new challenges. However, many universities and research institutes are not well equipped for 'interactive' and 'cross-disciplinary' science (Röling, 1996). They often employ scientists who follow linear models of innovation and are often more 'research' than 'innovation' oriented due to prevailing reward structures and funding arrangements.

In natural resource management research, a shift from "resource first" to a "people first" approach has become accepted (Chambers, 1983). From 'commodity' to 'people' was the new direction – humanization of science in action research was observed. Focusing on people and participation strongly influences the research process and outcomes. A recent but less pronounced move has been towards the social and cultural aspects of the fishery (Campbell and Salagrama, 2000). Moreover, an interest in process research rather than a complete focus on products of the research has gained relative importance. A blending of quantitative and qualitative tools in research is also now appreciated. Both adaptive and strategic types of research are recommended for short term and long term benefits (Edward, 2000). Flexibility of choosing a wide range of tools (qualitative and quantitative) is very important to grasp the real fact to assess any ideas critically.

In the 1980s participation was defined as a process by which participants or client groups influenced the direction and execution of development programmes to enhance well-being in terms of personal growth, income, self-reliance or other values. Local ownership and acknowledgement of analytical capabilities of local people (Chambers, 1994), are among the key tenets of participatory approaches. However, participation is complex and often misunderstood. All too often the term is used to describe a situation where village people are merely co-opted into an outsider's activities. Participation in its more advanced form is much more concerned with fostering relationships (Campbell and Salagrama, 2000), free from the normative biases of non-locals (Mohan and Stokke, 2000).

Finally, the importance of cross-disciplinary research in fisheries is also now more recognised. The World Bank (1992) reported that the level of integration of fisheries research with other sectors and disciplines has been low. Clearly the use of participatory approaches in fisheries research and development is comparatively new, but increasingly becoming more important as disciplinary approach have failed to embrace the complexity of needs. The above discussion on participation and participatory research indicates a new trend emerging between fisheries development and research.

1.8 Short description of SRS Project and the current part of the study

Considering the researchable context discussed above, a four year collaborative project was developed and implemented by the Institute of Aquaculture, University of Stirling, Asian Institute of Technology, Bangkok and Imperial College London with 5 partner countries (Bangladesh, Thailand, Vietnam, Cambodia, India) in South and South-east Asia to investigate the potential of self-recruiting species in aquaculture – and their role in rural livelihoods. In Bangladesh, Intermediate Technology Development Group (ITDG) - an international NGO was the key partner associate with Bangladesh Agricultural University (BAU), Mymensingh. A full four years (2001 – 2004) of field research comprising participatory community appraisal, household survey, intensive year round household monitoring and qualitative investigation were carried out as well as a one year farmers participatory trial. Finally, a one year (2005) dissemination phase was supported to share information and influence relevant decision makers. The research aimed to investigate the potential of SRS in existing aquaculture systems and identify and field test approaches that included SRS to optimize overall benefits to the poor. The purpose of the project was to characterise the role of self-recruiting species in different aquaculture systems, and to develop management approaches that enhanced 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.

However, this PhD study under the project focused on some specific areas of the whole project work..

1.9 Research objectives and key questions

The current study therefore focused on the following questions;

1) How do the SRS in farmer managed aquatic systems have different roles and importance to people?
2) Are these roles, importance and impacts on livelihoods different over time?
3) How, and in what ways, do these impacts on people's livelihoods occur?
4) Who benefits from the presence of SRS in aquatic systems and the relative importance of SRS.
5) Can aquaculture incorporating SRS be improved to benefit the poor?

The central focus of the current research was firstly to better understand people's livelihoods, their needs and priorities for SRS, and then secondly to relate this to the ecological and biological aspects of SRS management and their interaction with stocked species.

A working hypothesis was that the management of SRS within aquaculture systems in the northwest and south-central regions of Bangladesh is able to bring about sustainable nutritional, social, economic and environmental benefits (environmental benefits means better aquatic environment with diverse aquatic animals on which poor people rely on).

1.10 Framing working hypotheses and structure of the chapters

The research was conducted in 7 different steps. Based on the focus and sequence of investigation specific working hypotheses were formulated and framed in different chapters as presented (Table 1.4) below -

Table 1.4: Construction of thesis chapters and working hypotheses/activities

Chapters	Specific working hypothesis/activities
Introduction **[Chapter- 1]**	Concepts, rationale, context , scope and objectives
General methodology **[Chapter- 2]**	Road map of the research, frame work, time line, study sites and overview of steps
Understanding rural livelihoods, aquatic systems and SRS **[Chapter- 3]**	1. Sources of AA and SRS are different in two zones 2. Ponds, rice-fields and rice field ponds with rice fields are the three key FMAS in both zones and have different levels of access by households 3. Livelihoods are affected by gender, well-being and zone 4. Criteria for defining the importance of SRS are affected by gender 5. Importance of popular AA and SRS is affected by well-being and gender. 6. Access to pond aquaculture by well-being and zone is different 7. Livestock and poultry numbers are important poverty indicators 8. Cutting the dikes of ponds and rice fields is a common practice in the management of SRS 9. Education level is an important factor in farmer perceptions towards SRS. 10. Household access to other assets such as land and livestock are indicative of well-being level and relative importance of SRS in their livelihoods

Table 1.4 contd.

Area of investigation	Specific working hypothesis/activities
Seasonality of food consumption and the role of aquatic animals in rural Bangladeshi diet **[Chapter- 4]**	1) Percent contribution of aquatic animals in rural diet is minimal and consumption is affected by well-being and zone 2) Percentage contribution of SRS, stocked and wild aquatic animal (AA) consumption is affected by zone and well-being 3) Diversity in consumption of SRS is the same in both zones. 4) SRS are particularly important during the vulnerable food deficit months and has an important relationship to the availability of other food items, income and expenditure.
An on-farm trial to assess the impacts of promoting SRS with stocked carp polyculture in Bangladesh **[Chapter- 5]**	1) Incorporation of SRS in carp polyculture at semi-intensive level will negatively affect the production of commonly cultured carps. 2) Consumption, income from carp and SRS is similar among different farmer types. 3) There are social benefits of including SRS in carp polycultures
[Chapter- 6] ***General discussion***	Summary findings, contribution, implications and related others works in the same area. Follow on research

An important part of the research framework was to assess the roles of self-recruiting species (SRS) in aquaculture in terms of the perspectives of a range of people dependent on aquatic resources. Individuals and groups of different levels of well-being, resource access and of different gender were used to assess the broader livelihoods impact.

Chapter 2
Methodological overview

2.1 Introduction

This chapter describes the nature of the research process before briefly reviewing the methods and tools and overall research framework. A description of the study sites is given together with the research timeline and a sequential road map of different parts of the study. The systematic investigation focused at different levels (household, community, national) over a period of four years in two regions of Bangladesh.

2.2 Brief review of the key tools and techniques

The main approaches and methodological context of the research have been reviewed in Chapter 1. The specific methods and tools used for the current study are detailed in different chapters and included qualitative participatory tools such as – scoring, seasonal calendars, resource mapping and focus group discussions. Household surveys and a farmer participatory trial were also major components of the study. Broadly the study followed a focus towards micro- (household/individual), meso- (community) and macro- (national stakeholders) levels where a different range of tools and techniques was used based on the context.

The analysis of livelihoods has gained wide acceptance as a valuable means of understanding the factors that influence people's lives and well-being, particularly those of the poor in the developing world (Carney, 1998; Davies, 1996; Rennie and Singh, 1996; Bernstein et al., 1992). However, it has been criticized also for its lack of explicitness on power and political relations, including those dealing with gender equity and human rights (Carriere, 2001). It is critical to examine household asset portfolios and understand how assets interact with the context to influence the selection of livelihood strategies, which in turn determine well-being. Siegel (2005) suggests combining quantitative and qualitative spatial and household level analyses (and linked spatial and household level analyses) to deepen understanding of the complex relationships between assets, context, livelihood strategies, and well-being outcomes. The Sustainable Livelihoods Approach (Carney, 1998) was used as the main analytical framework to explore the multiple dimensions of poverty, rural livelihoods and role of SRS.

A situation appraisal using a community-based participatory approach was the first step to understand the broader context, vulnerability, trends, shocks and assets etc. Chambers (2002) pointed out that good PRA/PLA, which evolved out of RRA, is at best a process of appraisal, analysis and action by local people themselves. Such appraisals can be both empowering to local people and move beyond a simplistic overview. Truly extended PRAs can move from 'description' to analysis using the power of scoring and ranking exercises. Matrix ranking or scoring is a more refined method, whereby farmers are asked beforehand to identify a number of relevant criteria in judging - useful to evaluate different options, preferences and getting better understanding of a situation (Jiggings & De Zeeuw, 1992; Chambers, 1994). However, there is no guarantee of sufficient political support and backing within communities to work on specific problems and solutions, even if they emerge at the top of a list in a ranking and scoring exercise. Ranking and scoring exercises depend on how they are organized and the data analysed may run the risk of making negligible significant differences of opinion and interests. Community decision making can never take place on the basis of ranking only, but must be accompanied by wider negotiation efforts (Leeuwis, 2004; Pretty et al. 1995; Chambers, 1994). Taking all these criticisms into account such techniques were used to assess the relative importance of various household activities, relative household well-being and to determine the consumption preference of popular aquatic animals in the current study. Scoring was done on an individual basis within groups to capture intra-group variations. However, in some cases it was also carried out with small focus groups.

The appraisal (PCA) was later shared and presented at a macro-level national workshop which finally identified specific areas and directions of investigation. It was also important to validate the strategic direction of the research with higher level policy makers, development practitioners and researchers. Following the PCA phase, household surveys were conducted to gain more detailed insight of aspects identified during the earlier community level assessment. Snow & Thomas (1994) stated that survey techniques for data collection are particularly useful in gathering data on issues such as past experience and motives, which is not possible using contemporary observation. Personal interviewing has some limitations, of which researcher and interviewee bias is considered to be the most serious (Duhaime and Grant, 1994). However, personal interviews allow exploration of more complex, individual or community level issues.

Understanding gained both from PCA and one-off household surveys typically only provide indication of seasonal trends. A longitudinal part of the study was necessary to capture food consumption, income and expenditure patterns and associated information over an annual cycle through sampling using three day and seven day recall methods. A number of factors, such as day of the week or season, may contribute to daily variation in dietary intake in a systematic manner. The magnitude of these influences is largely determined by cultural and ecological factors (Willett, 1990). The longitudinal study aimed to cross-check and quantify insights derived from PCA and household survey considering complex seasonal perspectives.

Later a farmer participatory trial was conducted to assess the impact of farmer management on outcomes of polyculture actively including SRS. Leeuwis (2004) discussed that .farmers are likely to engage already in ‘experimental’ activities, even if this may not be immediately clear and visible to outsiders. Farmers’ experimentation can take many forms, which usually deviate to a large extent from the ways in which scientists think about experiments. Farmers do not always ‘run’ different experimental ‘treatments’ (including a control treatment) simultaneously. Instead of comparing simultaneous treatments (as scientists usually do), they may well compare different ‘treatments’ over the years. And instead of having their own ‘control treatment’ they may well use other farmers’ farms and practices as a point of reference. Thus between-farm comparisons are an important form of farmer experimentation. The organisation of the trial attempted to build on these farmers’ natural research intentions and intuitive approaches. The farmer participatory trial in this study was collaborative and collegial by the nature of the participation and explored farmers’ experimental experience using a monthly group discussion approach. Biggs (1989) has suggested four levels of participation in farming research: contract, consultative, collaborative and collegial.

A combination of both qualitative and quantitative methods has gained credibility in research (Kanbur, 2001), and the current investigation includes these two types of methodologies. Integration includes using one type of method to identify key categories to be studied with the other, or using insights from one method to inform the sample design to be used with the other method. The current study emphasised triangulation of key findings between the community level appraisal, household level assessment, year round monitoring and farmer participatory trial. The whole research process followed an action research approach as described by Elliott (in Hopkins, 1985):

- Initially an exploratory stance is adopted, where an understanding of a problem is developed and plans are made for some form of intervention strategy. *(The Reconnaissance & General Plan)*
- Then the intervention is carried out. (The *Action* in Action Research)

- During and around the time of the intervention, pertinent observations are collected in various forms. (Monitoring the implementation by *Observation*)
- The new interventional strategies are carried out, and the cyclic process repeats, continuing until a sufficient understanding of (or implement able solution for) the problem is achieved *(Reflection and Revision).*

The research process was iterative or cyclical in nature in that observations were discussed monthly and was intended to foster deeper understanding of a given situation, starting with conceptualizing and particularizing the problem and moving through interventions and evaluations. A representation of an Action Research (AR) protocol by Kemmis is provided in Figure 1 which was useful in the context of current methods.

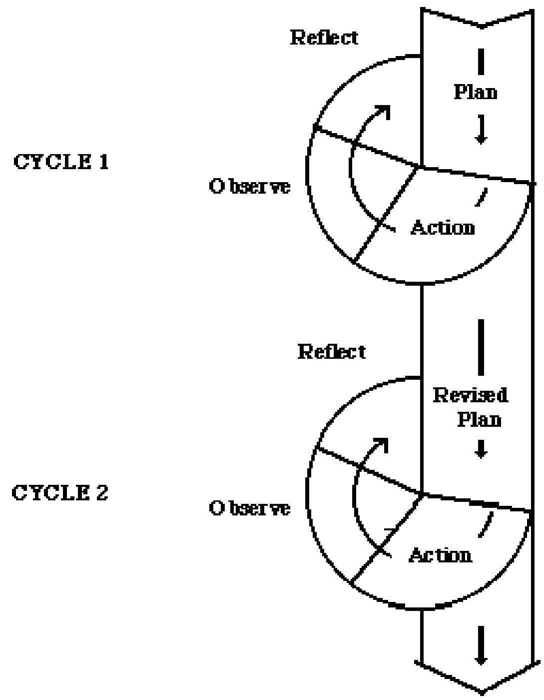


Figure 2.1: Action Research Protocol after Kemmis (cited in Hopkins, 1985).

The current study followed an action, observation and reflection method, revised its hypothesis and plans at each step before proceeding to the next step. As the whole research was collaborative and collegial by nature, the mode of this action research related to both researcher and participants of the study. Participating households continuously provided feedback prior to start each step from PCA to qualitative social investigation. The whole research started from a macro- and community-level understanding, crossed through to a farmer participatory trial and gender/social investigation and finished with a dissemination phase. The research continues with farmers still carrying out actions on the lessons they learnt, and capacity for research is retained at various levels and among different stakeholders.

2.3 Stakeholders or the target audience of the research

There are always numerous ways in which a community or population can be segmented into 'stakeholders' or 'target audiences'. In most situations, for example, one can differentiate between people who have distinct demographic, agricultural and/or socio-economic characteristics. Along such lines, one could distinguish ‘stakeholders’ according to age group, gender, family life cycle, religion, farm size, ethnic group, agro-ecological zone, education level, farming system etc.(Leeuwis, 2004). To investigate the hypotheses underpinning the current study a wide range of stakeholders from two zones (section 2.4) of Bangladesh were involved (Table 2.1 & 2.2)

Table 2.1: Types of stakeholders or target audiences of the study in different sections

Stakeholders and different parts of the study	No. of households /participants
1. PCA /focus group in 18 communities of two zones :	
Poor Men Group	90
Poor Women	90
Better off men	90
Better off women	90
2. National level workshop (national level in Dhaka)	
Government Officials	35
Non-Government Officials/NGO	43
Academicians/students	60
3. Baseline survey (in two zones)	
Aquaculture households (households with ponds)	79
Non-aquaculture households (without ponds)	40
4. Longitudinal study- one year monthly monitoring (in two zones)	
Low well-being group	22
Medium well-being	14
High well-being	14
5. One year farmer participatory trial (only in the northwest zone)	
SRS Positive farmers	10
SRS Negative farmers	12
SRS Neutral farmers	7

2.4 Study site

In Bangladesh, the study covered two zones (Table 2.2) based on duration of flood, position with the watershed and project working areas of the research partner ITDG-Bangladesh. The first zone was the northwest Bangladesh (NW) an upstream area where seasonal flood is short-lived. The zone is also characterised by poor, sandier soils and seasonal drought. There is a trend towards community resources being privatised and the role of farmer-managed resources becoming increasingly significant. Large open access water bodies are relatively uncommon. Three districts (Dinajpur, Panchaghar and Kurigram) were selected purposively from a total of 8 districts in the northwest region to represent distance from a large river and type of aquatic systems present.

The second zone was located within low-lying districts in south-central Bangladesh (SC) where extensive annual floods merge many individual farmer resources into larger temporary community water bodies. Floods tend to be relatively long term and large open water bodies (such as lake/*beel*, *baor*) are numerous. Three districts (Rajbari, Faridpur and Goplagonj) were selected purposively out of a possible five districts based on their distance from the river Padma and types of aquatic systems present. Both zones were considered to be moderate to high food insecure areas of the country.

Table 2.2: Zone and district characteristics

Northwest zone	South-central zone
Zone characteristics	Zone characteristics
• Up stream area • Both poor and fertile soil present • Drought longer/Flood shorter • Flood short durational • Generally less open water bodies • Food inure sec	• Down stream/low-lying area • Poor/Sandy and some fertile soil • Flood longer /drought shorter • Flood stay longer • Many open water bodies • Food insecure
District characteristics	District characteristics
Kurigram • Attached to two rivers (Tista and Brammaputra river) • Capture dominant , both aquaculture and culture based and capture fisheries, present • Flood affected area, flood stay 2 months • Poor productivity of soils mostly sandy	Rajbari • Attached to the river Padma, low-lying district • Flood duration at least 3 months • Capture dominant, both aquaculture, culture based and capture fisheries present, few perennial ponds • Moderate productivity of soil • Riverine area
Dinajpur • 80 km from Tista river • Short duration of flood (15 -30 days) • Aquaculture dominant, both aquaculture, capture, culture based fisheries present • Comparatively productive soil, well-known for quality rice producing area	Faridpur • Close to the river Padma • Flood duration 3-4 months • Both aquaculture and capture present, many perennial ponds • Moderate productive soil
Panchaghar • 50 km from Tista river • Very short duration of flood • Very less capture fisheries and reliance on aquaculture high • Sandy poor soil	Gopalgonj • 30 km from Padma river • Flood stays longer more than 5-6 months • Highly flood affected area, • Capture and culture fisheries present – a lot of shrimp farms, mostly perennial ponds. Big flood plains and wet land areas. • Also as some tidal affected area without salinity. A lot of common aquatic resources present, Most of the land produces one crop of rice only

Source: PCA

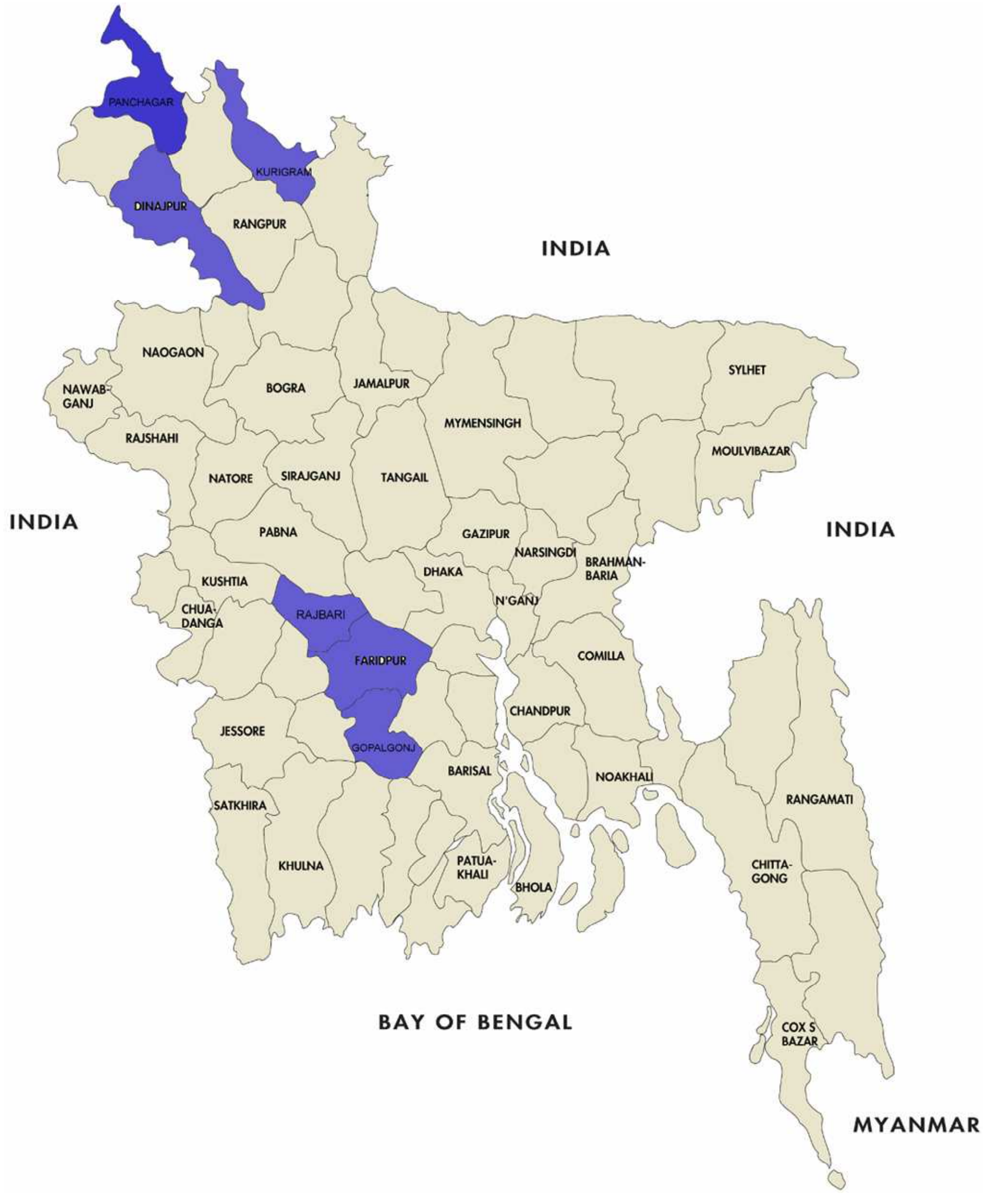


Figure 2.2: The map of Bangladesh showing study sites; upper highlighted areas encompassed of north-west districts and lower highlighted areas encompassed of south-central districts.

2.5 Research frame work and timeline

The research framework was designed following the DFID-Sustainable Livelihoods framework (Carney, 1998). It was designed in line with the broader SRS Project framework presented below in Figure 2.3. The project started in 2001 and finished in March 2006. The dissemination phase of the project, was concerned more with institutional uptake and sharing and was not included (2005-06) in this study. Therefore the research framework (Figure 2.3) covered the livelihoods context, assets, strategies and outcomes. A summary table on activity and actors is presented in Table 2.3.

Time frame	Tools/methods	Outcomes/area of investigations

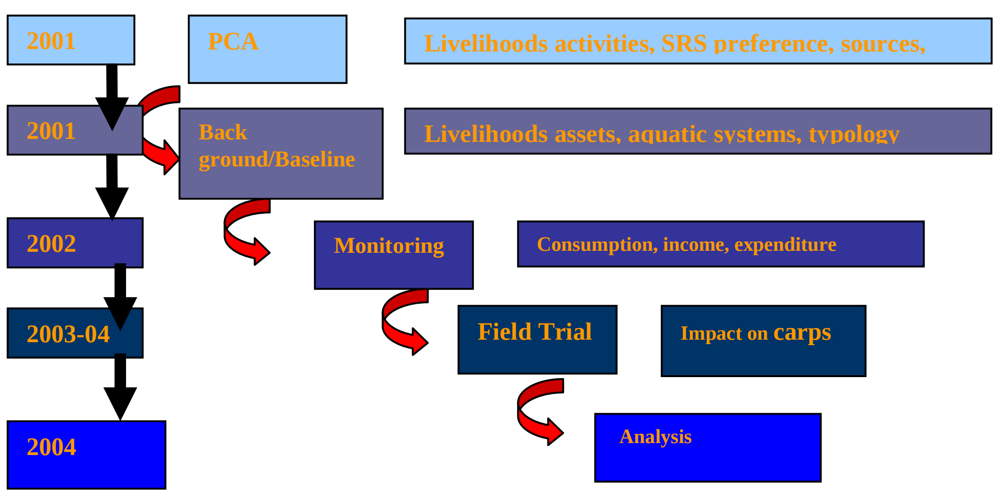


Figure 2.3: Research frame work and timeline.

Table 2.3: Summary table of activities and actors of the current research in Bangladesh

Actors	Project planning	Proposal Writing	PCA & Data entry	PCA final data analysis	PCA report	Stakeholder Workshop	Back ground survey	Background survey primary final data analysis	Household Monitoring,	HM Data analysis	Field Trial design /implementation	Trial data Analysis	Final analysis and thesis write up
Institute of Aquaculture													
Dr. Dave Little ****	x	x	x	x	X	X	x	x	X	x	x	x	x
Anton Immink #			x		X	X	x	x	X	x	x	x	
ITDG-B													
Faruk-Ul-Islam **		PhD x p	x	x	X	X	x	x	X	x	x	x	x
Al Masud,*			x			X	x		X				
K.C. Shaha*			x			X	x		X				
S. Islam*			x			X	x		X				
N. Shams*											x		
BAU													
Dr. M. A. Wahab		x	x		X	X	x		X		x	x	x

* Research Assistant ** Researcher PhD Student, # Project Coordinator, *** Local Supervisor, **** Principal Supervisor, BAU= Bangladesh Agricultural University, ITDG-B= Intermediate Technology Development Group-Bangladesh

2.6 Roadmap of the research

The current research followed an action research process (cyclic) where one step led to the next including some parallel activities. It began with developing a clear understanding of communities and the macro context before investigation at household level. The research methodologies used were more qualitative in nature at the beginning and at the end, but more structured and quantitative in the middle with baseline, trial and longitudinal studies. The major steps of the study were as follows:-

Step 1: Community level Assessment - Participatory Rural/Community Appraisal

This first step of the research in the field was to understand the broader livelihoods context, livelihoods activities, seasonal trends, vulnerabilities, aquatic animal species preference, criteria of importance and sources of aquatic animals, A total of 360 participants from 18 communities in 6 Districts of two zones participated in this phase of work (Figure 2.3). A multi disciplinary team of 3 - 6 members composed of staff with a fisheries or social science (both 3-5 male and 2 female staff) background used a wide range of PRA tools such as resource mapping, well-being analysis, activity matrix, preference scoring and source ranking, time line, seasonal calendar, transect over a period of six months from March 2001 to August 2001. This step generated a broader understanding on the context of livelihoods, well-being and major categories of rural people. The preference for different SRS and their sources were identified. The importance of farmer managed systems to the overall supply of aquatic animals was established. The exercise also allowed livelihood assets and management actions regarding aquatic systems and attitudes of farmers to be explored. The findings of the participatory community/rural appraisal (PCA or PRA) were presented to a wide range of stakeholders including development workers, researcher/academicians and government policy makers which followed the step 2.

Step 2: National Level Stakeholder Validation Workshop –

Following the Community Appraisal (PCA) stage a national level workshop was organized in August 2001 which was attended by 138 participants from universities, research institutes, Department of Fisheries, private sector, NGOs, donors and policy makers. This was a four day (20 - 24 August) exercise to analyze, clarify and present PRA findings in order to get feedback from broad range of stakeholders and to disseminate the research findings so far. The workshop gained a good deal of local attention from policy makers and the general public, and featured in national English and local language daily newspapers.

The workshop also allowed the researchers to further develop their conceptual broader understanding of the prospects and constraints of SRS culture and conservation. It informed a further need for characterising aquatic systems and defining management strategies. The workshop confirmed the need for a deeper understanding of the specific roles of SRS and assessment of their importance in the food and nutritional security of rural households.

Step 3: First household level assessment: a one off household background survey on farmer managed aquatic systems, SRS and aspects of rural livelihoods

The study aimed to understand the management approaches and relative importance of SRS and the major characteristics of farmer managed aquatic systems and livelihood aspects. 119 households were sampled from 12 communities (10 households per community) of two zones within 4 Districts (Dinajpur, Panchagohr, Rajbari, Faridpur) from September 2001 to November 2001.

To ensure coverage of all major types of farmer-managed aquatic systems, samples were stratified by whether or not households practiced ‘conventional’ aquaculture involving the stocking of hatchery fish. Three communities from NW and 3 from SC zone involved in the participatory appraisals were excluded to reduce the sample size due to limited resources. Communities were sampled from the previously identified PRA communities following the same criteria (as distance from a river and presence of all types of farmer managed systems) and a total 10 households per community was sampled from ‘aquaculture’ and ‘non aquaculture’ groups using a proportionate randomised approach as aquaculture and non-aquaculture households were not present in the same number in all communities.

This background survey provided information on household assets, physical characteristics of, and access to, farmer managed aquatic systems, the diversity of SRS management activities and range of exploited species. It served as a basis for the selection of the households covered later in the monitoring survey.

Step 4: Baseline survey of the households on households regarding livelihoods status and associated issues

Baseline information was collected from 51 households (5 households per community) in 10 communities located in 4 districts of two zones in December 2001, prior to the start of year round monitoring (Step 5) exercise with the same households from January 2002. Households were sampled following a stratified randomised method as in the background survey. The sample size was less than in the previous background and PRA (Step1) due to limited resources. However, considering factors like continuous access to farmers, interest, and distance from project office for a longer period the study was based on 51 households of which 40 were identified as aquaculture and 11 non-aquaculture.

This section also followed a stratified method of sampling to ensure coverage of the types of farmer managed aquatic systems. Samples were stratified by practice of conventional aquaculture including the stocking of hatchery seed as in step 3. The five households per community were randomly sampled from the list of households surveyed in step 3.

Information on specific household profiles and livelihoods assets and farming systems were investigated as a basis for exploring seasonal differences thorough the monthly monitoring of those households.

Step 5: Household level year round monitoring on food consumption and livelihoods dynamics.

The seasonal dimension of livelihoods and aquatic resource management were monitored with the same 50 households from 10 communities (5 households per community) in 4 districts (Dinajpur, Panchaghor, Rajbari, Faridpur). Households were interviewed based on a structured questionnaire (Appendix 4) and through using a series of maps (Appendix 1) on a monthly basis from January 2002 to December 2002 through a full annual cycle.

This section of study especially focused on the contribution/role of aquatic animals compared to other main food items and the role of SRS in rural diets. The sources, of SRS impact of consumption on nutritional status and food vulnerability was also assessed. Better knowledge of the seasonal dynamics of SRS production and consumption in rural Bangladesh was expected to inform better fisheries policy.

Step 6: Intervention phase - One year Farmer Participatory Trial

To assess the impact of actively managing SRS on conventional carp poly culture in one district of north-west Bangladesh, 29 households in three communities were sampled following a stratified random method to conduct a farmer participatory trial for 12 month from May 2003 to April 2004. Households were stratified as ‘aquaculture’ (i.e. with FMAS) and ‘non aquaculture’, then based on their existing management practices/actions on managing SRS aquaculture households were again stratified as SRS positive (n=10)- those who undertake some deliberate actions to keep SRS in their system, SRS neutral (n=7) – households that neither eradicated nor encouraged SRS and SRS negative (n=12) – deliberately prevented entry of SRS or attempted their removal by netting. The study analyzed the interaction between carp and SRS, production, consumption and resultant socio-economic impacts.

2.7 Data analysis

Initially data was entered in FoxPro, then exported to Microsoft Excel and finally to SPSS for analysis. In some parts of the study (e.g. farmer trial), data was directly entered into Excel and, following final data arrangement was exported for analysis to SPSS. Microsoft Access was also used for preliminary analysis of data from the longitudinal study. Errors were detected and necessary corrections were made after export. Entered data was also checked randomly against the raw data/questionnaire. Qualitative data were coded where appropriate to facilitate handling and analysis.

Standard descriptive and inferential statistical methods were use to analyse baseline and monitoring survey and trial data. Descriptive statistics such as frequency tables, mean standard deviation (SD) were used for primary analysis. ANOVA and GLM , post hoc analysis were employed for comparing sample means to identify the relationships between variables and significant differences/association among them. Intra and inter group variations between different well-being groups, farmer types and zones that influenced livelihoods, role of SRS, resources, SRS production, consumption were identified. In the GLM model zone, well-being, farmer type were usually used as fixed factors and community as a random factor. Community was nested within zone for all analysis. Only in the longitudinal study zone, well-being and month was used as fixed factors and household identification number (ID), community was used as random factor, community was nested within zone and ID was nested with in zone, community and well-being. All main effects and two way, three way, four way interactions were evaluated.

As correlation is one of the most important and basic test in elaboration of bivariate relationships, to indicate both the strength and the direction of the relationship between a pair of variables correlation coefficient were also used in some cases where necessary. Specific tools, test and area of analysis presented in Table 2.4.

Table 2.4: Tools and programs used for data analysis

SL	Tools	Program	Areas of analysis
1	Descriptive statistics	SPSS	Distribution of households in a community, mean number of people per households, general frequency distribution
2	Association between categorical variables	SPSS: Chi-square test	Identifying association between two variables such as education-well-being. Mainly used in the background survey (Chapter 3 & 4, Appendix 8 & 9)
3	Univariate analysis	SPSS: ANOVA, GLM, Post hoc test (Tukey)	Identifying significant difference among one variable with more than one independent Used in background survey, monitoring (Appendix 10) and Farmer participatory Trail (Chapter 3, 4, 5) For example, carp and SRS production, consumption in three farmer type. T-test between SRS POS and NEG types.
4	Linear association	SPSS: Correlation coefficient	To identify how strongly pairs of variables are associated. Used in Chapter - 4, For example , between consumption and income, consumption and diversity of SRS
5	Bar and pie diagram	MS Excel and SPSS	Graphic analysis of the findings. Used in Chapter-3, 4, 5. For example percent contribution of food item, % contribution of SRS, stocked and wild fish.

Chapter 3

Understanding rural livelihoods, aquatic systems and SRS

3.1 Introduction

This chapter describes the broader features of livelihoods and household assets. Characteristics of farmer managed aquatic systems (FMAS) in terms of their physical and social features were assessed, and the conventional perceptions of aquaculture and farmer attitudes towards SRS are also presented. The effects of gender and well-being perspectives on the importance of SRS and households livelihoods were investigated. The major factors affecting vulnerability and the importance of different livelihood activities were considered. The current study follows a livelihoods framework to examine household assets, vulnerability, institutional issues, livelihoods strategies and outcomes. This chapter begins by explaining broader vulnerability factors and the features of important livelihoods activities, gives an analysis of land and water access and proposes a typology of FMAS. Finally relevant aspects of livelihood assets are linked to the various roles of SRS. The results in this chapter were derived from national (macro), community (meso) and household (micro-) level investigation through the participatory community appraisal (PCA; step 1), stakeholder workshop (step 2) and household level back ground survey (step 3) of the study. A detailed methodology of steps 1-3 described in this chapter, are based on the outline and overview introduced in chapter 2. In particular, the overall importance of livelihoods activities, sources of aquatic animals and characteristics of key farmer managed aquatic systems are reported. Indication of SRS management practices and their relationship to broader livelihood strategies is described in this section.

People draw on a set of capital assets as a basis for their livelihoods and it is important to understand the capitals available to individual households which support their ability to secure livelihoods strategies such as gaining access to different aquatic systems. A series of choices determine the livelihood strategy exercised by individuals and households over the use of assets. Livelihoods are vulnerable to shocks, trends and seasonality (Soussan et al. 2003; Chambers, 1989; Davies, 1996). Some factors such as credit markets, asset strategies, labour market, seasonality and risk which affect livelihoods also need to be understood (Ellis, 2000). Material and social circumstances of how people survive are important to understand (Escobar, 1995). Fishery- related livelihoods are particularly complex, dynamic and adaptive (FMSP-4, 2006). Livelihood connections particularly with different forms of aquaculture are also complex, for poorer households. The growth of aquaculture in Bangladesh has both positive and negative effects. The issue of providing a consumption safety net for poor rural households is a crucial issue to understand while commercialising both the fishery and aquaculture sectors (Muir, 2003). In a context of scarce land and competitive use of water, appropriate forms of aquaculture accessible for poorer households need to be understood. Species linked issues to consumption, social benefits, importance of livelihoods activities, men and women's choice of species are also important to analyse rural livelihoods in connection with aquaculture and the broader fishery sector. However, rural aquaculture is not merely a question of targeting the poor. It demands a comprehensive understanding of contextual circumstances, operating environments and enabling conditions. Current knowledge gaps largely concern environmental and social aspects, and the livelihoods aspects of the small-scale and poor farmers (ADB, 2005). The role of different species currently in use and potential expansion of small-scale aquaculture based on new species with potential needs greater understanding to assess their livelihood impact (Muir, 2003). Therefore, the current study sought to better define this livelihood context.

Sustainable and productive use of, and access to, resources such as land and water are cornerstones in efforts to maximize their contribution to growth and poverty reduction, and provision of environmental services (Lovett et al. 2006). A holistic systems assessment of rural peoples' livelihoods depends on an understanding of key physical resources and the ecological systems that support them. Perspectives from a production unit, whole farm, livelihood and broader geographical context are required to properly understand rural aquatic systems and their role (Little et al. 2000; Karim 2006). Farmer participatory research emphasises the importance of understanding the entire system. A farm is a system composed of interacting subsystems that include land, labour, capital, crop and animal production, off-farm income, social and economic components, physical and biological components (Selener, 2006). To capture the high degree of social interaction between households and communities, livelihoods need to be analysed at several levels. It is also important to consider overlap and interdependency between the broader livelihoods and aquaculture systems to get a clear indication of their actual or potential interrelationship (Pollock, 2005).

The potential gains of, and prospects from, the Bangladesh fisheries sector (aquaculture, culture based and capture fisheries) depends on the quality and availability of Bangladesh's physical and biological aquatic resources and its impact on livelihoods (Muir, 2003). In Bangladesh, the effective management and conservation of aquatic resources is challenged by poor understanding of its type, ownership and improper management. The multiple use nature of aquatic resources and their vulnerability to human interactions and climatic changes are also constraints (Ahmed, 1999).

A clear understanding of the types of aquatic systems, ownership of aquatic resources, fish stocks and their management (specific management actions) are important for promoting any form of aquaculture (FAO, 2004). Little et al. (2004) emphasized that as aquaculture continues to expand through the creation of new habitats, the availability of SRS will become increasingly linked to their production within aquaculture systems. However, agricultural intensification might adversely affect the availability of SRS from farmer managed systems (e.g. rice fields) and encouraging SRS in FMASs might also undermine the success of stocking-based aquaculture.
The broad researchable issue with the study is that the inclusion of SRS as a part of aquaculture can enhance benefits to the livelihoods of the poor.

Working hypotheses under this chapter are

1. Sources of AA and SRS are different in two zones
2. Ponds, rice-fields and rice field ponds with rice fields are the three key FMAS in both zones and have different levels of access by households
3. Livelihoods are affected by gender, well-being and zone
4. Criteria for defining the importance of SRS are affected by gender
5. Importance of popular AA and SRS is affected by well-being and gender.
6. Access to pond aquaculture by well-being and zone is different
7. Livestock and poultry numbers are important poverty indicators

8. Cutting the dikes of ponds and rice fields is a common practice in the management of SRS
9. Education level is an important factor in farmer perceptions towards SRS.
10. Household access to other assets such as land and livestock are indicative of well-being level and relative importance of SRS in their livelihoods

Objectives of this chapter are to –

1. Investigate farmers' attitudes to managing SRS and the relative importance of different livelihood activities
2. Identify key factors that tend to optimize the importance of SRS within farmer managed aquatic systems.
3. Analyse assets and access to different FMAS in two zones.
4. Analyze management actions in FMAS in relation to SRS

3.2 Methods

The participatory community appraisal (step1) of the research process gave a preliminary understanding of the sources of aquatic animals in both zones, and some physical features of the aquatic systems from farmers descriptions during PRA exercise. These findings were cross-checked during the stakeholder workshop (step 2) resulting in an improved typology of aquatic systems for the study area and characteristics of main types of FMAS. The characteristics of FMAS, SRS management actions and their relationships to livelihoods were investigated in depth in a further background survey (step 3).

3.2.1 The Participatory Community Appraisal (PCA; step 1)

The main purpose of the PCA was to understand the broader livelihood and ecological context thorough an assessment of livelihood activities, seasonal trends, importance of aquatic animals, criteria of measuring importance and sources of aquatic animal in the study area. Eighteen communities from 3 northwest and 3 south-central districts participated in the study between March 2001 to August 2001.

Sample

According to McMillan and Schumacher (1989), the determination of sample size should take into consideration several factors; such as - the type of research, research hypothesis, financial constraints, the importance of the results, the number of variable studies, the method of data collection, and the degree of accuracy needed. Following a stratified random method households were sampled from the communities located in two zones. Each step from zone to household level followed some specific criteria and method which presented detail in Figure 3.1.

PCA grouping

Figure 3.1 describes that based on ecological characteristics as 1) Upstream-down stream of river 2) Duration of flood 3) Types of aquatic systems two zones were purposively selected represented by 3 districts as Panchaghar, Kurigram, Dinajpur in northwest (NW) and another 3 districts as Rajbari, Faridpur, Gopalgonj in souh-central (SC) zone.

District within each zone were selected considering above 3 criteria and distance from a major river. Kurigrame, Rajbari were considered districts close to the river, Panchaghar, Faridpur intermediate and Dinajpur, Gopalgonj were distant from the river. Then three villages were purposively selected from each district following specified criteria (Figure 3.1). As each village consisted of 3 communities, one community from each village (*Gram*) was randomly sampled. Usually a community (*Para*) consisted of around 35 households.

Following a stratified random approach as described in Figure 3.1, 20 participants from 10 households (5 richer men, 5 poorer men, 5 richer women and 5 poorer women in each focus group) per community were sampled randomly for the focus group scoring and discussion exercises. The scoring for livelihood activities were based on focus groups segregated by gender and well-being (poorer men -PM, richer men - RM, poorer women- PW, richer women - RW where each person scored independently. The importance of aquatic animals was scored by groups after discussion among the group members. Resource mapping, seasonal calendars and major sources of aquatic animals were also group activities.

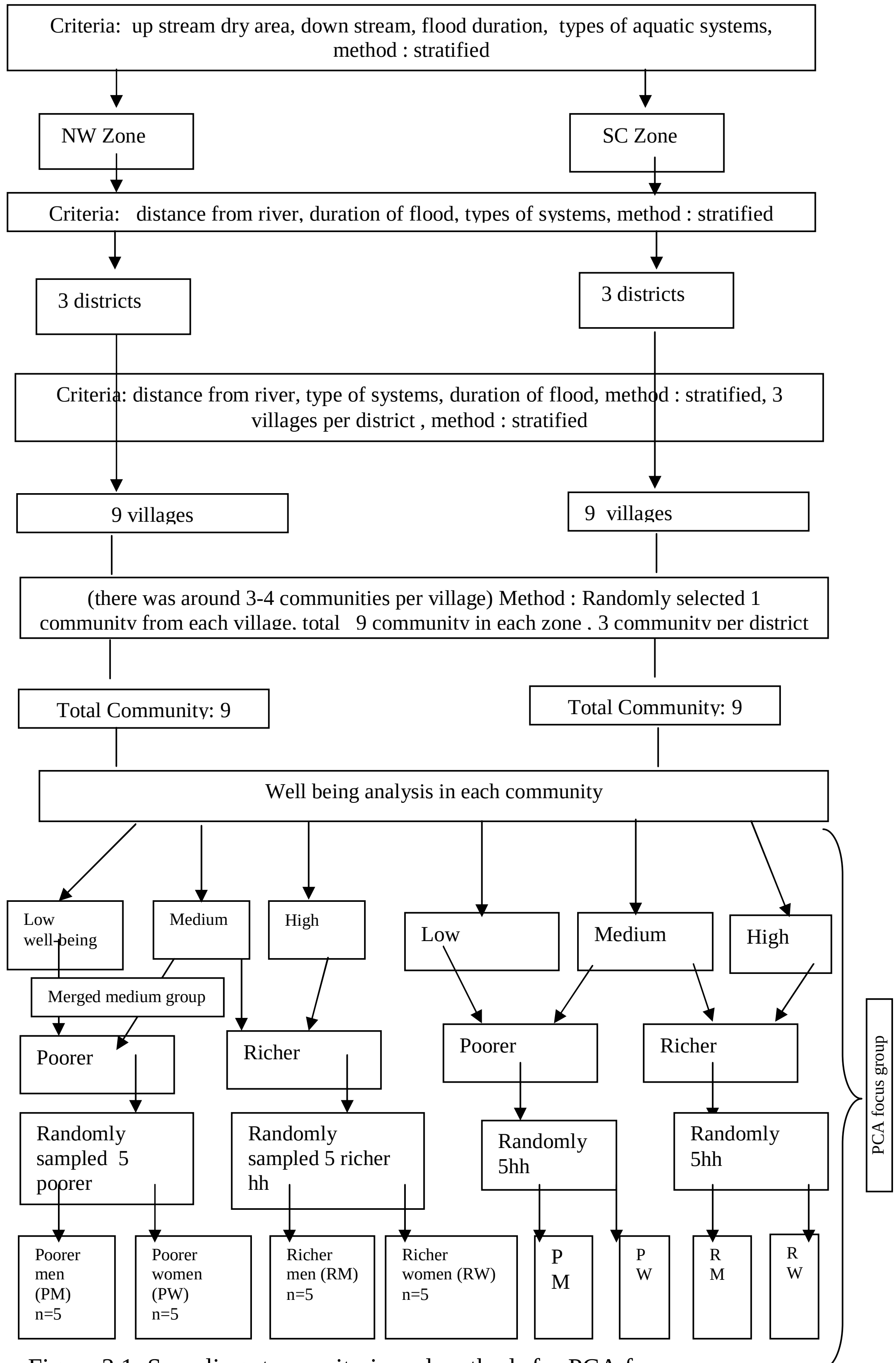


Figure 3.1: Sampling steps, criteria and methods for PCA focus groups.

Tools

Specific PRA tools included – village resource maps (Appendix 1), well-being scoring, activity matrices, preference and aquatic animal source scoring, development of time lines and seasonal calendars, transects of agro-eco-system and land use. Focus group discussions were used to undertake activities that yielded both quantitative (score) and qualitative (contextual, non-numeric) information (Appendix 2.1). Dried beans and large poster papers were used for scoring/ranking exercises. The number of beans used in scoring exercises followed specific rules to allow statistical analysis of the findings**.** The study was focused at a community level and its social and geographical boundary. Six PRA sessions were held during which a sequence of activities was conducted in each community on different days. These activities were held over during a total of 108 days within a five month period. Focus group participants invested around 4-5 active hours per day for different sessions. Some snacks and food were provided to the participants.

Well-being analysis

Wealth ranking, scoring is a widely employed method in which a small number of knowledgeable community members categorise village or community households into wealth ranks using a set of pre-established criteria (Afonja, 1992). Chambers (1994) also described the method as part of an approach that built on local values and knowledge to understand socio-economic stratification.

The names of all households' heads in a community were listed from 2-3 key informants (individuals experienced about the village context, older and respected by other villagers). A mixed group of 10 participants represented by poorer, richer (men, women, pond owner, non-pond owner/fisher) was formed to facilitate a discussion on general social classification in the community (Appendix 2.2), their key resources, socio-cultural aspects and income sources. General factors that were considered to affect well-being were 1) main occupation, 2) land holding, 3) savings, 4) education, 5) house material, 6) health, 7) access to television, radio, agricultural equipment/machine etc. Once a mutual understanding of the basis of the scoring was established among participants a group scoring exercise (consensus on a score for a household by all participants, collective mean) was followed to score each household from the list. This group scoring on a consensus basis was done to avoid individual bias of intentionally designating someone into a particular well-being group. The strength of this scoring approach is the open consultation and mutual agreement of scores. Usually, one person took a lead to start the process asking someone's name and then others comment on him/her on the basis of agreed criteria. A total of 20 beans for each household were used to score each household in turn. The highest possible score for each household was 20 and the lowest was 1. From the score participants categorised households into three groups as poor (Low well-being), medium (Medium well-being) and rich (High well-being). The number of ponds and main occupation were also recorded to identify aquaculture and non-aquaculture groups. After the mixed group scoring process the score was cross checked by one representative participant from each well-being and gender group (nominated by their own group). Views were again exchanged and revisions, if appropriate, made. An example of scoring process is presented in Table 3.1.

Choosing the subjective and /or objective ways to well-being analysis depends on context (Bebbington, 1999). Qualitative indicators gives an insight as to the scale of the problem and the qualitative indicators are more adept at addressing causal issues. The appropriateness of how and what to measure depends on what the information is needed for, by whom and at what scale and the resource available (Thorpe, 2001).

Table 3.1: Example of well-being scoring at Surjanagar (community), Rajbari

Household SL no.	Occupation	No. of Pond*	Score		Remarks
1	Business	2	**********	10	Medium
2	Business	1	*************	13	Medium
3	Agriculture	1	***************	15	Rich
4	Agriculture	2	***************	15	Rich
5	Business	02	***********	11	Medium
6	Labour	-	**	02	Poor
7	Business	4	***************	15	Rich
8	Labour	-	***	3	Poor
9	Agriculture	1	******************	18	Rich
10	Rickshaw puller	-	***	03	Poor
11	Agriculture	1	*********	09	Medium
12	Business	1	****	4	Poor
13	Business	-	*****	5	Poor
14	Business	1	********************	20	Rich
15	Agriculture	3	*************	13	Medium
16	Teacher	1	*****************	17	Rich
17	Agriculture	2	****************	16	Rich
18	Business	1	********	08	Medium
19	Service	1	************	12	Medium
20	Business	-	******	6	Poor
21	Teacher	-	******	06	Poor
22	Service	-	**********	10	Medium
23	Business	-	*******	7	Poor
24	Labour	-	***	3	Poor
25	Labour	-	**	02	Poor
26	Agriculture	1	*****************	17	Rich
27	Agriculture	2	***************	15	Rich
28	Small trade	-	******	6	Poor
29	Farming	-	*********	9	Medium
30	Agriculture	2	***************	15	Rich
31	Agriculture	1	********	8	Medium
32	Business	1	*********	9	Medium
33	Small business	1	**********	10	Medium
34	Agriculture	1	*****	5	Poor

* ponds includes both large ponds (d*ighi)*and ditches used for aquaculture

source: PCA

A higher number of beans indicated a better off status, and fewer indicated poorer household. Scores between 1-7 considered as ‘poor’, Score 8 -14 ‘medium’, Score 15 - above considered as ‘rich’ by the participants.

Time line

In each community a historic timeline was drawn by a mixed group of 10 participants representing different sub-groups (poor men, rich men, poor women, rich women) within each community which gave a historic record of the key events in the community in relation to their livelihoods (Appendix 2.3). The events were considered and identified collectively (Table 3.2) by participants and recorded by the facilitators

Table 3.2: Example of a time line conducted with a mixed group in Munshipara, Shakehat in Panchagorh district

Year	**Key event**
1943	Experienced famine and many hungry people came here for food (1350 Bengali year)
1968	Farmers start sugar cane cultivation
1971	Liberation war and people leave for India and stay there for few months
1986	NGO activity start (by RDRS)
1989	Fish disease occurred
1990	Start cultivation of HYV(High yielding variety) rice
1994	Start improved methods of fish culture
1995	Lift pump (small irrigation machine) supplied by and NGO (RDRS)
1996	Cultivation of water melon as cash crop starts

Source: PCA

Livelihood activity matrix

Livelihood activities including those that were both economic and non-economic were considered and listed before scoring by gender and wealth segregated groups (PM, RM, PW, RW) in each community. This reflected their assessment of the household as a whole. Five participants in each group were encouraged to individually score the important activities. The total number of beans per respondent was fixed at 20 (for all activities) to score the set of activities identified by the group. In the northwest region activity scoring was carried out by male groups due to a lack of time and resources, however in some cases more detailed information on livelihoods options were collected (Appendix 2.5 and 2.12).

An example of the activity of the activity matrix is presented in the following table 3.3.

Table 3.3: Example of an activity matrix produced by better off female group at Surjanagar

Activities*	Name of individuals					
	Alya	Roushan	Amena	Irain	Lucky	Total
Rice farming	6	5	6	4	5	26
Wheat farming	1	0	2	0	1	4
Vegetable cultivation	2	2	2	2	1	9
Poultry rearing	1	2	1	2	1	7
Cow/goat rearing	0	1	1	1	2	5
Household activities	8	8	6	10	9	41
Prayer	1	1	1	1	1	5
Jute cultivation	1	1	1	0	0	3
Total	20	20	20	20	20	20

*their perception of the household as a whole
Source: PCA

Aquatic animal (AA) importance ranking

Criteria of measuring importance of aquatic animals

Criteria of importance of different aquatic animal such as abundance (high abundance), income (profit), taste (good taste) for the preference of different aquatic animal including SRS were listed by each group in communities and scored for their relative importance. The criteria were established in group discussions based on how each group valued aquatic animals locally. The total number of beans against all criteria was 20 in all groups. This gave a relative importance score for each criterion (Table 3.4) for all species. As each species was scored (in the next step) against all criteria separately a score of relative importance was generated first for all criteria.

Table 3.4: Criteria scoring in Tulagram by rich men (RM) group

Abundance	Income (profit)	Easy to catch (easy to harvest)	Taste (good taste)	Costly (high price)	total
6	4	2	5	3	20

After getting the list of criteria of measuring importance, each group listed the name of their important aquatic animals , then scored all mentioned species for one criteria (e.g. abundance) using a maximum of 10 beans per species. Then, all species was scored for the second criteria in a similar way and so on. Finally the relative importance score of each criterion was multiplied with the actual score for each species. An example of scoring presented in Table 3.5.

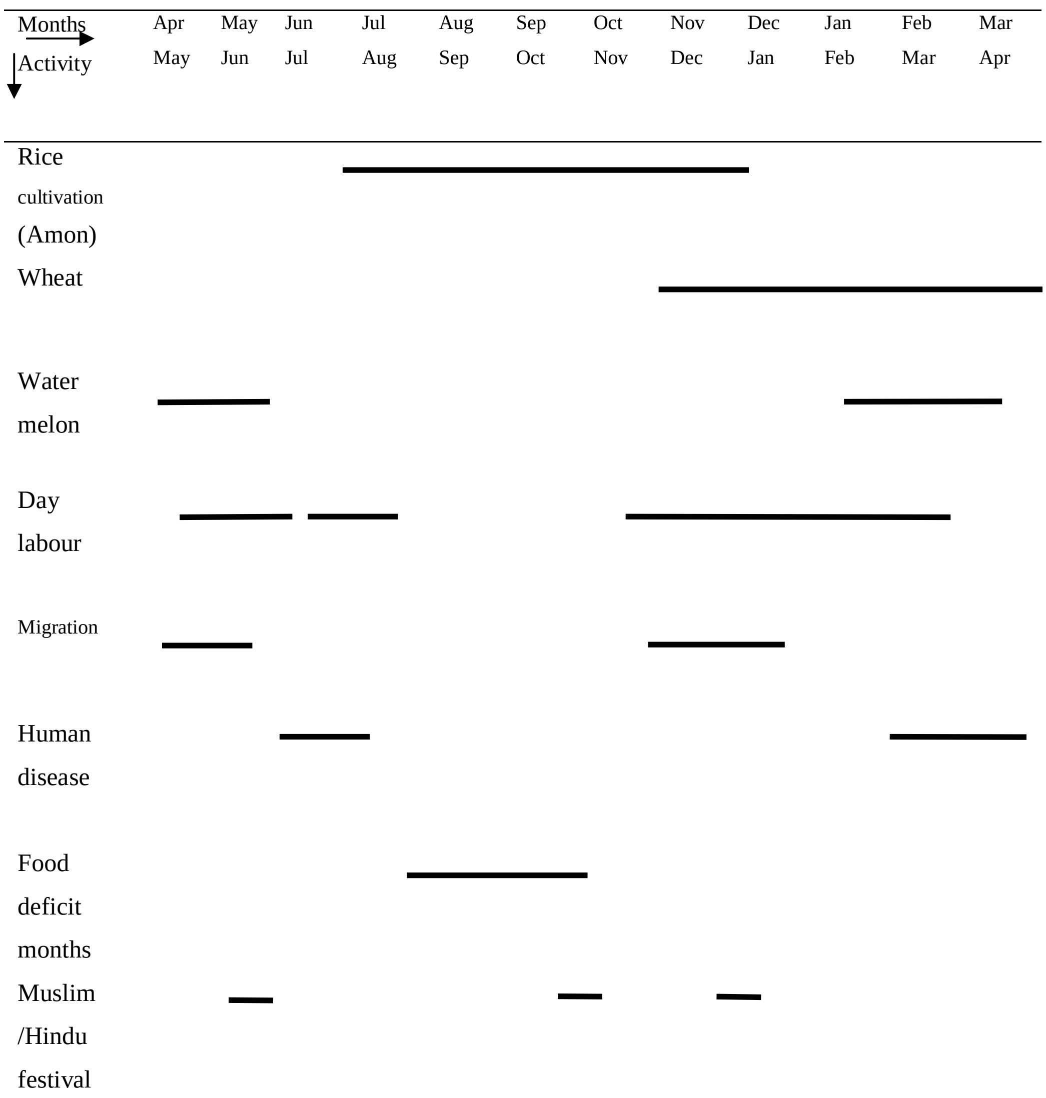
Table 3.5: Example of scoring of important aquatic animal by poor men at Surjanagar, Rajbari

Species (local & scientific name)	High Abundance	High income	Easy to catch	Good taste	High nutritional value
Koi (*Anabas testudineus*)	24	24	10	40	24
Bale (*Glossogobius guris*)	18	16	8	15	12
Kholla (Rhinomugil Corsula)	12	12	4	20	9
Royna (*Labeo gonius*)	6	4	10	15	9
Shal baim (*Macrognathus sp.)*	6	4	2	20	15
Magur *(Clarias batrachus)*	18	20	6	50	30
Foli *(* Notopterus notopterus*)*	6	4	4	25	18
Pabda (*Ompok pabda*)	6	4	2	45	24
Mola (*Amblypharyngodon mola*)	18	16	10	25	12
Tara Baim (*Mastacembelus aculeatus*)	24	20	4	20	15
Gulsha (*Mystus bleekeri*)	6	4	2	30	15
Tangra (*Mystus viattus*)	12	12	2	25	12
Kholisha (*Colisa fasciatus*)	42	20	12	15	6
Taki (*Channa punctata*)	54	32	14	15	9
Shinghi (*Heteropneustes fossilis*)	24	24	8	45	27
Bata (*Chirrhinus reba*)	30	28	10	25	15
Puti (*Puntius sp.)*	60	40	20	15	6
Shole (*Channa striata*)	12	12	4	20	12
Gutum (*Lepidocepahlichthys guntea)*	18	12	4	10	9
Chapila (*Gudusia chapra*)	6	4	2	10	12
Chela (*Chela cachius*)	6	4	2	15	9
Gochi baim (*Macrognathus pancalus*)	24	20	12	20	9
Tatkini (*Chirrhinus reba*)	24	24	8	25	12
Kajoli (*Ailia colia*)	6	24	2	30	18
Kakila (*Xenetotodon cancila*)	6	4	2	10	6
Batashi (*Pseudeutropius atherinoides*)	6	4	4	20	9
Chanda (*Paranbassis baculis)*	12	4	8	5	3
Prawn (*Macrobrachium sp*.)	54	40	16	30	15

Source: PCA

Seasonal calendars

Seasonal calendars of important livelihood activities, household income expenditure, village life and general weather conditions were drawn up by four separate groups (PM, RM, PW, RW) and mixed groups in each communities. A mixed group of 7-8 participants was formed taking representatives from all four groups. Livelihood activities were drawn up by the four focus groups whereas income, expenditure, weather was drawn from mixed groups due to time and resource constraints. An example of a seasonal calendar exercise is presented in Figure 3.2.



Source:PCA

Figure 3.2: Example of a seasonal calendar by a focus group of poor men in Munshipara.

Village map

Village maps were drawn for each village by mixed participants from each group which identified main aquatic resources in the village, crop growing areas, households, roads, market etc. The facilitators particularly helped participants to distinguish between open and farmer managed systems for each household The location of boundaries of aquatic and terrestrial systems within the bigger picture of the village were emphasized (Appendix 1).

Sources of aquatic animal

The availability of different aquatic animals obtained from different sources (open and FMAS system) was scored by mixed groups (equal representation from PM, RM, PW, RW) in each community using a total of 20 beans for 5 different sources. Canals, *beels* and rivers were considered as open system and pond, rice fields (flood-plain rice fields) were considered as FMAS (Appendix 2.3). Seasonal nature of harvests of AA was also investigated in some cases (Appendix 2.13).

Analysis

Scoring data were analyzed using Excel and SPSS. For the livelihoods activity and AA preference analysis GLM (General Liner Model) was used identifying variation due to zone, gender, well-being (fixed factors) and community (random factor). Descriptive facts from maps and individual narratives, seasonal calendars and time lines were summarised through qualitative interpretation.

3.2.2 Detailed methodology of national level stakeholder workshop (step 2)

A national level workshop was organized six months after the initial field work (August 19-24, 2001) in order to share and validate relevant aspects of SRS research issues, primary findings and for making future research plans. One of the most important parts of the workshop was to cross-check the characteristics of aquatic systems and to assess if the findings were generalisable to other areas of Bangladesh. It also allowed insights to be gained concerning the perspectives of different institutional stakeholders in Bangladesh.

The one day workshop was organized by the Intermediate Technology Development Group-Bangladesh, Dhaka inviting participants who were country partners of the project in Bangladesh. Government officials particularly from the Department of Fisheries, Water Development Board, academics (university teachers and students), researchers, and NGO staff were invited in the workshop. A questionnaire was circulated among participants with specific questions regarding their interest (questions on reasons of participation in the workshop, most important and immediate task/strategies they would prioritise for SRS issue). Out of 138 participants, 37 participants responded to the questions in written form during the meeting (although all of them gave feed back orally during group exercises) which were analyzed to explore institutional perspectives.

Also during the workshop, different working groups (research team members of around 4-5 in each group) clarified the typology of farmer managed aquatic systems and access to the systems. They listed the characteristics of sites, key farmer managed aquatic systems and importance of stocked species and SRS in the systems.

In the open workshop day, a group exercise was facilitated among the stakeholders asking the following questions:

1. Give your opinion on the relevance of the project to improve livelihoods of the poor.

2. What are your experiences regarding SRS in aquaculture? How could our project results most compliment them?
3. Which of the observations identified in our preliminary study are more useful?
4. In what form would you like to receive further information that the project produces?
5. Do you have any questions or clarifications about any aspects of the project?

3.2.3 Detailed methodology of the household level background survey (step 3)

The six month Participatory Community Appraisal phase of the research characterised the broader general context of livelihoods and SRS management in two zones in Bangladesh. The background study was planned to further investigate and triangulate the ecological and livelihood impacts of specific farmer managed systems and SRS within the broader farming system. This survey served as a basis for the selection of households for the next step of a baseline and monitoring exercise at the household level. The background survey focused on investigating the specific characteristics of farmer managed aquatic systems and their relationship to the livelihoods of rural people (Appendix 3).

More than one hundred (119) households from 12 communities in two zones were sampled using a randomised stratified approach (Table 3.6). A total of 9-12 households per community was sampled from ‘aquaculture’ and ‘non aquaculture’ groups using a proportionate randomised approach as aquaculture and non-aquaculture households were not present in the same number in all communities. Aquaculture households mainly had culture ponds and non-aquaculture households did not have culture ponds but they had rice-fields or none of the systems.

Well-being was ignored during sampling although each household was subsequently identified as low, medium or high using the analysis from the PCA exercise. In each community there were around 30 households.

Table 3.6: The sample distribution

Zone	Community	Aquaculture	Non-aquaculture
Northwest	1	7	4
	2	7	4
	3	8	1
	4	5	4
	5	6	4
	6	2	7
South-central	1	6	3
	2	7	2
	3	7	3
	4	5	4
	5	8	3
	6	11	1

3.2.4 Data collection

Data collection occurred through an individual household survey. Three well trained staff having educational background of MSc and BSc in fisheries were engaged to collect household data using a pre-tested questionnaire.

Staff coaching and field testing of the questionnaire: The survey questionnaire was first discussed among the study team including externals and then field tested in some communities as an important requirement.The team was informally trained during the PCA facilitation. The reaearcher closely checked survey data randomly if any mistake is done.

3.2.5 Data analysis

Collected information was entered into a spreadsheet checked, coded before doing statistical analysis. The entered data were randomly checked against the raw data sheets. Further consultation with research assistants and some cases with the community people were required. MS Excel was also used for organizing the data set. Some primary analysis (descriptive, graphs etc.) was carried out using MS Excel. Finally, data was exported from Excel to SPSS for conducting Chi square and General Liner Model tests. AQU Households were further classified as positive, neutral or negative towards SRS based on the management of their aquatic systems, specifically if they allowed or eliminated SRS. SRS positive (POS) - allowing SRS in their systems, SRS neutral (NEU)- those who neither eradicated nor encouraged SRS deliberately and SRS negative (NEG) group actively preventing entry of SRS and eliminating them if observed. Well-being categories were Low, Medium, High well-being groups designated from the PCA well-being analysis.

3.3 Results

3.3.1 Perceptions of well-being and gender group

Well-being and gender based perceptions of the households in both zones were collected which was an important list to index and analyse livelihood relations. Households defined well-being based on the range of assets and perceived vulnerabilities. The stratification of well-being and gender based on local knowledge is presented in Table 3.7 and 3.8.

Table 3.7: Well-being perception among households

High well-being	Medium well-being	Low well-being
Northwest :		
1. Can save after maintaining their household cost	1. Can't save after maintain their family cost	1. Can't maintain their household cost with their income
2. Educated, children are also educated (Human capital)	2. Not so educated, Children are going up to secondary level	2. Mainly non educated, children are going up to primary school
3. Live in good house (brick, tin)	3. Thatch or tin made house	3. Rice or wheat straw made house
4. More land, own ponds (natural/physical)	4. Few agriculture land (usually not more than 2 acre),own ponds	4. Very less agricultural land ,sometimes less than 1 acre
5. Profession: mainly agriculture, service and business	5. Profession: Agriculture (Share crop), service or small business	5. Profession; Mainly day labour
6. Have good health (Human)	6. Good health but can't spent lots during sick.	6. Bad health, at the time of illness they go to quack doctor for cheap medicine
7. Mostly own TV, cassette player, irrigation machine (many of them)	7. Less access to TV, cassette player, modern agril equipment	7. Do not own such assets
8. Have good clothes (Physical/social)	Have clothes	Inadequate or poor clothes
South-central 1. Not indebted but they lend money (Financial capital) 2. Are educated and able to send children to good school (Human) 3. Own good house (half brick or strongly made by tin) with good furnishers, television, motor cycle and cassette player (Physical) 4. Own large tracts of fertile and well-irrigated land (Natural) 5. Sometime have salaried jobs or earn income from land and business. Employ others to work on their land. 6. Good health and can spend more money for treatment when necessary. 7. Many of them own TV , cassette player, irrigation machine Others : 8. Own several large livestock 9. Have full stomach 10. Can borrow from banks easily. 11. Have political contacts (Social)	1. Not indebted, may lend to others 2. A few are educated and are able to educate their children to a reasonable school (Human capital) 3. Own a reasonable house and in some cases have bi-cycle, motorcycle. 4. Own sufficient land. 5. Earn from land (shared, own), and small business, may have salaried job. Hire others to work on their land. 6. Good health. 7. Own television or cassette player, hire irrigation machine. 8. Own a few large animals. 9. Well fed. 10. Can borrow from banks 11. Have political contacts.	1.Indebted to others. 2. A few families send their children to government schools for a few years but the parents are not educated themselves. 3. Thatched roof house. 4. Own insufficient land or no land. 5. Mainly labour, small petty trade. Work on their own/shared land and work for others at low wages. 6. Frequently fall ill. 7. Do not own television, cassette player 8. Own a few goats. 8. Do not have enough to eat every day or buffer food stock for the time of scarcity 9. Can not borrow from bank easily. 10. No /very less political contacts/less influence

Note: SL numbers do not mean order of importance; source: PCA

Characteristics of households determining well-being are complex and linked with ownership of various assets. Levels of well being and rural poverty was identified by levels of savings, education, house type, land, occupation, health, home appliances, clothing, food security, access to livestock and poultry, political linkages and influence, access to credit/services and ownership of fish ponds in both zones.

Selling labour was an important indicator for poorer men and women describing people of low well-being (Table 3.8). Ownership of land, food security, nature of profession, health, and access to modern recreational and agricultural equipment, level of income characterised the better-off in both zones. Gender perceptions are also summarised in Table 3.8 Access to land, selling labour, power and influence in the society mainly differentiated rich and poor men in both zones whereas access to land, working hours, the nature of daily physical work differentiated poorer and richer women. Poorer women had lack of access to land or ponds. However, they tended to have more NGO contacts than the better-off. This findings from PCA stage gives a context of well-being in both zone to link the role of aquatic animals and livelihoods.

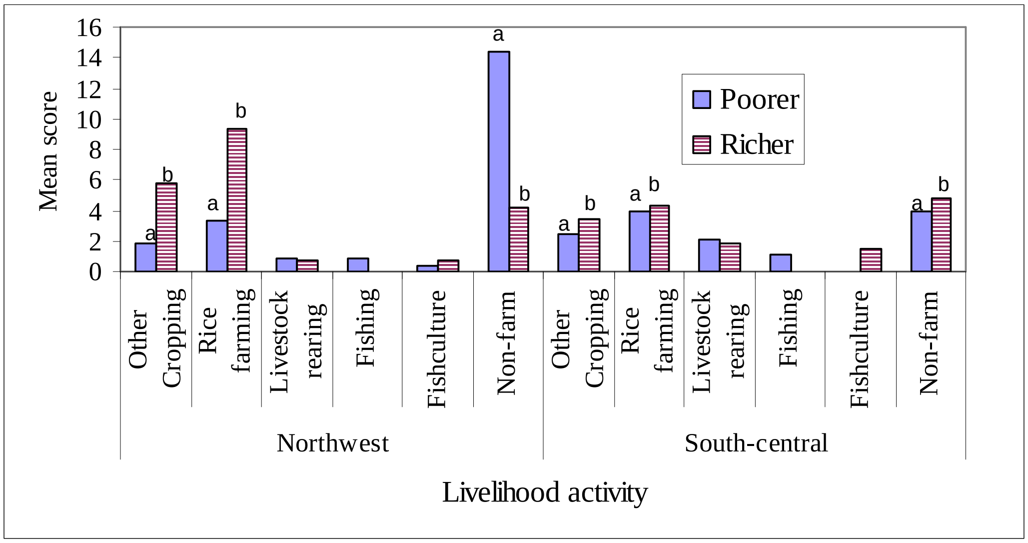
Table 3.8: Perceptions by gender and well-being in both zones

Rich men	**Poor men**
Cultivate rice and some cash crop on their own land. Have more land and business. Have influence on others in the community	Sell labour in rice and other cash crop fields. Cultivate in share cropped lands. Many of them earn from rickshaw/van pulling, migrate for selling labour. May also earn from petty trade. Usually own (shared, rented land) below 100 decimal of crop land. Some have nothing except the homestead, or between 5 -50 decimal land. Less influence, power.
Rich women	**Poor women**
Mainly do post - harvest work of their crops in their house. Work on homestead garden. Have livestock's and help in small-scale irrigation in the crop fields. May own some land. Main period of relaxation in rainy season (June to August)	Wage labour in richer households. Usually do not migrate to sell labour. Engaged with NGOs Have poultry and some home garden(less than richer women) Normally do not own any land or pond Work more hours than richer women. Main period of relaxation in rainy season (July, Aug, Sep) October to February busiest time.

Source:PCA

3.3.2 Overall importance of different major activities to livelihoods

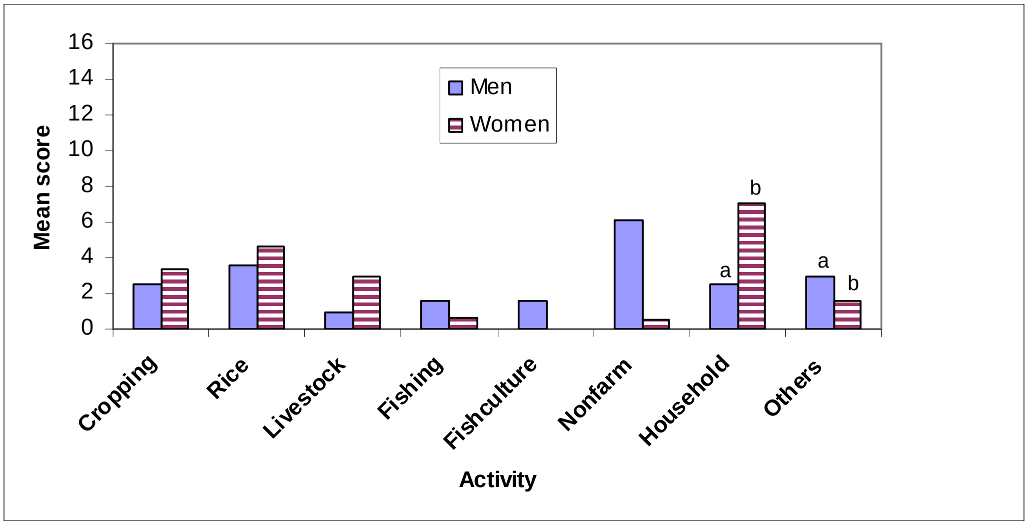
Livelihoods activities were more diversified in the south-central than northwest zone. Rice farming was far more dominant as an activity in the northwest than the south-central zone. Both gender and well-being affected important activities with significant differences observed between involvement of the better-off and poorer (Figure 3.3 & 3.4). Fishing was more important to poor men and aquaculture of much greater significance to richer men. Non-farm activities were more important for the poor in the northwest and men in general. Poorer people in the northwest were significantly more dependent on non-farm activities (such as labour, rickshaw pulling etc.) than the better off.Importnace of livelihood activities such as other cropping, rice farming and



Source: PCA

Figure 3.3: Importance of major livelihoods activities to livelihoods by well-being. (a,b means -significantly affected by group)

non-farm activities were significantly ($P<0.05$) affected by well-being and zone (The livelihoods of poorer households were both agriculture and non-agriculture dependent. Figure 3.4 shows cultivation of rice and other crops are important to both men and women. Even though women are not usually engaged in fishing, they perceive the importance of fishing to their household. Livestock (poultry) and household activities were scored as being comparatively more important to women (Figure 3.4) than men.



Source:PCA

Figure 3.4: Overall importance of different major activities to livelihoods by gender in south-central zone (n=120), data from 6 community in SC; a, b shows significantly affected

Importance of household (non paid, reproductive activities) and other activities were significantly ($P<0.05$) affected by gender.

Primary and secondary occupation (from household survey)

The key primary and secondary occupations detailed from the household survey confirmed the preliminary findings of the PCA in both zones. Primary and secondary occupation was categorised into 5 major groups as farm, labour, business, service and others. Farming was relatively more dominant among the better-off in the northwest than south-central. Labour (agricultural, non-agricultural and special forms of skilled labour) were dominant occupations among the poorer people in both zones. Business or petty trading dominated among poorer people in the south-central but not in the northwest zone. Whereas service or monthly paid employment including government and non-government service was a small portion of overall occupations it was dominated by the better-off (Table 3.9). Non-aquaculture households were of low and medium well-being and based livelihoods mainly on labour and petty trading.

Table 3.9: Primary occupation of household head (n=119)

zone	Farmer type	Well being	Primary Occupation of household head					Total
			Farming	Labour	Business	Service	Others	
Northwest	AQU	Low	03 (42.86)	02 (28.57)	01 (14.29)	01 (14.29)	00 (0.00)	07 (100.00)
		Medium	08 (61.54)	02 (15.38)	01 (07.69)	00 (0.00)	02 (15.38)	13 (100.00)
		High	14 (93.33)	00 (0.00)	01(06.67)	00 (0.00)	00 (0.00)	15 (100.00)
	NON	Low	06 (35.29)	09 (52.94)	02 (11.76)	0.00	0.00	17 (100.00)
		Medium	04 (57.14)	03 (42.86)	00 (0.00)	0.00	0.00	07 (100.00)
		High	0.00	0.00	0.00	0.00	0.00	0.00
South-central	AQU	Low	06 (35.29)	03 (17.65)	07 (41.18)	01(05.88)	0.00	17 (100.00)
		Medium	08 (61.54)	00 (0.00)	05 (38.46)	00 (0.00)		13 (100.00)
		High	07 (50.00)	00 (0.00)	04 (28.57)	03 (21.43)	0.00	14 (100.00)
	NON	Low	04 (30.77)	03 (23.08)	03 (23.08)	0.00	03 (23.08)	13 (100.00)
		Medium	03 (100.00)	0.00	0.00	0.00	0.00	03 (100.00)
		High	0.00	0.00	0.00	0.00	0.00	0.00

Source: household survey

Farming (Agriculture/crop, fish culture, poultry), Labour (skilled labour, wage labour/day labour, rickshaw and van pulling, agricultural and non agricultural labour), Business(small medium , fishing, fish seed trading), Service (monthly paid job, advocate, teacher), Others (carpenter, tailor, pottery, herbal-doctor)

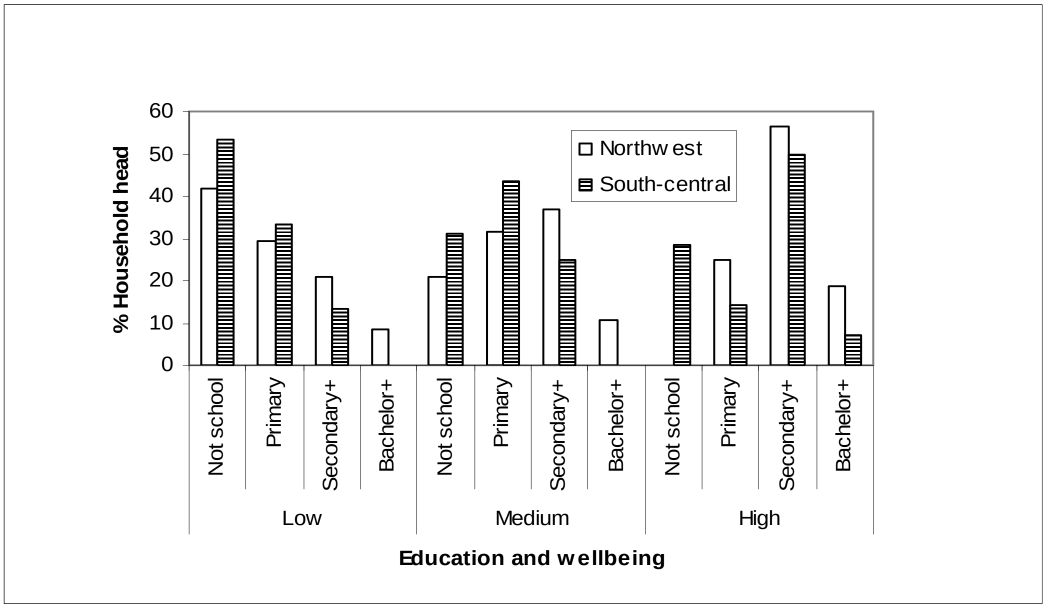
Farming and some petty trade/business were the major secondary occupations across all well-being categories and zones. No significant association was found between farmer type and secondary occupation**.** Farmers’ attitudes towards SRS were not significantly affected by secondary occupation.

3.3.3 Livelihoods assets

Human capital

Education

Education level of household heads was significantly related to well-being level and farmer type (Figure 3.5). Poorer people (low well-being) had worse access to education particularly at secondary and bachelor level than better-off. The better-off (including medium well-being) tended to have experienced primary to higher secondary (secondary+) level education.

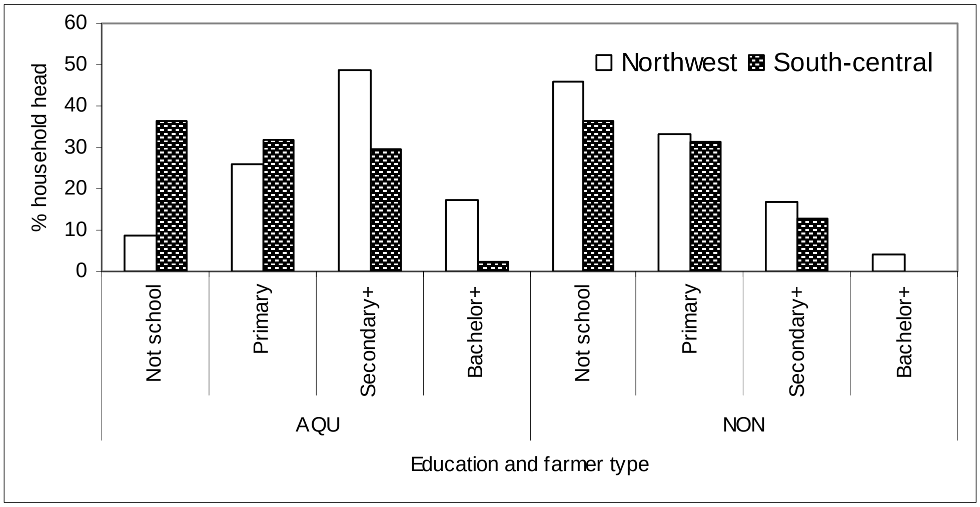


Source: Household survey

Figure 3.5: Education levels by well-being (n=119; secondary + = class VI to XII, Bachelor+ = graduate, post graduate).

Richer people had better access to secondary and bachelor level education. Aquaculture (AQU) households enjoyed significantly (P<0.05) more access to education than non-aquaculture (NON) households (Figure 3.6).

The proportion of household heads educated to primary level was unaffected by either zone or by farmer type. A zone related difference was found among household heads who had not attended school by well-being and farmer type (Figure 3.5 & 3.6).



Source: Household survey

Figure 3.6: Attainment to education by aquaculture (AQU) and non-aquaculture (NON) type (n=119).

There appears to be a big drop out from secondary+ level to bachelor level among poorer households. Farmer's perceptions of SRS management were not significantly related to education level.

Household size

Most of the surveyed households had between 2-5 members in both zones based on total household members of all ages including dependents.

Table 3.10: Household member by farmer type (n=119)

Zone	Farmer type	Household member category			Total
		2 - 5	6 - 8	09 - 14	
Northwest	AQU	17 (48.57)	15 (42.86)	3 (08.57)	35 (100)
	NON	17 (70.83)	4 (16.67)	3 (12.50)	24 (100)
South-central	AQU	23 (52.27)	15 (34.09)	6 (13.64)	44 (100)
	NON	12 (75.00)	2 (12.50)	2 (12.50)	16 (100)

Source: Household survey

There was no significant association between farmer type (AQU, NON) and household size. However, a higher percentage of AQU households had between 6-8 household members compared to NON households that had comparatively fewer household members (Table 3.10).

General health condition of the 1st household (usually household head wife) member

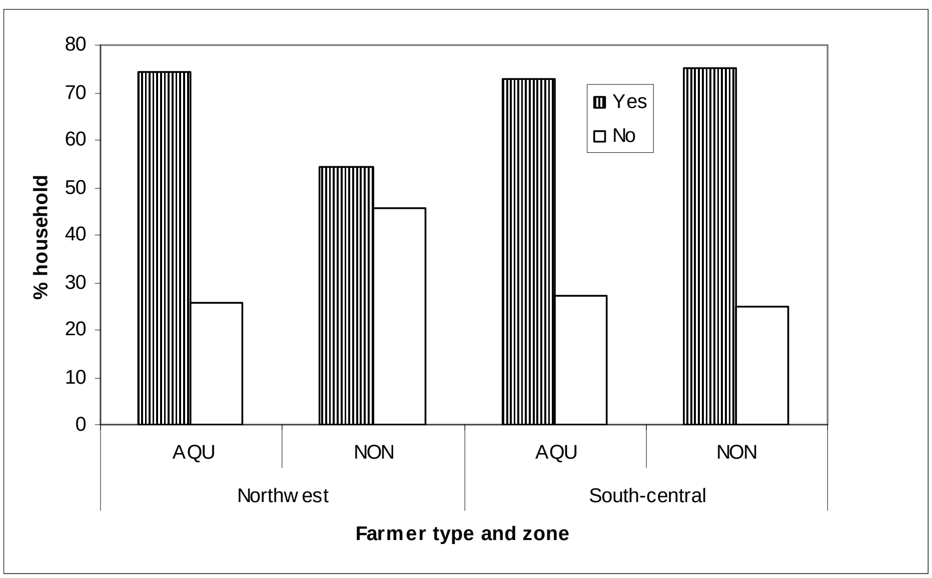
Usually the 1st household member in both zones was female, mainly the wife of the household head. The household level survey found that health condition of 1st household member was generally good and there was no significant difference by zone supporting the observations during the PCA. However, women's health was comparatively poorer in the northwest than south-central zones.

Financial capital

Access to formal credit, the number of sources of credit and seasonal patterns of income and expenditure, were investigated to understand the level of financial assets and their relationship to SRS and aquaculture. Access to informal financial support is described under social capital.

Access to formal credit

Access to credit was not significantly associated with household well-being and farmer type (AQU, NON) in either zone. However, the availability of formal credit was comparatively higher in the south-central zone than in the northwest zone (Figure



3.7).

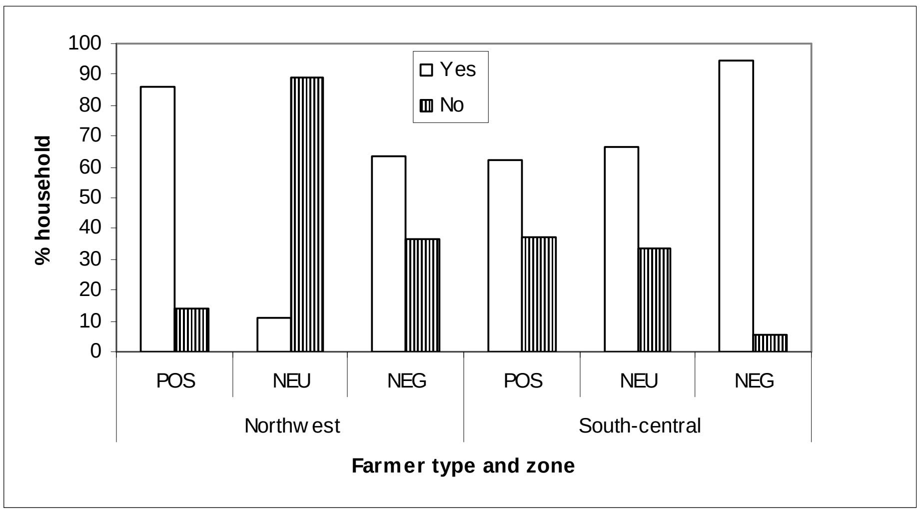
Source: Housheold survey

Figure 3.7: Access to formal credit by aquaculture and non-aquaculture households (n=119).

Households may receive credit from more than one source. Households in the south-central zone had access to a greater number of credit sources (ranged 1-3) than the northwest.

Selling of fish

Selling of fish was significantly (P<0.05) associated with farmers attitude to SRS (positive, neutral) but not by well-being group. Households from SRS NEU type sold comparatively less than POS and NEG category. NEG category households usually sold more than POS or NEU (Figure 3.8).



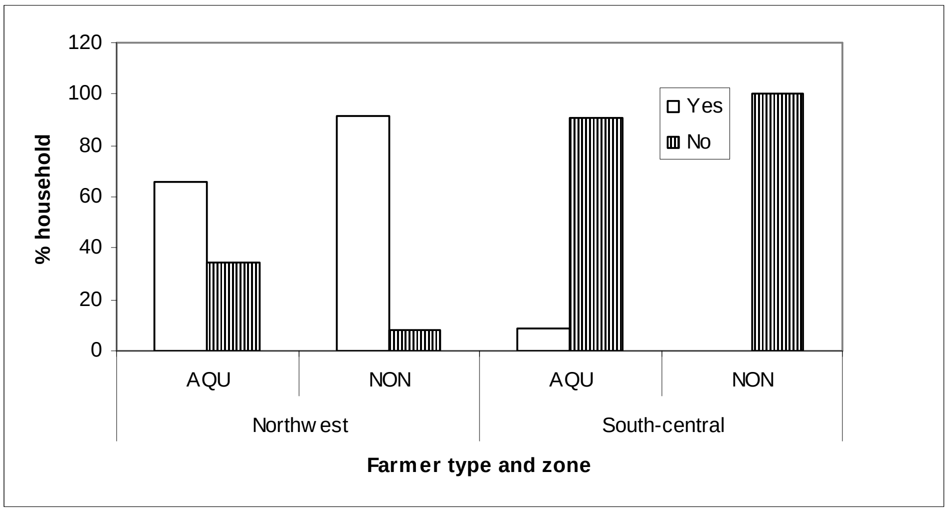
Source: Household survey

Figure 3.8: Selling of fish by farmer type (n =78).

Sixty eight percent (68%) of the aquaculture (AQU) households were found to sell more fish than they consumed, the balance only consuming and not selling. Income from fish appeared to be higher in south-central zone compared to the northwest. Incomes from other sources are compared with that from sale of aquatic animals in Chapter 4.

Social capital

Household social assets and their impacts on well-being and gender were investigated, particularly through enquiring into inter household relationships, informal financial support and participation in social activities such as festivals and those related to kinship linkages. Households were found to receive informal financial support from relatives and friends as an important part of social capital, particularly in the northwest zone. Informal financial support to households was significantly (P<0.05) affected by zone and farmer type (AQU, NON).



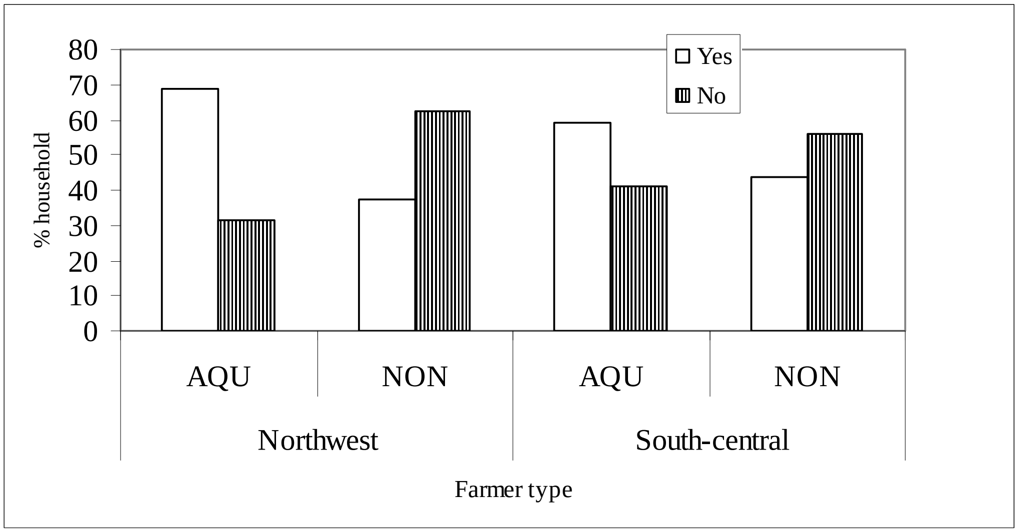
Source: Hosuheold survey

Figure 3.9: Proportion of households obtaining financial support from friends and relatives (n=119)

Non-aquaculture (NON) households in the northwest had more informal financial support from friends and relatives than in the south-central (Figure 3.9). This is also related to the findings on formal credit sources which was relatively higher in south-central zone (Figure 3.7). Participation in religious and cultural festivals of both Hindu and Muslim households throughout the year are important aspects of social capital discussed later in Chapter 4.

Physical capital

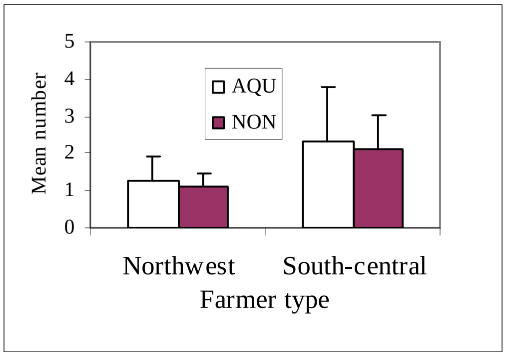
Access to key home appliances like – televisions, cassette players, motorcycles, and irrigation pumps were affected by well-being (Table 3.7). Poorer people had less access to these assets than the better off in both zones. Ownership of fishing gear was important in terms of access to fishing and its relation with aquaculture and SRS. Access to fishing gear was significantly (P<0.05) associated with zone and farmer type (Figure 3.10). Box trap, gill net, cast net, hook, long line, small lift net, seine net, lift net, bamboo fence were the fishing gears mentioned by the surveyed households.

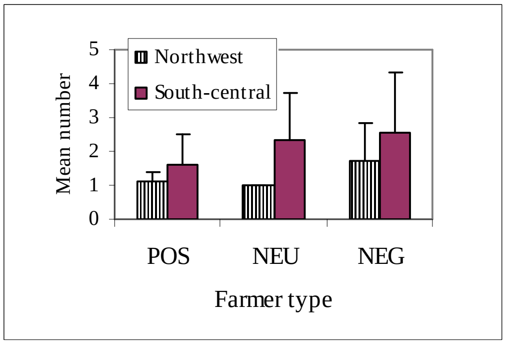


Source: Household survey

Figure 3.10: Access to fishing gear by aquaculture and non-aquaculture type (n =119).

Non-aquaculture (NON) households had significantly ($P<0.05$) less fishing gear than aquaculture households. The ownership of all types of gear was higher in the south-central zone than northwest (Figure 3.11 & 3.12). NON households mainly had gill net, box trap and long line. The mean number of fishing gears used was comparatively less in POS and NEU farmer type than NEG (Figure 3.14).Mean number of gear was also higher in south-central than northwest in all farmer types.





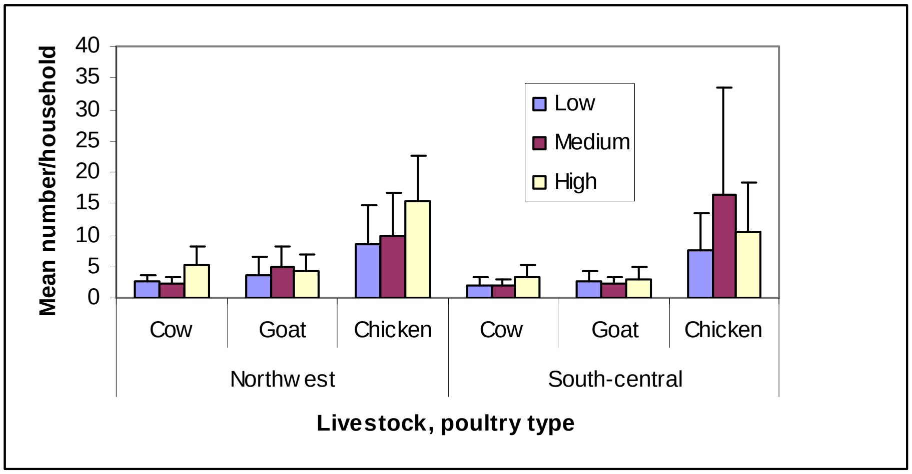
Source: Household survey

Figure 3.11: Mean number of fishing gear per household (n= 66)

Figure 3.12: Mean number of fishing gear per household by POS, NEU, NEG farmer type (n= 50)

Livestock and poultry herd size

The mean holdings of cows, goats and chickens was significantly ($P<0.05$) affected by well-being (Figure 3.13) and farmer type (AQU,NON) but not by farmer attitudes towards SRS management.



Source: Household survey

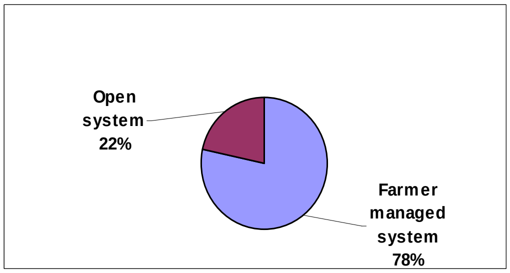
Figure 3.13: Mean number of cows, goats and chickens per household by well-being.

Natural capital

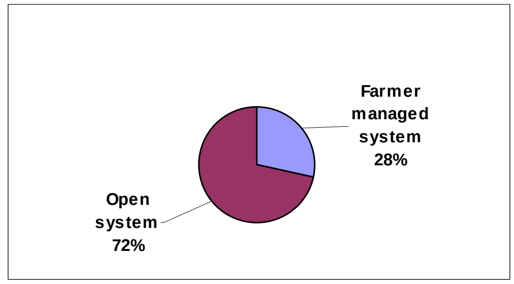
Analysis of the major sources of aquatic animals during the PCA gave an overview of the aquatic systems where various aquatic animals were managed and harvested. The PCA also explored information on the classification of FMAS for the two zones of Bangladesh and their location within the broader ecosystem. In the Dhaka stakeholder workshop a typology of FMAS was drawn up that included the importance of, and access to, SRS and stocked species. The background survey further provided detail with respect to access and physical characteristics of the FMAS in both zones.

Sources of aquatic animal from PCA

The major source of popular aquatic animals consumed was found to be different in the northwest and south-central zones. Aquatic animals were harvested mainly from open systems (72%) – canals, *beels*, and rivers in the



(A)



(B)

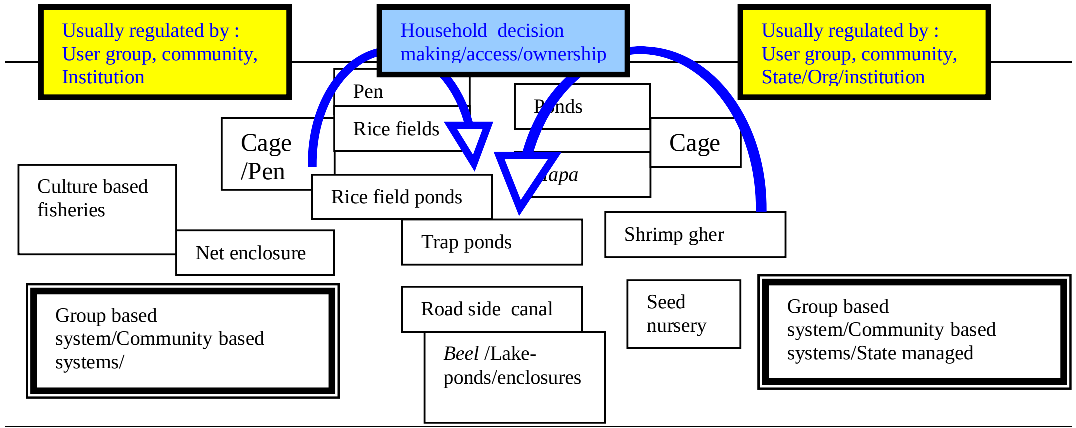
Source: PCA

Figure 3.14: Sources of popular aquatic animals including SRS in two zones (A= NW, B=SC zone).

south-central zone whereas in the drier northwest areas they were mostly harvested from farmer managed systems (78%) (Figure 3.14).

Locating FMAS and SRS

In Bangladesh, fisheries water resources were broadly categorised as – inland open water comprised with river lake, flooded depressions etc., inland closed water comprised with ponds, rice-fields, shrimp farms etc. and marine water. However,open and closeness is defined by the season (Chapter 1). It is important to understand the location (where it is exist/found) of 'farmer-managed aquatic systems' in the diverse type of water resources in Bangladesh. PCA findings noted that although they were found to concentrated within inland closed water (Figure 3.15) FMAS can also be found in inland open and marine waters, for example in the form of cages or enclosures. Figure 3.15 elaborated different types of water resources, aquaculture, fisheries management and culture based fisheirs practices in Bangladesh and shown where FMAS such as pond, rice field pond, shrimp farm, canal, cage, pen were located in the broader aquatic resources in Bangladesh.



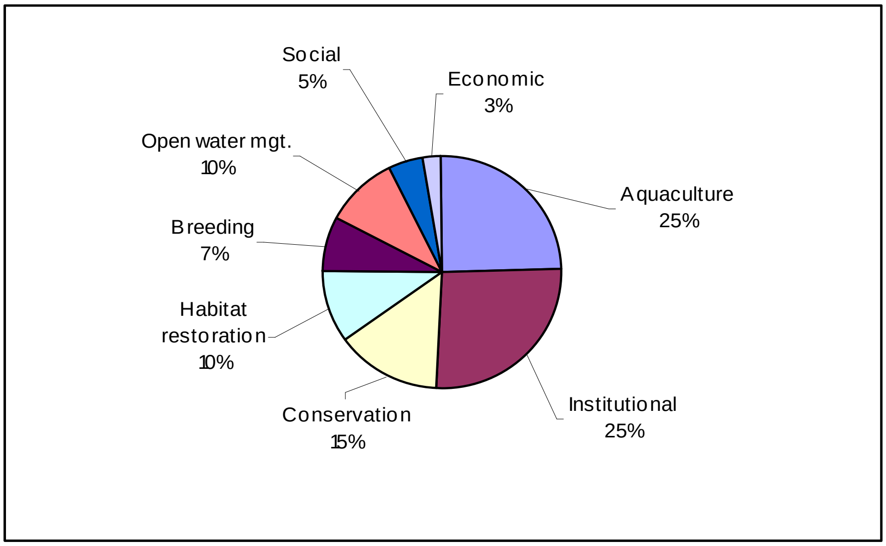
Inland Open waters	Inland closed water	Marine water area
Rivers (during dry season) and large canals *Beels* (lake) and *haors* (large deeply flooded depressions) Kaptai lake Flood plains (seasonal)	Ponds and tanks *Baors* (oxbow lakes) Coastal shrimp farms (These are classified as inland closed water resources in Bangladesh)	Economic Exclusive Zone

Source:PCA

Figure 3.15: Locating FMAS in the broader aquatic systems of Bangladesh.

SRS, aquaculture and related general view from macro level stakeholders:

In response to the prioritisation of tasks regarding the management of aquatic animals in general or SRS specifically, the stakeholders in the Dhaka workshop identified different issues presented in Figure 3.16. Management of SRS in aquaculture (25% of stakeholders) and institutional aspects (25%) of their promotion and in research such as the role of specific departments,



Source: Dhaka stakeholder workshop

Figure 3.16: Prioritisation of SRS and aquatic animal management in the broader development context perceived by various stakeholders (% of total stakeholders with multiple response) in Dhaka workshop (N=37).

government, NGOs and their policy and priorities for conservation (15%) were emphasized by a higher percentage of stakeholders. Research and promotion of SRS in aquaculture, its institutional aspects (such as role of organisation, policy priority) and conservation of SRS appeared to be important area of work from stakeholders view.

Relative importance of stocked aquatic animal (AA) and SRS in different FMAS

A range of FMASs were identified during the PCA exercises and were validated at the Dhaka workshop in terms of importance to give an overview of the location specific diversity of aquatic systems (Table 3.11). In the PCA group exercise sources of AA were investigated and discussed with participants which later reported by the research staff in the stakeholder workshop.

Table 3.11: Types of FMAS and importance of SRS and stocked species from it by zone

Type of FMAS	Northwest		South-central	
	Importance of stocked AA	Importance of SRS	Importance of stocked AA	Importance of SRS
Grow out pond	+++	+	+++	++
Rice field	+	++	++	+++
Rice field pond	++	+++	++	++
Trap ponds	+	++	+	+++
Nursery pond	++	0	++	0
Ditch	++	+	+	++
Lake pond (*beel* pond)	+++	++	+	+++
Pen culture	+	+	+++	++
Cage culture & Cloth enclosure*(hapa)*	++	0	++	0
Shrimp farm (*ghe*r)	0	0	+++	+
Natural small basin in flood plain areas (*Koom*)	0	0	0	++

Source: Dhaka stakeholder workshop
+++ (very high importance) - 0 no importance

FMAS were found to be important both for stocked aquatic animals (AA) and SRS. In some systems such as rice field, trap pond, lake ponds SRS were more important than stocked (Table 3.11).

Typology of farmer managed aquatic systems in Bangladesh

Initially 11 types of FMAS were identified in the study areas (Table 3.13). The systems were differentiated by both social and ecological characteristics in terms of their main use, access, benefits to poorer and richer people, sources and availability of AA, location, physical characteristics (e.g. size and dike construction etc). Both agro-ecological zones have almost the same types of FMAS systems except prawn farms *(gher*) that only occurred in the south-central zone.

A short description on the typology of location specific FMAS is given below that was derived from group discussions during the PCA resource mapping, field observation and stakeholder workshop in Dhaka.

1) **Grow out culture ponds**

Farmers mainly stock carps and SRS is considered as by-catch. Grow out culture ponds can be seasonal or perennial in terms of water availability. Such ponds can have strong or weak dikes depending on location and management practice. They may or may not have links to adjacent rice fields or canals. They can be located next to the house or away from homestead. The relative importance of grow out ponds appeared to be higher in the south-central zone than the northwest zone (Table 3.13).

2) **Rice-fields**

Rice fields are mainly sources of SRS which are harvested using traps, nets and by hand. Tilapia, common carp and silver barb are also stocked in many rice fields. Rice fields have ditches or deeper lower areas. The importance of SRS tended to be greater in rice fields than stocked species in both zones. However, rice fields in south-central zone are more diverse and showed more potential for SRS than in the northwest.

3) **Rice field with ponds**

These may be termed as rice field associated ponds. A pond is constructed within a rice field boundary to culture both stocked species and SRS. Farmers stock carps in the ponds and at the end of monsoon when the rice fields dry up SRS are encouraged to enter the pond. This is a common strategy in the northwest zone where rice fish culture is constrained by water scarcity. SRS juveniles or brood fish harvested in the rice fields or other water bodies were sometimes restocked in such ponds before selling at a better price in the dry season.

4) **Trap Ponds**

Small ponds are located within lowland rice fields or in flood plain areas where SRS are attracted and harvested. They are distinct from rice field ponds by being physically small and their primary purpose being for trapping. Traps ponds are also usually smaller than stocked ponds. This kind of pond is more common in the south-central zone than in the northwest zone. Wild carps can be harvested in trap ponds in areas located close to rivers.

5) **Nursery ponds**

Nursery ponds are normally used to produce fish seed but outside of the season may also be used to produce food fish. SRS are not important during the seed nursing period as such ponds are sanitized but outside of this period they may be used for trapping or keeping wild fish.

Advanced fry nursery is one form of seed nursing. Some poorer people tend to use the same pond both for fish seed and food fish production. In the pre-monsoon period (April, May) they stock early stage fry and nurse them for a short period of 2-3 weeks before selling as advanced fry. The pond is then used as a grow-out unit for the rest of the year. This practice is more important for poorer than richer households and common in both zones. It also indicates that poorer households tend to utilise their pond water more efficiently than richer people.

6) **Ditches**

Ditches are small ponds mostly holding water only seasonally and located close to the households or by the road side. Poor farmers use them to stock fingerlings for food fish. In flood-affected areas ditches are common next to households as the earth is removed as borrow to raise the house compound. Also ditches can be located in rice fields or at road sides as rain water culverts. Both SRS and stocked species are typically managed. However, there is a high risk of loss of stocked fish by flood. Ditches are more common and productive in the south-central zone due to higher water availability.

7) **Lake pond (*beel pond*)**

These are a special type of trap pond located close to *beels* which become inundated in the rainy season and only appear during the dry season when they are leased to individuals or groups of fishers, mostly to harvest non-stocked fish. Some larger ponds are stocked with carps in the post flood period but SRS is the most important part of the harvest. These are more common in the low lying areas (south-central) and are not common in the northwest zone.

8) Pen/enclosure

Sometimes a corner of an open water or lake is enclosed (compartmentalised) using net or bamboo fence for culturing stocked fish, however SRS is also a significant part of the harvest due to its link to open water. Pens are more common in areas close to rivers. These systems are more important for both cultured species and SRS in south-central than northwest zones.

9) **Cages and hapas**

These are water based systems suitable for landless and non-pond owners to grow fish and fish seed. *Hapas* and small cages ($1m^3$) are used for nursing and to raise tilapia, silver barb and tilapia over periods of 2-4 months respectively where a suitable water body was available. This intervention has been targeted mainly by NGOS and projects to landless and poor women to enhance access to fish culture.

10) **Prawn pond (called *gher*)**

This is a type of integrated system based on enclosing deep rice land to grow fish and prawn in the water and fruits, vegetables on the dike. They are constructed particularly for raising prawn, however mixed culture of shrimp and white fish is common in low-lying areas. This system is not found in the northwest zone.

11) **Natural small basin in flood plain areas**

This is a natural small basin created through the strong current of river in flood plain or sand bar areas (close to river) where wild fish from the river are trapped and caught by the people living close to river. Conflicts can arise with harvest of the non-stocked species in larger basins.

Table 3.12: Types of FMAS based on linkage with other systems and SRS

Generic systems	Specific systems and common terms
Ponds (not linked to rice fields; P)	Grow out pond
	Nursery pond/Advanced fry nursery
	Prawn farm (*gher)*
Linked Ponds/Rice field ponds (linked to rice-fields; Prf)	Rice field pond
	Trap ponds
	Lake pond (*beel* pond)
	Ditch
	Natural small basin in flood plain (*Koom*)
Rice fields (Rf)	Rice fields not associated with ponds

Source: Dhaka stakeholder workshop

A major descriptor of the FMASs presented in Table 3.12 is if they are stand alone, typically those that are managed at a higher level of intensification and commercialisation or physically linked to larger more extensive systems (e.g. trap pond, lake pond, rice field pond). Based on this characteristic e.g. with rice fields, other water sources FMASs were finally grouped into three generic types as - ponds'(P), 'Rice field pond'(Prf) and 'Rice field'(Rf) for further analysis.

1) **Ponds (P)**

Mean areas ranged from 0.02 to 0.15 ha in both zones by well-being and farmer type presented in Table 3.10. The mean size of ponds was significantly affected by zone

(P<0.05) and well-being level (P<0.05) group (Table 3.13). The number of ponds in the south-central zone (51) zone was found to be more than double that in the northwest (22). Mean pond size was also significantly (P<0.05) affected by farmer type (i.e. POS, NEG, NEU) and by zone. POS type ponds were comparatively smaller than NEG in both zones.

Ponds are usually closed systems with strong high dikes mainly for commercial carp culture or seed rearing. These ponds are usually located in the homestead area surrounded by the household compound, vegetable garden or a road with few opportunties to link with rice fields or small canals. Most households (95.5% in northwest, 97.2% in south-central) stock hatchery-reared species. Stocked fish tend to be more important than SRS, and SRS is perceived as secondary crop, or eradicated.

Table 3.13: Mean area of different FMAS of households by well-being and zone

Zone	Well-being level	Mean pond area (ha) per household	N	Mean Rice field pond area (ha) per household	N	Mean rice* field area per household (ha)	N
Northwest	Low	0.06 ± 0.06	3	0.07 ± 0.10	4	0.99 ± 1.24	11
	Medium	0.05 ± 0.05	10	0.10 ± 0.10	3	1.22 ± 1.43	17
	High	0.06 ± 0.07	9	0.12 ± 0.11	11	2.67 ± 2.03	16
South-central	Low	0.10± 0.07	12	0.04 ± 0.04	6	0.28 ± 0.19	12
	Medium	0.14 ± 0.13	11	0.13 ± 0.06	4	0.77 ± 0.48	16
	High	0.16 ± 0.08	13	0.22 ± 0.10	4	1.66 ± 2.36	14

* Mean total owned rice field area per household
(not all households had 3 FMAS, 58 ponds, 32 rice field pond and 86 rice field were used)

Source: Housheold survey

Table 3.14: Mean area of different FMAS by farmer type and zone

Zone	Farmer type	Mean Pond area per household (ha)	No of ponds	N	Mean Rice field pond area per household (ha)	No. of pond	N	Mean Rice* field area per household (ha)	N
North West	POS	0.06 ± 0.05	4	4	0.11 ± 0.10	13	12	2.23 ± 2.57	12
	NEU	0.03 ± 0.01	7	7	0.04 ± 0.01	3	3	1.35 ± 0.59	10
	NEG	0.08 ± 0.07	11	11	0.15 ± 0.13	3	3	2.54 ± 1.77	11
South-Central	POS	0.07 ± 0.05	4	3	0.07 ± 0.05	6	6	0.66 ± 0.30	6
	NEU	0.10 ± 0.08	23	18	0.16 ± 0.12	10	7	1.10 ± 2.22	16
	NEG	0.18± 0.10	24	15	0.1	1	1	1.12 ± 0.96	13

- Mean total owned (purchased) rice field area per household,

Std Deviation is at the right end of the figure

Source: Hosuheold survey

2) **Rice field ponds - ponds linked to rice fields (Prf)**

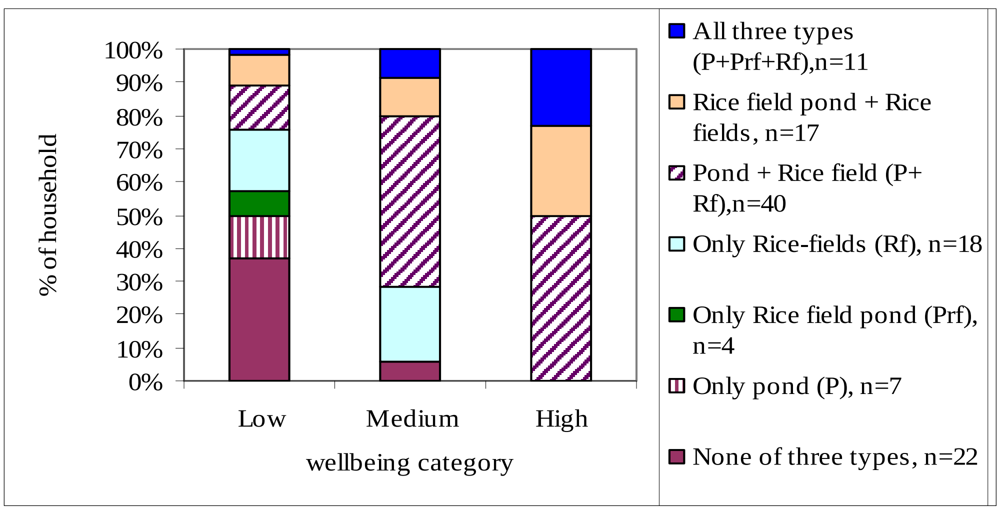
The mean area of rice field ponds (Prf) is presented in Table 3.13 & 3.14 by farmer type and well-being. Mean area was significantly affected by well-being ($P< 0.05$) and farmer type (POS, NEU, NEG; $P<0.05$) but not by zone (Table 3.13 & 3.14). Better off households owned larger rice field ponds in both zones. Almost all households in both zones (88.9% in the northwest and 85.7% in the south-central) stocked hatchery seed in this type of pond. Pond dikes were either constructed high in many cases or kept low in some parts to allow SRS from adjacent fields. Such ponds may be completely or partially flooded after heavy rain. Rice field ponds are used for both stocked and non stocked fish. Farmers tend to cut dikes temporally to allow fish entry into the pond when the rice fields begin to dry up.

3) **Rice fields (Rf)**

This was defined as owned (purchased) rice land including rented out, shared out and leased out lands (but not rented or shared in) belonging to the household. Mean total rice field area per household is presented in Table 3.13 & 3.14 by zone, well being and farmer type (all were owned rather than accessed by the households to avoid double counting of resource). Mean area of rice field per household was comparatively higher in the northwest zone that the south-central. Rice fields were defined here as non-stocked rice fields with no deliberate linkage to ponds. Farmers harvest SRS from rice fields mainly using different types of trap. Rice fields may incorporate very small ditches but they are not stocked. Essentially these systems were rice fields un-modified for fish culture.

Ownership to different association of FMAS

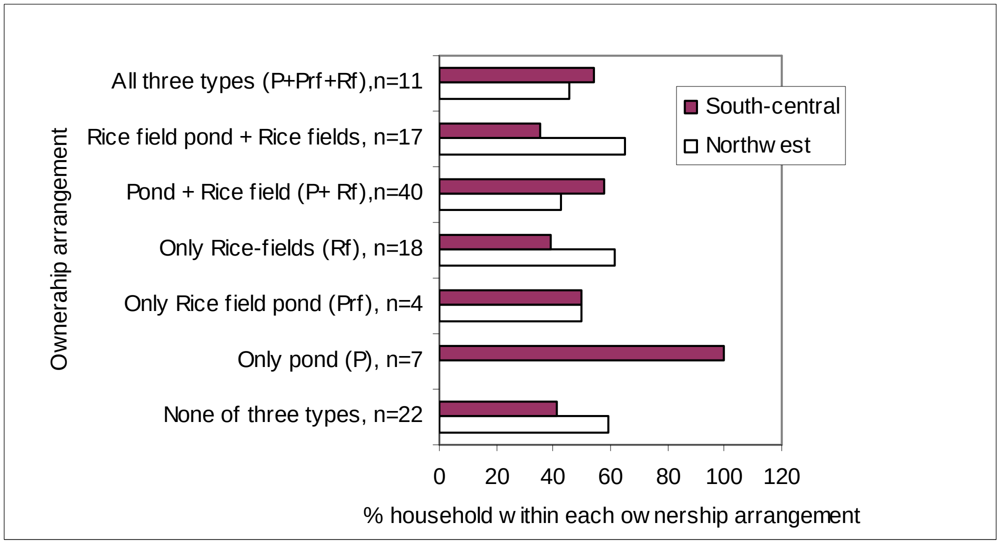
The association of ownership of and access to different types of FMAS by category of household was investigated. Association of three types of FMAS by well-being is presented in Figure 3.17. Better off households own more FMASs than poorer. Low well-being households rarely own all three types of system together and around one third of such poor families do not own any of the three systems (Figure 3.17). Poorer households have comparatively better access to rice field ponds (Prf) and rice fields (Rf) than ponds (P).



Source: Household survey

Figure 3.17: Association of different FMAS by well-being (N=119 i.e. all AQU, NON households, Low = 54, Medium =35, High =30).

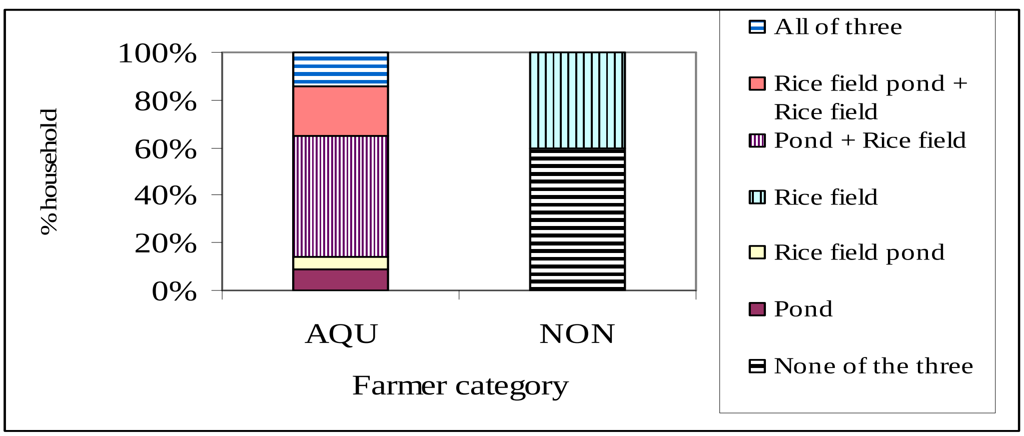
Ownership of the different FMASs was significantly ($P<0.05$) affected by zone. Ownership of only ponds (P) was higher in the SC than NW (Table 3.14), and ownership of both rice field (Rf) and rice field associated ponds (Prf) was more common in the NW than in the SC. The percentage of households having all three systems together was higher in the SC than NW (Figure 3.18).



Source: Hosuehold survey

Figure 3.18: Ownership arrangement of FMAS by zone (N=119, northwest 59, south-central 60).

The association between ownership of different FMAS and aquaculture (AQU) and non-aquaculture (NON) households is presented in Figure 3.19.



Source: Hosuehold survey

Figure 3.19: Association of FMAS by AQU and NON households (n=119).

Sixty percent of non-aquaculture (NON) households do not own any of the three FMAS systems and 40% have only rice fields. It was clear that the NON group of households do not practice conventional aquaculture due to lack of a pond but rather they access fish from rice fields and other sources.

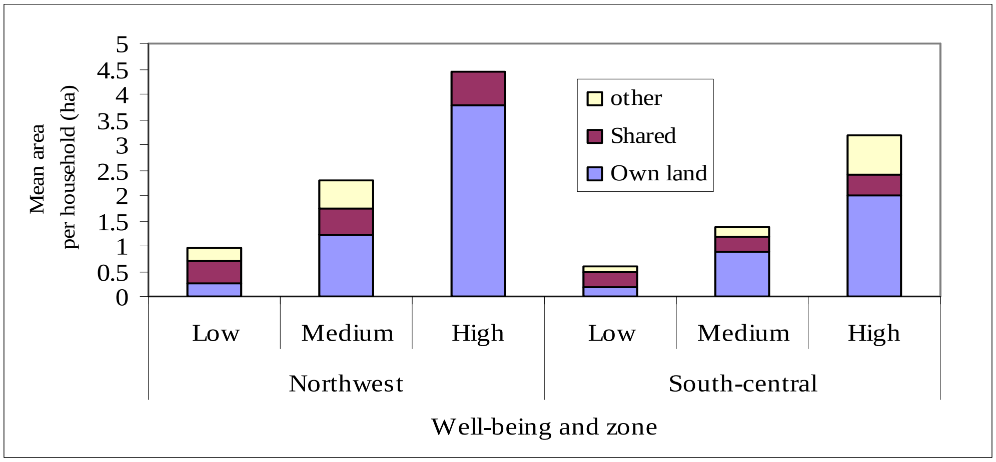
Different land ownership of households

Share cropping (mainly rice land) is a common arrangement for accessing land and water. Usually poorer (< 20 % of total households) or landless people sharecrop land owned by richer households. 33.34 % of the surveyed households (n=12) in the northwest and 66.66% (n=24) in the south-central zone share cropped some land. Overall nearly one third of all households share cropped some land. The mean area of share-cropped land per household (across zone, well-being) was 0.38 ha (±0.23). The number of households sharecropping land was twice as much in the south-central zone than the northwest. Better-off households also sharecropped land, particularly in the SC zone (Table 3.15).

Table 3.15: Mean area of land (ha) share cropped per household (n= 36)

Zone	Well-being	Mean	N	Std. Deviation	% of Total N
Northwest	Low	0.42	5	0.14	13.89
	Medium	0.53	6	0.28	16.67
	High	0.66	1		2.78
South-central	Low	0.30	16	0.23	44.44
	Medium	0.32	4	0.10	11.11
	High	0.40	4	0.29	11.11

The pattern of land ownership by household is presented in Figure 3.20. The mean area of owned land (p=0.01) and share cropped land (p=0.04) was significantly affected



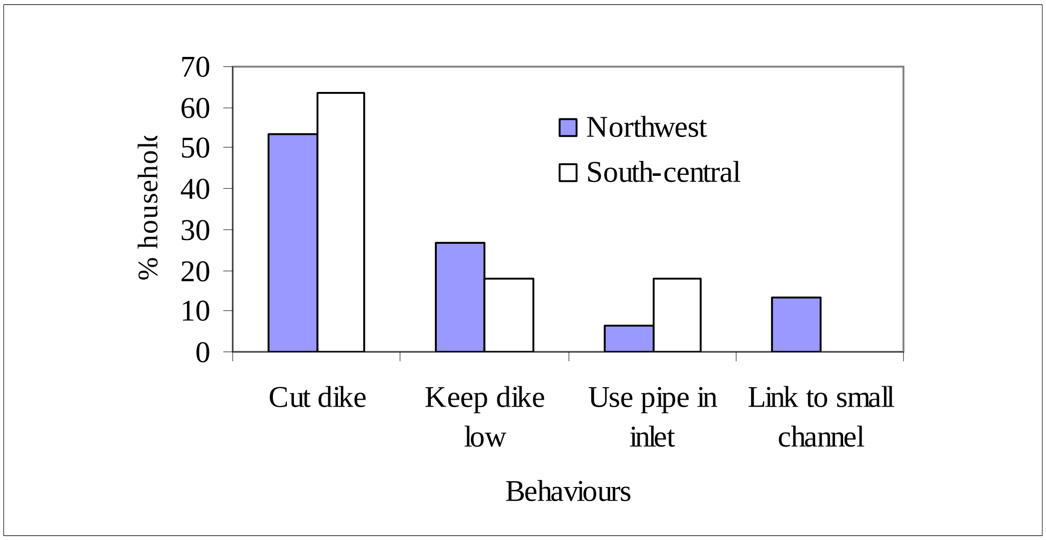
Source: Hosuehold survey

Figure 3.20: Different type of land ownership of households by well-being and zone (Shared= share cropped land, own land = purchased land, other = leased/rented etc.).

by well-being and zone. The northwest region was highly heterogonous in terms of land holding between poor and better off. The relative importance of sharecropping and leasing in to poorer households in both zones is clear. Share cropped land was particularly important to the poorer households in both zones compared to owned land. However other (rented, leased) land was also important to the poorer households in both zones. Only 13 households rented out land to others of which six households were from low well-being, 5 from medium and 2 from high well-being group. The mean area of rented out land was 0.35 (± 0.43, n=13) ha per household. 13 households from northwest and 24 households from south-central zone remarked on the rental terms of lands (leased out). Poorer households tend to lease out land to better off households to secure a loan during periods of financial crisis. In both zones land was found to be commonly used as collateral for loans with the loan provider using the land until the loan is repaid.

Deliberate actions to manage SRS in FMAS

Various actions (Figure 3.21) were found to be used by SRS positive households for encouraging SRS in their systems. The main purpose of the various actions or behaviour and modifications to FMAS was to improve the access of SRS from nearby deeper perennial water sources or adjacent aquatic systems such as rice fields.



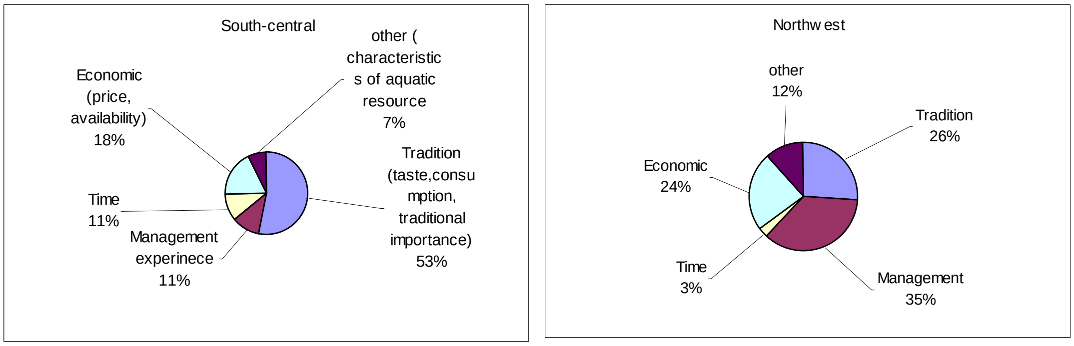
Source: Hosuehold survey

Figure 3.21: SRS positive behaviours (northwest=15, south-central=11).

Cutting pond or rice-field embankments/dikes to allow entry of SRS into the system during the rainy season is the most common pro-SRS action. Some households cut rice field dikes and link the adjacent pond with rice fields in late rainy season to encourage fish to enter the pond as the rice field dry outs. Embankments and dikes are also cut to allow free drainage of water during heavy rains and also prevent flooding and loss of fish. Valves or traps may be placed at the entrance of such drainage points to catch fish or allow them to enter selectively. Some households also raise dikes to protect and retain the SRS in their systems at some times of the year. Alternatively, and depending on the characteristics of the system, one side of the rice field or pond may be kept open to the adjacent rice field or water source. A bamboo fence or net can be used to retain fish in the system once they have entered. Instead of physically cutting the dike households especially those with large embankments, a pipe may be inserted through the embankment to allow SRS selective entry in terms of size and species. Farmers are also found to make small channels in rice fields or adjacent to the pond to attract wild fish to the pond or towards a deeper water pocket.

Knowledge and reasons for not eliminating SRS from the systems

Although farmers' attitudes towards SRS management was investigated through an assessment of livelihood assets, a particular question was asked during the background survey to the households who did not try to eliminate SRS (ie NEU and POS) to identify reasons for keeping SRS in their system. Traditional practices, economic reasons related to the price of SRS and supply and a knowledge of biological management issues are the three most important factors given by households for not eliminating SRS from their system.



Source: Housheold survey

Figure 3.22: Why households do not eliminate SRS? (n=79; Tradition = Taste & consumption related traditional importance, Management experience= knowledge of predator, feeding of SRS, selective entrance of SRS, Time= no time, busy with other job, Economic = high price, scarcity, other = resource type, characteristics of ponds).

Tradition to keep some SRS in their ponds and a preference for the taste were the most important factors in both zones. Knowledge of management (biological management) of SRS seemed to be higher in the northwest than south-central (Figure 3.22)

Important aquatic animals harvested from different FMAS

The availability and importance of the barb (*Puntius sophore)*, spotted snakehead (*Channa punctatus*), mola carplet (*Amblypharyngodon mola*), minnows (*Esomus danrika*), walking catfish (*Clarias batrachus*), stinging catfish (*Heteropneustes fossilis*) was most important and almost the same in the three types of FMAS in the northwest zone. The importance of mola (*Amblypharyngodon mola*), stinging catfish (*Heteropneustes fossilis*), walking catfish (*Clarias batrachus*), minnows (*Esomus danrika*) was less in the south-central zone than in the northwest but snakehead murrel (*Channa striatus*) and climbing perch (*Anabus testudineus*) were relatively more important in south-central zone than northwest (Table 3.16). The barb (*Puntius sophore*) and spotted snakehead (*Channa punctatus*) was similarly important across FMAS and zone. One of the important aspects of the species harvested in the FMAS was the presence of both prey and predator species - an important aspect of SRS management in linked FMASs.

Table 3.16: Important available SRS harvested from different type of FMAS (n for each system 46, 55 & 32 in pond, rice field pond and rice field, % of households within each system was considered, figure in parentheses indicates % and n on the left) source: Household survey

System	**Northwest** 1st important SRS	n (% of household within each FMAS)	2nd important SRS	n (%)	**South-central** 1st important SRS	n (% hh)	2nd important SRS	n (% hh)
Pond	*Puntius sophore*	10 (58.82)	*Puntius sophore*	05 (29.41)	*Puntius sophore*	20 (68.97)	*Channa punctatus*	15 (51.72)
	Amblypharyngodon mola	03 (17.65)	*Esomus danrika*	04 (23.53)	*Channa punctatus*	05 (17.24)	*Puntius sophore*	05 (17.24)
	Channa punctatus	02 (11.76)	*Channa punctatus*	04 (23.53)	*Channa striatus*	02 (6.90)	*Channa striatus*	04 (13.79)
			Clarias batrachus	02 (11.76)				
	Others	02 (11.77)	Others	02 (11.77)	Others	02 (6.89)	Others	05 (17.25)
	Total	17 (100)	Total	17 (100)	Total	29(100)	Total	29(100)
Rice field pond	*Puntius sophore*	26 (60.47)	*Esomus danrika*	14 (32.56)	*Puntius sophore*	08 (66.67)	*Channa punctatus*	06 (50.00)
	Amblypharyngodon mola	07 (17.28)	*Puntius sophore*	10 (23.26)	*Channa punctatus*	03 (25.00)	*Mystus sp*	03 (25.00)
	Channa punctatus	05 (11.63)	*Channa punctatus*	08 (18.60)	*Anabus testudineus*	01 (08.33)	*Puntius sophore*	02 (16.67)
	Others	05 (10.62)	Others	11 (25.58)	Others	00 (00.00)	Others	01 (08.33)
	Total	43 (100)	Total	43 (100)	Total	12 (100)	Total	12 (100)
Rice-field	*Puntius sophore*	11 (61.11)	*Channa punctatus*	05 (27.78)	*Puntius sophore*	07 (50.00)	*Channa punctatus*	06 (42.86)
	Channa punctatus	04 (22.22)	*Esomus danrika*	05 (27.78)	*Channa punctatus*	04 (28.57)	*Puntius sophore*	03 (21.43)
	Clarias batrachus	02 (11.11)	*Puntius sophore*	03 (16.67)	*Anabus testudineus*	02 (14.29)	*Channa striatus*	02 (14.29)
			Clarias batrachus	03 (16.67)				
			Heteropneustes fossilis	01 (05.56)				
	Others	01 (05.56)	Others	01 (05.54)	Others	01(07.14)	Others	03 (21.42)
	Total	18 (100)	Total	18 (100)	Total	14 (100)	Total	14 (100)

Criteria of measuring importance of aquatic animal

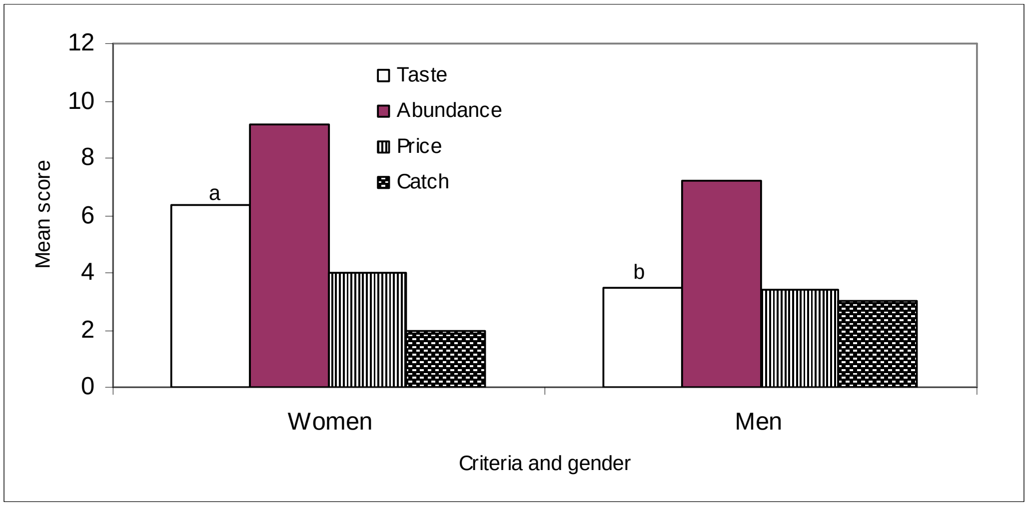
Generally it was found that households perceive the criteria of importance of aquatic animals in terms of high abundance, good taste, good for health, high income and social aspects such as being preferred by children and older people. The criteria used to assess the importance of aquatic animals varied with gender. Women judged taste, nutritional value for children and value for health as being most important. Men identified abundance and ease of capture as being more important. The list of criteria mentioned by different groups presented in Table 3.17.

Table 3.17: Criteria of importance by gender, well-being and zone

Gender	Richer		Poorer	
	Northwest	South-central	Northwest	South-central
Men	High abundance	High abundance	High abundance	High abundance
	High price		High price	High Price
	Good taste	Good taste	Good taste	Good taste
	Easy to catch	Easy to catch	Easy to catch	Easy to catch
	Good for consumption		Good for con.	
	Can purchase		Can purchase	
		Bring income		Bring income
		Costly/high value		Costly/high value
Women	High abundance		High abundance	
	High price		High price	
	Good taste	Good taste	Good taste	Good taste
	Preferred by children	Pref. by Children	Pref. by children	Preferred by children
	Preferred by old		Preferred by old	
	Easy for cooking/cleaning	Easy cooking	Easy for cooking	Easy for cooking
		Good for health		Good for health
			Easy to catch	

Source: PCA

'Easy to catch' was mentioned by both men and women in the northwest but was only mentioned by men in the south-central and being good for health was only mentioned by women not men. Taste (good taste), abundance (high abundance), high



Source: PCA

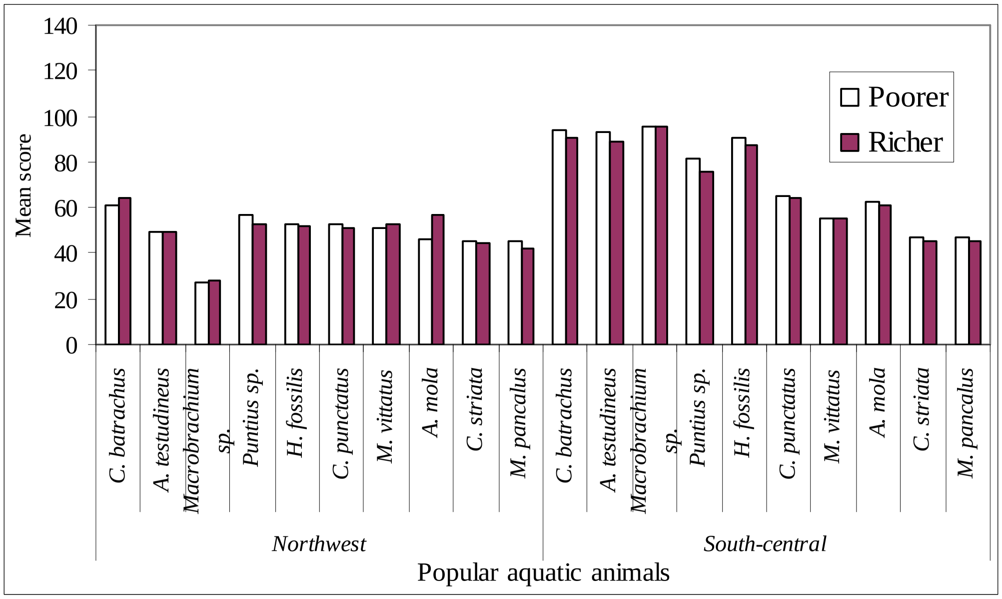
Figure 3.23: Importance of common criteria by gender (a, b means significant difference)

price and 'easy to catch' were commonly mentioned by both men and women. Importance of the criteria 'taste' among households across zone was significantly ($P<0.05$; ie. $P=0.00$, $df=1$, $F=56.26$) affected by gender not in case of the criteria - abaundance, price and catch (Figure 3.23).

Importance of aquatic animals

Relative importance of aquatic animals was significantly affected by gender (Figure 3.24 & 3.25) and zone. Some aquatic species were important to all four groups (richer men, richer women, poorer men, poorer women) of people, including *Clarias batrachus, Heteropneustes fossilis, Puntius* sp., *Anabas testudineus* and *Macrobrachium, Clarias batrachus*, *Anabas testudineus*, *Puntius* sp. *Mystus vittatus* which were mentioned in all 18 communities.

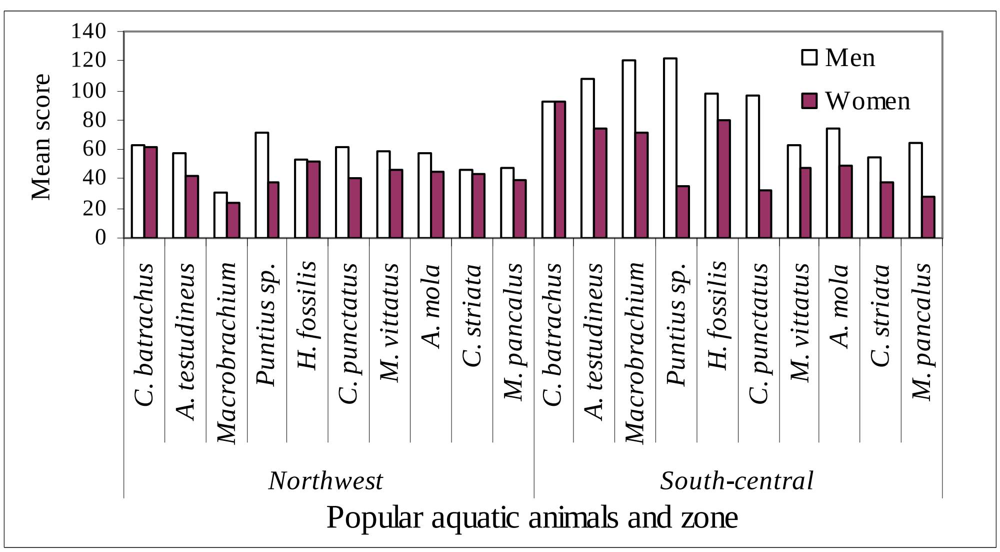
Clarias batrachus, Anabas testudineus, Macrobrachium, Puntius sp., *Heteropneustes fossilis, Channa punctatus, Mystus vittatus, Amblypharyngodon mola*, *Channa striata, Macrognathus puncalus* were the species that scored highest and were mentioned by most communities. The importance of *Clarias batrachus, Anabas testudineus, Macrobrachium, Puntius* sp., *Heteropneustes fossilis* are found to be relatively higher in the south-central that northwest (Figure 3.24).



Source: PCA

Figure 3.24: Importance of aquatic animal by well-being.

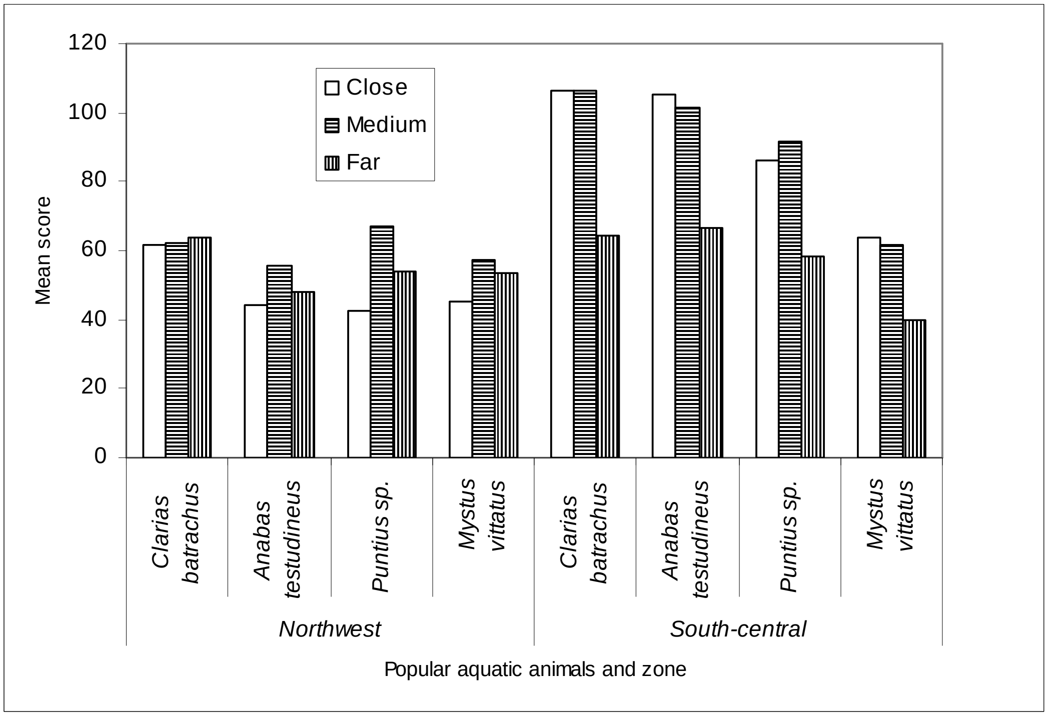
Clarias batrachus, Anabas testudineus, Macrobrachium, Puntius sp., and *Heteropneustes fossilis* were relatively more valued by women (Figure 3.27).



Source:PCA

Figure 3.25: Importance of aquatic animal by gender.

The impact of the distance of the community from a major river to the relative importance for the most important four species was analysed.



Source: PCA

Figure 3.26: Importance of popular aquatic animals by distance from a river.

The importance of *Clarias batrachus*, *Anabas testudineus*, *Puntius sp*. *Mystus vittatus* varied with distance from a major river in the south-central zone whereas this trend was not obvious in the relatively drier northwest zone (Figure 3.26).

3.4 Discussion

3.4.1 Well-being, livelihood activities and rural aquaculture

Well-being indicators were found to relate to household savings, education level, house type, land ownership, occupation, health, home appliances, clothing, food security, access to livestock and poultry, political linkages and influence (Figure 3.5, Figure 3.13, Figure 3.20) on others, access to credit & services, ownership to fish ponds in both zones (Table 3.7 & 3.8). Poor women's well-being was related to a relatively lower burden of household work and long working hours and selling of labour, lack of leisure period, lack of ownership of productive resources such as land, pond. A recent study in the northwest and southeast Bangladesh also described that women's involvement in agricultural labour and domestic work is often as a result of crisis and debt. Women had to conduct agricultural work in addition to domestic tasks (Seeley et al. 2006). Apart from agro-ecological differences characterized by the level of flood and drought, the main difference between zones was related to land ownership (Figure 3.20), importance of aquatic animals (AA), fishing and level of livelihood diversification. Landholding, education level and social influence were also important distinguishing indicators of well-being groups. Selling labour was an important indicator for poorer men and women (Table 3.8) and also an important determinant of well-being. Selling labour is dominant among poorer households in the northwest zone compared to the south-central zone as economic activities are less diversified in the northwest. However, better-off people are also involved in the labour market but tend to have more specialised roles. Poorer (including low and medium well-being group) households have less access to education (Figure 3.5) which generally affects their livelihood standard particularly access to social networks, better employment and services. A recent CARE study on poverty in rural Bangladesh indicated that educational access is a major problem among the poorest groups which relates to the costs of educational participation, provision of schooling and other learning opportunities (Seeley et al. 2006). Another similar study also suggested that formal and informal learning opportunities, employment oriented skill training, nutrition and primary health education could be more important for them (CARE, 2003). Mahbub and Roy (1997) conducted a study to explore the nature of well-being in Bangladesh using a variety of participatory ‘rapid appraisal’ approaches. They found the main indicators of well-being were fixed income, access to food as three meals a day, children’s education, small family size, health, access to medical services, and a comfortable/better life which are similar or close to indicators such as income, health, education, food security of the current study. Livelihood activities were more diversified in the south-central than northwest which might be related to the higher risk of flood, greater availability of formal credit and a lower dependency on land. Less availability of formal credit in the northwest zone perhaps increased dependency of households on informal financial support from relatives. Fishing was more important to poor men and aquaculture of much greater significance to richer men in both zones. Fishing includes the exploitation of open water systems and also harvesting of fish from farmer managed aquatic systems such as road side canals, rice fields, rice field linked ponds, trap ponds etc. Typically catches from such systems are not reflected in official statistics (FAP-16, 1995). Access to fishing gear indicates that both aquaculture and non-aquaculture households rely on fishing but that aquaculture households have greater capacity for, and dependence on fishing than non-aquaculture households. Type of gear (gill net, seine net, cast net, traps, lift net) indicates that they have more access to fishing in both common pool and FMASs than non-aquaculture households. The majority of rural households in Bangladesh fish from privately own ponds, community water bodies, open water bodies and rice fields (Lovett et al. 2006). Harvesting of some SRS requires special types of traps or gear such as gill nets, box traps, and lift nets that are different than those used for carps. Poorer people tend to use cheaper traps or nets for fishing to meet their household consumption needs. The poor with limited purchasing power have to rely on fishing for fish when they can not grow and buy other food like vegetables during periods of flood. Gupta & Shah (1992) mentioned that ‘the development of commercial aquaculture or high-input, high-output aquaculture could increase national production, but will not benefit the rural resource poor farmers who do not have purchasing power. However this study found that a range of petty trades and skilled labour is common among the poor as a strategy to diversify livelihoods at times of poor access to land and water that would allow purchase of basic food. The current part of the investigation concluded that livelihoods of the poorer households were associated with both agricultural and non-agricultural activities. This diversification is probably a function of their lack of ownership of land and water resources. The higher diversity of livelihoods in the south-central zone compared to the northwest might be a partly a coping mechanism by households in response to the severity of flood that affects them and also due to better access to formal credit. This also related with the growth in non-farm and service sector. Related study shown that growth in per capita income (recorded in 2001 population census) created the market for agricultural products and diversified the agriculture sector and growth of service sector activities in Bangladesh (Hossain and Bose 2000).The underlying factors that accelerated economic growth in 1990s were agricultural diversification (including fisheries and livestock sector) and the development of non-farm sector (Hossain et al. 2002). Poorer households in the northwest are more highly engaged in non-farm activities such as labour selling (agricultural and non-agricultural), rickshaw pulling, petty trade compared to south-central due to very poor access to land by the poorer than better off households in the northwest. Fishing is significant for the poor in both zones and fishing in rice fields (both owned and share cropped rice fields) in particular. The poor fish in both shared and their own land or even neighbours land. Other livelihood studies in Bangladesh describe that for many poor families, fishing is a way of reducing their vulnerability to risks by supplementing and diversifying their incomes. Small scale-fisheries and aquaculture also can act also as a ‘safety net’, providing a source of income when other employment opportunities are limited (FMSP-1 & 2, 2006). When land-based systems are integrated with agriculture by stocking fish in rice fields and ponds (Edwards, 2000) such activity should not be underestimated in rural aquaculture. Experience from Cambodia suggests that sustainable management of the rice field fishery and associated resources needs to be high on the national agenda for many countries. This important resource should not be overlooked in any agriculture and infrastructure development initiatives to address rural food and nutritional security of the poor (Gregory and Guttman, 2002).

3.4.2 Ownership and access

The current analysis showed that the ownership and access patterns of FMAS including associated land was important to understand (Table 3.13 & Figure 3.17, 3.18, 3.19 & 3.20) pro-poor small-scale aquaculture and fisheries and overall aquatic animal management. Understanding resource size, location, access to different species harvested in the systems is important to determine strategies of SRS management as well as broader aquatic resource management. The current study confirmed that FMAS are important both for stocked species and SRS in two zones (Table 3.11). The importance of various FMASs and open water systems varies seasonally with the availability of water in dry and rainy season. Thus it is important to consider a pro SRS management approach to expanding aquaculture for the poor. The current study found that importance of SRS in some FMAS such as rice fields, rice field ponds, trap ponds, lake ponds was higher than in grow out ponds (Table 3.11) and poorer households had relatively more access to rice fields and rice field ponds (Table 3.17) than ponds. However, with lack of ownership of ponds the poor had an interdependence among different households in a community for such resources. This context might encourage households towards a group based (local resource users group) or community based resource management approach in a community with collective and individual actions (Little et al. 2004). In the northwest zone, disparities of land holdings between better off and poorer households were high and related to long built power relations between social groups. The share croppers tended to be loyal to their land owners (CARE, 2006). A higher number of agricultural labourers among the poor reflected higher incidence of poverty in the northwest than in the south-central where livelihoods were more diversified. The current investigation concluded that rice field associated FMASs have comparatively more potential for the low well-being group where poorer households may get chance to access more SRS through sharecropping and by other fixed rent tenancy arrangements of rice fields. Access to SRS might be associated with access to rice fields even not owned by the poor. Mean owned land holdings of richer people were comparatively higher in the northwest zone than south-central. Depending on land is perhaps a more vulnerable strategy for the better off in SC zone compared to NW due to the severity of flood almost every year. This reflected the power structure of the zones. Traditional power structures are giving way to new power relations mediated by many factors such as change in land tenancy, easy communication, market forces etc. Fixed-rent tenancy is gaining prominence with the farming intensification with modern varieties (Hossain et al. 2002). Change in land tenure arrangements from conventional sharecropping to fixed rent tenancy and medium term leasing arrangements (Toufique and Turnton, 2003) can also bring positive management for SRS in future with less conflict with land owners. However, fixed rent arrangement may not be suitable for the very poor living in ecologically vulnerable areas. Better off households shifting to non-farm livelihoods may create opportunity for the poor with land based livelihoods under different tenancy arrangements. Mean rice field area per household was also higher in the northwest than south central reflecting a greater reliance on rice farming in the northwest than south-central. The linked nature and association of different FMAS also indicates that it may require both household and some collective management of SRS seasonally among households within a specific area. This may be even more important in the northwest due to scarcity of water (in the dry season) and could be important for dry season refuge management. The greater presence of open systems (like rivers, lakes, *beels*) in the SC zone was also linked to the availability of SRS in the FMAS.

Agricultural intensification and commercialization might become a threat to the sustained availability of wild species and SRS. The intensification of rice farming may undermine the value of SRS and wild species for food and income of the rural poor. However, there will be different level of intensification in different agro-ecological zones where pro-SRS management practices can be applied. Increased application of fertilisers in rice fields may have a neutral, or even positive, impact on production of aquatic animals but intensification is usually associated with increased use of pesticides and more controlled water management practices which frequently have a negative impact (Gregory and Guttman, 2002). In a Fisheries Sector Review in the Lower Mekong Basin it was reported that the increasing number and commercialisation of trap ponds appear to contradict the general decline of wild stocks reported over years (Mekong Committee, 1992; Fedoruk and Leelapatra, 1992). Little (1996) reported in a review of rain fed rice field in northeast Thailand that the sustainability of rice field fisheries in which wild fish are being trapped more intensively is unclear, more trap ponds may pose a threat to remaining stocks. Such ponds may be a form of ‘resource capture’ by the better-off. However, harvest from trap ponds can be increased with minimal management such as modest feeding of simple inputs, fertilisation etc. (Gregory and Guttman, 1996), even for indigenous small species not originated from hatcheries (Mazumder and Lorenzen, 1999, Felts et al., 1997).

Focus group discussions during the PCA on the type of FMASs and survey results on type of gears used by the poor (such as box traps, gill net, using hands) and land ownership pattern revealed that poorer people access SRS and other aquatic animals from FMAS such as rice fields, ditches etc. Other studies also reported that traditionally, rural people have relied on inland fish sources caught on their farms in rice fields or ditches or nearby water bodies or purchased from local markets (Prein, 2002). Friend & Funge-Smith (2002) suggested that lack of land ownership for rice fish culture in paddy fields or pond culture can constrain the capacity of aquaculture to have a significant impact on the poor if they are landless. But the current study indicates that poor and landless may benefit from access to SRS and other AA irrespective of ownership of rice fields. Access to resources might be more important than ownership (Kelkar et al. 2000*)*. McAndrew & Little (2000) noted gaining access is important for the poor to exploit productive opportunities providing that there is no conflict with others. Haque (2007) observed in a recent study in northwest Bangladesh that households do not necessarily intensify production in all their rice plots in the same way and SRS management may be more important in some plots than others. He also noted that SRS could coexist and yield productively in high yielding irrigated rice managed for production of juvenile fish. Farmers investing in production of juvenile common carp and Nile tilapia tend not to use pesticides and to manage water carefully. Therefore, intensification of rice farming may enhance potential opportunities for SRS management. A relative paucity of open systems in the Northwest may also explain the relative importance of FMAS in this zone compared to the SC where opportunities for wild fish capture remained relatively high. This information might be important for the formulation of region specific strategies for SRS management.

Pond based conventional aquaculture appears to have less impact on the poor as their direct access to SRS in such systems is typically less. Constraints within sharecropping agreements may need to be overcome before potential can be realised. Rice field ponds in a shared tenure system may require different arrangements for rice and fish since any pro-SRS modification of land or dikes on shared land would require informal arrangement or formal agreement with land owner. In a share cropping arrangement (*Barga*) distributing the produce between land owner and cultivator is based on established local custom and changes due to various factors (CARE, 2003) but traditions have been under pressure since the rapid expansion of high yielding variety of rice (HYV) and some other crops. A trend is for land owners to move towards fixed term leasing and for share cropping to become the preserve of managing non-irrigated traditional crop lands (Banglapedia, 2006). In a baseline survey in the southeast region of Bangladesh it was reported that many land owners prefer to lease out the land at a fixed rent rather than sharing out to avoid the burden of supervision. Leasing at a fixed rent allows more independent decision making of rice and SRS management. But, poorer households, being less able to afford to pay fixed rents (CARE, 2003) may suffer from these changes. However, poorer housholds may get easier access to crop loans from NGOs. Therefore, both share cropping and fixed rent leasing of land or rice fields are potential resources for pro-SRS management by the poor. Muir (2003) reported that the benefits of crop and fish management in rice field systems were clear but that poaching, shared management conflicts, use of pesticide and water management issues were notable constraints for any integrated fish management strategies.

1.4.3 Importance of aquatic animals and women's livelihoods

The results from both the PCA and household level survey were complementary in terms of the information they provided regarding the relative popularity of aquatic animals. The current study examined the perception of importance of non-stocked aquatic animals both in farmer managed and open systems. The value or importance of different foods was based on their perceived economic, social, traditional and health benefits. The criteria used to measure importance such as 'high abundance' and 'good taste' varied by gender which might be due to cultural acceptance, different culturally determined knowledge about the value of food, and specific importance to their health (Roos et al.2002). The importance of some important species varied with the distance of the household from a river particularly in the south-central zone which might be related to the natural abundance, suitable breeding places of species close to river. For example *Clarias batrachus* and *Anabas testudineus* are floodplain breeders (Paul, 1997). SRS might be a more important commodity closer to a river (or a perennial water source) in low lying areas. Gregory and Guttman (1996) related interest in stocking fish to proximity of farmers' aquatic systems to perennial water bodies that acted as refuges for wild fish. Evidence from other sources also shows that the dependence on fish is usually higher for people located in coastal areas and around major river systems (FMSP-3, 2006). The criteria identified by women to value aquatic animals tended to be more associated with a family well-being or health focus rather than direct cash benefits perhaps due to their greater knowledge of food values or nurturing role within the family.

Womens' livelihood activities remained much more household centred and related to livestock rearing and household work and with less involvement in non-farm activities compared to men, reflecting social and cultural barriers and a lack of social support and opportunity to participate in diversified livelihoods activities. However better access to micro-credit and participation in various NGO along with education, access to services etc. has started to bring a shift in women's traditional livelihoods (CARE, 2006).

Women represent a separate group among the poor, typically being the most disadvantaged, vulnerable and insecure because of the adverse effects of the law on inheritance; early marriage; limited education; high maternal mortality; less participation in economic activities and household and community decision making. Women, when they can work also suffer lower incomes than men. Women were usually not involved in the management of large water bodies, but aquaculture is an activity that interests women, particularly in groups (CARE, 2005).Women's participation in different forms of agricultural activity depends on their class and family landownership pattern (McCarthy, 1981). Their involvement in agricultural labour, might be a result of crisis and debt. Women belonging to large households are entirely responsible for post-harvest crop/food processing including labour supervision. The women from landless families who have no access to tenancy arrangement or mortgage sell their skills as agricultural labour to other households

(Wallace et al. 1986). Rural women in Bangladesh work long hours of the day on domestic chores which start from gathering the food and fuel to preparing meals, nursing children, looking after old and socially superior male household members, tending the domestic animals and growing fruits and vegetables along with post-harvest activities (Khan, 1993). Several studies indicated that women are constrained by undeveloped skills and illiteracy, limited training opportunities, lack of information, poor political representation, landlessness and a number of underlying factors including socio-cultural and family dynamics and perceptions of women's competency (Jones, 2004).

Rice and other crop-related activities appeared important to women as they had less access to other livelihoods options. Even though women were not usually engaged in fishing in many areas, they perceived the importance of fishing to their household, reflecting the traditional importance of fishing in Bangladesh.

The high nutritional value of fish, particularly for vulnerable groups such as infants and pre-school children, pregnant and lactating women is known to researchers and farmers (Edwards, 2000; Roos et al.2004), and some societies target specific species as food for these categories (Thilsted et al. 1999). This nutritional value may be considered as a factor in their preference. Although the importance of animal protein in the diet is controversial certain amino acids (e.g. lysine) contained in fish are very important under certain circumstances (Gregory and Guttman, 2002). Morales (2006) analysed the different criteria used to measure importance of aquatic animal in three south-east Asian countries (Vietnam, Cambodia, Thailand) and found they could be aggregated into several categories namely – value for processing, versatility, lack of bones, good taste, value for family consumption, high monetary value, marketability, convenience of purchase, low cost, fast growth, ease of culture and availability. He also found no significant differences in perception of criteria by gender but that criteria related to food consumption were more important in areas where aquaculture was less developed. In contrast, criteria relating to income were more important in areas where aquaculture is more developed.

The aquatic biodiversity (fish and other organisms associated with ecosystem functions even not used by humans) in rice field associated systems is rich and diverse in some parts of south Asian countries which perform important ecosystem functions and management of the usable animals and plans serve as the major source of protein and essential fatty acids and hence is essential for a balanced diet and nutritional and environmental security for the rural people. It was noted in a session of FAO's International Rice Commission that rice fields produce much more than rice in Cambodia, China, Laos and Viet Nam (FAO, 2002). The Commission noted that aquatic organisms are collected from rice-based ecosystems on a daily basis in the rainy season. More than 100 aquatic species including fish, reptiles, amphibians, crustaceans, molluscs, insects and plants were identified in farmers' own catch, although the same range of products are not regularly consumed in South Asia. The diet in Southeast Asia is mainly dominated by rice, fish and leafy vegetables and lacks the cereals and pulses with more complete amino acid profiles which, for example, are found in South Asia (Gregory and Guttman, 2002). However, aquatic biodiversity is under threat from pesticide use, destruction of flooded forest habitat and illegal fishing tools. Managing resources with a more holistic view will be important (FAO, 2002).

Although the presence of popular species was similar in both zones some variability of species in three FMAS by zones (Table 3.16) was due to agro-ecological differences, level of agricultural intensification and the presence or absence of large open water bodies. Some species of AA are common in all three FMASs, perhaps explained by the permeable nature of FMASs which allows a discontinuous exchange of nutrients, water and species across different but contiguous aquatic systems. Understanding of the integrity of aquatic systems has been identified as an issue in attempts to characterise different aquatic systems (Grimm et al. 2003). FMAS and aquaculture will be increasingly important in Bangladesh due to the decline in open water resources. However, the quality and availability of Bangladesh's physical and biological resources are important to achieve the current expectation from the fisheries sector (Muir, 2003).

3.4.4 Attitudes to SRS and management

The different prevailing attitudes to SRS, as positive, negative or neutral of households were not significantly affected by education, well-being, household size, or the ownership of livestock and poultry. Positive attitudes to SRS was associated with a traditional preference for their taste, seasonal patterns of availability, income and environmental conditions such as flood, winter etc. Attitudes to SRS were influenced by the characteristics of resources available to the household. For example ownership of rice fields and/or rice field associated ponds encouraged a positive attitude. A range of factors were associated with interest in producing SRS including maintenance of traditions, having knowledge of their management, economic benefits (higher price of some species and scarcity), social value of species (distribution, entertaining guests) as well as specific preferences of certain household members. Additionally the specific characteristics of the pond type and/or adverse conditions for successful stocking were related to having a SRS positive attitude. Farmers' knowledge and experience of the management of SRS was higher in the SC zone compared to NW. This was related to their relatively higher abundance and agro ecological characteristics of the SC zone. The SRS positive behaviours were mostly associated with efficiency of capture, however cutting dike to allow water and digging small channel was for in situ production of SRS (Figure 3.21).Deepening of ponds was not mentioned as positive behaviour and might be constrained by ownership arrangements. Farming practices are shaped in a series of social interactions between different people at various points in time and in various locations, with in the context of a wider social system. Farmer practice is shaped by their beliefs about the biophysical and social world, what they aspire to achieve, are able to do, allowed or expected to do (Roling & Kuiper, 1994). Agricultural decisions are not made solely by the individual 'head of households', but extend to other household and/ or community members (Maarse et al. 1998).

The current study identified various actions, apart from stocking and fertilising ponds such as cutting and raising of dikes, making canals, using pipes to channel AA and water which bring positive benefits for households but which were often undermined in conventional aquaculture practices. However, such SRS positive management may undermine the success of stocked aquaculture and require a balanced management strategy involving stocked species and SRS in FMASs.

Rice field fisheries in many countries are not well tested and documented to the same level as conventional aquaculture models. In Cambodia, small-scale farmers are able to switch readily between culture and capture based systems, between closed and open systems However, experience from Cambodia suggests that there is a need to better manage small-scale fisheries to provide fish for rural food security which could reduce the need for small-scale aquaculture in low land rice growing areas. It is important to understand how we approach the issue of fish security in rice farming systems, as farmers are found to move freely between fisheries and aquaculture to meet their household food security. Distinctions between small-scale aquaculture and flood plain and rice field fisheries might have to be managed in a more integrated and complementary manner in the future if these ambitions are to be met (Gregory and Guttman, 2002).

Chapter 4

Seasonality of food consumption and role of aquatic animals in the rural Bangladeshi diet

4.1 Introduction

Previous chapters demonstrated the importance of aquatic animals and, particularly SRS in terms of meeting consumption, income needs and social benefits. However, the seasonal dynamics of food consumption, income and expenditure are known to be complex. Longitudinal, panel-based enquiry is useful to understand the complexity of these aspects and the vulnerability of dependent livelihoods (Gillingham and Islam, 2005).

Hunger is one of the most obvious dimensions of poverty in Asia (Chatterjee et al. 2004). The concept of food security is related to physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life for all people all the time (FAO, 1996). The mere presence of food in the economy, or in the market, does not entitle a person to consume it (Sen, 1981) and hence the importance of considering food security in terms of employment, income and other factors. Adequate food supplies are an obvious precondition for feeding everybody but very importantly the command over these supplies (Kracht, 1996), command over resources and particularly the seasonal availability of quality food items are of greater concern particularly for the poor.

Seasonality has long been recognised as a key determinant of nutritional status for people in low income countries (Tetens et al. 2003). Affluent, technically advanced societies have escaped from the effects of nutritional seasonality by means of the cash economy, modern food processing and storage techniques, and worldwide transportation of food stuffs but there are many areas of the world which are still vulnerable to seasonal food shortages caused by winters or dry seasons when crops can not be grown (Prentice and Cole, 1994). Bangladesh is one of those countries where seasonal differences in the availability and intake of food and the effect of seasonality on the nutritional status of people are well recognized (Abdullah, 1989). Occurrence of flood may constrain production and disrupt transportation. Agricultural policies in Bangladesh have not yet been directed specifically at households, which still lack the resources needed to grow or purchase enough micronutrient-rich foods, such as animal foods, fruits and vegetables (Torlesse et al. 2004). Decreased food production, abnormal increases in food grain prices and non-availability of jobs reduce food entitlement of rural people, especially smallholder farmers and landless labours (Paul, 1998).

There is very little specific information available on the current seasonal availability and consumption of different types of aquatic animal. Information from ‘snap-shot’ surveys may not reflect the real picture of household consumption over different seasons. Aggregated data do not account for the context of transitory food insecurity, seasonal disparities of consumption at household and even individual level and the influence of various factors on such conditions (Sahn, 1989).

Current patterns of aquaculture and culture-based fisheries in Bangladesh are dominated by stocked carps and there is concern regarding the dominance of these species on the sustainability of the wide range of non-stocked species consumed which currently play an important role in the Bangladeshi diet. A better understanding of the seasonal availability of SRS would contribute to developing strategies to alleviate poverty.

A large proportion of Bangladeshi people, particularly women and children, suffer from malnutrition and aquatic animals are known to play an important role in the Bangladeshi diet (Roos et al. 2004; Torlesse et al., 2004). Aquatic animals (AA)-which were clearly segregated in this study as wild, stocked and SRS species might be a more important, or cheaper, source of high quality protein (Saengrut, 1998) than other substitutes such as - meat, eggs and pulses. Although aquaculture is growing with the decline of wild fish stocks, a deeper understanding is required on integrated and combined food based strategies to combat particular malnutrition and seasonal food vulnerability for the growing population of Bangladesh. Research on demand for fish by species or product category is fairly new in developing countries. In a fish consumption analysis in Bangladesh fish was categorised as six types – ‘Illish’, ‘live fish’, ‘carp’, ‘assorted small fish’, ‘shrimp’ and ‘dried fish’ (Dey, 2000). However, aquatic animals that are harvested from open waters or in farmer managed systems were not shown separately in any study and the source of fish consumed by households is also unclear. Abdullah (1989) studied intra-household food distribution patterns and the seasonality of availability in Bangladesh and found adult food intake correlated with seasonal activity pattern and availability of food. However, any variation in seasonal consumption of aquatic animals from different sources in the diets of rural people has to be understood in relation to consumption of other food items, household income and expenditure. Considerable disparities are believed to exist, and to be growing, in fish consumption levels between richer and poorer households and between rural and urban areas (Gupta and Shah, 1992).

Therefore, this chapter focuses on the role of aquatic animals within the context of the other main food items in the rural diet and its likely impact on nutritional status, food vulnerability and household income and expenditure which might inform decision makers to better understand food consumption poverty - its seasonal dynamics and help developing a 'food based strategy' to combat malnutrition in rural Bangladesh.

Hypothesis

The importance of SRS within overall rural diets varies seasonally and affects the vulnerability of poorer groups.

4.2 Methodology

The memory of food intake fades rapidly as the variability of the diet and number of items increases. In general immediate recording of food choices is preferable to minimise memory loss. The 24-hour recall, pioneered by Burke (1974), McHenry (1939), and Kruse et al. (1940), is the most widely used dietary assessment method. The method is relatively rapid but the most fundamental limitation of the 24-hour recall method is that dietary intake from day to day is highly variable (Witschi, 1990). In recall methods the number of days and which days in a week or month chosen are important to consider. Five day or seven day recall methods have been used in several consumption studies (e.g. Roos, 2002; Gibson, 1990). Seven day recall methods may become difficult to apply when food items are diverse. However, because of extensive personnel costs and the burden on respondents, a frequent compromise is to decrease the number of days (frequency of sampling) of recording (Witschi, 1990). Therefore, the current study used a 3 day recall method for food consumption and 7 day recall method for estimating income and expenditure monthly over an annual cycle.

Food consumption was monitored on a monthly basis with 50 households from 10 communities. Households were randomly sampled from three groups stratified by well-being level in each community during previous wealth ranking exercises (Table 4.1). Communities were also selected from the previous baseline and PRA study communities following a stratified randomised method already described in Chapter 3. The sample size was proportionately reduced to around half of the baseline sample (119 households) based on the household's interest to participate and available resources. The households were closely monitored using a questionnaire conducted with the household head alone or with a family member during January 2002 to December 2002 in two zones of Bangladesh. Data concerning food consumption included both its type and source(s). The weight of food items was considered as wet weight of raw food either purchased or obtained from other sources prior to cooking Half of the total households in each zone were interviewed in the first half, and the remainder in the 2nd half, of each calendar month. Each interview took around 2-3 hours. Household information regarding left over food was collected since cooking food curry for consumption over two consecutive days was often practiced. Also the frequency and consumption of communal meals with extended family were also noted.

Table 4.1: Sample distribution of households interviewed in panel assessment of consumption, income and expenditure

Zone	No. of Community	Low	Medium	High	Total household
Northwest	4	13	6	7	26
South-central	6	9	8	7	24
Total	10	22	14	14	50

A small group of 11 non-producer households (4 from south-central and 7 from northwest) were also monitored to better understand consumption of non-producing low income households.

Data Analysis

Data was collected and entered into a FoxPro database, exported to Excel for checking, coding, cleaning and arranging. MS Access was also used to arrange the dataset in a required form. Finally, SPSS 12.1 version was used for statistical tests.
In General Liner Model (GLM) zone, well-being and month was used as fixed factors and ID, community was used as random factor, community was nested within zone and ID was nested within zone, community and well-being. All main effects and two way, three way, four way interactions were evaluated.

Three day consumption data was converted to a weekly basis for analysis. Household income and expenses data were collected based on the seven days and any monthly fixed income was converted to weekly basis.

4.3 Results

4.3.1 Contribution of aquatic animals to the rural diet

Aquatic animals were one of the most important components (3rd most important by weight, 2nd most important by cost) of diets for households in all three well-being categories in both zones. Overall, irrespective of zone and well-being level - cereals mainly rice constituted nearly half (48%) of the food consumed in terms of weight. Vegetables were relatively more important than aquatic animals in terms of the total amount consumed by the households. The percentage contribution of pulses, eggs and aquatic animals and other food items are presented in the Figure 4.1. Overall rural diets were highly dominated by cereals and vegetables.

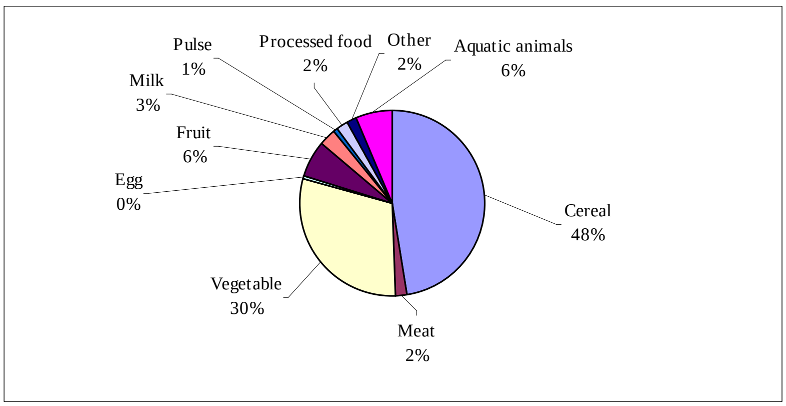


Figure 4.1: Percentage contribution of different food items by weight to the overall diet in the study area (processed food = fried & puffed rice, traditional cake; pulse = dried pulse; milk = wet milk; aquatic animals = SRS, wild, stocked, marine; meat = beef, chicken, mutton/goat meat, duck/pigeon meat).

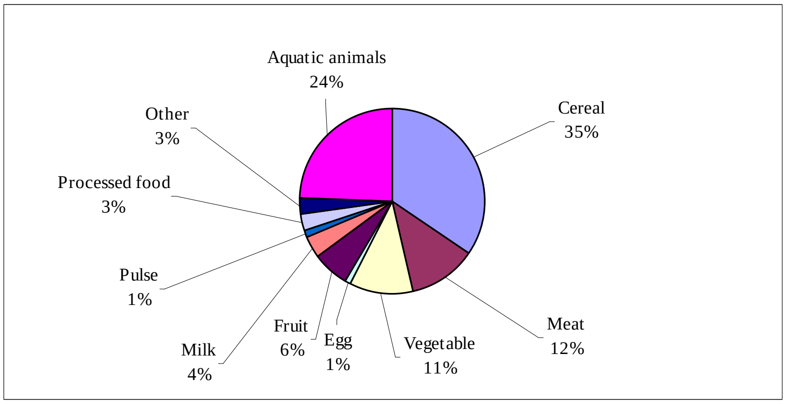


Figure 4.2: Percent contribution of food items by expenditure with household food budgets in the study area (calculated the price of food items @58 Taka = 1 USD currently expressed as %; processed food = fried rice, puffed rice, traditional cake etc.).

Considering the expenditure on different food items by the household cereals, aquatic animals, meat, vegetables and fruit were the most important items purchased (Figure 4.2).

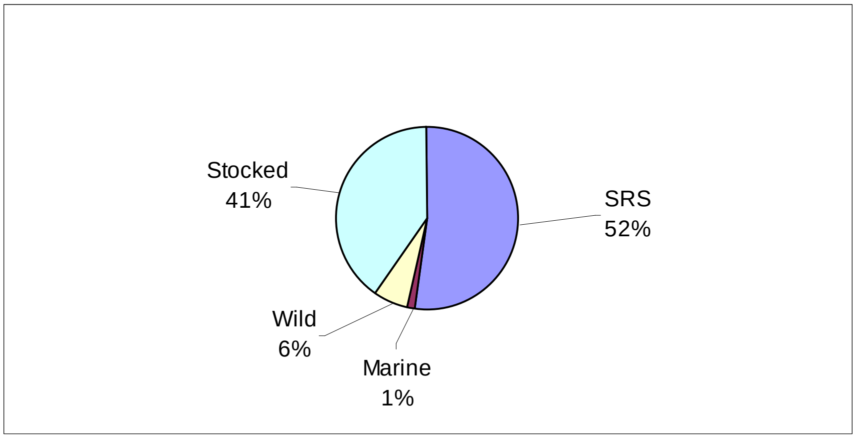


Figure 4.3: Percent total contribution of different types of AA to household diets in two agro-ecological zones of Bangladesh.

SRS accounted for 52% of the total aquatic animal consumption and was a very important animal protein source in rural diets (Figure 4.3).

Table 4.2: Mean per capita per week (g) consumption of different food items in the study area (N= 50)

Zone	Well-being		Food items												
			Cereal	Wild fish	Stocked fish	SRS	Marine	Meat	Vegetable	Fruit	Egg	Milk	Pulse	Processed food	Other
Northwest	Low	Mean	3984.16	6.23	125.49	134.82	18.10	51.70	1944.49	226.94	14.71	226.93	27.99	143.44	87.73
		Std. Deviation	1442.98	74.77	202.31	303.88	75.28	162.49	1133.09	924.13	35.04	545.35	75.56	231.78	166.84
	Medium	Mean	3430.75	4.49	138.38	325.68	7.29	110.94	2090.50	527.41	16.40	221.68	33.83	215.02	132.28
		Std. Deviation	961.12	28.58	206.78	338.45	43.72	281.87	1095.03	1585.56	38.60	507.63	69.29	277.50	199.40
	High	Mean	3975.37	8.53	260.87	222.52	8.93	260.25	1835.13	247.56	10.13	322.34	78.62	66.15	96.05
		Std. Deviation	1346.57	47.81	331.92	286.35	48.00	318.59	972.26	923.75	31.64	621.73	89.72	125.33	154.36
South-central	Low	Mean	3373.29	53.00	133.54	355.38	0.00	126.10	2583.31	604.62	31.46	118.29	99.95	88.53	250.06
		Std. Deviation	880.18	130.11	253.94	441.44	0.00	275.01	1466.26	915.24	53.90	358.91	114.48	360.92	475.49
	Medium	Mean	3451.74	80.70	228.71	285.17	0.00	179.67	2460.44	740.48	51.18	227.11	134.93	128.69	133.51
		Std. Deviation	947.70	182.86	285.13	319.74	0.00	307.72	1103.14	1076.55	58.44	376.79	124.26	341.30	237.60
	High	Mean	3171.48	35.42	377.75	284.64	0.00	247.21	2827.48	773.42	56.68	295.60	126.36	163.66	61.68
		Std. Deviation	1620.22	124.79	414.39	324.94	0.00	390.89	2042.27	889.60	73.39	439.69	161.33	310.80	235.78

4.3.2 Aquatic animal consumption

Mean consumption of aquatic animals was significantly associated by well-being, zone and month ($P<0.05$). Low well-being households in the south-central zone consumed nearly double the amount of AA than households ranked similarly in the northwest (Table 4.2). Poorer (low and medium well-being categories) households relied significantly more on SRS than richer people ($P<0.05$). Consumption of stocked aquatic animals was significantly associated with well-being but not by zone (Figure 4.4). Better off households are more dependent on stocked species than SRS and wild fish. No significant interaction was found for the consumption of wild fish between zone, well-being and month (Figure 4.4). However, consumption of wild fish was higher in the south central (SC) than in the northwest (NW) zone.

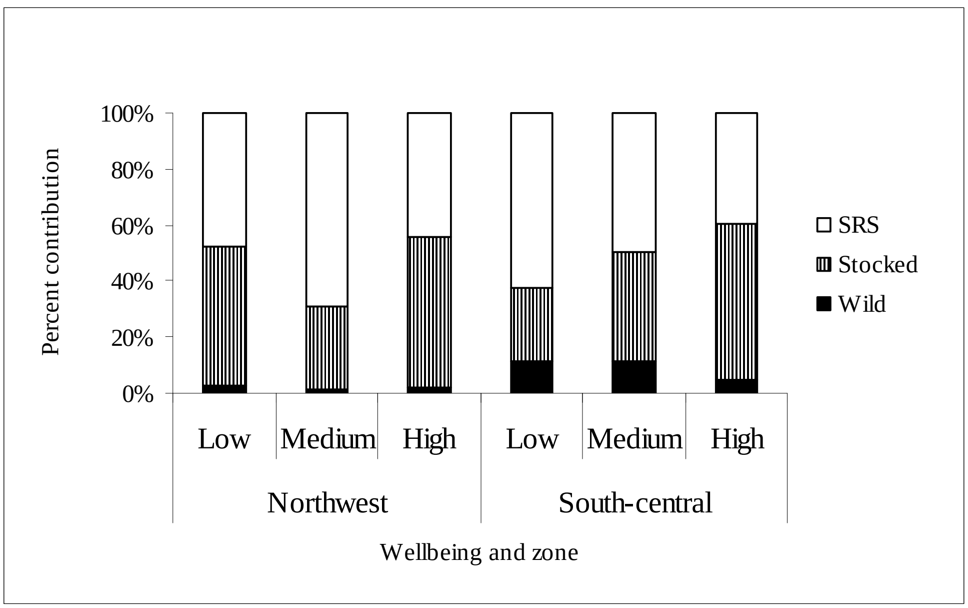


Figure 4.4: Percentage contribution of aquatic animals by well-being and zone (N=50).

There were differences in both absolute and relative consumption levels of fish between the two zones. In the NW zone, better off households consumed nearly double the amount of aquatic animals (AA) than poorer households. Medium level households consumed almost as much as the better off particularly in the NW zone. In the SC zone the better off consumed only slightly more AA than the low well-being group (Table 4.2)

4.3.3 SRS diversity and consumption

The diversity of species available appears to have an impact on consumption levels. The mean number of SRS species consumed per household over the year was significantly affected by zone but not by well-being. The mean number of species consumed by households in the SC zone was significantly higher than the NW (Figure 4.5).

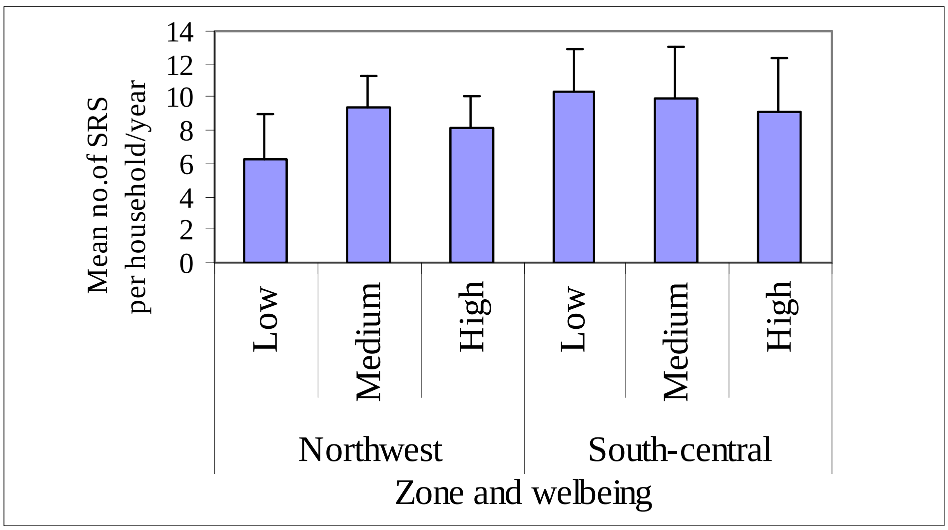


Figure 4.5 : Number of only SRS species consumed per households per year by well-being and zone.

The total number of SRS species consumed per household per year was also significantly correlated (Figure 4.6) with the amount of SRS consumed per household per year . Pearson's correlation was significant

(r =0.719) at the 0.01 level (P< 0.05). The highest mean total number of species

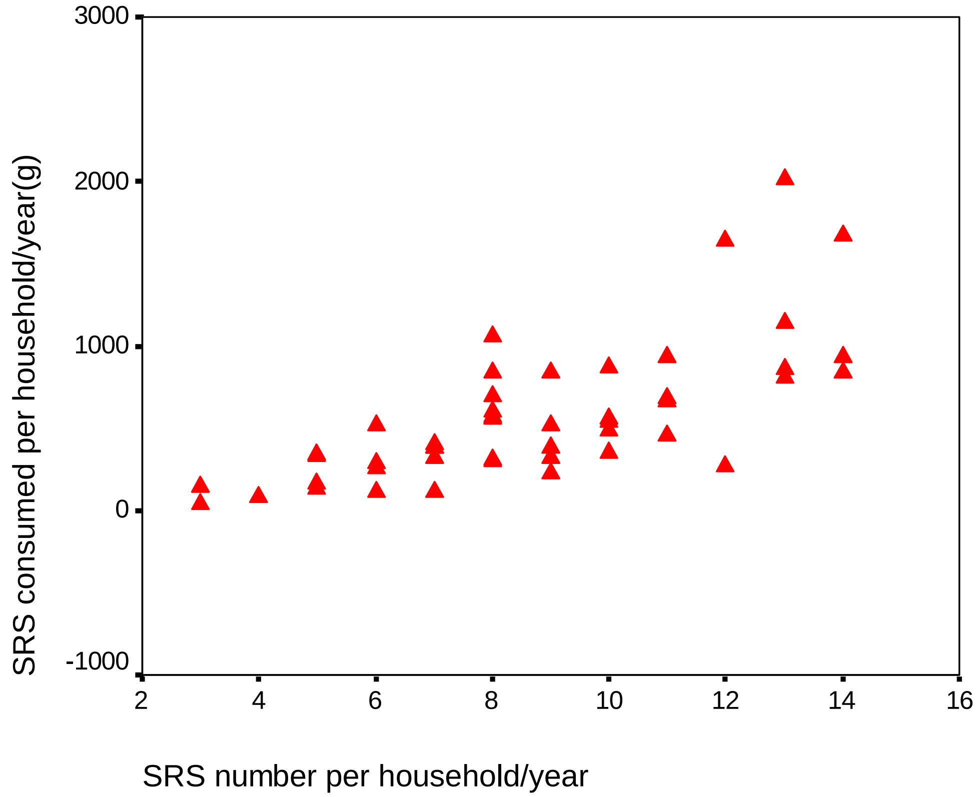


Figure 4.6: Association between SRS diversity and consumption in the study area.

consumed was 14 per household and 30 different type of species of SRS were recorded over the year in both zones.

Consumption pattern of aquatic animals

SRS consumption was significantly affected by zone, well-being and month ($P<0.05$). July to October was the peak consumption period of SRS in the NW zone and June to November in the SC zone. April - June in the NW zone and April-May in the SC zone are the low consumption periods for all three well-being groups. Consumption of SRS was relatively lower in the dry winter months particularly in January and February, but also in April and June in the NW and February, April, May in the SC zone. During this period stocked species appeared to play a larger role in diets (Figure 5.6) in both zones particularly among the high and medium well-being groups. Poorer households in the NW zone are particularly vulnerable to low consumption of aquatic animals during the dry season compared to those in the SC zone (Figure 4.7)

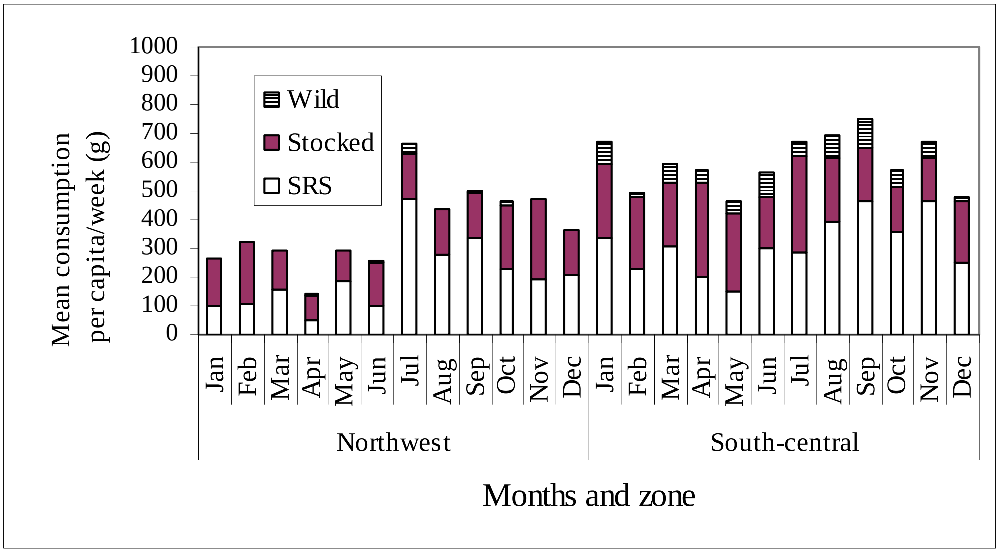
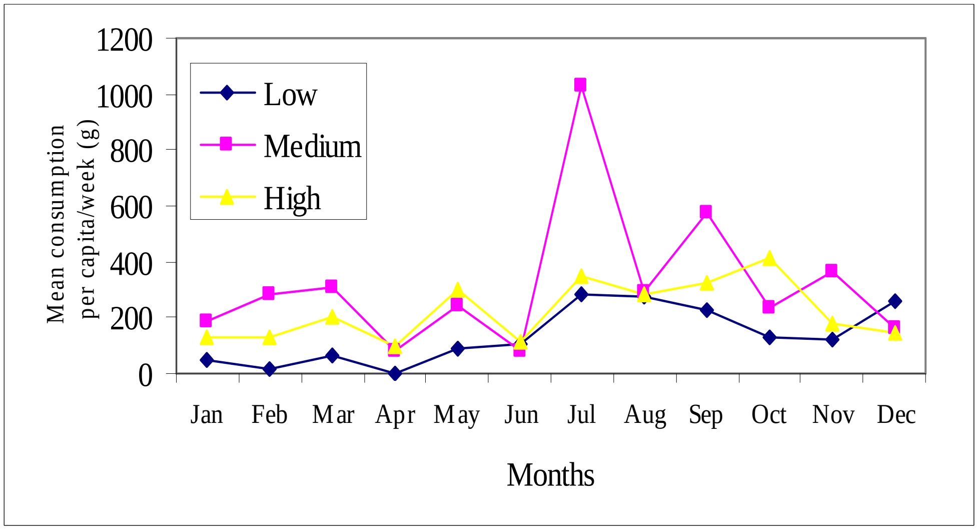
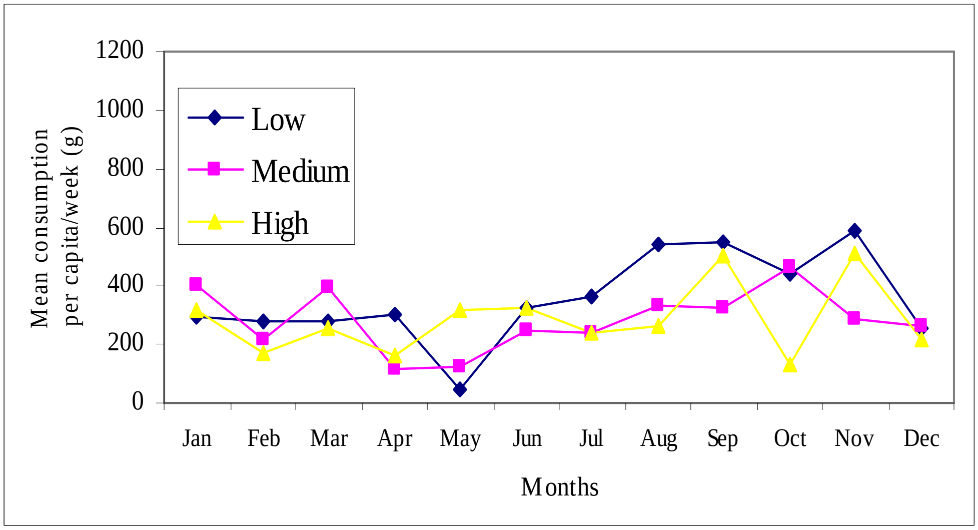


Figure 4.7: Seasonality of SRS, stocked and wild fish consumption by zone.

Poorer households consumed more SRS in the SC than in the NW zone whereas medium and high well-being groups consumed similar amounts of SRS in both zones. No significant interaction was found for wild fish consumption by well-being, month and zone (Figure 4.9).

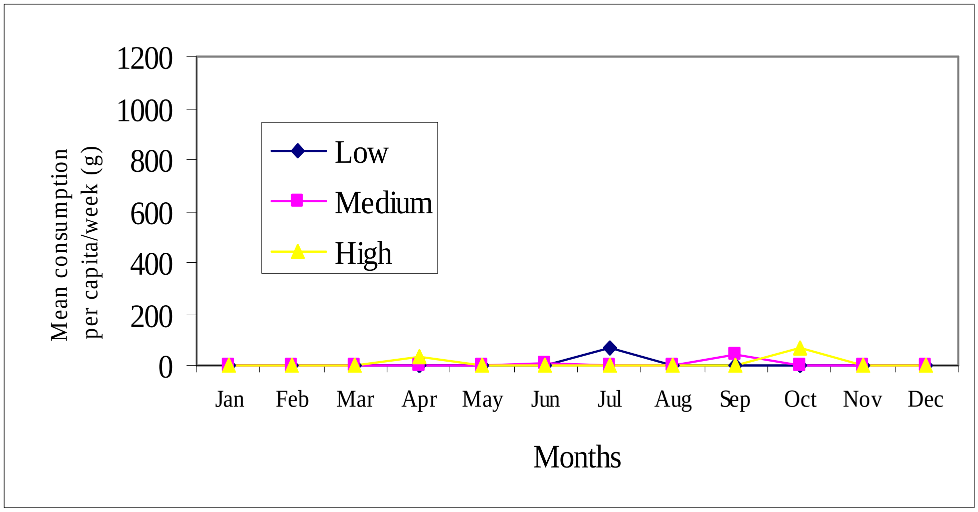
However, high and medium well-being households consumed slightly more wild AA than poor households, particularly in the SC zone (Figure 4.9).



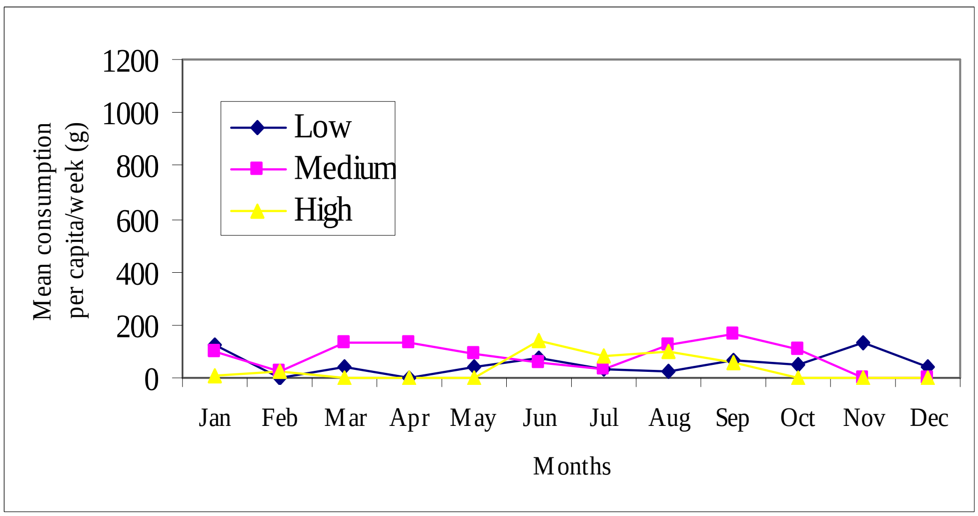


(B)

Figure 4.8: Seasonality of mean SRS consumption by well-being in northwest (A) and south-central (B) zone.

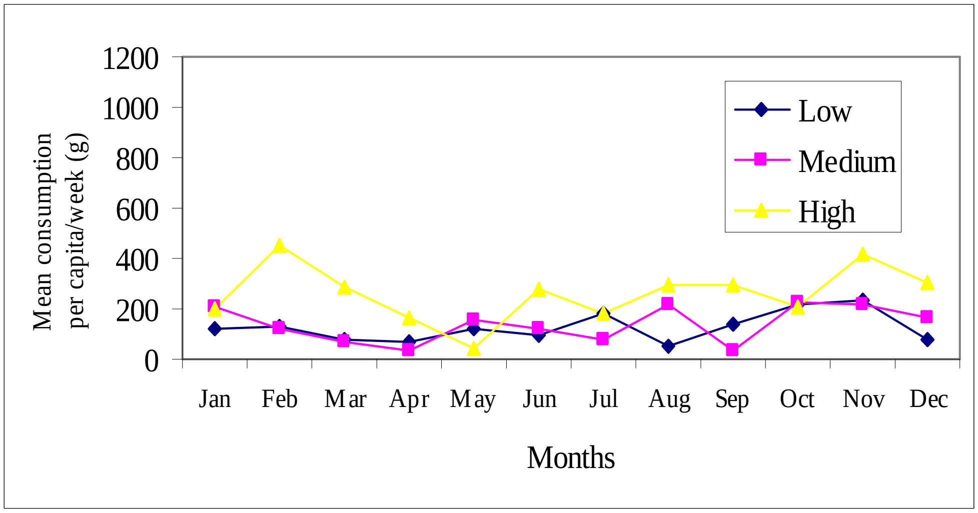


(A)

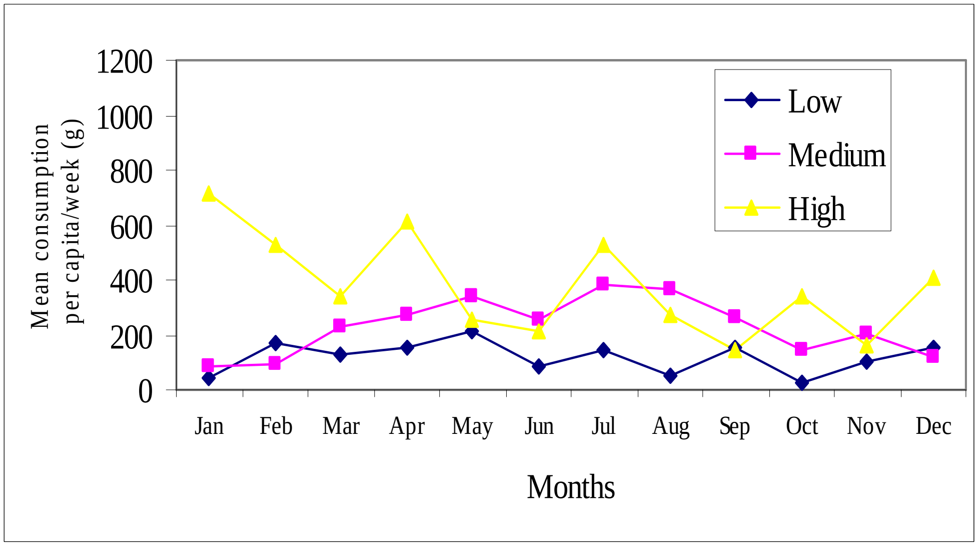


(B)

Figure 4.9: Seasonality of mean wild aquatic animal consumption by well-being in northwest (A) and south-central (B) zone



(A)



(B)

Figure 4.10: Seasonality of mean stocked aquatic animal consumption by well-being in northwest (A) and south-central (B) zone.

Better off households consumed significantly more stocked fish throughout the season than medium and poor households in both zones. Poorer and medium households consumed particularly little stocked fish between June and October when SRS was their main source of fish for consumption (Figure 4.10).

Consumption of aquatic animals by the non-producing low income groups

The aquatic animal consumption of 11 low income non-producing households (4 from south-central, 7 northwest) including a van puller, rickshaw puller, day labourer, tailor, pottery hawker and fisher was analysed to better understand consumption pattern among non-producing very low income households. Mean consumption of SRS among this group was significantly affected by month and zone (P<0.05). Consumption of SRS was also significantly less in the northwest zone than south-central. February, April, June in the northwest and April, May, December in south-central were low SRS consumption months. Mean SRS consumption was 181.5 and 396.6g/capita/week in northwest and south-central zone, respectively. Mean consumption of stocked aquatic animals was 121.1g and 109.8g/capita/week in northwest and south-central, respectively and was not significantly affected by zone or month.

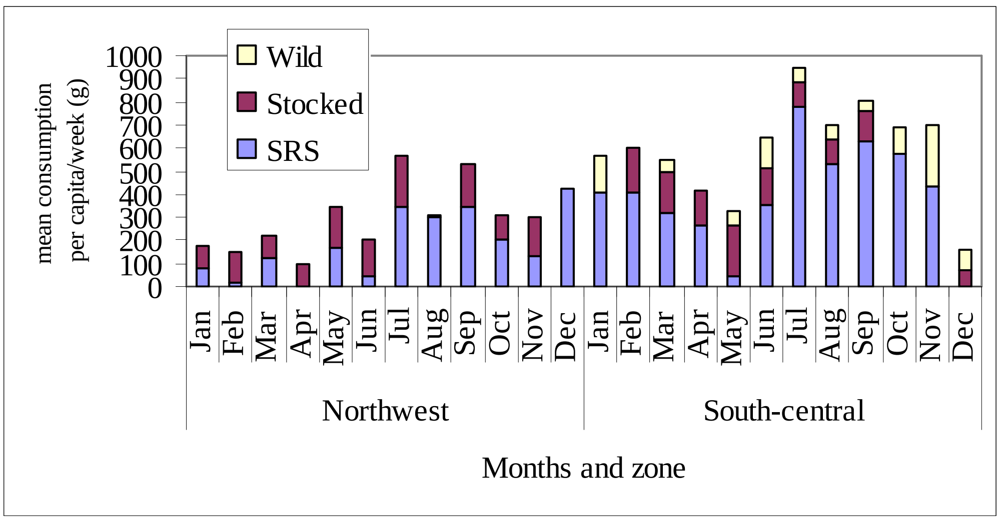


Figure 4.11: Mean consumption trend of aquatic animals of some low income households (non producer).

Mean consumption of wild aquatic animals was 186.12 g /capita/week in the south-central zone, but there was apparently very minimum consumption at all in the northwest zone. Mean consumption of all three types of aquatic animals (stocked, SRS and wild) was 302.5 and 592.16g /capita/week in northwest and south-central, respectively (Figure 4.11).

4.3.4 Sources of aquatic animals consumed

Farmer managed aquatic systems were found to be important in both zones, but open systems were much more important in the south-central zone compared to the northwest. Similar findings were also found in the PCA stage of the study described in the chapter 3. For the two zones taken together farmer managed aquatic systems (FMAS) contributed 31% of all aquatic animals followed by open systems (26%), market purchases (22%) and received as gifts (21%) (Figure 4.12). Percentage contributions from the market and as gifts were almost similar in both zones and better off households consumed more purchased fish than poorer households in both zones. Gifts were found to be relatively more important to poorer than better off households (Figure 4.12 & 4.13).

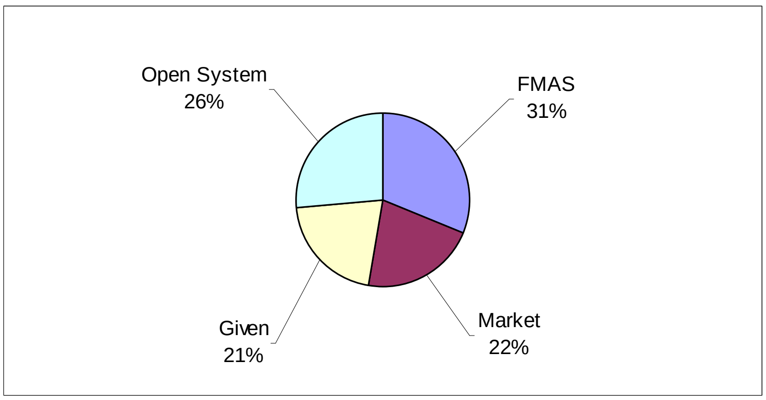
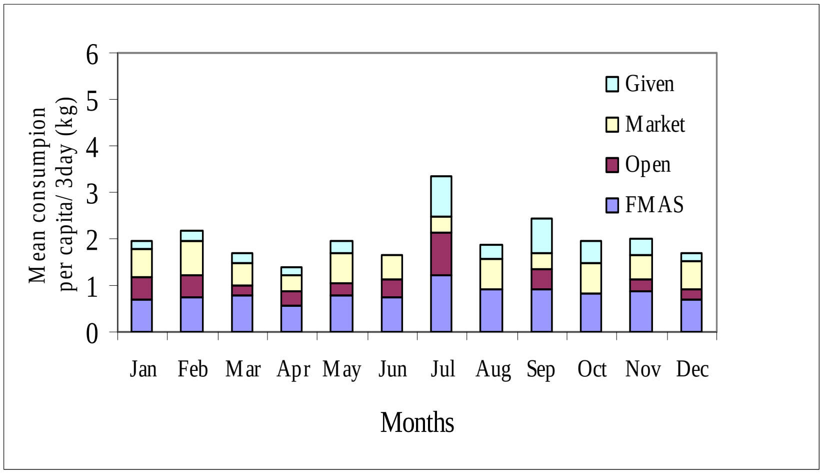
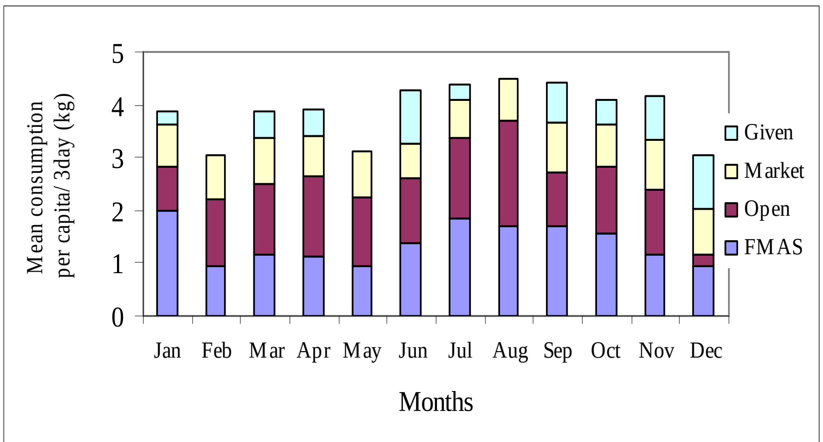


Figure 4.12: Contribution of different sources of AA consumption (FMAS = Pond, Rice field, own systems, Open System = Bee/lake, River, large open floodplain depressions, Market = Purchased from district, sub-district, village market, eaten at hotel, bought from local area, Given = gift from relatives, free catch in neighbours rice fields).

FMAS was an important source of aquatic animals throughout the year in both zones although their availability became constrained as they dried out and water areas decreased in the dry season in both zones. When yields from FMAS were seasonally low overall production was low. Fish caught both in FMAS and open systems were important year round in the SC zone and importance of gifts was also greater in the SC than NW zones (Figure 4.13).



(A)



(B)

Figure 4.13: Seasonality of the different sources of aquatic animals consumed by zone and months (A= Northwest zone, B= South-central zone).

4.3.5 Vegetable consumption

Vegetable consumption was significantly affected by zone, well-being and month ($P<0.05$). The availability of green vegetables appeared to decrease in the rainy season between May to October in both zones at the time when SRS consumption increased relative to the dry season months. Vegetable consumption was relatively higher in the SC than NW, but within zones households of different socio-economic levels consumed a similar amount (Table 4.3, Figure 4.14).

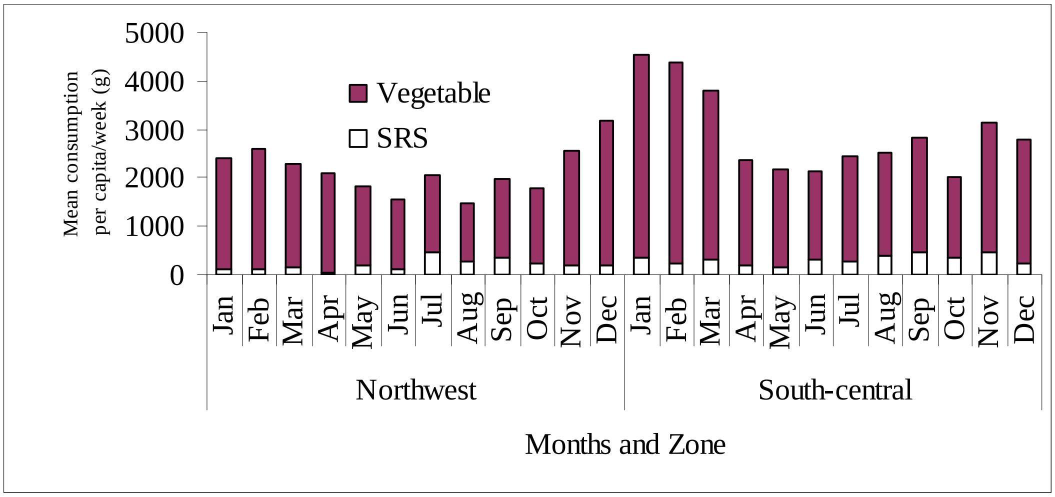
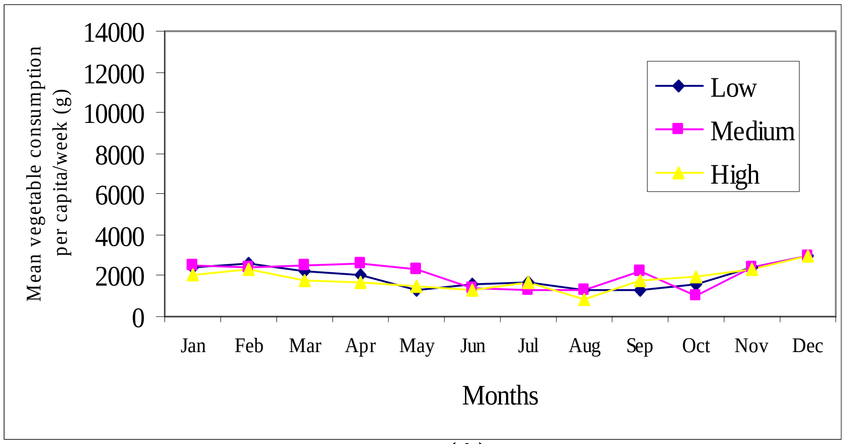
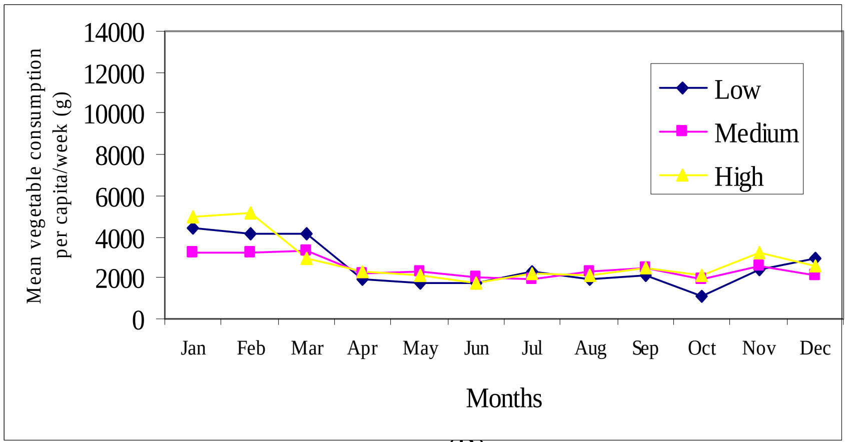


Figure 4.14: Seasonality of mean vegetable and SRS consumption in the northwest and south-central zone.



(A)



(B)

Figure 4.15: Seasonality of mean vegetable consumption in the northwest (A) and south-central (B) zone by well-being.

4.3.6 Cereal (mostly rice) consumption

Cereal consumption was higher in the NW zone among low well-being households compared to the same group in the SC zone (Table 5.3, Figure 4.16). However, March – April, July, October-November (around 4-5 months) were low consumption months in the NW zone and May, September, October were the low consumption months in the SC zone.

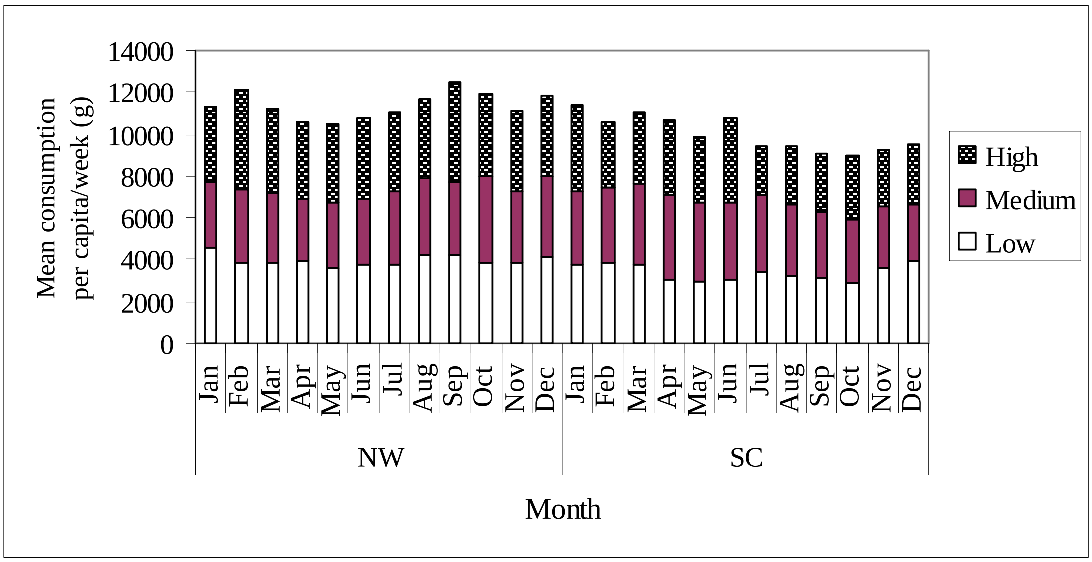
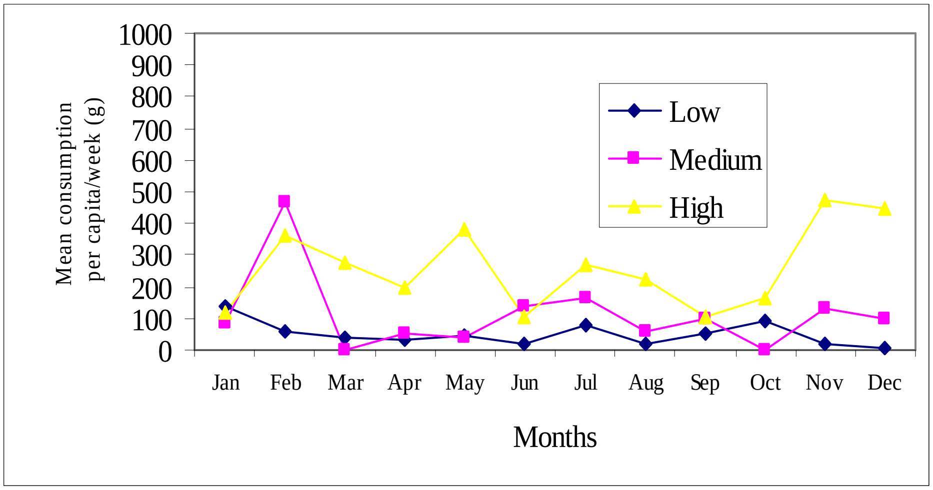


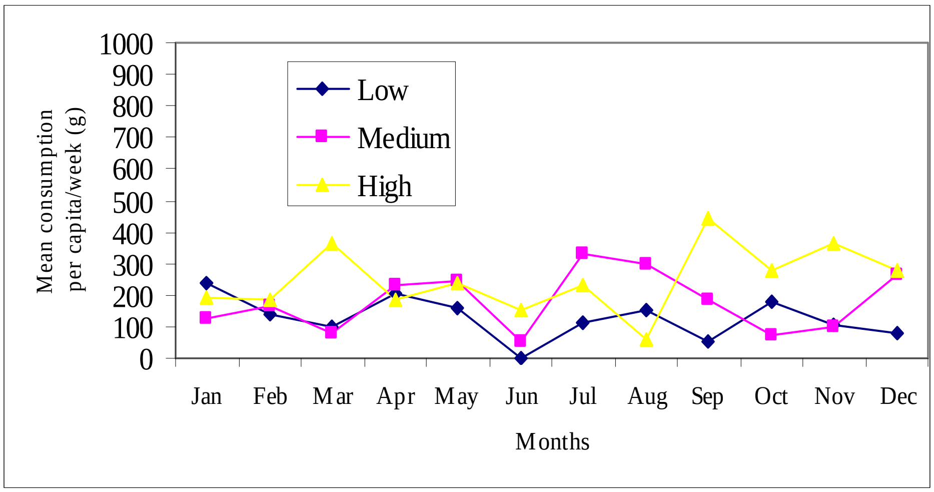
Figure 4.16: Seasonality of mean cereal consumption in northwest and south-central zone by well-being.

4.3.7 Meat consumption

Meat consumption was significantly affected by well-being ($P<0.05$) but not by zone and month (Figure 4.17). Inequality of consumption was found to be higher in the NW zone. Mean per capita consumption was higher by a factor of 5 and nearly 2 in better off compared to poor households in the NW and SC zones, respectively.



(A)



(B)

Figure 4.17: Seasonality of mean meat consumption in northwest (A) and south-central (B) zone by well-being.

4.3.8 Fruit consumption

Fruit was consumed at almost the same level as aquatic animals and was significantly affected by zone and month ($P<0.05$) but not by well-being. Fruit consumption was relatively higher in the rainy season (May – July) in both zones compared to the dry and winter months (January, February, and March). Seasonal consumption of SRS and fruit is presented in Figure 4.18.

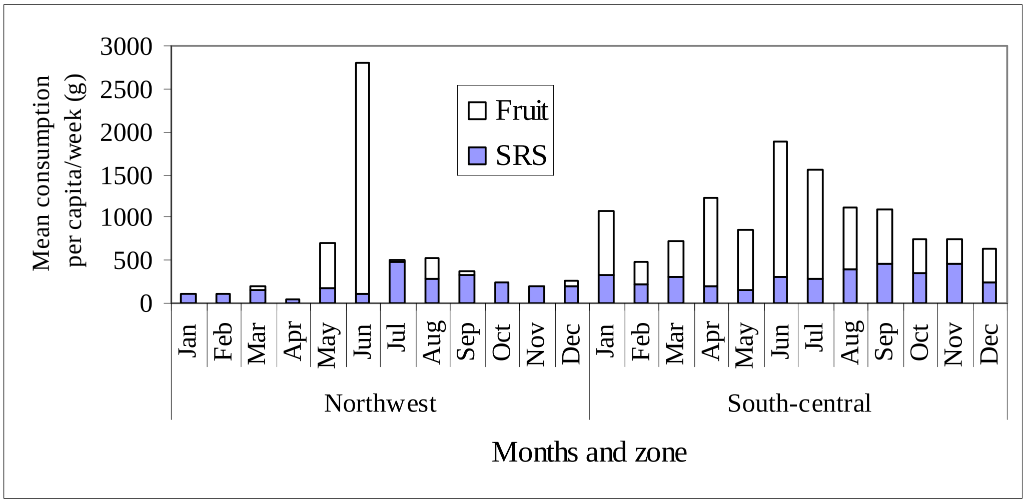


Figure 4.18: Seasonality of mean fruit and SRS consumption in northwest and south-central zone.

4.3.9 Pulse consumption

Pulse consumption was significantly affected by month and zone (P<0.05). It was significantly higher in the SC zone compared to the NW and households consumed more in the rainy season when green vegetables were relatively less available. Consumption of pulses and SRS were both therefore relatively higher in the rainy season (July, August, and September) particularly in the SC zone (Figure 4.19).

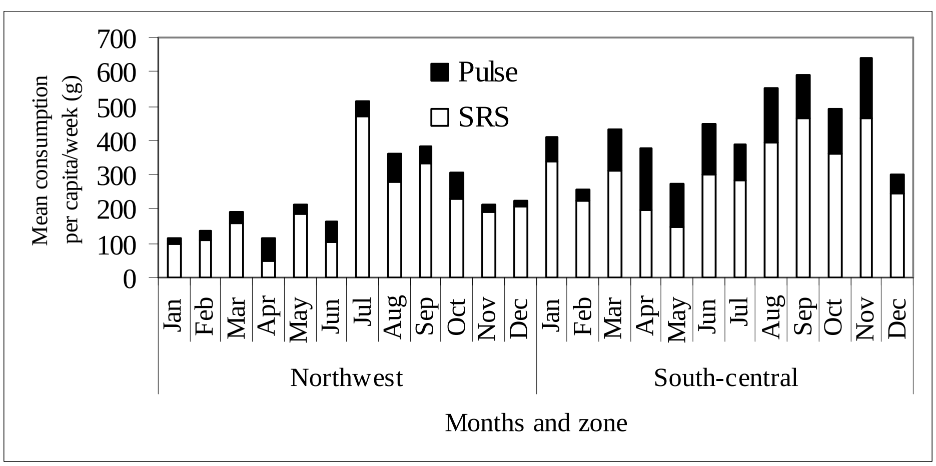


Figure 4.19: Seasonality of pulse and SRS consumption by zone.

4.3.10 Egg consumption

Egg consumption was not significantly affected by zone, well-being or month. However, egg consumption was relatively higher in the SC zone than NW (Figure 4.20).

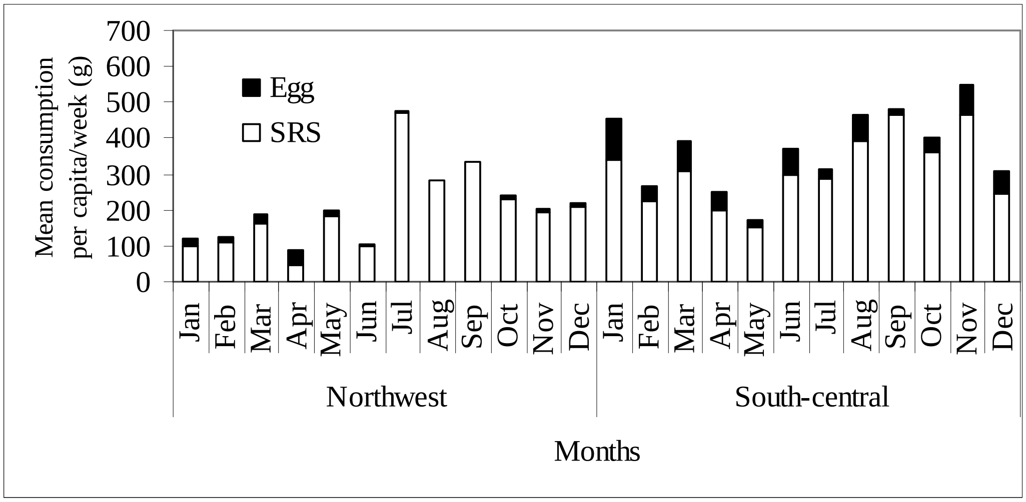


Figure 4.20: Seasonality of mean egg and SRS consumption in the northwest and south-central zone.

Egg consumption was relatively higher in the winter (November to May) months in both zones than during the rainy season.

4.3.11 Milk consumption

Milk consumption was significantly affected by zone, well-being and month ($P<0.05$). Milk consumption appeared to play an important role in the diet during the dry season months (March, April, and May) when SRS availability and consumption is low (Figure 4.21).

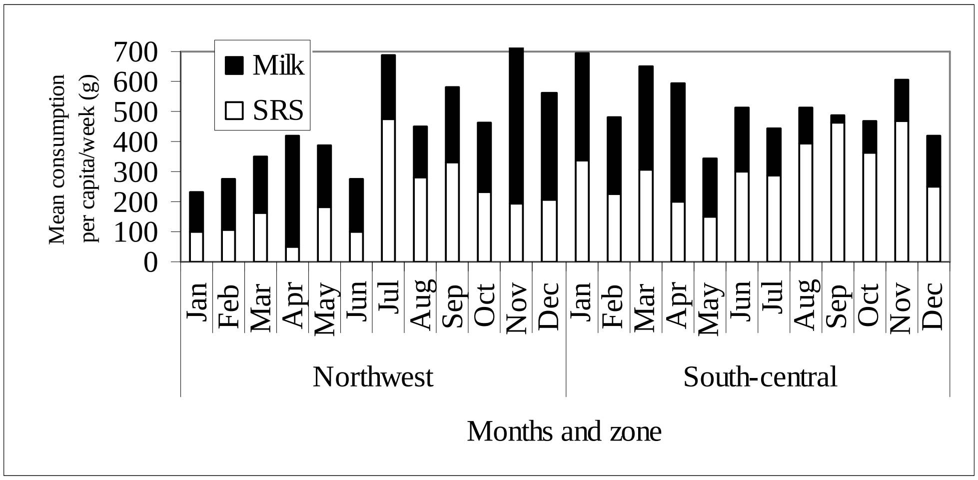
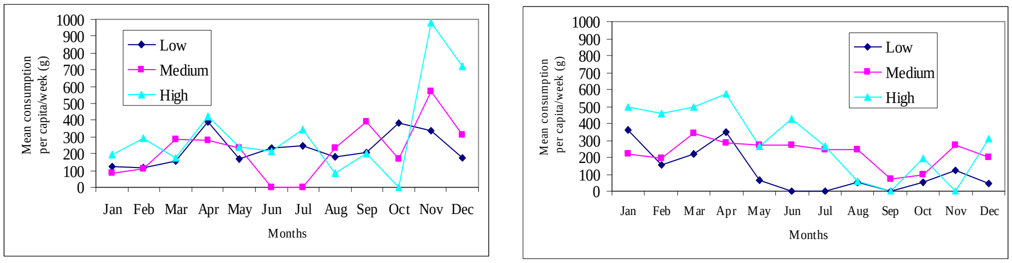


Figure 4.21: Seasonality of milk and SRS consumption in northwest and south-central zone.



(A) (B)

Figure 4.22**:** Seasonality of milk consumption by well-being in the northwest (A) and south-central (B) zone.

Milk consumption appeared to decrease during the rainy season (June, July and August) and increase in the dry winter months in both zones (Figure 4.22).

4.3.12 Different sources of household income

Total household income was significantly affected by zone, well-being and source ($p<0.05$). Rice, other farm produce and livestock were the major sources of income in the NW and aquatic animals, business, other farm produce, agricultural and non-agricultural labour (wage) were most important in the SC zone. The contribution of aquatic animals to household income was higher in the SC zone compared to the NW zone. Mean income by well-being and zone was presented in the Table 4.3.

Table 4.3: Mean per capita income (USD/week) from different sources for households of different well-being in northwest and south-central zones (N=50) of Bangladesh

	Northwest			South-central		
Sources	Low	Medium	High	Low	Medium	High
Aquatic animal	0.10 ± 0.66 (4.02)	0.09 ± 0.42 (1.44)	0.34 ± 1.89 (5.20)	1.23 ± 2.95 (27.95)	0.73 ± 2.90 (13.77)	1.30 ± 4.32 (21.17)
Livestock/Poultry	0.23 ± 1.40 (9.24)	1.04 ± 3.06 (16.69)	0.13 ± 0.70 (1.99)	0.10 ± 0.83 (2.27)	0.39 ± 1.88 (7.36)	0.03 ± 0.13 (0.49)
Rice	0.68 ± 3.34 (27.31)	2.77 ± 7.61 (44.46)	3.69 ± 7.21 (56.42)	0.03 ± 0.25 (0.68)	0.57 ± 1.56 (10.75)	0.69 ± 1.76 (11.24)
Other farm produces	0.21 ± 0.78 (8.43)	1.25 ± 4.01 (20.06)	1.79 ± 4.97 (27.37)	0.32 ± 0.93 (7.27)	0.99 ± 2.68 (18.68)	1.14 ± 2.60 (18.57)
Services	0.02 ± 0.10 (0.80)	0.05 ± 0.30 (0.80)	0.18 ±1.05 (2.75)	0.28 ± 0.86 (6.36)	0.16 ± 0.41 (3.02)	1.46 ± 4.02 (23.62)
Wage/driving	0.84 ± 1.14 (33.73)	0.02 ± 0.33 (0.32)	0.00 ± 0.00 (0.00)	1.17 ± 1.84 (26.59)	0.32 ± 0.73 (6.04)	0.14 ± 0.63 (2.28)
Business	0.20 ± 0.85 (8.03)	0.34 ± 0.77 (5.46)	0.41 ± 1.15 (6.27)	0.96 ± 1.86 (21.82)	2.14 ± 2.87 (40.38)	1.39 ± 2.68 (22.64)
Others	0.22 ± 1.48 (8.84)	0. 74 ± 3.53 (11.88)	0.00 ± 0.00 (6.27)	0.32 ± 2.39 (7.27)	0.00 ± 0.00 (0.00)	0.00 ± 0.00 (0.00)
Total	2.49 ± 4.43 (100.00)	6.23 ± 10.01 (100.00)	6.54 ± 8.39 (100.00)	4.40 ± 3.99 (100.00)	5.30 ± 4.80 (100.00)	6.14 ± 6.93 (100.00)

Note: Figure in parentheses is percent (%) by column and ± value is std. deviation.

Pearson Correlation between household income and food consumption:

Table 4.4: Pearson Correlation (r) between household income and food consumption

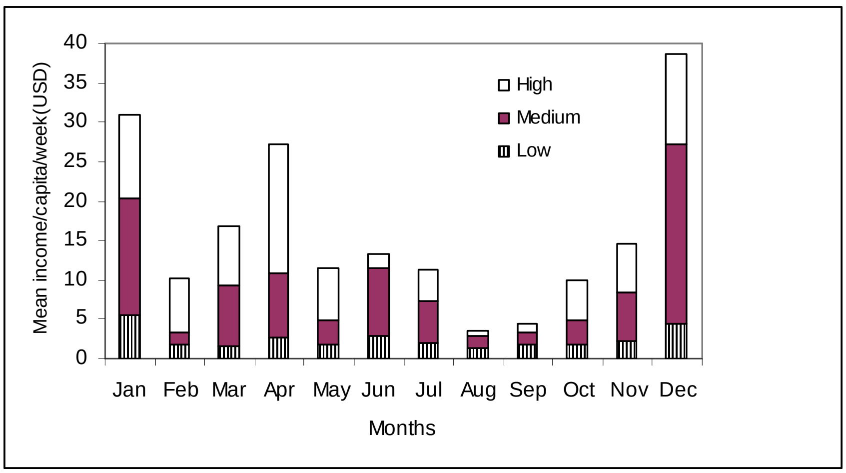
Item	SRS	Stocked fish	Fruit	Meat	Pulse	Vegetable	Egg	Other	Marine fish
r	0.43	0.63	0.50	0.58	0.57	0.62	0.36	0.18	-0.20

Correlation is significant at 0.01 levels (2-tailed)

There was significant (P<0.05) positive correlation between household income and consumption of meat, fruit, pulses, vegetables and stocked fish and moderately significant positive correlation with SRS and eggs. The correlation with marine fish consumption was weak.

4.3.13 Overall income trend

Total income level of households was significantly affected by zone, month, well-being and sources (P<0.05). In both zones - February, May, August, September, October were the low income months among low and medium well-being groups. November, December, January, June were the high income months (Figure 4.23). In SC zone higher income found in May for the richer households.



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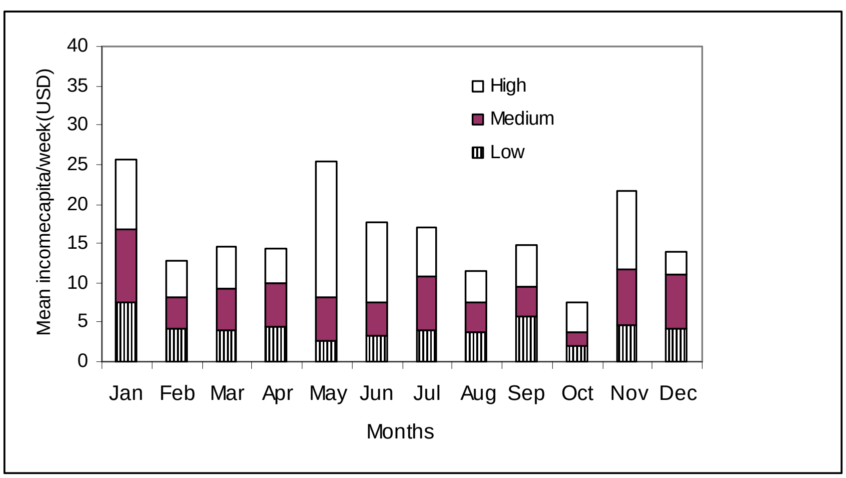
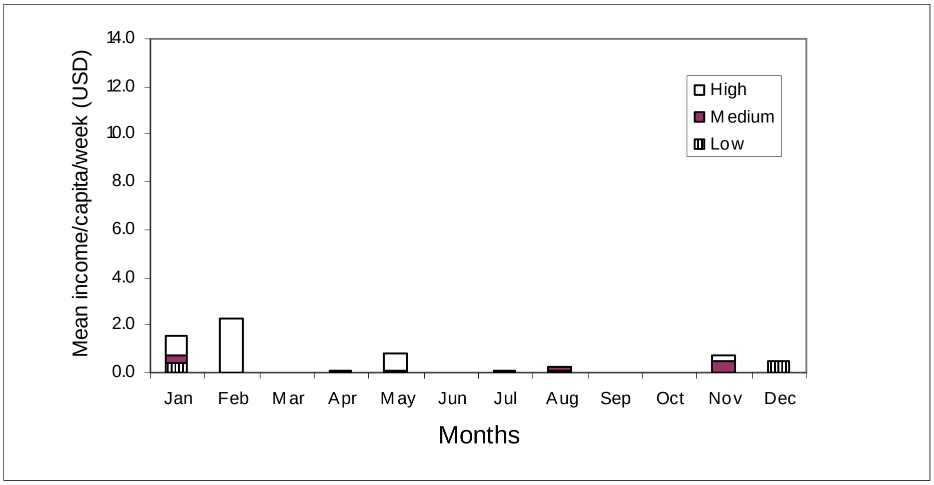


(B)

Figure 4.23: Annual trend of income in the northwest (A) and south-central (B) zone by well-being (N=50).

4.3.14 Income trend from only aquatic animals

Income from sale of aquatic animals was significantly affected by zone ($p<0.05$) . Aquatic animals contributed relatively more to household income in the SC zone than in the NW (Table 4.3).



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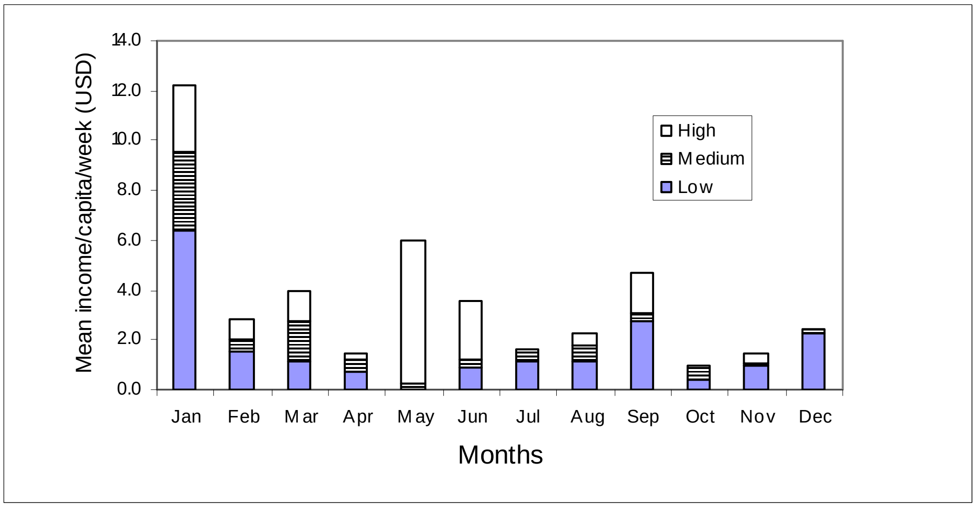


(B)

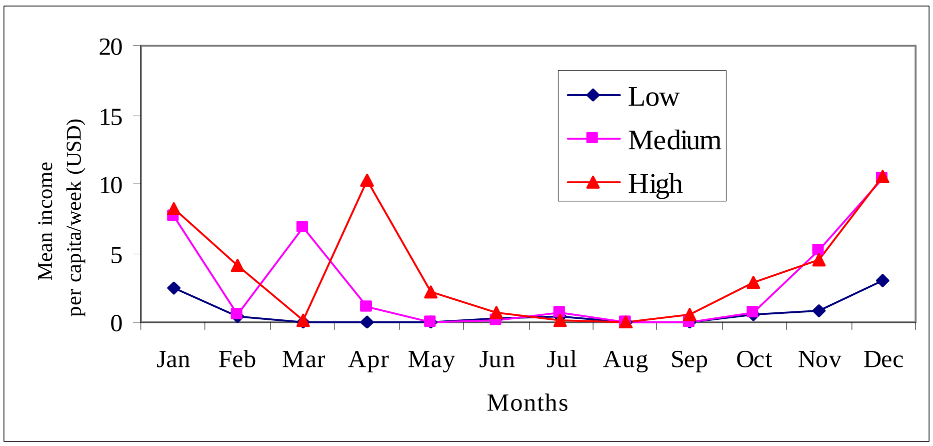
Figure 4.24: Yearly income trend from aquatic animal in the northwest (A) and south-central (B) zone by well-being.

In the SC zone the higher contributions to income from sale of aquatic animals occurred in the month of January, February, March, May, August, September, October, December and in the NW it was in November, December, January and

February. Income from aquatic animals was generated over a longer period in the SC than NW (Figure 4.24).

4.3.15 Income from rice

November, December, January, April, May, June in the NW zone and May, June, October, November, December in the SC zone were the rice selling months (Figure 4.25). Income from rice was relatively less in the SC zone compared to NW zone (Table 4.3).



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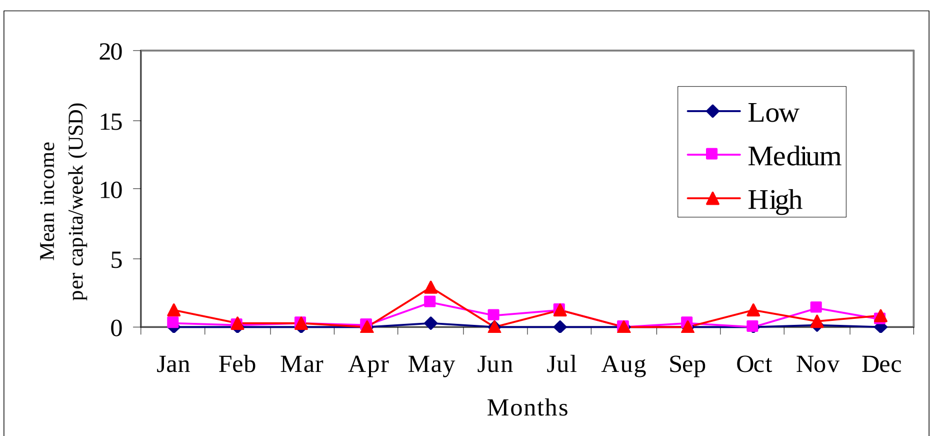


(B)

Figure 4.25: Income trend from rice in the northwest (A) and south-central (B) zone.

Particularly poorer households in the SC zone earned very little from rice production in the SC zone and they earned less than the better off from rice in both zones as presented in the Table 4.3 and Figure 4.25. The better off in SC earned as much from rice as the poor in NW.

4.3.16 Income trend from wage (agricultural, non-agricultural labour, technical skills)

There was a large disparity in the importance of wage labour between well-being groups. Income from agricultural and non agricultural labour (including technical skill like machine operation, driving, repairing etc.) appeared as an important source of income, particularly in the dry and winter months, for the low well-being group in both zones.

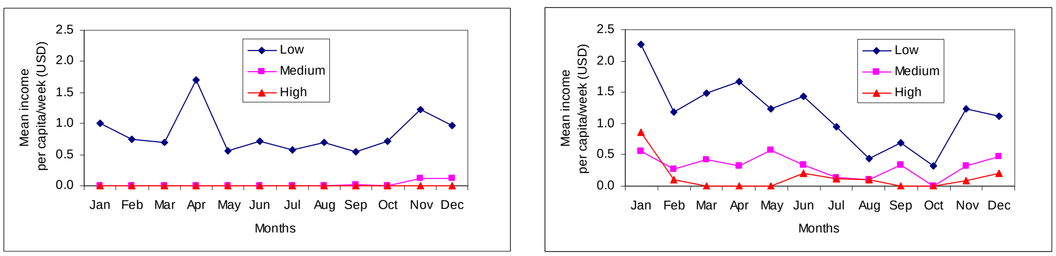


Figure 4.26: Income trend from agricultural, non-agricultural labour (mechanical skills) in the northwest (A) and south-central (B) zone by well-being.

Income from selling labour was higher and occurred over a more extended period of the year in the SC than NW zone. Wage labour was also a component of income in medium and better off households in the SC zone which was very minimal among the same groups in the NW (Figure 4.26).

4.3.17 Sources of household expenditure

Food, farming inputs/needs, livestock, health and social costs (e.g. travel, dowry, festivals and entertaining guests) were the major sources of expenditure in both zones. Food was the highest source of expenditure among all well-being groups in both zones. The proportion of expenditure on aquaculture was relatively higher in the NW than the SC. Over all, expenditure for farming needs (agriculture) was around 5 times and livestock was 2 times higher than aquaculture. Poorer people in the SC zone spend more on aquaculture compared to NW. The proportion of expenditure on education was higher in the SC than NW zone and higher among better off people. Expenditure on both health and social activities was much higher in the NW than SC (Table 4.5).

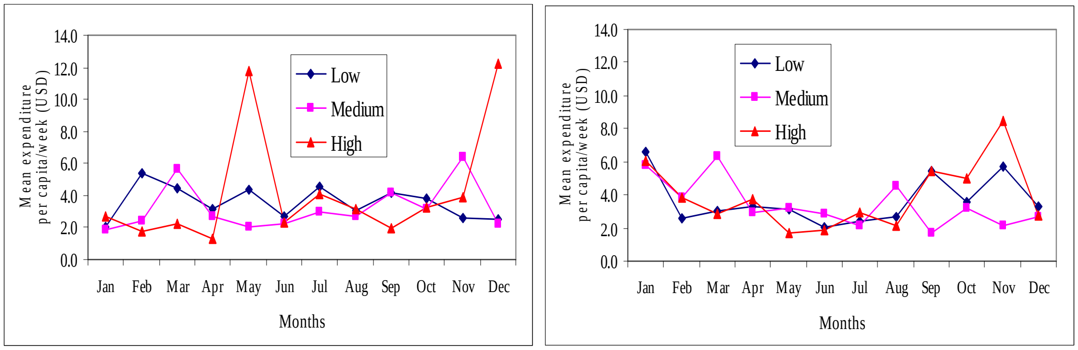
Table 4.5: Mean per capita expenditure (USD/week) by category for households of different well-being in northwest and south-central zone.

	Northwest			South-central		
Sources	Low	Medium	High	Low	Medium	High
Food	2.68 ± 3.46 (72.43)	2.15 ± 3.14 (67.33)	1.88 ± 3.16 (44.6)	3.07 ± 3.20 (84.53)	2.91 ± 3.65 (84.24)	2.97 ± 4.99 (76.16)
Farming need	0.08 ± 0.20 (2.16)	0.42 ± 0.62 (13.20)	0.33 ± 1.16 (11.7)	0.22 ± 0.56 (6.20)	0.27 ± 0.64 (7.79)	0.35 ± 0.98 (8.85)
Aquaculture	0.05 ± 0.28 (1.35)	0.02 ± 0.13 (0.64)	0.09 ± 0.33 (2.1)	0.08 ± 0.67 (2.09)	0.04 ± 0.32 (1.16)	0.01 ± 0.03 (0.15)
Livestock	0.19 ± 1.68 (5.14)	0.01 ± 0.06 (0.30)	0.28± 2.19 (6.6)	0.02 ± 0.12 (0.56)	0.11 ± 0.43 (3.26)	0.09 ± 0.38 (2.37)
Education	0.01 ± 0.04 (0.27)	0.01 ± 0.04 (0.21)	0.07 ± 0.35 (1.7)	0.15 ± 0.80 (4.01)	0.08 ± 0.24 (2.30)	0.32 ± 0.84 (8.29)
Social	0.10 ± 0.85 (2.70)	0.17 ± 0.67 (5.43)	0.24 ± 1.49 (5.8)	0.01 ± 0.12 (0.34)	0.02 ± 0.22 (0.79)	0.01 ± 0.08 (0.24)
Health	0.28 ± 1.12 (7.57)	0.34 ± 1.93 (10.69)	0.20 ± 0.81 (4.8)	0.06 ± 0.29 (1.57)	0.01 ± 0.13 (0.37)	0.12 ± 0.62 (3.04)
Others	0.17 ± 0.43 (4.59)	0.07 ± 0.27 (2.11)	0.96 ± 5.93 (22.7)	0.03 ± 0.17 (0.83)	0.0 ± 0.00 (0.00)	0.04 ± 0.2 (0.82)
Total	3.56 ± 4.08 (100)	3.20 ± 3.98 (100)	4.21± 10.83 (100)	3.63 ± 3.48 (100)	3.45 ± 3.71 (100)	3.89 ± 5.78 (100)

Note: Figure in parentheses is percent (%) by column, std. deviation (±) on the right end of each value

4.3.18 Total Expenditure

Mean total expenditure of the household was significantly affected by zone, well-being and month (p=0.04). Relatively more expenditure occurred in the months of February, March, May, June, November, December in the NW zone and January, February, March, April, May, October November, December in the SC with differences



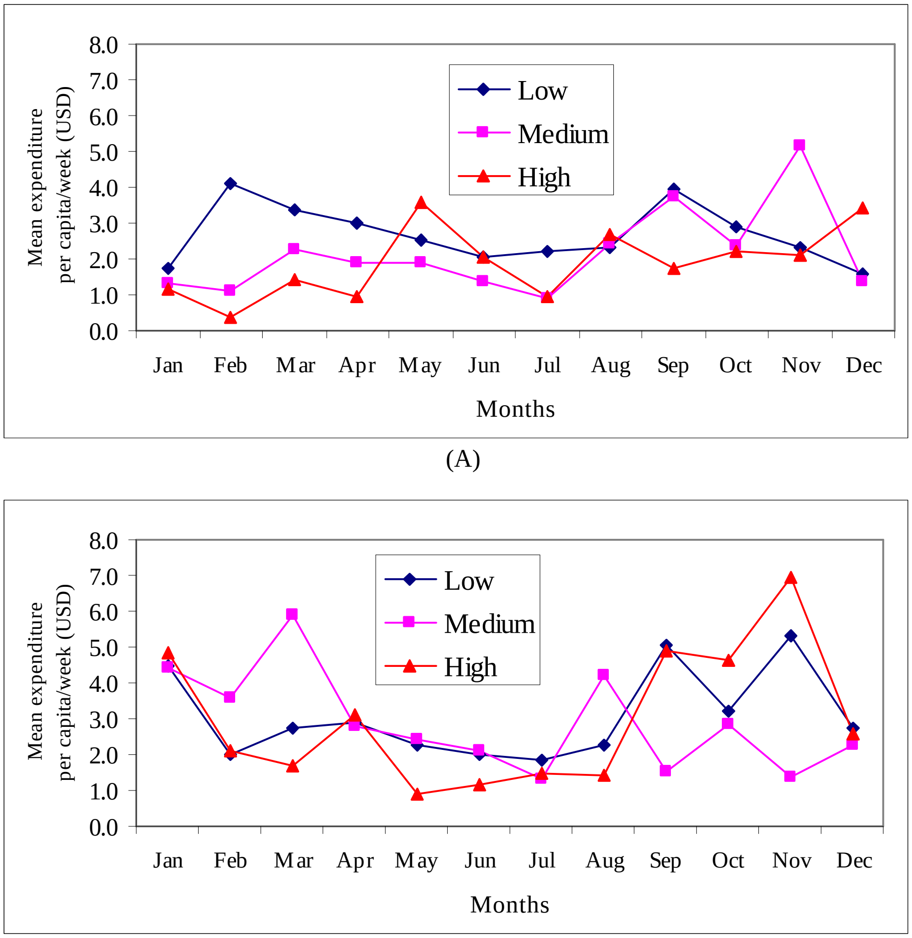
(A) (B)

Figure 4.27: Year round expenditure trend in the northwest (A) and south-central zone (B).

in well-being groups as presented in the Figure 4.27. The difference in the mean total expenditure among three well-being category was less in the SC whereas the gap between high and low well-being households was higher in the NW than SC (Table 4.5). In March, April, May, November and December expenditure was relatively high because of the purchase of farm inputs and during the time of rice harvest when households sold rice.

4.3.19 Food expenditure

Food expenditure – the highest type of expense for all well-being groups was significantly affected (P<0.05) by month (Figure 4.28). Food expenditure peaked between August – October and February – April ('hungry months' or food deficit months) when households are compelled to buy rice. In contrast SRS was found to be more available in this period and (Figure 4.10) cash expenditure on purchasing aquatic animals was low during this period. SRS availability was complementary to food expenditure during these crucial months.



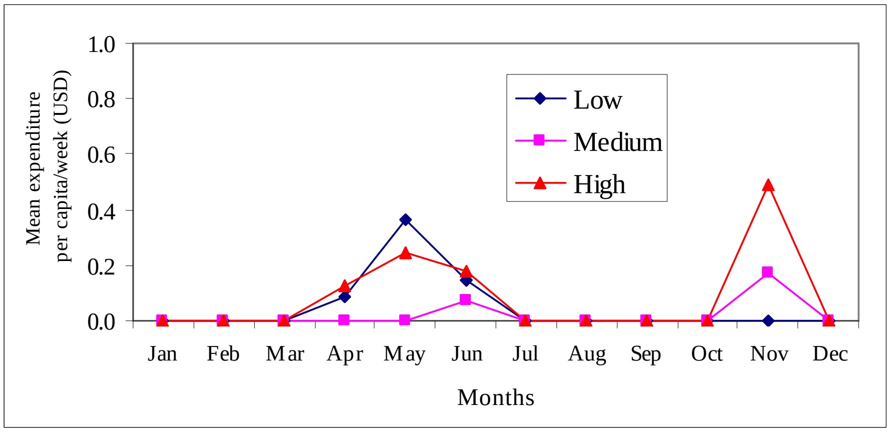
(A)

(B)

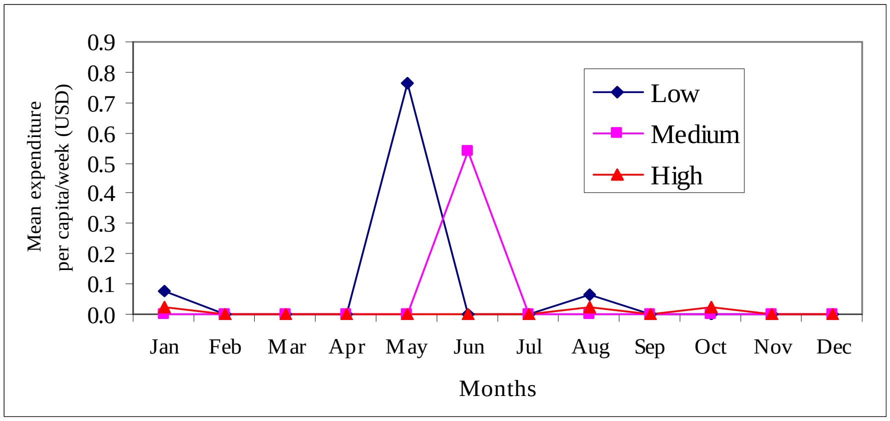
Figure 4.28: Food expenditure trend in the northwest (A) and the south-central (B) zone by well-being.

4.3.20 Aquaculture expenditure

Expenditure on aquaculture was marginally affected by the time of the year but not significantly affected by zone or well-being level. Higher expenditure occurred from April - July and November-December in both zones relating to stocking and harvesting periods respectively. This period of investment in aquaculture coincides with the time of rice harvests for *boro* (April-June) and *amon* (Nov-Dec) respectively and the seasonal availability of SRS started to (Figure 4.29) increase in July. High and medium well-being households in the NW also found to invest relatively more in the months of November.



(A)



(B)

Figure 4.29: Expenditure trend from aquaculture in the northwest (A) and south-central (B) zone by well-being (N=50).

4.3.21 Health expenditure

Health expenditure was significantly affected by zone ($P<0.05$). Mean per capita per week (USD) health expenditure and its percentage contribution to overall expenditure is presented in the Table 4.5 by zone and well-being group. An assessment of seasonal trends in health expenditure (Figure 4.30) shows that health expenses occurred most in the periods of February-March, June-July, November-December, mainly during periods of change in the main seasons (in very hot, cold and rainy months).

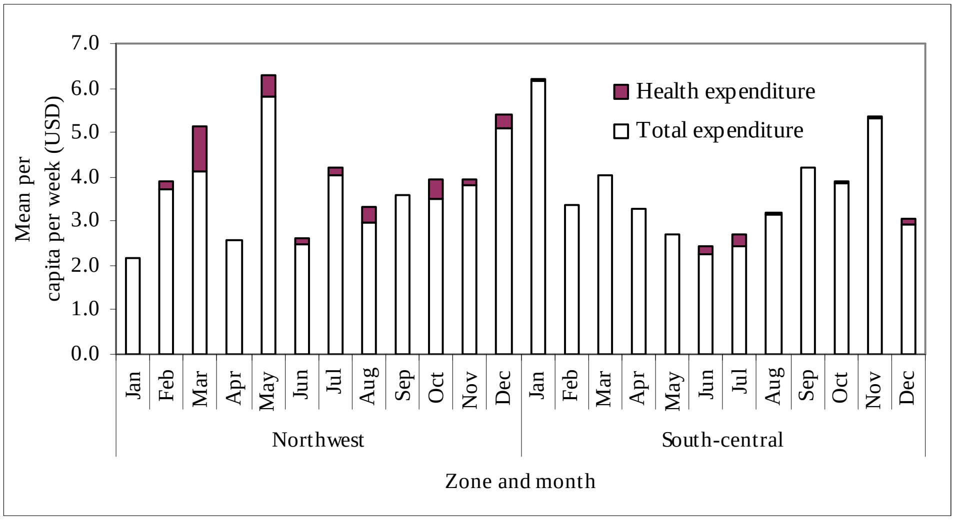


Figure 4.30: Total and health expenditure trend in the northwest and the south-central zone (N=50).

Mean annual health expenditure was higher in the NW zone than SC and was not affected by well being. Health expenditure coincided with the higher expenditure months of the households in the northwest zone which increase vulnerability of the poor.

4.3.22 Vulnerability

Vulnerability was examined in terms of exposure to shocks, trends, seasonality and risks at community and household level. This was linked with households assets and ability to cope with specific adverse situations of livelihoods in particular months of the year. Based on the timelines and seasonal calendars produced during the PCA, a qualitative assessment of vulnerability was obtained. Findings of the quantitative baseline and particularly monitoring household surveys linked vulnerability to poor access to land, water and credit and limited assets. Incidence of seasonal illness, seasonality of income from rice, wage and aquatic animals and duration of low income and food insecure months were important determinants of vulnerability. Both environmental and household level shocks (social cost, dowry) have been mentioned in two zones in PCA, baseline and household monitoring. Environmental shocks that included flood and drought were common in both zones. However, flood occurred over longer durations in the SC than in the NW zone and winters are longer and cooler in NW than SC possibly explaining the greater occurrence of disease symptoms among households during this period. There were several months when consumption of key foods decreased to very low levels. March- May and September-October were the most food insecure months in both zones. Flood was a constraint to growing vegetables and rice in the SC zone and affected consumption levels and created food insecurity.

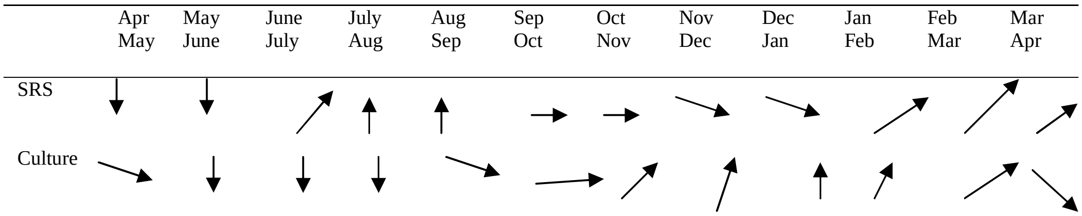
February, March, September, October, November, December were generally low fruit consumption months in both zones. Lack of food and poor nutrition possibly explain the poor health experienced in particular months in the northwest zone. Households in the SC zone experienced a longer fishing period than the NW households reducing consumption and income vulnerability occurring because of limited availability of aquatic animals. Limited opportunities for income generation from waged labour in the NW compared to SC was a risk for poorer households to support their livelihoods in low income months. Higher health and food expenditure among poorer households and less opportunity to sell their labour in the NW zone made them more vulnerable compared to SC. Higher dependency on informal sources of credit and higher social costs (dowry) in the NW zone also increased vulnerability among the poorer households. Seasonal scarcity of aquatic animals and poorer access to aquatic resources by the poor were the major factors contributing to vulnerability of rural livelihoods of both zones in the study area (Figure 4.7). Poor access to education at the post-primary level for the low well-being category (Chapter 3) and poor health conditions (Chapter 3; Chapter 4; Table 4.5 & Figure 4.30) were also found to be important factors increasing vulnerability. Health vulnerability was influenced by season and coincided with low income months in both zones and was more critical for the poorer households.

Table 4.6: Features of vulnerability in both zones

Northwest	South-central
Macro level shocks: Severe flood occurred in 1988, famine in 1974 severely threatened livelihoods. Fish disease in 1989-90 was severe threat to fish culture including wild stock. Incidence of severe drought once every after 10 years.	**Macro level shocks:** Severe flood in 1988, 2000 and famine in 1974 severely threatened livelihoods. Frequency and duration of flood was higher than the northwest. Massive use of pesticide starts in 80s, severe fish disease occurred in 1989-90 and negative impacts of dam, flood control barrage on fish availability observed in 90s.
Seasonality: (community, household level) **1. Flood, drought, cold** Both flood and drought are common but the duration of flood is relatively shorter (less severe) in the northwest zone as it located in the upstream of major rivers. Usually get rain from June – August. November to March around 5 months cold winter, sometime may longer till April. March April and May are the drought months.	**Seasonality: (community, household level)** **1. Flood, drought** Usually in Aug, Sep, Oct heavily affected by flood. Flood stays longer. March April and May are the drought months.
2. Food deficit months May, June and September , October, March, April food deficit months. Poorer affected more than richer households.	**2. Food deficit months** April, May, June and October are the food deficit months. Get less period to grow vegetable due to long duration of flood. Poorer affected more than richer.
3. Low income months Around 6-7 months. Very low in August, September, October.	**3. Low income months** Around 6-7 months. Poorer migrate more for work.
4. Bad health/disease Usually get sick in March, April, June, July, August, December, January,	**4. Bad health/disease** Usually get sick in March, April, June, July, November and December.
5. Low fishing months (SRS, wild) December to June (7 months). February-March very low. Scarcity of fish higher than the south-central.	**5. Low fishing months (SRS, wild)** February to June (around 5 months)
6. Job/labour scarcity months August, September, October	

Source: PCA and household monitoring

The seasonal importance of SRS was more critical in the northwest zone than south-central. Between April- August when stocked fish are less available in the NW, but availability of SRS improved from June with the beginning of monsoon (Figure 4.31)



Upward to downward direction of arrows reflects higher to lower availability; Source: PCA

Figure 4.31: Seasonal availability of SRS and cultured fish in northwest zone.

Small-scale open fisheries are prone to over exploitation and threatened by competition for water and pesticide abuse. Frequent drought, shortage of water, sandy soils and the long winters (in northwest) make aquatic systems vulnerable to overexploitation and decline, in turn increasing the vulnerability of people dependent on them.

Weather, ecological factors and social events

Seasonal weather characteristics including rain fall, temperature, sunlight, flood, drought and social events like festivals and some related activities and conditions like health, disease of fish, selling of labour, fishing presented in Table 4.7 & 4.32.

Table 4.7: Summary of a seasonal calendar on weather, social aspects in northwest zone based on several groups (number 1 to 10 was used as a scale, higher number reflects higher intensity of rainfall, sun light etc.)

Events	Apr May	May Jun	Jun Jul	Jul Aug	Aug Sep	Sep Oct	Oct Nov	Nov Dec	Dec Jan	Jan Feb	Feb Mar	Mar Apr
Rain fall	2	6	10	10	6	4	2					1
Temperat-ure	6	5	7	6	10	4	2				1	4
Sun light	9	6	4	3	5	7	5	3	2	1	10	9
Festival		*Puja*				*Puja*		*Eid*	*mela*		*Eid, mela*	
Disease/ health			Fever								Chicken pox	
Migration	6	7						5	6			
Fishing				5	7	2					3	3
Selling labour	4	6		5			6	5			6	5
Flood				6	5							
Drought	5	6									6	7

Puja= Hindu religious festival, Eid= Muslim religious festival, mela= village fair; Source: PCA

The harvest of SRS and aquatic animals were affected by season and related to consumption vulnerability. Overall consumption for aquatic animals which peaked in August-September and was lowest in February, March and April in the northwest Bangladesh. In the south-central consumption peaked in October-December, and was lowest in April-June. Months from May to July are the breeding months for most of SRS and natural seed availability was higher in June, July and August. Drought might affect survival of SRS during the dry season (Figure 4.32 & Table 4.7).

Factors	Apr May	May Jun	Jun Jul	Jul Aug	Aug Sep	Sep Oct	Oct Nov	Nov Dec	Dec Jan	Jan Feb	Feb Mar	Mar Apr
Weather (Temp., sunlight, rain)	Hot, sunny, stormy	Hot. sunny, cloudy thunder	Hot & Humid, rainy.	Hot., humidity high, rainy	Hot, humidit y high, rainy	Temperate low & foggy night	Temp. cold , foggy night	Cold winter start, shiny day	Shiny day, Cold, foggy night	Shiny day, cold, foggy night	Shiny day, Foggy night	Hot, sunny day, foggy night, dry weather
Festival	Puja, Mela	Puja	Puja	Puja	Puja	Puja & mela	Religious conventio n	Religious convention	Religious conventio n, cultural song festival	Religious convention, cultural song festival	Puja, Eid, marriage ceremony	Puja, Eid
Migration (Human)/ Labour sell	Home	Home	Home	Town	Town	Home	Town	Town	Town	Town	Town	Home
Health (human)	Not happy	Happy	Not happy, disease	Happy	Happy	Happy	Happy	Not Happy, disease	Moderate	Moderate	Happy	Not happy, disease
Flood drought	Drought			Flood							Drought	
Breeding Month (SRS)												
Disease (SRS)												
Fishing												

Eid=Muslims festival , Puja= Hindu festival, Mela= village fair

Figure 4.32: Summary of seasonal calendar containing information about weather, social aspect and SRS in South-central zone

4.4 Discussion

4.4.1 Vulnerability, seasonality of food consumption and livelihoods

Poorer households in the northwest (NW) zone were more vulnerable in low income and food insecure months as they had limited wage employment and a poor enabling environment for diversified livelihoods compared to the south-central (SC) zone. Both flood and drought prone areas were reported as the most disadvantaged and food insecure areas in Bangladesh (CARE, 2006). Food insecurity in the NW was also associated with seasonal shortages of rice and less availability of aquatic animals compared to the SC zone although NW zone was agro-ecologically favourable for quality rice and vegetables (longer flood free months) compared to SC zone. A recent livelihoods study in northwest Bangladesh pointed out that exposure to major shocks such drought and flood has the strongest negative influence on food security (CARE, 2006) which was also confirmed by the current study. The current study also showed that the hunger months were longer in the NW zone compared to the SC zone. This appears to be related to more limited diversification of crops and market smoothing and lack of opportunities to source alternative income during these months. The severity of hunger months could be less where alternative staples are promoted (Gillingham & Islam, 2006). The CARE livelihoods survey (2005) reported the first and the most severe hunger season occurred over the months of August, September and October and the second hunger season spans the months of February, March, April in the northwest Bangladesh which was similar to the current study findings. It is important to understand that a food supply system can be resilient when a crisis in one source of supply can be easily overcome by switching to other sources (Ellis, 2000).

Relatively poor access to formal credit in the NW zone resulted in a higher dependency on traditional money lenders and neighbours (Chapter 3) which might push them to indebtedness. Reduced consumption of meat, milk, fruit and pulses during vulnerable periods might be linked to household’s debt management strategy. Vulnerability has important social dimensions as well as those resulting from natural or economic risk factors. Social obligations such as dowry, bride wealth, weddings or funerals may result in an already precarious ability to cope with adverse events becoming even more so (Chambers, 1983).Social expenditure presented in Table 4.5

was higher in NW zone than SC. Likewise, insecurity of land tenure under rental or crop share tenancy, and insecurity of wage employment in agriculture, add to livelihoods risks and increase vulnerability (Ellis, 2000).

Lower savings and more debt were reported as indicators of poor well-being and vulnerability in the current study (Chapter 3). Higher dependency on informal sources of credit in the NW zone might increase the risk of poorer households who received loans from money lenders at high interest rates. Poorer households became more vulnerable when access to credit and formal health support services are poor in a given area (Gillingham & Islam, 2006). There is a tendency among poorer households to use the loan money for consumption purposes, such as buying food or healthcare, especially among poorer households (CARE, 2006). Households can encounter difficulties making repayments and become trapped in a ‘spiralling debt cycle’, with the risk greatest for the poorest (CARE, 2006).

The seasonal variation of food consumption, income and expenditure demonstrated the transitory food insecurity and dimension of the vulnerability particularly of poorer households. Environmental factors such as floods and drought resulted in seasonal food scarcity and low income in some months. Islam (2002) reported flash flood makes pond owners vulnerable to the loss of stocked fish. However, flood can also result in gains of SRS within FMASs that might counteract losses of stocked fish. Seasonal scarcity of aquatic animals and access to aquatic resources were important factors contributing to vulnerability of rural livelihoods of both zones in the study area**.** It is important to consider poverty and hunger status of the poor, seasonal fluctuation of food intake, area specific food status, disparity of consumption among poorer and better off people, traditional or culture specific nutritional behaviour, dependency on specific type of food by the poor, distributional characteristics related to social perceptions of food quality in food security analysis (Chen et al. 1981). Insufficient consumption of micro-nutrients (called ‘hidden hunger’) may endanger health, shorten life expectancy, retards the cognitive potential of children, and directly reduce productivity – also an important aspect of considering the type and quality of food consumed by the people.

The current study found that the rural diet was dominated by cereal and vegetables in terms of total weight consumed and quantity of foods such as meat, eggs, milk, pulses, aquatic animals were consumed in relatively small amount in the study area (Table 4.2, Figure 4.1 & 4.2) and appeared to be close or below to the minimum national requirement level. Levels of aquatic animal consumption were slightly better than meat and pulse consumption. Consumption disparities between cereal and vegetables among poorer and better off households in the two zones might be related to the low availability and purchasing power, as well as location specific production levels. The growing periods for vegetables and rice also appeared to be affected by the longer duration of flood in the south-central zone than in the northwest. Hossain et al. (2004) reported in a review of food security status in Bangladesh that considered the minimum intake required for balanced nutrition of meat, milk, fish, eggs and pulses were still close or below the minimum requirement level but that consumption of cereals, vegetables and fruit had improved relatively more. They highlighted that the normal diet of Bangladeshi people is seriously imbalanced with inadequate consumption of fat, oil, protein, and with more than 80 percent of calories derived from cereals. They also noted that the imbalance reflected a seasonal variation of availability, insufficient production of non-cereal foods, the low level of income, traditional food preferences, and traditional perceptions of food value and lack of nutritional education. The imbalance found in the current study also might be due to the above causes including high price of the food items. It might be also due to lack of policy to address the seasonal disparities in the distribution of consumption (transitory food insecurity). The current study showed the seasonal pattern of consumption which also reflects the cropping pattern, local availability of food in specific zone. Abdullah (1989) states that the availability of food at household level is primarily determined by the cropping pattern because most households are directly or indirectly dependent on agriculture for their food supply. However, the supply and availability of food was also related to market linkages. He also related food intake to lower requirements of food in some months (December) when farmers have less agricultural activities, or they might reduce consumption levels as a coping mechanism over certain periods . The current study found that food expenditure was relatively low in December but health expenditure may go up at the beginning of the winter season. It was difficult to explain this food expenditure in terms of lower food requirement as households were engaged with diversified livelihoods activities throughout the year apart from farming or agricultural activities. However, labour requirements were lower from August to October in both zones perhaps leading to lower food requirements. Particularly poorer households might reduce the consumption level of major foods as they have to buy rice in these months. Higher availability of AA play an important complementary role in this period to reduce household food budgets. On the other side, availability of food at national level depends not only on domestic production but also on imports and exports (Hossain et al. 2004). Current understanding from the food consumption trends revealed that availability of rice, eggs and fruits might be related to imports from neighbouring countries, especially India. However, increasing production per capita or availability of imports does not necessarily lead to a corresponding increase in consumption by the poor (Kent, 1997). The current study suggested that this was related to specific food types. For example, in case of AA production, greater availability of cheaper SRS increased consumption among the poorer households. Numerous factors combine to contribute to poor nutrition outcomes including gender-biases in household food distribution and human capital investment, micro-nutrient deficiencies, deficiencies in maternal education, inadequate clean drinking water and sanitation facilities, and weakness in the access and quality of maternal and child health services (Allen and Gillespie, 2001). The current study found that consumption of various food items was associated with seasonal availability, household income pattern and characteristics of agro-ecological zones. Brown *et al.* (1982) states that in countries without extensive food preservation and transportation systems, seasonal effects can be relatively strong.

Aquatic animals – the 3rd most important contributor by weight (after cereal and vegetable) and 2nd most valuable (after cereal) contributor by price (Figure 4.1 & 4.2) reflects a higher dependency on fish compared to meat, pulses and other animal protein sources and was found as an important item of the rural diet. This part of the study confirmed that aquatic animals accounts for 24% of the total household food budget and importantly SRS accounts for 52% of the total aquatic animal consumption. This important role of SRS occurred almost year round in the south-central and more than half of the year in the northwest with disparities between better off and poorer households. Although there were methodological differences, other household level fish consumption studies in Bangladesh revealed that small fish or wild small indigenous fishes accounted 43% – 84% of the total fish consumption

(Minkin et al., 1997; Roos et al. 2004). SRS offered income, food and social benefits and reduced vulnerability particularly among poorer households. This is particularly important for the quality of the poor people's diet and micronutrient deficiencies (Roos, 2001). Current evidence confirmed the important role of AA and particularly SRS in rural livelihoods.

The study confirmed that the availability of SRS was highest from July to December (monsoon and post monsoon months) and relatively lower in dry season from January to June (Figure 4.6, 4.7) especially in the NW. Although some lake (*beel*) associated FMAS like lake, ponds and some perennial ponds were harvested between January and April (Gregory and Kamp, 1999), over all SRS and AA consumption level was lower in the dry season. Culture based strategies can focus on supply during the lean SRS consumption period to combat seasonal disparities in the distribution of consumption. The study confirmed that consumption of SRS was strongly linked with the seasonal availability and varied by zone which often poorly reflected in the national statistics. Current findings also indicate that stocking of AA reduces seasonal vulnerability and SRS provides seasonal bonus. Other studies have shown that factors that determine the consumption level include the availability of food in the market or on the farm, the command over adequate resources to grow or purchase food, and the desire to acquire sufficient food (Pinstrup-Andersen, 1985). The current study also clearly identified (Figure 4.6) the complementarities of SRS and stocked species, particularly in the dry months. The importance of stocked species (perhaps the cheaper ones) particularly in the dry season was also found to be important along with SRS for the poor.

The mean number of species consumed by the households in the SC zone was higher compared to NW zone which was probably explained by the greater amount of perennial water and refuges in the SC zone. Therefore, creating dry season refuges could be an important strategy to maintain diversity and increase availability of AA. Consumption of SRS was strongly correlated with the diversity of species and harvest from FMAS was important for the consumption of AA of the poor. Therefore, a wide range of species diversity was also a factor for higher consumption of SRS compared to limited stocked species. This also suggests a higher quality of diets in which SRS are important. There are about 300 species of fish and 20 species of prawns in

Bangladesh (Rahaman, 1989) and many of them are raised in farmer managed systems and are important for consumption. The sensitivity of different species to the different types of agricultural systems is an important aspect related to the agricultural intensification and availability of food for the poor. Availability and abundance of SRS in other Southeast Asian countries are threatened by agricultural intensification, environmental degradation and destructive fishing practices (Soubry, 2001; Beaton, 2002; Gregory and Guttman, 2002; Morales et al. 2006). Maintaining biodiversity is essential to agricultural production and food security particually in developing countries where people depend on natural resources for their food and income.. Conflicts between intensification of farming and biodiversity can be solved only by sustainable farming practices (Thrupp, 2000). Biodiversity supports ecosystems and the way they function. This in turn supports the people that depend on them. Maintaining a rich biodiversity of species that are consumed as food by the people is an important indicator for securing ecosystem services and sustainable development in many developing countries of Asia. And in this regard, fisheries are unquestionably of paramount importance. In Vietnam (Mekong Basin), the intensification of rice farming, particularly the excessive use of pesticides has been found to undermine the value of wild stocks as food and income for poorer people. The principles of managing wild stock in capture fisheries need to be applied in aquaculture for sustainable aquaculture development so that aquaculture does not become a great threat to biodiversity and food security of the poor (Paul, 2003).

Mean consumption of aquatic animals and SRS was significantly affected by well-being, zone and month. This chapter further confirmed that poorer households significantly rely more on SRS compared to stocked and wild species although, the level of consumption significantly varied by zone. Among poorer households SRS consumption was nearly double in the SC zone than NW. This is because of seasonal availability, diversity of species, traditional preference and access to FMAS and open systems including supply of AA in the market and social nature of such assets (received as gift from neighbours).This also suggest the importance of this type of study has regional differences, and potentially development strategies are likely to be very diverse.

Mean SRS consumption was double in the south-central than in the northwest zone among low income non-producers such as rickshaw pullers, van pullers, pottery hawkers, day labourers and poor fishers. Consumption of SRS was higher than stocked and wild species which reflect the importance of SRS also among this group. This also reflects a relative scarcity of SRS in the NW compared to the SC zone. The major species consumed were relatively few i.e. *Puntius sophore, Channa punctatus*, *Esomus danricus*, *Lepodocephalus guntea*, *Macrobrachium sp*.(small prawn), *Hypopthalmichthys molitrix, Barbus gonionotus* and small size cheaper *Cirrhinus mrigala, Catla catla and Labeo rohita.* Generally these households did not stock aquaculture ponds (mostly no pond), however some of them had small rice field linked ponds (trap ponds/non-stocked) indicating the importance of markets and other farmer managed systems as a source of SRS for this type of poor. Particularly non-agricultural day labourers (except fishers) may not get enough time during working hours for catching free SRS from some FMAS, however, they sometimes set traps at night to catch fish in FMAS in their own or neighbour's rice fields. The availability and access to food by vulnerable groups, including food deficit farmers in rural areas, small and marginal farmers, and poor urban households are more critical as they may be chronically, seasonally or periodically unable to afford adequate diets (Chatterjee et al. 2004). From the income analysis, it was found that aquatic animals contributed an average of 12% to the household income which was significantly affected by zone. This income was particularly important in low income months for the poor. Therefore, AA is especially important for the poor for its seasonal availability, time convenience, and access and income pattern. The poor are often regarded as being particularly dependent on natural resources (FMSP-3, 2006). Aquatic animals appeared to be a more accessible food item for the poor than meat and pulses due to the seasonal pattern of their availability and diverse sources. Similar conclusions have also been drawn from other studies in Southeast Asia which revealed that non-stocked aquatic animals play a very important role in food consumption of rural households when access to other food such as rice, vegetable, fruit are limited. It is also reported by the Fisheries Management Science Programme (2006) that fish are especially important for the poor as they are often one of the cheapest and most accessible sources of protein available. Fisheries provide food for consumption, employment, and financial income, and a food source when other sources such as agriculture are at seasonal low (Little et al. 2004; FMSP-3, 2006).

During the PCA focused group discussion (Chapter 3) it was recorded that the price of SRS were cheaper by a factor of 2-3 times in the highly available months than the scarce months, poorer households might utilize the seasonal advantage of the availability and price of SRS while buying from the market. PCA facilitators recorded poorer households consumed mainly low value SRS – *Puntius sophore*, *Channa punctatus*, *Esomus danricus*, *Lepodocephalus guntea*, *Macrobrachium sp*.(small prawn) and cheaper stocked species such as *Hypopthalmichthys molitrix*. However, changes in the price of SRS will have more impact on the poor. Although the inflation-adjusted cereal prices in Bangladesh have fallen by 40 percent over the past 25 years, the real price of lentils, vegetables, and animal products have increased by 25-50 percent. Real fish prices have doubled. Small fish prices are seasonally high in between February to August. Dietary quality for the poor may be in decline due to these price effects (Bouis, 2004).

The current study confirmed the disparity of consumption of AA by well-being, found that over all better-off households consumed nearly two times more AA than poorer (Figure 4.3). Poorer households including small and marginal farmers may be seasonally and periodically unable to afford adequate diets (Chatterjee et al. 2004). However, disparities in consumption are also related to access to farmer managed aquatic systems (Chapter 3). Disparity may increase if the availability of aquatic animals are threatened by agricultural intensification and environmental degradation (Gregory and Guttman, 2002; Morales et al. 2006). Market interventions such as aquatic animal distribution networks and location specific pro- SRS aquaculture practices of both low value and high value SRS and increasing the supply of cheaper stocked species in the lean consumption period of SRS (particularly in dry season) might have significance to reduce disparity of consumption in future.

Other related work in Bangladesh also highlighted the importance of SRS. Roos (2001) using five-day recall methods in a fish consumption survey (8 months) categorising the seasons into three parts as pre-harvest, harvest and post-harvest periods in Kishorgonj in 1997-98 found small indigenous fish consumption was higher in October than July and large fish consumption was also higher in October than in July. Average fish intake in all households (84 poor households) was

21kg/person/year which was close to the current study findings. Wild small indigenous fishes were found to contribute 84% (Wild, SRS or both was not clear) of the total fish consumption which was higher than current findings (52%) reflecting area specific variations. However, it can be noted that Kishorgonj is a fish dominant area compared to other parts of Bangladesh and the methodology was not fully comparable to the current study. In a study in Saturia, Jessore and Mymensingh area (1996-97), it was found that vegetable consumption varied little with income. In contrast, animal and fish consumption roughly doubled between low and high income households (Bouis, 2004). Consumption of animal and fish based dietary components accounts for 20-25 percent of food budget on average (Bouis, 2004) in Bangladesh. In the current study it was 24% of the food budget which reflects the increase in price of meat and fish. Poor dietary quality -a low intake of vegetable, fruits, pulses, animal and fish products is a primary cause of micronutrient malnutrition (Bouis, 2004). Small fish is an important dietary source of vitamin A and calcium in poor households in rural Bangladesh (Roos et al. 2003) and the replacement of small fish with cultured carp species may have a negative impact on the nutritional quality of the diet in these households (Gillespie and Haddad, 2003). Data from 1999-2001 published by the Bangladesh Nutritional Surveillance Project (NSP) showed that the diversity of non-rice food intake in rural Bangladesh was low. NSP revealed a seasonal variation of consumption of fish, vegetables and fruit. Consumption peaked in December for fish and green leafy vegetables and in June for yellow or orange fruits (Torlesse et al. 2004) which supports the current study findings. A survey of 761 households in the southwest part of Bangladesh found that cereals constituted a major portion (60%) of the diet, followed by vegetables. The study also indicated that consumption of fish, pulses, meat, milk, eggs and fruits were low compared to their national requirement level (Halim, 2002).

Seasonal availability of other foods such as cereals, fruit, vegetables, milk and pulses needed to be understood while defining the roles of SRS in the context of the overall diet. The current study found that mean consumption of fruit, pulses and SRS started to increase in June- July when green vegetable consumption decreased over the same period. Consumption of milk and eggs was also relatively higher in the winter months when SRS consumption was lower particularly in the NW zone. Milk production is usually related to the availability of grass/fodder and rice harvesting seasons in rural areas. Fodder cultivation is constrained by flood in the low lying flood prone areas, and scavenging egg production also increased during rice harvest time in winter in rural areas. The availability of dropped grain is an important feed source in rural areas. Vegetable growing might have been affected by flood duration in the SC zone. Bouis (2004) reported that vegetables do not grow well during heavy rain and hot temperatures and cannot be grown on land that is subject to flooding, or the risks of doing so is too high. Additionally many types of vegetable can not be stored.

Rice (cereal) consumption varied by zone but contributed around 25% of the household income in the current study. Although there are peak and lean rice production periods mean rice consumption, as a staple food, varied little by well-being group and month. The principal rice crop (*amon)* was harvested in November – mid January and *boro* rice harvested between mid-March to May. The availability of rice peaks after the *amon* harvest and reaches its lowest level in late September to November (Abdullah, 1989). Households cut other costs and maintained an almost similar rice consumption level year round. This reflects the general increase in cereal production and intensification of the production system in recent years. However, to maintain rice consumption for daily living, households have to reduce other costs. The gap between better off and poorer households might also be reduced due to market support. Abdullah (1989) found that the availability of rice is seasonal and energy intake is affected by season which reflected the shortage of cereal production at the time of the study and indicates that the situation of the hunger months might have improved. The rural diet was found to be highly dominated by rice. But a diet containing adequate energy may lack sufficient micro-nutrients and total energy intake is not necessarily a good indicator of dietary quality (Torlesse et al. 2004). Although rice production increased in Bangladesh seasonal smoothing of distribution and managing price would be important to reduce disparity in consumption. Poorer households may also have been forced to sell rice to buy other essential household goods or medical cost even at a cheaper price immediately after the harvest.

4.4.2 Sources, income and expenditure

Although total water area decreased (e.g. in rice fields) in the dry season, FMASs play important role year round as a secure source of aquatic animals. Access to FMAS and open systems varied by season which has impacts on household consumption of fish particularly for the poor. For example, when fish from rice field fisheries, rivers and lakes become limited during the dry season, dependence of households on ponds for fish consumption increased. When food expenditure (particularly for rice) goes up in the months of September-November households rely more on SRS from FMAS such as ditches and ponds. Poorer households in particular also try to sell labour during that period as a response to lack of food security. Households were also found to respond to shocks through borrowing money from money lenders, selling land, selling tree products and farm products such as fish. Therefore, income from non-farm sources (wage employment) become most important during food insecure and low income months in both zones. This also complements food expenditure of poorer households. Higher health expenditure in the NW also indicates the risks of getting sick or injured while selling wage labour during low income months.

Food is a commodity, which can either be grown or purchased from the market (Bowles et al. 2006) or, in the case of aquatic animals harvested from managed or open water sources. The current study identified four sources of aquatic animals as – farmer managed aquatic systems (FMAS), open systems (ie river, lake etc.), market and given by others (free access) which are important to increase availability and consumption of the households. Many aquatic animals particularly SRS were found to be collected or harvested from other people’s ponds, managed lands and rice fields or freely given by relatives and neighbours. Aquatic animals (AA) are also part of people’s social network. AA consumed from the market and received as gifts were also sourced from both FMAS and open systems. Gifted (21%) fish is an important aspect of the food security of the poor. Gifts included those fish that are accessed freely from neighbours’ and relatives’ FMAS. Aquatic animals gifted and accessed free are particularly important for the poor lacking ownership of land and water. Availability of fish was related to gifts from neighbours and relatives and a form of social capital. Livesey (2000) also reported that nearly 20% of the harvested SRS are given away (gift) which is slightly more than the proportion of stocked species, to friends and neighbours by the pond and other aquatic resource owners. He also found cheaper SRS such as *Puntius sp.* and *Mystus sp.* dominated the rural markets, yet SRS as a whole dominated district markets in the northwest Bangladesh particularly in the monsoon and post monsoon period. Understanding the characteristics of FMAS indicate an informal access/entitlement to land and aquatic systems by the poor. This is an interesting social arrangement as access to land, water and financial capital (credit for inputs) are major constraints for the poor (Muir, 2003). Catching free SRS from a share cropped, owned or neighbour's paddy field is a common traditional practice has special importance to the poor- a different type of entitlement of FMAS. However, informal opportunities of such food supply may diminish as cultures become more intensified and more species go to market (Muir, 2003).

Lovett et al. (2006) reported that poor people tended to rely more heavily on access to privately owned ponds for fish resources in the dry season than in the wet season in fish dependent developing countries. From the understanding gained of the seasonal nature of both FMAS and open systems in the current study, it was clearly evident that both systems played an important role throughout the year for the supply of AA. FMAS such as rice fields may dry up at some part of the year when open systems (e.g. rivers, lake) still retain water for aquatic animals-this should result in them being complementary rather than competitive. When consumption of AA from FMASs was low (in the dry months) overall consumption of AA was low which reflects also the scarcity of AA from open sources in the dry season.

ADB (2005) reported that direct beneficiaries of aquaculture development have largely been pond owners (0.5 -1.0 ha) and medium scale landholders (1-2 ha) in Bangladesh which corresponds to the land holdings of the low and medium well-being groups in the current study. The report highlighted access to land and water being the key requisite for fish farming for the poor. The current study found annual fish consumption of all households (poorer and better off) was 25.6 kg/person reflecting area specific disparities by well-being which is closer to Roos's findings in Kishorgonj (21Kg/person/year) only with poorer households. Several studies have methodological differences that make direct comparisons problematic. Total annual AA consumption in SC was 1.5 times higher than NW. This was related to the greater availability of water both in FMAS and open systems as SC zone is geographically a low-lying area.

Muir (2003) has highlighted that the consumption of aquatic animal for poorer people is critical amongst both rural and urban populations. The poorest members of the communities depend on access to floodplains, *beels* (lake), road side borrow pits etc. during food insecure months. Changing land access and ownership and unplanned aquaculture, is reducing access of the poor to such resources (Haque, 2007). Therefore, understanding different types of FMAS and open system and their seasonal feature is important to design aquaculture and fisheries management in a complementary manner to increase and sustain aquatic animal supply.

Selling of rice and other farm products, livestock, aquatic animals, business/petty trade, agricultural and non-agricultural labour (skilled wage) were found as the major sources of household income in the study area with a location specific combination of both farm and non-farm sources. Income from off farm sources might complement household expenditure on food particularly for the poor. In a case study in Kishorgonj, northeast Bangladesh rice farming, fish farming, micro-enterprise wage labour and fishing was reported as important primary occupations of rural households. Rice farming and fish farming were mentioned as two important secondary occupations (ADB, 2005). The current study confirmed that aquatic animals contributed around 12% to household income which was significantly higher in the SC zone, suggesting that the potential of income will vary by zone and it may contribute around from 4% - 25% to the poorer households income in some areas.

Livesey (2000) in a study in the northwest Bangladesh stressed that SRS constituted an important source of income for pond owners, especially as ‘free’ input to pond, so being an economic advantage (when sold at market), especially for the poorer section of the aquacultural population. He highlighted that SRS appear to have a higher profile compared to stocked species as indicated by a high proportion of fish sold, at the district market. In contrast in that study stocked species contributed over 70% of the proportion of fish sold in rural markets. River species or wild stocks in general had minimal presence in local rural markets (*bazaars/hats)* and road side markets, but were more evident in the district markets where they sold for a higher price.

Food, farming inputs/needs, livestock, health and social cost (e.g. travel, dowry, festival, entertaining guest) were the major sources of expenditure in both zones. Food was the highest single source of expenditure among all well-being groups in both zones. In an ADB case study in Kishorgonj, Bangladesh the other areas of households expenditure reported were – food, children's education, health, housing, clothing, land purchase/rental, festivals/social obligations, and purchase of livestock. The study identified June – August and November - January as the periods of greatest food deficit, coinciding with crop-growing periods as well as social and religious events when households had major expenses (ADB, 2005).

The current study found that health expenditure increased at the onset of the rainy season (June, July August) and winter months (December, January) mainly before and after food insecure hunger months particularly among low and medium well-being categories in both zones. This might relate to food scarcity or lack of quality foods or change in weather. The higher health expenditure in the NW might be because of a longer winter and seasonal scarcity of food. It might be also related to free Government and NGO free health services which complement the household health budget. Illness of household members and shortage of food have been mentioned as a major crisis of the households in other studies (ADB, 2005). Relatively higher income flows from SRS and stocked fish in November, December and January might support the households for their health expenditure.

4.4.3 Influence of income and expenditure on responses to seasonal pattern and shocks

Reduced income poverty levels have given a large boost to reducing hunger in Asia (Chatterjee et al. 2004). Household income from rice, other farm products, aquatic animals and petty trade/business significantly contributed to the increase in total household income (positive significant correlation, rice, r=0.76; farm produces, r=0.59; business/trade, r=0.32; AA, r=0.37). Different levels of household income mainly derived from rice selling, wage labour, business, other farm produce, aquatic animals and its seasonal dimension affected rural well-being in the study area. Similarly household expenditure for purchasing food, farming inputs/needs and other important costs such as health and social expenditure affected the well-being of studied population. A greater proportion of cereal and vegetables were usually grown by the households whereas meat and fruit were usually purchased. Aquatic animals were both produced and purchased by the households.

Income of the poorer households in SC zone was higher than in the NW which was related to diversity of income sources such as wage selling, fishing, fish culture etc. Higher expenditure on health and food and low income from wage labour and aquatic animals made the poorer households more vulnerable in the NW. However, households were found to respond to seasonality related shocks by seeking off-farm labouring opportunities such as van, rickshaw pulling, boating etc. Types of coping strategies reported in other similar studies are – forced sale of livestock, advanced wages for labour, migration for work, mortgaging land, selling of land or borrowing money from money lenders (Gillingham & Islam, 2005). Advanced wages for labour, selling and borrowing money from relatives, land mortgage and leasing out have been reported in the current study (Chapter 3).

Consumption of stocked fish led to higher household food expenditure than SRS. Households relied more on SRS than stocked fish when food expenditure increased particularly during October-November. This might be due to the availability of cheaper SRS in the FMAS. However, it was found that with any increase in income, both stocked and SRS consumption is likely to increase.

SRS was particularly important in the late monsoon, low income, vegetable- scarce months. Egg and milk consumption appeared to be more important to rural diets in SRS scarce months (winter seasons). Increased availability of milk, eggs, fruit, and vegetables in SRS-scarce months might be important to define area specific food strategies to combat malnutrition for the poor.

Food expenses were the highest expenditure source among low income households and varied over the season. Food based strategies therefore need to consider SRS management if they are to have influence on the availability or distribution of food within households. It was clear that SRS reduced cash expenses for food during low income months. However, household adjustment of food budgets might be affected by many other factors such as illness, festivals, entertainment, children’s preference, price, social value of foods etc. Little is known about the manner in which food preferences vary with food expenditure and nutrient intake. In designing and targeting food programmes, desegregation by class is essential because the poor respond differently to changes in price and total expenditure (Pitt, 1982).

The availability of SRS was particularly important during low income months (Aug, Sep, Oct) both for earning cash from AA and reducing the amount used to buy other foods. SRS availability from August – October was complementary to household food expenditure. Consumption of SRS was relatively less affected by household income compared to consumption of stocked fish. Households in both zones were found to consume less rice and AA in the dry months - March, April, May when SRS consumption was also low particularly in the NW zone (Figure 5.10, 5.16). If household income increases consumption of almost all food items was found to increase. The current study revealed that income from rice, wage labour particularly in the dry season (January to April) might help the poorer households to buy aquatic animals and other foods at this time. There is a great shortfall of AA and SRS between January to June when the price of SRS is usually 2-3 times higher than during the monsoon period. This would be a potential period of developing SRS based aquaculture or market interventions to increase supply of AA and others foods. Poorer households need access to cheaper AA in those months. The demand and supply inconsistencies also have to be tackled.

Mean rice consumption varied by zone and month relating to the production cycle and availability in the market. Therefore increases in the price of rice will have impacts on the consumption of other food items as poorer households secure their staple food first. In Bangladesh, the 3 rice-harvest seasons are the *amon* (November–December), the *aus* (March–April), and the *boro* (May–June). The *amon* harvest is traditionally the most important, but the *boro* harvest has gained in importance over the past decade because of the introduction of high-yielding rice varieties and modern technology (Tetens et al. 2003). This harvest period is important in relation to income from rice and its relationship with other items and even for poorer people employed at harvest. Haque (2005) observed introduction of stocked based aquaculture in *boro* rice fields increased opportunity of SRS harvest from such systems in pre-monsoon period.

When rice prices fall, functionally landless households are able to spend more on non-rice foods. As the price of rice and household expenditures on rice fall, functionally landless households were found to spend more on non-rice foods (Torlesse et al. 2003). Rice accounts for 40% of the total spending by rural households in Bangladesh and considered as a powerful determinant of real income, consumption and nutrition of the poor (Torlesse et al. 2004).

Finally to address the seasonal shortfall of AA particularly SRS and other important food items it is very essential to consider the complex seasonal pattern of consumption, interactions with income, expenses of households of different well-being groups and by different regions. However, direct working experience with farmers using participatory approaches would better justify the complex features of production of SRS and stocked species, consumption and sale from FMAS. Further validation of these findings by direct farmer participatory trials was sought, the results of which are presented in the next chapter.

Chapter 5

An on-farm trial to assess the impacts of promoting SRS within a stocked carp polyculture in Bangladesh

5.1 Introduction

Chapter 4 quantified the current role of aquatic animals particularly SRS in terms of consumption, income, social benefits and the seasonal dynamics of these aspects. However securing the benefits of SRS within FMAS also containing other stocked species is little understood. Any promotion of SRS within conventional polyculture has yet to be strongly prioritized in Bangladesh. The previous sections (Chapter 3 & 4) confirmed that SRS are relatively more important for the poor particularly, for meeting consumption needs compared to stocked species. However, pond polyculture is the main aquaculture production system in Asia, especially in Bangladesh and India (FAO, 1997; Reddy et al. 2002). Promotion of conventional aquaculture in Bangladesh has not only ignored the value of SRS, but extension agencies have even promoted use of piscicides for complete removal of such species from the systems. Despite this farmers often ignore such advice and actively encourage SRS within their aquatic systems (Livesey, 2000). The conventional attitudes to SRS might reflect concerns that they have negative impacts on stocked fish. Certainly there is a lack of available protocols to manage such systems in which SRS are integrated within conventional polycultures. The present study was therefore devoted to understand the impacts of integrating SRS within carp polycultures as managed by farmers.

The culture of a combination of carps together (polyculture) was founded in AD 618 at the beginning of Tang Dynasty in China and is a milestone in Chinese aquaculture (Ling, 1977; Li, 1994). Polyculture in aquaculture is the association of fish species of different complementary food and feeding habits to more effectively utilise the available variety of foods present in a pond or aquatic system (Milstein, 2005; Azim et al. 2002). Polyculture has been promoted as a means of increasing yields from semi-intensively managed systems with an appreciation of ecology and the synergies of growing together species with complementary feeding and living habits (Beveridge & Little, 2002). This culture system ensures more complete use of the food and space available in the system than monoculture as in many cases one species enhance food availability for other species (Hepher et al. 1989; Rahaman, 2006). Polycultures can include predatory fish species such as walking catfish (*Clarius batrachus.*), snakehead (e.g.*Channa striata*) and sea bass (*Lates* sp.) stocked in polycultures to control recruitment of species that overpopulate the system and then compete for food and space with other stocked fish. Stocking some SRS may reduce direct feeding competition between smaller, less valuable SRS and stocked carps (Little et al. 1991, Das et al. 1999, De, 1991, Bocek, undated). Also the management of stocked species, particularly the stage and size of stocking the seed are likely to affect success. Use of 'large' carp seed is known to limit losses due to predation (Little et al. 1991). Polyculture is also considered as the preferred system for low-value species, though in some countries (e.g. Philippines or Indonesia) monoculture of either tilapia or carp may also be pro-poor (Briones et al. 2004). Availability of suitable and complementary seed of wild species was critical to the original development of polycultures in China and the same was true for Indian carp polyculture (Chevey & Lemasson, 1937). These polycultures became mainstream and spread outside of limited geographic areas after hatchery technique were developed and promoted but in the Indian sub-continent riverine carps were to some extent initially developed as self-recruiting species. Seasonal ponds or '*bunds*' that fill quickly at the time of first rains, were used to stimulate spawning of Indian major carps in West Bengal over a hundred years ago (Sharma & Rana, 1986). However, polyculture researchers in Bangladesh have largely ignored the potential of non-stocked species found in the system.

The need for both biological and social information about the potential for hatchery seed and non-stocked SRS suggested that any trial needed to be conducted on-farm using a participatory approach. The impact of management on SRS-carp polycultures given the different perceptions was the focus of this trial

A major incentive for research in integration of SRS into conventional pond aquaculture is that these small species may contribute more critically limiting elements to the diet particularly various micronutrients. Kohinoor (2000) made a thorough evaluation of the biology and potential of three small fish species mola (*Amblypharyngodon mola*), chela (*Chella sp.*) and punti (*Puntius sp*) in culture and recommended the inclusion of mola (*Amblypharyngodon mola*) in carp poly culture. These species are important because they are relatively cheaper to purchase and a good potential source of vitamin A if included regularly in the diet. This approach, however, relied on development of breeding protocols for these species and thus suffered the constraints of a hatchery-led approach.

Previous sections of the current study showed that SRS is relatively more important than stocked and wild species in the rural diet. FMAS such as ponds, and rice field linked ponds are important sources both for stocked and non-stocked species (Chapter 3). Chapter 3 also explains that farmers were likely to encourage SRS into their aquatic system by cutting or raising dikes, using bamboo fences, pipes, screens at the outlet, linking ponds with rice fields and small canals, or by making tiny channels to attract SRS into the ponds. They also used pipes with valves to stop SRS escaping from ponds or rice fields. A pre-trial discussion with farmers explored farmers interest in SRS positive management practices such as keeping some SRS brood fish, restocking collected juveniles and cutting dikes to selectively encourage SRS to enter farmer managed systems. The current study so far found that 'fish culture' and 'polyculture' as practiced by farmers are heterogeneous and open to non-stocked aquatic animals and yet these have not conventionally became the focus of research into polyculture. Conventional aquaculture is highly biased to stocking of only carp seed and removing all SRS from culture environments. Semi-intensive aquaculture as promoted by most development agencies appears to have missed the poor farmers' reality of managing diverse aquatic animals for their food, income and tradition. Predation of small fish (such as tilapia) by snakehead *(C. striata*), partial harvest of fish to control breeding, stocking of small number of predators to control reproduction of some fish, use of overwintered fish seed have been reported in polyculture by several studies (Edwards et al. 1994; Little et al. 1991; Little et al. 2002; Kaewpaitoon, 1992 & Lovshin et al 2000). With a lack of understanding about stocked and non-stocked species, the conventional wisdom is that SRS are weeds in culture systems and need to be removed (Livesey, 2000). But this may not be the farmers' reality and there has been a lack of appropriate research to investigate such realities.

The impact of management on SRS-carp polycultures given the different perceptions was the focus of this trial. Controlled on-station trials have limitations to capture such realities of farmers and a participatory research process was more likely to yield useful knowledge where researcher could engage in a process with farmers, they could both learn and the more complex outcomes in terms of likelihoods were more likely to be apparent. . There are many approaches to conduct on-farm, participatory trials (Biggs, 1989) Farmers' trials or on-farm trials do not usually take place under very controlled conditions but rather in the context of a wider farming system. There are many uncontrolled conditions and different horizons of comparison can be applied; farmers are also likely to take into account a range of variables like researchers (Leeuwis, 2004). In such a context possible approaches for an on-farm trial were 1) fully prescriptive situation where the decisions of the researcher on management are carried out 2) all decision are made by the farmer 3) the research process encompasses aspects of both 1 & 2 , and seeks to accommadate the needs of both. The current farmer participatory trial was collaborative in nature and followed the option 3 where farmers and researchers made joint decisions and shared agreed actions. Campbell and Salagrama (2000) describes a more developed view of participatory research where the community has some control of the research. In the current trial, sampled households in each community were facilitated to make analysis of their own situation, problems, needs and resources.

The current field trial area in the northwest region of Bangladesh is characterized by drought, sandy soil and long winters (Morrice, 1998), which make pond polyculture systems vulnerable for managing fish and in turn, increase the vulnerability of the households involved. Farmers in the northwest zone, where large open water bodies are relatively uncommon, usually rely more on farmer managed small-scale systems. .In some systems commercial carp culture is not profitable due to a scarcity of water, poor quality seed and prolonged winter. Unfder such conditions the farmers' desire to maintain naturally spawned and recuited aquatic animals along with hatchery-derived carps might have special significance. To over come such constraints farmers were recommended to use fast growing species in their polyculture although in reality access to quality seed is limited. Some farmer were found to encourage SRS in ponds with stocked species. In Bangladesh, some extensive work was done on pond aquaculture of some indigenous species and they listed about 30 species suitable for small-scale aquaculture based on scarcity, low food conversion ratio and high financial return (IFADEP, 1996). Thilsted (1997) observed that larger fish (typically carps) promoted as the core species in aquaculture do not contribute to calcium intake. Large cultured species are typically not eaten whole and are often harvested as cash crops, thus having less impact on the nutritional status of poor. Roos et al. (1999) demonstrated the feasibility of managing the small indigenous fish mola (*Amblypharyngodon mola*) in conventional poly culture to combat malnutrition associated with vitamin A deficiency in rural areas of Bangladesh. Similar work conducted in the rural ponds of Mymensingh villages (Roy et al. 2001) aiming to look at the interaction with stocked carps also recommended mola in polyculture. Alim et al. (2004) in a polyculture trial with major carps and small indigenous species in Bangladesh used large carp at 10000 ha^{-1} along with small species punti (*Puntius sophore*) and mola (*Amblypharyngodon mola*) at 30,000 ha^{-1} (total 40,000 ha^{-1}). All this work indicated the potential of small indigenous species in polycultures although the stocking protocol was not widely known or practiced by farmers.

It is important to mention the patterns of polyculture in northwest Bangladesh to understand the context of SRS. Morrice (1998) reported stocking density (14820 ha^{-1}) in a silver barb (*Barbus gonionotus*) based polyculture in the northwest region of Bangladesh. He used a fingerling stocking density of silver carp (*Hypophthalmichthys moilitrix*) 3,952 ha^{-1}, silver barb 7,410 ha^{-1}, Common carp (*Cyprinus carpio*)1482 ha^{-1}, Catla (*Catla catla*) 988 ha^{-1}, Rui (*Labeo rohita*) 988 ha^{-1}. A bulk of the increase in number was taken by up by silver barb which was recommended to harvest by October or November. He also noted the necessity of partial harvest to maintain individual growth at such high stocking densities. Perhaps partial harvest was also important to manage SRS found in such types of polyculture. Islam, et al. (2004) reported carp stocking densities in used in polyculture in Bangladesh ranged from 15,000 -17,000 fingerlings ha^{-1} and he pointed out that stocking density was a critical factor when a species reproduces within the system. However, any management intervention regarding SRS needs sound understanding of location specific polyculture practices. Gregory and Guttman (1996) related interest in stocking fish to proximity of farmers' aquatic systems to perennial water bodies that acted as refuges for wild fish. Yoonpundh (1996) demonstrated that farmers raising SRS in Thailand have a variety of strategies based on natural and stocked recruitment to optimize their system. It is clear that new management strategies need to be developed for incorporating SRS within carp polycultures.

Understanding from the previous investigations described in Chapters 3 and 4 lead to the following objectives:

1. Quantify the impact of incorporating selected SRS on carp production.
2. Measure consumption, income and other social benefits of maintaining SRS in the farmer managed aquatic systems.

5.2 Materials and methods

5.2.1 Study site

The previous analysis indicated that SRS were relatively more important in the drought-prone dry land areas of northwest Bangladesh than in low land areas in which flood is prolonged and open aquatic systems more common and diverse. On this basis Panchaghar District was targeted for the farmer participatory trial.

5.2.2 Village description

Households were selected from three communities purposively having similar types of aquatic system, farmer's interest and well-being status within Panchaghar district (Figure 5.1). Water for aquaculture is available for only 6-8 months in around 60% ponds, the remainder being deeper perennial ponds. Seasonal ponds tend to dry up between February and April (Appendix 5).

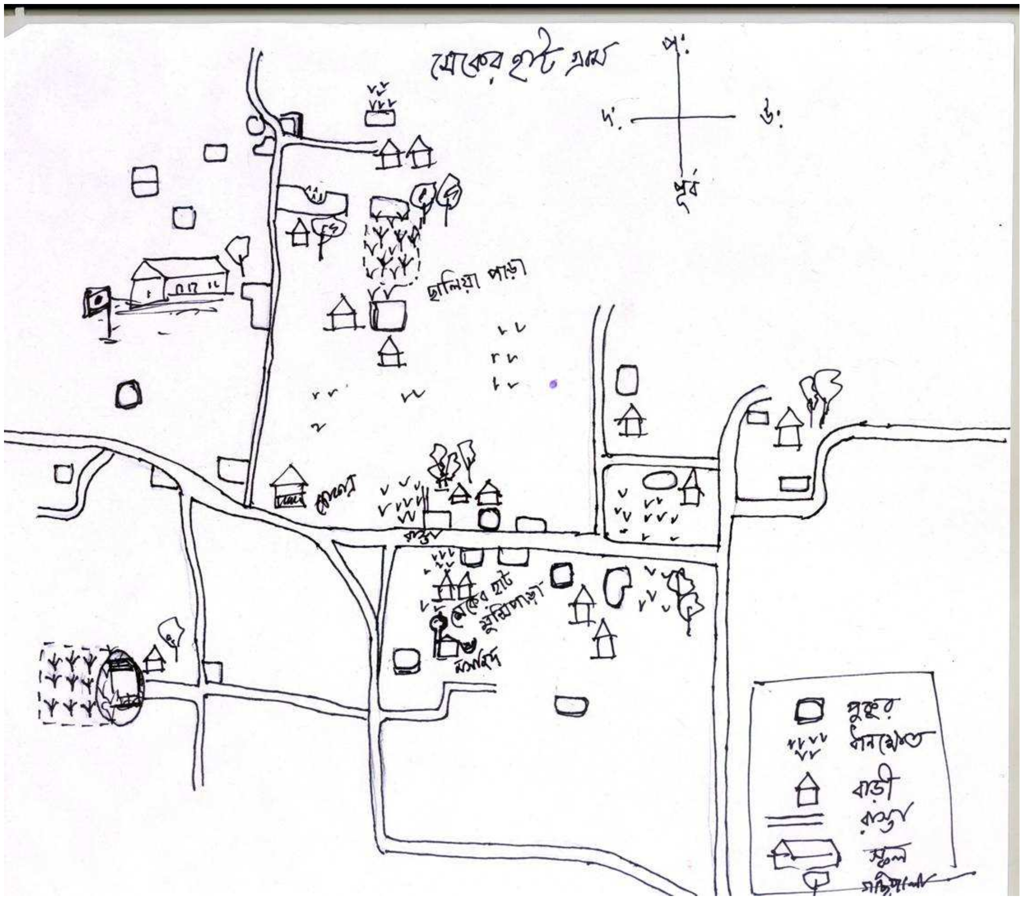


Figure 5.1: Village map of Shaker hat showing ponds, roads and rice fields (Source PCA).

This is a dry area of northwest Bangladesh with soils characterised by low to moderate water holding capacity. Impacts of seasonal floods are of short duration in the area but the prolonged winter negatively affects fish culture (Morrice, 1998). Ground nut, sesame, wheat, vegetable, water melon, rice, recently HYV rice and jute are the main cash crops. The literacy level in all three villages was under 50%. Villagers were found to aware of the extension messages from government Fisheries Department and some NGOs on fish culture.

5.2.3 Farmer identification and participatory research design

The effects of incorporating SRS into conventional carp poly culture were studied in 29 farmer managed ponds over a period of 12 months from May 2003 to April 2004. Firstly, all households (hh) in each community (around 35 households, 2-3 community in a village) were stratified as either ‘aquaculture’ (having ponds or linked ponds) or ‘non-aquaculture’ households from a list of all households collected from 2-3 experienced villagers. A period of two months (March-April) was used for observation of SRS management action and farmer behaviour and to identify real research needs. Different households expressed their ideas, experiences in regard to the research such as allowing selective entrance of SRS into the ponds, keeping dikes open for a certain period, keeping some brood fish in ponds to breed etc. Some households did not agree to allow SRS to enter into their systems. Apart from informal contact, community level meetings and household visits, a formal meeting of all participant households were arranged prior to starting the trial where aquaculture households were finally stratified into SRS positive (n=10), SRS neutral (n=7) and SRS negative (n=12) group based on their past management behaviour on SRS management (Table 5.2). Households were also categorized as being of low, medium and of high well-being from previous assessments made during the PCA. The research idea and the design was discussed, clarified and confirmed by the participants (Table 5.1) in the formal meeting. SRS positive farmers (POS) decided to practice deliberate actions to encourage SRS by i) keeping *Clarias batrachus* and *Heteropneustes fossilis* brood fish and ii) stocking some collected juveniles of *Anabas testudineus, Clarias batrachus* and *Heteropneustes fossilis* along with commonly stocked carps and iii) allowing SRS to selectively enter the ponds from adjacent rice fields at a particular time by cutting the dike of the water body. Negative farmers (NEG) took deliberate actions to prevent entry of SRS by raising the pond dike or removing SRS from their system by netting. Neutral category (NEU) households took no actions to remove or prevent SRS. Species choice for stocking some brood fish and fingerling was proposed by the SRS positive farmers where the researcher shared the advantage and disadvantages with them. It was agreed by the participants that the three groups of households (SRS Positive, Neutral, and Negative) would follow otherwise similar management actions throughout the season. Farmers’ different interests and ideas on the research design were summarised and presented to them for final feedback. Then the following design was jointly validated by the farmers and researcher (Tables 5.1 and 5.2).

Table 5.1: Study design validated by the farmers

Farmer type (no. of household)	Carp	Keeping SRS brood	Stocking SRS juvenile	Allowing selected SRS
POS (10)	Carp poly culture	Stocked brood	Stocked juvenile	Deliberately allowed SRS by cutting dike
NEU (7)	Carp poly culture	-	-	did nothing actively
NEG (12)	Carp poly culture	-	-	Prevent SRS entering by raising dike, partially eradicated if entered

Table 5.2: Farmer type by well-being

Farmer type	Well being group			Total
	Low	Medium	High	
POS	2	5	3	10
NEG	6	4	2	12
NEU	2	3	2	07
Total	10	12	7	29

All FMASs were rice field linked or rice field adjacent ponds except only four were not linked to rice fields (1 in POS, 1 in NEG and 2 in NEU).

5.2.4 Pond preparation

Pond preparation practices had already been introduced to farmers by the local Government Fisheries Extension Project in that area. Farmers were familiar with pond preparation and the use of organic and inorganic fertilizers at recommended doses. However, farmers adjusted actual amounts used according to their situation and own judgement. Most trial ponds were dried out before starting the trial. The initial biomass of fish in ponds is which farmers did not agree to remove all water but which contained left-over (8 ponds) fish and overwintered fish seed was estimated by netting 2-3 (Table 5.3). Initial biomass was later adjusted with the newly stocked carp fish seed.

Table 5.3: Pond status at beginning of the trial

Farmer type	Mean pond area (ha)	Pond status	Mean weight of remaining fish seed (kg/ha)
POS	.04 ± .02	7 ponds were dry, 3 ponds with some remaining fish	27.0 ± 63.4
NEU	.03 ± .02	5 ponds were dry, 2 ponds with remaining fish	6.25 ± 13.4
NEG	.03 ± .02	9 ponds were dry, 3 ponds with remaining fish	20.79 ± 35.5

5.2.5 Stocking ponds

Based on available related references and local availability of fish seed farmers followed the stocking density of the regional (Northwest) government extension project for carp polyculture as total 14822 ha^{-1} of fingerling (5 cm) (which *Hypophthalmichthys molitrix* 3952 ha^{-1}, *Catla catla*/ (Bighead carp) 1482 ha^{-1}, *Labeo rohita* 741 ha^{-1}, *Barbus gonionotus* /*Oriochromis niloticus* 6670 ha^{-1}, *Aristichthys nobilis* 494 ha^{-1}, *Cirrhinus mrigala* / *Cyprinus carpio* 1482 ha^{-1}. SRS juvenile of three selected species were stocked in addition to carps at a total density of 12,350 ha^{-1} of which *Anabas testudineus* , *Heteropneustes fossilis*, *Clarias batrachus* (Linnaeus) was 4940 ha^{-1}(average initial weight each 2g) 3705 ha^{-1} (5.6g) and 3705 ha^{-1}(11g) respectively only in case of SRS positive farmers (POS). They were able to stock these species between July-August. SRS positive (POS) farmers also managed to stock *Clarias batrachus* brood at 100 brood ha^{-1} (3 brood /pond ; mean pond size 0.03 ha) av. wt 187 g and *Heteropneustes fossilis* (Bloch) brood of average wt 18g and at density 400 brood ha^{-1} (12/pond) at male : female = 1:1 in SRS positive ponds in June. Farmers along with some fishers obtained brood fish from a local *Thana* (sub-district) Council pond.

The current study recommended a total stocking density of 27672 ha^{-1} of which 14822 ha^{-1} were carps including silver barb and the rest (12850 ha^{-1}) were SRS in POS type based on available literature on carp-small indigenous species polyculture in Bangladesh. NEG and NEU group only had 14822 ha^{-1}. Additionally POS households deliberately cut the dike to selectively encourage some SRS to enter their ponds.

5.2.6 Pond management

It was recommended that fish were fed with oil cake, duckweed, sesame cover, assorted grasses/duckweed as supplementary feed usually at 3-5 % of the total weight of fish assumed in their ponds (farmers usually used cast net to estimate the growth and overall biomass once or twice a month) and fertilized the pond with urea at around 25 kg ha^{-1}, TSP 12.5 kg ha^{-1} and cow dung 1729 kg ha^{-1} on a weekly to fortnightly basis. The pond input application rates were discussed among participants at the doses already promoted by other NGOs and Northwest Fisheries Extension projects but actual amount and frequency applied were based on the farmers own decision.

5.2.7 Monthly meeting and group discussion with farmers

Group discussions to explore issues arising with farmer participatory experiments are useful (Leeuwis, 2004). Every month, farmers shared current problems in a meeting, discussed the on going situation, discussed their pond and fish observations and decided collectively for new actions on management. Meeting reports (Appendix 6) were prepared by field staff and researchers used as tool of the research to record information on problems, progress and thus facilitate a researcher farmer interacion.

5.2.8 Consumption, sale and inputs recording

Households were provided a record book to record the amount of fish sold and consumed. Sales data were easily recalled, as fish were usually weighed at sale. Consumed quantities were recalled by the household head, however measurements were occasionally made to cross-check estimates based on a kitchen balance or the farmers own measuring balance. Field visits were made by researchers on a weekly basis when record books were checked and information copied down before entry into the computer monthly. All inputs like fertiliser, lime, and feed were recorded by the farmers when applied and this data was similarly checked weekly to fortnightly by the field staff and researcher.

5.2.9 Harvesting

All ponds were finally harvested by March 2004 after pumping out water, all fish were weighed. Farmers were encouraged to harvest, consume and sell both SRS and carps as normal throughout the trial.

5.2.10 Supplementary investigation

Although the data of consumption and sale were recorded during the trial at household level, a supplementary investigation was also made on proportion of consumption and sale of SRS from 29 farmers. This was done as households had some remaining fish in their pond even after final harvest after March 2004.

5.2.11 Result sharing and validation workshop

One farmer evaluation workshop was organised after the final harvest at the end of the research which sought to incorporate farmers' comments, evaluation, and suggestions regarding the trial. The trial farmers were also encouraged to make a plan at individual and village level on SRS management and conservation for the next (post-trial year) year of the trial.

5.2.12 Data analysis

All data were entered into the MS Excel, checked and exported to SPSS for analyses. Data was analysed by farmer type (POS, NEU, and NEG). Well-being effect (as Low, Medium, and High) was only analysed in some cases but not as a part of main analysis due to lack of enough replicates under each farmer type. Farmer type and well-being (some cases) were used as fixed factors in GLM model. All structured and contextual data and facts were arranged, grouped and coded using excel and analyzed using SPSS. Post hoc test (Tukey test) was used in case of production and consumption, inputs and cost benefit analysis between three groups of households. Monthly meeting records with farmers were used in establishing causes of some results.

5.3 Results

5.3.1Vulnerability context

The general vulnerability context of farmers has already been described in Chapter 4. However, monthly meetings with participatory trial households revealed that small-scale aquaculture is constrained by lack of adequate water particularly in the dry season and growth of fish slows down during the prolonged winter in the northwest area. This confirmed findings of the community level PCA exercise and several field visits. Most ponds were found to naturally dry up by February or March. Poor access to quality carp seed is generally a constraint for commercial aquaculture as the location is far away from commercial hatchery seed sources. Trial farmers also confirmed during monthly meetings and individual contacts that August - October were a low income period and February, March, April, September, October were the food insecure months. These findings confirmed those obtained during the year round monitoring presented in the chapter 4. It was found that sources of wild fish were limited in the study area and farmers were more reliant on their small ponds and rice fields in the rainy season to secure adequate amounts of fish for consumption.

5.3.2 Pond inputs and investment

The actual quantity and investment of commercial and on-farm inputs applied by the farmers over the culture period presented in Table 5.4 & 5.5. In general feed and fertilizer applications were not significantly affected by farmer type except for some categories of feed.

Table 5.4: Mean actual amount of commercial and on-farm inputs (kg/ha) applied by the farmers

Farmer type		Purchased inputs					On-farm inputs				
		Lime	Urea	TSP	MP	Oil cake	Cow dung	Rice bran	Duckweed	Sesame	Other feed
POS	Mean	323.00	264.00	159.02	7.08	84.00	8297.31	2263.52	2410.79	580.69	109.30
	Std. Deviation	79.45	133.61	81.49	12.11	214.03	5817.48	1135.32	1795.88	547.31	243.01
NEU	Mean	433.90	366.00	212.91	17.46	110.58	6717.72	2494.00	1635.80	123.44	220.18
	Std. Deviation	170.73	232.08	154.96	25.35	95.62	2113.02	1037.71	1559.22	224.29	526.39
NEG	Mean	346.00	320.00	175.79	3.17	203.52	4673.48	4672.00	2165.24	320.39	46.97
	Std. Deviation	256.98	134.97	75.30	9.21	358.97	2631.04	4422.23	2227.77	406.40	115.41

Note: TSP= Triple Super Phosphate, MP = Murate of Potash

Table 5.5: Mean investment (USD/ha) for purchased and on-farm inputs used by the farmers

Farmer type		Purchased inputs					On-farm inputs				
		Lime	Urea	TSP	MP	Oilcake	Cow dung	Rice bran	Duckweed	Sesame	Other feed
POS	Mean	38.36	27.70	37.99	1.22	17.32	35.66	66.64	28.09	20.37	9.46
	Std. Deviation	8.26	13.51	20.04	2.09	44.28	24.78	34.38	15.90	19.75	24.65
NEU	Mean	50.53	42.24	51.47	3.01	22.88	30.04	59.75	26.02	5.28	3.33
	Std. Deviation	18.36	24.66	37.37	4.37	19.78	9.78	41.57	26.66	10.94	4.81
NEG	Mean	32.45	33.68	42.22	0.55	41.94	23.86	90.72	28.15	13.84	5.67
	Std. Deviation	14.37	13.68	18.81	1.59	74.36	11.97	70.46	32.06	19.03	13.93

Note: TSP= Triple Super Phosphate, MP = Murate of Potash

NEU and POS households invested more in purchase of lime and other feed than NEG. Investment in oil cake was also higher in NEG than POS and NEU. Mean investment cost for other feed was higher in POS compared to NEU and NEG.

5.3.3 Investment in seed - carp and SRS

Mean total initial investment on carp and SRS (USD/ha) presented in Table 6.6.

Table 5.6: Mean investment cost (USD/ha) of carp and SRS by farmer type

Farmer Type	Mean investment on carp seed+ remaining fish	Mean investment on SRS brood	Mean investment on SRS juvenile	Mean total investment on SRS	Mean total investment on carp and SRS
POS (n=10)	519.35 ± 262.84	40.15 ± 46.13	200.89 ± 110.08	241.03 ± 111.66	760.38 ± 292.69
NEU (n=7)	608.82 ± 453.68				608.82 ± 453.68
NEG (n=12)	408.49 ± 234.52				408.49 ± 234.52

Figure is parenthesises n, SD on the right

The initial mean total investment in carp and SRS seed is presented in Table 5.6. Mean initial investment by POS and NEU households was higher than NEG. High variability was found in mean investment of SRS brood fish due to the scarcity and price variation.

5.3.4 Mean initial biomass

Mean initial biomass is presented in Table 5.7. Mean initial weight of carp seed was significantly affected by farmer type.

Table 5.7: Mean initial weight (kg/ha) of carp and SRS by farmer type

Farmer type	Mean initial weight Stocked carp seed+ remaining fish seed	Mean initial weight SRS brood	Mean initial weight SRS juvenile stocked	Mean total initial wt. of SRS brood and juvenile	Mean total initial wt. carp +SRS
POS (10)	226.1 ± 120.42	8.4 ± 9.32	42.23 ± 31.39	50.60 ± 32.43	276.72 ± 135.75
NEU (7)	244.9 ± 147.46				244.91 ± 147.46
NEG (12)	143.3 ± 63.34				143.28 ± 63.34

Figure in parenthesis is N, and SD in the right end.

POS households stocked an extra of 50.6 kg/ha SRS juvenile and brood fish compared to other two types of households (NEU, NEG).

5.3.5 SRS and carp production

Net production of SRS was not significantly affected by farmer type and well-being (P>0.05). Figure 5.2 presents the percent contribution of SRS species in the total harvest. Stocking brood fish and juvenile of *Clarias batrachus*, *Anabas testudineus* and *Heteropneustes fossilis* didn't increase SRS production in POS households compared to NEU and NEG.

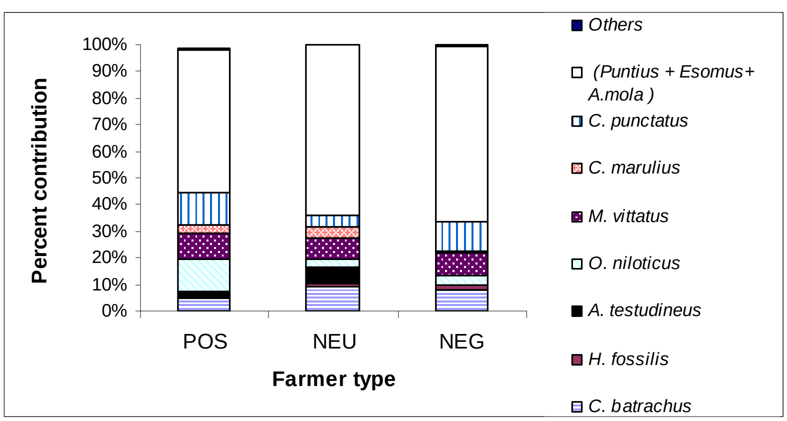


Figure 5.2: Percentage contribution of different SRS net production by farmer type.

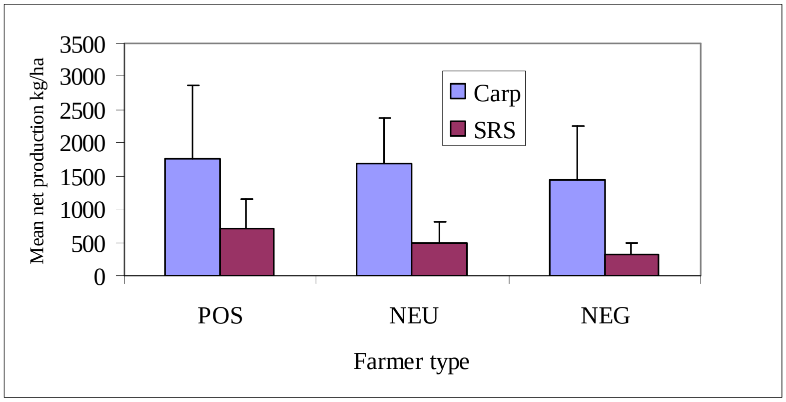


Figure 5.3: Comparison of carp and SRS production by farmer type (n = 10, 7, 12 for POS, NEU & NEG respectively).

Net carp production was also not significantly (P>0.05) affected by farmer type at 1753.70 ±1105.12, 1690.43±695.76, 1452.98 ± 803.29 kg/ha in POS, NEU and NEG type households respectively (Figure 5.3) and also not significantly affected by well-being.

5.3.6 Survival rate of major stocked species

There was no significant difference in the survival rate of main carp species by farmer type. However, *Labeo rohita* (Figure 5.4) and *Catla catla* also showed poorer survival in POS and NEU household ponds but this was not significant.

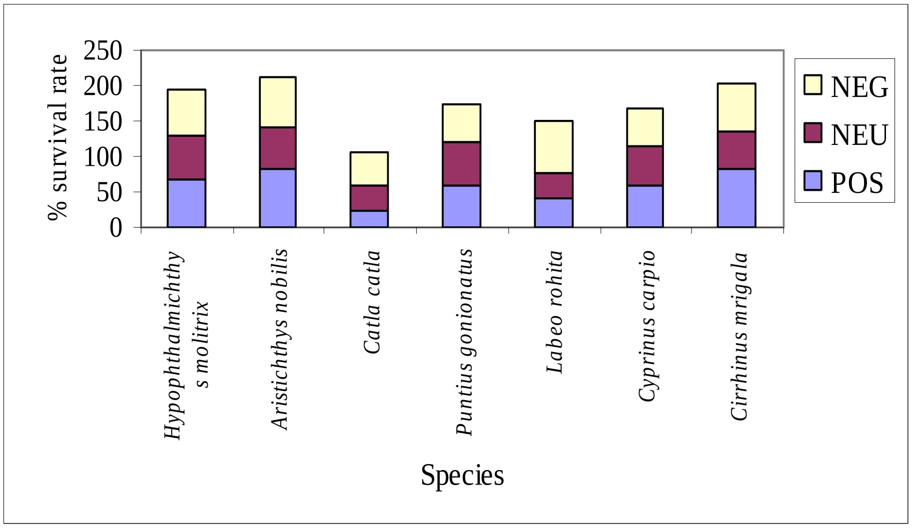


Figure 5.4: Survival rate of major stocked species.

5.3.7 Consumption, sale and distribution of SRS and carps

Consumption, sale and distribution of SRS and carp was not significantly affected by farmer type (P>0.05) and well-being. Overall carp accounted for 76% and SRS accounted nearly one quarter of (24%) of the fish consumed by households sourced only from the trial ponds. Consumption, sale and distribution of carp and SRS during the study period is presented in Figure 5.4. Consumption of SRS from the trial ponds (excluding other sources) was less than stocked carps in the three groups (POS, NEU, NEG). Mean consumption of SRS by all households was around 4 times higher than the quantity sold.

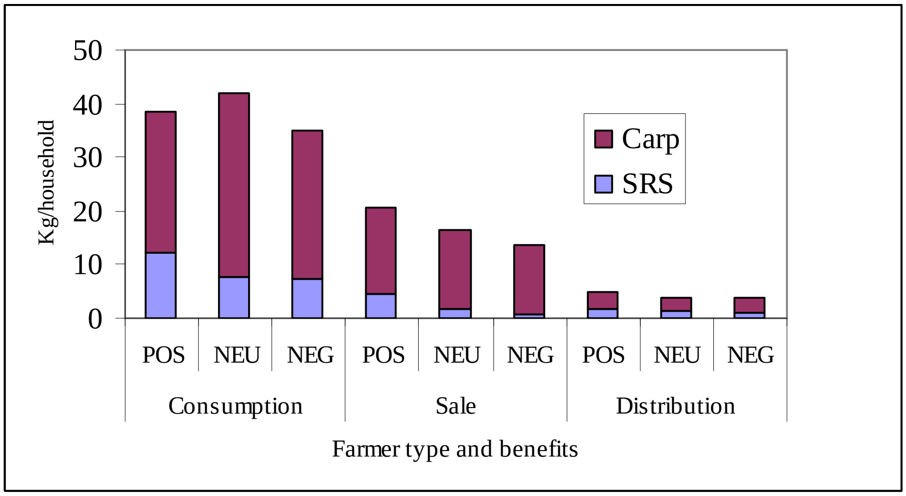
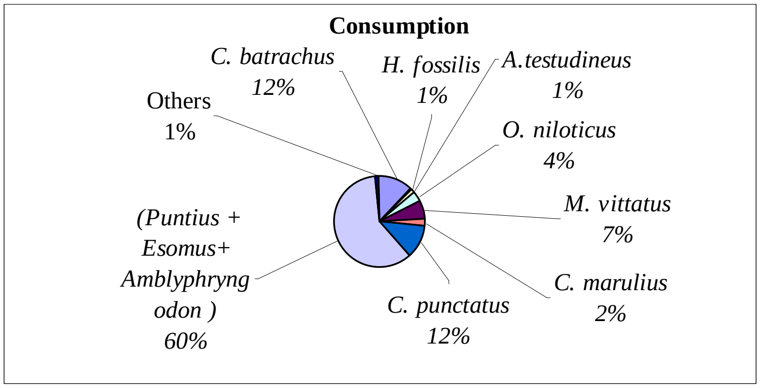
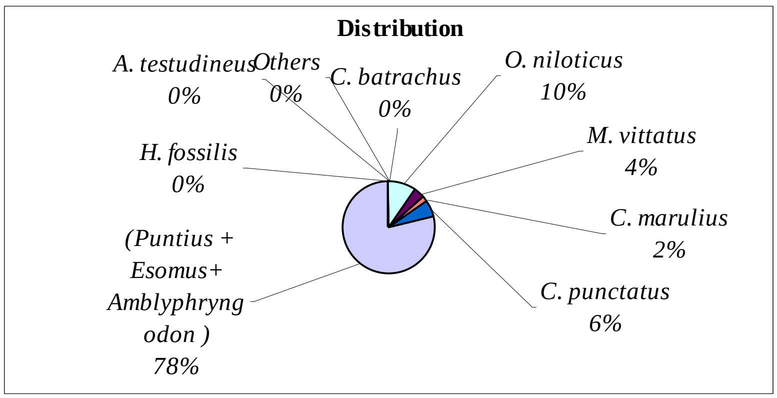


Figure 5.5: Contribution of carp and SRS in consumption, sale and distribution.

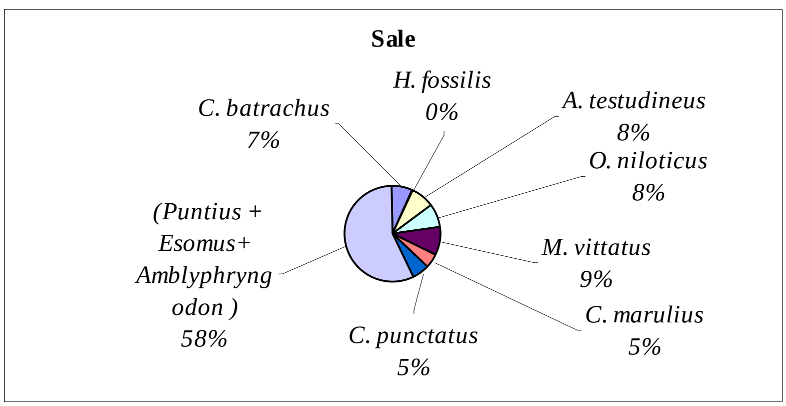
SRS consumption and sale was relatively higher in POS and NEU than NEG. Contribution of different SRS to consumption, sale and distribution is presented in Figure 5.6. Three species - *Puntius sophore*, *Esomus danricus*, *Amblyphryngodon mola* which were difficult to record separately because of their size were found to be the most important group of species (constituting more than 50% of all SRS) in consumption, distribution and sale among SRS.



(A)



(B)



(C)

Figure 5.6: Percent contribution of SRS consumption, distribution and sold amount from trial ponds (A= consumption, B= distribution, C= sale).

Apart from these three species, *Clarias batrachus, Channa punctatus, Mystus vittatus* were also found to be relatively more important species for consumption. *Mystus* *vittatus, Oriochromis niloticus, Clarias batrachus, Anabas testudineus* were relatively more important species for sale (Figure 5.6).

An additional inquiry at the end of the season on consumption with all farmers also revealed that most of the richer and poorer households eat more SRS than they sell. A minority of poorer farmers (30%) sold more SRS than they consumed.

5.3.8 Investment and net return

Mean annual investment was 1043.19 ± 365.12, 903.38 ± 496.69 and 721.56 ± 343.89 USD/ha and net income was 1558.28 ± 1109.81, 1284.15 ± 738.45, 952.09 ± 618.79

Table 5.8: Mean annual (USD/ha) investment and return by farmer type

Farmer type	Mean annual investment	Mean annual gross income	Net income/net profit
POS (10)	1043.19 ± 365.1	2601.47 ± 1299.05	1558.28 ±1109.8
NEU (7)	903.38 ± 496.7	2187.53± 564.58	1284.15 ± 738.4
NEG (12)	721.56 ± 343.9	1673.66 ± 671.87	952.09 ± 618.8
Average	876.35 ± 403.2	2117.63 ± 978.45	1241.28 ± 857.5

± = Std. deviation

USD/ha for POS, NEU and NEG type respectively. Mean annual investment was not significantly affected (P>0.05) by farmer type and well-being. However, investment in POS was higher than NEU and NEG (Table 5.8).

5.4 Discussion

5.4.1 Impact on carp and SRS productivity

The current study confirmed that the three SRS species *Amblypharyngodon mola, Puntius sophore, Esomus danricus* were the most important part of total SRS harvest in trial ponds under three categoroes of farmers. Presence of species such as *Clarias batrachus, Channa punctatus* and *Mystus vittatus* were also important. Importance of these species were also identified in the PCA, background survey (Chapter 3) and household monitoring (Chapter 4) analysis of the current study. No significant difference in SRS net production among the three groups suggests that none of the management strategies (stocking of SRS brood fish and juveniles, cutting the dike of ponds) increased the SRS yield in the POS treatment compared to doing nothing or actively attempting to eradicate and then prevent re-entry. Presence of some carnivorous SRS in the system may reduce any direct feeding competition with small less valuable SRS and stocked species. The use of large carp seed (bigger than normal) might have reduced predation and reduced nascent competition. The fact that stocked carp yields were unaffected suggests the complementary nature of their feeding habits and SRS. The lack of any improvement in yield of SRS despite positive steps to enhance their productivity suggests (1) the robustness of the species-system interaction and (2) a natural ceiling with the current system management to further yield improvements. However, the high variability within POS households might also have impacted on the result. It can be noted that mean pond size and household size was not significantly different in the three groups. The trial also suggests that the 'NEG' group may have found exclusion measures difficult to apply and that FMAS remained well connected to open systems despite management attempts to restrict them. The similar yields of the three species of unstocked SRS in each system suggest their suitability for conditions present in such culture ponds. *Puntius sophore* is a column feeder mainly consuming planktonic algae, rotifers, crustaceans, parts of insects, and debris (Dewan, 1973; Shafi and Quddus, 1974; Kohinoor et al. 2000). It is an important species found in village ponds (Ameen et al. 1984). *Esomus danricus* is a surface feeder consuming algae, protozoa, broken parts of higher plants and sand (Dewan, 1973; Parween et al. 1993) and *Amblypharyngodon mola* is a surface feeder, as an adult fish it consumes unicellular and filamentous algae, zooplankton, debris and plant parts (Miah and Siddque, 1992; Mustafa, 1991; Kohinoor et al. 2000). *Clarias batrachus, Channa punctatus* are more predatory on other small fishes (eg. *Esomus danricus)* and might have predated these smaller SRS.

Alim, et al. (2004) assessed the effects of adding different proportions of the small fish punti (*Puntius sophore*) and mola (*Amblypharyngodon mola*) (at 2:1; 1:1 and 1:2 ratio in three treatments) on the polyculture of *Labio rohita*, *Catla catla* and *Cyprinus carpio* (1:1:1 ratio) at a stocking density of 10000 fish ha^{-1} and 30000 fish ha^{-1} for small fish mola and punti. They found the differences in large carp production after stocking these small species of fish in different proportions were statistically marginal Both Rohu (*Labeo rohita*) and common carp (*Cyprinus carpio*) were marginally affected but household income was not significantly affected. In an another similar experiment of large carp polyculture with *Puntius sophore* and *Amblypharyngodon mola*, it was found that production of catla was not affected by addition of these species (Wahab et al. 2003). Akhterruzzaman and Kaiya (2003) found that culture of small indigenous species (*Amblypharyngodon mola, Amblypharyngodon mola, Labeo bata, Chirrhinus reba, Osteobrama cotio*) with other fast growing fishes (*Puntius gonionatus, Catla catla*) gave a production of 2.8 -4.5 tons/ha with a food conversion rate of 2.9 – 3.0 (feeding low in food chain) and offered an attractive financial return over a 8 month culture period in northern Bangladesh. Amin et al. (1984) indicated that *Puntius sophore* made a good contribution to production in polyculture. There is a dearth of literature regarding the inclusion of *Clarias batrachus*, *Heteropeustes fossilis* and *Anabas testudineus* in carp polycultures in Bangladesh although they are often found as non-stocked species in culture ponds. Das et al. (1999) reported the prospect of *Clarias batrachus* in Indian aquaculture and that culture can be conducted in small ponds (0.5–0.1 ha) and suggested a stocking density of 5000-10,000/ha in polyculture. Farmers prefer these species because of their higher price, good taste and health benefits (Chapter 4). Livesey (2000) also noted air breathing species such as *Clarias batrachus, Heteropneustes fossilis, Anabus testudineus, Channa striatus, Channa punctatus* were valued by farmers in northwest Bangladesh. This evidence together with the results of the current trial suggests the complementarities of both stocked non-stocked species and lack of any major conflicts in their husbandry. This might be relate to their different feeding niche and the low standing stocks and escaping of SRS.

The current investigation revealed that efforts to exclude SRS from the FMAS failed. SRS was found in the NEG ponds even if exclusion was attempted. Clearly there was also no measurable benefit of stocking costly SRS. and it is possible that some SRS such as *Clarias batrachus and Anabus testudineus* escaped from the ponds as mentioned by some farmers. Chapter 4 shown that the households peak consumption period of SRS was July –October in the northwest zone when farmers frequently harvest SRS from their ponds. Although total yield did not vary significantly *Catla catla* and *Labeo rohita* showed relatively poor survival in the current experiment possibly explained by food competition with surface and column feeding SRS. However, the quality of seed was reportedly poor for those two species. Some farmers reported that the timing of *Channa punctatus* entering the culture system is important. If those enter late in production cycle they are entirely beneficial as they can not predate larger carps and many types of SRS (*eg Puntius sophore)* but concentrate on low value minnows (eg. *Esomus danricus*) only rather than carps. Studies in Northeast Thailand suggests that species such as Channa *striata, Clarias batrachus, Anabas testudineus* feed on small barbs. These predators may crawl over land and successfully invade newly flooded ponds and rice fields (Middendrop, 1992). Some farmers preferred to allow the entrance of *Channa punctatus* into ponds later in July to August when carps were already larger and predator resistant. Little, et al. (1991) reported the experience in Thailand that predatory fish are practically impossible to exclude from culture areas and are themselves a valuable part of harvest, highly prized by farmers. He also noted that piscivorous fish such as snakehead (*Channa striata*) and climbing perch (*Anabas testudineus*) undoubtedly decimate the small carp and tilapia fry (of 2-3 cm length). However, farmers under the current experiment considered that the management of prey-predator relationship of some species can be improved by controlling the time of entrance into the system from adjacent water sources. Bocek (undated) noted that use of piscivorous fish in polyculture is experimental in most areas of the world. Piscivorous fish feed on other fish, and usually consume about 5 to 7g of prey in order to grow 1g. However, adding predatory fish to a polyculture system can increase the average weight of surviving prey. It is most efficient to use a predator that consumes small prey reducing intra-specific competition (Bocek, undated).

The result also suggests that attempts to complete eradication of SRS from semi-intensive level of management is ineffective. Trial farmers also noted that *Anabas testudineus* was prone to escape from culture ponds and therefore was risky species to culture, particular if they are stocked and , therefore, a consumption opportunity is forgone and/or cash is used to purchase broodfish or juveniles.This also explain why yields were poor compared to un-stocked systems (NEG/NEU). Over wintering of *Clarias batrachus* and *Heteropneustes fossilis* might be suitable in ponds with low depth and specially protected strong dike.

5.4.2 Consumption and selling of SRS

SRS accounted for nearly one quarter of the total consumption recorded from trial ponds indicating a substantive contribution of SRS to diets in such a dry area. However, apart from their own ponds households consumed SRS from other sources such as rice-fields, market and neighbours gift. Some SRS such as *Puntius sophore, Ambypharyngodon mola, Esomus danrika, Channa punctatus* are easy to catch particularly when monsoon waters recedes (September – November) allowing frequent harvest at this time. The supplementary investigation on consumed SRS confirmed that both the poorer and better-off consumed more SRS than they sell although a minority of poor households (30%) actually sold more than they consumed. Roos et al. (2001) reported from the Kishorgonj study that small indigenous species make a significant proportion of household consumption from ponds. The lower level of consumption from ponds was due to relative scarcity of water and aquatic animals in the Northwest (Chapter 4). They also found the dominant role of *Puntius sophore* (26% of the intake) among small SRS consumed which supports the current research findings. Poorer households sold both carp and SRS even if harvested in small amounts. In contrast better off households usually consumed rather than sold small amounts.

Chapter 4 revealed that SRS accounted for 52 % of the total aquatic animals consumed from different sources and the current part of the study confirmed that small household ponds (<0.05ha) were one of the important sources This section of the study concludes that i) attempts to completely eradicate SRS from ponds is ineffective and there are complementarities of managing SRS and stocked carps without major conflicts in their management or husbandry in FMAS ii) consumption of both carp and SRS from pond is important for the poor particularly in a fish scarce dry area where the research was conducted iii) the role of SRS in carp polyculture is beneficial in marginal aquatic systems in terms of sale, consumption and free distribution iv) smaller SRS particually *Amblypharyngodon mola, Puntius sophore, Esomus danricus* that can be easily harvested are more important for household consumption than other SRS.

5.4.3 Distribution of fish - a social capital

Households distributed similar amounts of both carp and SRS as gifts. The free distribution of SRS might be also associated with the fish harvest payment given in the form of SRS. Little (1998) and Cheftel & Lorenzen (1999) reported that even under commercial culture conditions, small "trash" fish, which are available to workers as payment in kind or are sold at low price thus contributing to the livelihoods of poor non-fish farmers in rural and urban areas.

5.5 Conclusion

Managing culture systems to maintain productivity of SRS may demand only avoidance of negative actions. Efforts to completely eradicate SRS from the system was found ineffective which indicates the importance of a management approach considering both stocked and non-stocked species or in other words farming aquatic animal with biodiversity (diverse species) and ecological concern. The lack of any improvement in yield of SRS despite positive steps to enhance their productivity suggests the robustness of the species-system interaction. No major conflicts between the management of carp and SRS, benefits of consumption and sale from SRS confirm the value of SRS within culture systems that has been greatly underestimated in the past. Importance of maintaining productivity of both cheaper and high value SRS is important for the poor for different benefits. Over all, consumption of both carp and SRS was higher than sale among the three farmer types confirming the importance of FMAS for household fish consumption in a dry area where other sources of fish are limited.

Chapter 6

General discussion

6.1 Introduction

This chapter will collate the key outcomes into an integrated whole and cross validate the summary findings outlined in Chapter 3, 4 and 5 in relation to the main working hypotheses. It will assess the evidence, highlight the key relationships, and summarise the contribution of this enquiry in the context of other research. Secondly, the research methods and their limitations will be discussed. Finally, some areas for further research and development of understanding will be indicated, and some suggestions for the improvement of current approaches to research and development in the Bangladesh fisheries sector presented.

6.2 Contribution to main hypothesis

Firstly, revisiting the chapters again will help to understand the linkage between key outcomes of the research. Chapter 1 gave an overview of related concepts, methods and reviewed the current situation of national and global fisheries, food security for an increasing population, the nature of conventional aquaculture, management of SRS, poverty and vulnerability. The review identified the growing importance of aquaculture compared to capture and culture based fisheries and importance of their complementarities, defined farmer managed systems and indicated the importance of integrating SRS within formal aquaculture focusing on the social dimension, biodiversity and ecological basis for sustainable farming. Seasonal complexity of defining close and openness of aquatic systems have been identified. It also pointed that common pool natural habitat in wet season can form a closed household managed system in dry season. With the degradation of common pool natural habitat people started to manage aquatic animals within their household managed systems. This transformation is very much linked with the access and ownership of aquatic systems. Land holding plays an important role in the participation of group, community based and household managed aquaculture and culture based fisheries. One of the key issues in growing aquaculture of Bangladesh is the inequality of benefit for the poor

(Gregory et al. 2007). Chapter 2 presented the conceptual frame work and a road map of the research in order to systematically examine the hypotheses. Chapter 3 described the context of rural livelihoods and its relationships with SRS, ownership and access to FMAS aquatic systems. The characteristics of livelihoods were further explored in chapter 4 through an exploration of seasonality and indications to define pro poor aquaculture. Attempts to include or exclude SRS within formal aquaculture were investigated in Chapter 5.

Chapter 3 placed the importance of aquatic animals and management of SRS in the broader aquatic, social and institutional context of Bangladesh. This clearly indicated the priority for integrated management of SRS with stocked carps in small-scale aquaculture within FMAS. Other issues identified as important in relation to SRS and aquatic resource management by policy makers and various stakeholders (in the national workshop) were- habitat restoration, conservation and open water management to maintain the integrity of broader ecosystem. The seasonal complexity of aquatic systems, specific types of aquatic animals and their consumption pattern in relation to other foods was the focus of Chapter 3.

If we look back to the five research questions and the main hypothesis, the key issue is the relative importance of SRS in aquaculture to sustainable nutritional, social, economic and environmental benefits for the poor.

The SRS management practices such as cutting dikes, using a pipe in the inlet and linking ponds with small channels identified in the household survey were also noticed as common practice in the farmer participatory trial. These measures were related to both efficiency of capture and *in situ* production of SRS and should not be neglected from standardised aquaculture practices. These management actions also indicated efforts to integrate the broader management of land and ponds particularly in drier areas. The PCA and household survey raised the question if should we exclude SRS from aquaculture. Later in chapter 5, the farmer participatory trial confirmed that deliberate efforts to exclude them from aquaculture systems were ineffective. This strongly established their value in the culture system. Analysis of the sources and priority species of AA cross validated in the various components of the study clearly indicated an approach to aquaculture that was not only limited to ‘ponds’ and stocked species could enhance benefits for the poor. This type of aquaculture is based on access to a diverse range of aquatic resources particularly FMASs such as rice fields, lake ponds, trap ponds and utilisation of both stocked and non-stocked species. One of the most important areas of investigation was access to aquatic resources by the poor. The varied sources of aquatic animals is shown by the diverse typology of farmer managed aquatic systems (FMAS) and showed the importance of both FMAS and open systems to sustain a self-supporting population of aquatic animals for nutritional security of the poor.

With the growing tendency of intensification of crops in lands and commercialisation, poorer households will have to face the reality of different tenancy arrangements. Although there is high prevalence of landlessness in Bangladesh among the poor, it is important to understand the nature of inequalities among households in accessing different types of farmer managed aquatic systems (FMAS). An understanding of aquatic systems that were managed by households irrespective of ownership (Chapter 3) is important to define the nature of poverty focused aquaculture However the current study showed that poorer households have more opportunity to access SRS through share cropping land compared to leased and other land ownership arrangements. This study has demonstrated that the contribution of SRS within aquaculture to the livelihoods and particularly the nutritional security of the poor has often been greatly underestimated.

The list of popular aquatic animals (chapter 3) identified by the current study was a useful starting point for strategic interventions on SRS research and development. There were no major contradictions with the identified importance of popular aquatic animals in different parts of the study (particularly in PCA, household survey and in the field trial). The importance of popular AA identified in the PCA was further understood from a seasonality perspective in terms of consumption, income and species diversity during the household monitoring. This confirmed a significant consumption disparity during the lean income months. Perceptions regarding the importance of AA and their availability were also related to their source and access to aquatic resources (land, pond etc.) by households. Environmental shocks such as flood and drought were also associated to consumption differences among household categories and in the study zones. People valued AA not only for nutrition but for a range of socio-cultural values such as ‘good taste’, ‘family members and guests’ preferences and economic factors such as ‘high price’ and ‘purchasing capability’ that determined the value of such food in society. In particular, among different sources of aquatic animals, SRS have an important role in reducing seasonal food vulnerability among the poor living in drier agro-ecosystems because of the scarcity of AA from open and wild sources (Chapter 4).

FMASs were found to be important both for stocked and non-stocked species. However, management of non-stocked species are likely to be system dependent; managing SRS in FMAS such as rice field, trap ponds, lake ponds etc requires greater attention for improved management. Considering the lack of ownership of the poor to land and ponds, the sustainable management of rice fields for SRS and other culture species was found important (Chapter 3). Keeping some bloodstock of walking and stinging catfish in ponds (Chapter 5) with commonly cultured carps identified certain difficulties during the farmer participatory trial probably related to a tendency for these species to escape and practical constraints to harvesting them without complete dewatering of ponds.

The current study demands a clear understanding of access to different FMAS that has implications for different SRS management actions such as cutting dike, linking channels and deepening rice field ditches in the dry season. Perceptions varied on the importance of AA and their availability related to the different sources, seasonal disparities of consumption and income over the year and variation in access to aquatic resources (land, pond etc.) among households within different categories. . Environmental shocks such as flood and drought were also variably important between household categories in the study.

The study clearly showed poorer people have greater reliance on SRS than the better off even if they do not own a FMAS. The aquatic resource holdings of the poor are much smaller than those of the better-off and more likely to be rice field associated systems which have relatively more potential for the harvest of SRS particularly for the poor. However, conventional ponds, mostly owned by the better off, were also important for SRS management could act as dry season refuges for conservation of SRS. Poorer households often have opportunities to manage SRS in share cropped lands (Chapter 3) by doing SRS positive actions such as raising and cutting dike to trap SRS although higher level of land modification and management may require extra permission from land owner. Unless the share cropped land is highly modified (excavation, digging lager ditches) by the poor share cropper land owner usually do not ask for a formal share of fish naturally produced or harvested. The harvesting of fish and other aquatic animals from inundated land has always been considered non-commercial free access of fish in Bangladesh. Fishes in flood plain rice fields are found to be treated as seasonal open and common property resource (Gregory et al. 2007).

Although aquaculture was dominated by the better-off (Chapter 3), the baseline survey revealed that 20% of pond ownership was by low well-being households and 21% from medium. Barman (2000) found in his study in northwest Bangladesh that although one third of all farming households had ponds, only one fifth of the poorest households were pond owners. The poor benefiting as producers however needs to be considered beyond their ownership of conventional ponds.

Barman (2000) also emphasized the need to consider the nutrition security of non-pond owner households. The current study showed that SRS were also important for non-producing low income households (Chapter 4, Fig 4.11) indicating their availability from nearby sources such as neighbours FMAS and markets.

Livelihoods of the poor are adversely affected by the scarce open natural resources. This may lead to higher dependency on FMAS in comparatively dry areas. The current study highlighted the relative importance of SRS in more marginal agro-ecosystem such as in the drier northwest zone. The significance of the FMAS as a source of AA was found higher in the PCA, stakeholder workshop and year round monitoring. This significance was further investigated only in ponds through a year round farmer participatory trial in the northwest zone.

In the PCA and stakeholder workshop FMAS were generally categorized as pond (not linked to rice fields), linked ponds and rice fields and the availability of SRS was more in the linked pond and rice fields. The availability of both SRS and stocked species was specified. The PCA also indicated FMAS was a more important source of popular AA in the NW (78%) than the SC zone where open systems dominanated. Dominance of open systems in SC zone was similarly confirmed by the household monitoring but FMAS were found to be important in both zones.

Different studies in Bangladesh have shown that common pool resources are highly important to the livelihoods of the poor but that pro-poor management regimes are critical if the poor are not to be excluded (Lovett et al. 2006). Again recently emerging floodplain aquaculture can not be solely considered as a community approach as landholding is the key issue in determining participation (Gregory et. al, 2007). Local land tenancy arrangements such as share-croppinging in rice fields (Taslim, 1989; Ellis, 2000) may increase access to land and as well as rice and SRS for the poor and landless. Contract growing of rice and leasing arrangement are more suitable to the medium and better off farmers. Better off people usually employ sharecropping arrangements to reduce the supervision burden which in turn creates opportunities for the poor. Leasing arrangement of lands also require very less supervision than share cropping have advantages for the land owner but the poor often can not afford a fixed rent amount considering risk of flood and drought. The current study also found that sharecropping made land more accessible to poorer households as a source of SRS. It can be noted that share cropping means only rice is shared not the aquatic animals.

Availability of SRS is important to the households from August to October when food expenditure (mainly related to buying rice) was found higher. Therefore, greater availability of both rice and SRS in that period could save cash from food budget to buy other essentials particularly for the poorer households. Availability of rice also reduces economic risks that these farmers potentially face (FAOSTAT, 2004; Lu & Li, 2006). Expenditure for rice is an important factor of income, consumption and nutrition of the poor (Torlesse et al. 2004).Rice production has been intensified mainly through the introduction of modern high yielding varieties, accompanied by new management practices such as mechanization and the application of chemical fertilizers and pesticides. Increasing demand for other grain, as part of crop diversification, may result in the area under rice cultivation being reduced particularly in dry season (Hossain et al. 2006). This is likely to stimulate further intensification which may shift the economic threshold of using pesticides in rice fields (Waibel, 1992; Waibel et al.1993). In other words, less or no pesticides are applied if the potential income from fish and the potential loss of fish due to pesticide application are considered. If farmers follow IPM in their *boro* rice production could also protect adjacent dry season fish stocks. Increase in income from rice and fish may help reduce pressure on farming families to sell their land inn Bangladesh (Gregory et. al, 2007). Haque (2007) observed in northwest Bangladesh that the production of juvenile fish within the *boro* rice crop (April –June) also created more opportunities to harvest wild fish from rice-fields Therefore, enhancing SRS yields and the production of stocked fish may be compatible with intensified rice production and overall reductions in pesticide use Rice–fish-farming systems have diversified China's agro-landscape and favoured the conservation and biodiversity of rice and fish species(Lu & Li, 2006) Such practices tend to reduce the levels of external inputs used ; for example pesticide use is 50% of that of modern, high-input rice production; sometimes, no pesticide application is required). Rural framers often have a good knowledge about natural fish resources if these are traditionally caught as a part-time activity. Small farms are usually complex, highly organised, efficiently balanced units and such integrated practices operated with the aim of maximising resource utilization and reducing risk are attractive (Prein, 2002).

The study also confirmed the complementarities of SRS and stocked fish over different periods of the year. The current study also supported the complementary nature between aquaculture and fisheries management strategies. Similar studies in Cambodia, north-east Thailand and in northern Vietnam recently concluded that non-stocked SRS are very important in the food consumption of rural households in locations and at times when access to other food types is limited (Little et al., 2004; Morales et al. 2006). Non-availability of such species will make small farmers and the landless more vulnerable when overall food production decreases, food prices increase and there is scarcity of employment (Paul, 1998).

6.3 Seasonality and livelihoods outcome

Examining seasonal dynamics of consumption, income and expenditure was a key focus of the current research which confirmed seasonality of food consumption patterns and distinguished clear difference between consumption of stocked, SRS and wild aquatic animals. Relations between household income, expenditure and food consumption were also explored. The factors that influenced SRS and overall AA consumption were further confirmed as seasonal availability (Chapter 4; Figure 4.6), species diversity (Chapter 4; Figure 4.4 & 4.5), traditional preference in terms of taste (Chapter 3), access to the farmer managed and open aquatic systems (Chapter 3), supply in the market (Chapter 4; Figure 4.11 & 4.12) and the availability of gifts from neighbours. The seasonal dynamics of household food income and expenditure (Chapter 5) were crucial factors in defining the role of SRS in aquaculture. Food was the highest source of expenditure in both zones and among poorer households. Increased availability, and subsequent lower cost of securing AA is, therefore, likely to help poorer households access other essential foods.

Aquatic animals are one of the most important contributors to the rural Bangladeshi diet after cereals (rice) and vegetables but there is a decline in their availability from natural sources. SRS from FMAS and neighbours reduced the cash investment on household food purchase – the highest expenditure source among low income households in both zones. Therefore, a sustained availability of both stocked and SRS species has significant impacts on the livelihoods of the poor

If we relate the seasonal calendars on general weather derived from the PCA and the seasonal dynamics of AA consumption and sources from year round monitoring, it is clear that the relative levels of flood and drought constructed the nature of sources of AA and affected consumption of AA at the household level over the year. Well-being disparities in access to, or consumption of AA, was mainly due to variable access to aquatic resources resulting from such climatic phenomenon. The specific characteristics of FMASs, particularly their capacity to insulate households from such seasonality, is indicated by their importance as a source of fish during certain months (January to June). This supply smoothing appears to benefit the poor of both aquaculture and non-aquaculture households. There were important differences between the zones in respect of seasonality however-indicating the importance of specific agro ecological conditions' especially duration of surface water availability on supply, and consumption of aquatic animals. The pre-monsoon dry period (April and May) was the lowest consumption period in both zones and higher consumption period is relatively longer in the south-central zone than northwest might affect the health security of poorer households in northwest.

The total amount of SRS consumed over the year was strongly correlated with diversity of SRS species consumed which suggest the significance of maintaining and farming AA with biodiversity. Chapter 5 clearly indicates an approach to farming AA with diversity of species is important .The available agro-biodiversity is the basis of survival particularly for small scale farmers. Biodiversity safe guard the production system even in a adverse environmental condition. Integration of different crops or weeds with animals such as fish in rice fields are important to better utilise the resource. Concentration of increasing the productivity of very few crops and enormous simplification of agricultural system is no longer sustainable for long term food security. This will make our food production system very vulnerable to cope with changes in conditions, such as global warming (LEISA, 2006).

The importance of livelihood activities, main and secondary occupation and sources of household income was investigated at community and households level during PCA, back ground survey and household level year round monitoring. This gave a clear picture of well-being indicators. The most important observation was that the low well-being group mainly supported their livelihood through sale of their labour, including agricultural and non-agricultural labour, van, rickshaw pulling, fishing and some petty trade in both zones. They may diversify their options to cope with seasonal constraints and vulnerabilities. Diversification of income source appeared to be related to inadequate incomes from a single source. Agriculture (farming rice, other crop, fish culture, poultry, livestock), service and business were common among the better-off in both zones with SC being more diversified (higher level of income among poor than NW) with some petty trade. Agriculture based on share-cropping, service and small business were common among medium well-being households. However, fishing remains important to the poor. Other studies also revealed that 80%

of rural households in Bangladesh traditionally catch fish for consumption or sale (FAP 16, 1995) and there is greater dependency on fishing among the poor compared to the better off; fishing may be critical when other livelihoods options are limited. Bush (2004) in a study in Vietnam highlighted that well-being is a factor that influences the use of living aquatic resources and fish ponds are an inspirational asset reflecting wealth and class in a society. With the degradation and decrease in open water resources, the dimensions of fishing will change and a greater reliance on smaller-scale farmer managed systems is likely. The expansion of aquaculture may create labour (wage for fishers) opportunities for fishers. Faruque (2007) has found that aquaculture has stimulated and diversified opportunities for employment of fishers in three areas of Bangladesh. Sen (1999) cited that ‘the effect of human capital for increasing long-term economic growth is important and human capital has strong income-poverty reducing effects’. Further, Sen et al. (1997) suggested that ‘small scale aquaculture can contribute to poverty alleviation provided that extension approaches and methods are appropriate and flexible’. Gupta et al. (1999) suggested that 'in addition to technological innovation, an institutional approach is vital if resource poor farmers are to benefit from technological advancement.' The roles of aquaculture development to poverty alleviation need to understand its broader impacts on livelihood outcomes. Non-economic activities such as – prayer, relaxation/leisure time, festivals, marriage ceremony, household works should be taken into consideration while looking at livelihoods outcomes. Increases in income may be a route but not a solution to the vicious nature of poverty. From the mid 1980s the multidimensionality of poverty has been recognised fully, which essentially covers both income and non-economic dimension of poverty (Chambers, 1985; Sen, 1997; Maxwell, 1999). Diversification of livelihoods has also been identified as an important strategy for higher impact on poverty through reduced vulnerability (Frankenburger et al. 2000; Alison and Ellis, 2001; Ellis, 2001).

The current study revealed that exposure to flood and/or drought, poor access to education, poor access to land and aquatic systems, bad health, and opportunities for alternative income sources in low income and food deficit months were important factors in the vulnerability context at the study sites. SRS reduced household vulnerability through enhancing the productivity and stability of aquatic systems and in so doing income, nutrition and indirectly, health.

IFAD's (International Fund for Agricultural Development) new Strategic Framework (2002-2005) views poverty as multidimensional and characterised by vulnerability, exclusion and powerlessness. The framework emphasises strengthening poor people's capabilities to access assets. Current study also pointed accumulation of different assets for the poor and highlighted to clearly understand the seasonality context of the assets and livelihoods strategies. Many researchers have analysed poverty using various indicators such as - income and expenditure (Chaudhuri and Ravallion, 1994; Gaiha, 1989) which highlighted income poverty; access to land, and other assets (Chaudhuri and Ravallion, 1994; Gaiha, 1989; McCulloch and Baulch, 2000) that reflected ownership and access to resources; levels of education and skills (Gaiha 1989, Jalan and Ravallion, 1998, McCulloch and Baulch, 2000, Rodgers and Rodgers, 1993) that has relationship with well-being; health (Jalan and Ravallion, 1998); food security (Braun, 1995; Chaudhuri and Ravallion, 1994; Jalan and Ravallion, 1998) which highlighted consumption poverty. The current study found poverty was related to most of the above indicators with food security, income, expenditure, health security, access to land and geographical context being of greatest importance. Poverty in the northwest zone was associated with poor consumption and health security than the south-central zone. Income of the poor was nearly double (Chapter 4) in SC than NW reflected their diversification of livelihood options. Similar observation was noted in the household survey that petty trade was dominant among poorer household in the SC zone than in the NW.

6.4 SRS within formal aquaculture

The year round farmer participatory trial confirmed the value of SRS within culture systems and a lack of conflicts with the husbandry of carps. This contrast with common opinion whereby SRS have been regarded as weed fish and their exclusion from formal aquaculture promoted. Moreover it was clearly found that the common approaches to exclude SRS were ineffective. The study found a range of species of both commercial and non-commercial SRS present in the systems were important to both poorer and better off households in terms of consumption, income, sale and distribution. Consumption of SRS from the trial ponds was not significantly affected by farmer type and well-being group which again indicates the importance of FMASs other than ponds for the poor. More deliberate attention towards SRS management in

FMASs in the lean season may also expand niche benefits for non-pond owners and vulnerable social groups such as fishers. Fishers may get extra employment opportunity in the dry season if aquaculture of SRS expanded in dry season. However, some studies in Bangladesh recommended that the poor may not equally benefit from flood plain aquaculture than the better off households (Gregory et. al, 2007). The complementarities of stocked fish to SRS, particularly during dry months are also an important message for the balanced promotion of aquaculture to combat the seasonal shortfall of aquatic animals. The study recommends future emphasis on the management and conservation of both commercial and subsistence orientated SRS in FMAS, particularly during the lean season. Maintaining the integrity and permeable nature of FMAS, its linkages with open systems are probably critical for the sustained availability of populations of such self-recruiting species..

Previous studies indicated that SRS are a particularly important resource for poorer people in environmentally vulnerable areas. There is a widespread perception however, that such species have a negative impact on stocked carp poly cultures. The findings in Chapter 5 suggested that there was no major conflict in the presence of popular SRS as - *Clarias batrachus, Heteropneustes fossilis, Anabas testudineus, Oreochromis niloiticus, Mystus, Channa marulius, Channa punctatus, Puntius sophore, Amblyphyron, Esomus danrika* with the commonly cultured carps although the lack of an effective ‘no-SRS treatment’ meant that it was not possible to rigorously confirm this under on-farm conditions. Most probably these SRS filled vacant or underutilized spatial and/or feeding niches within the system. The relatively low density of SRS, partly an outcome of the normal practice of partial harvest , may also be a factor.The lack of impact of stocking some SRS species, especially those capable of leaving aquatic systems, suggests that carrying capacity of these species is self-regulating. Little (2002) emphasized the importance of a ‘silent’ harvest of un-stocked species that remain in culture systems, find their own way in or are actively encouraged by farmers to enter at times of flood valued by rural people. He also pointed out that maintaining or enhancing SRS may not lead to large increases in cash flow but that their role in food security was likely to be high. Following a stocking protocol the importance of integrating *Amblypharyngodon mola and Puntius sophore* on large carp poly culture of Bangladesh has been recently evaluated (on station research) and described as a simple way to improve rural aquaculture through positive social, nutritional and economic benefits (Alim et al. 2004). Livesey (2000) observed that farmers sought to reintroduce SRS following extension service support for removing SRS from their culture ponds. This study also concluded that complete exclusion of SRS from the farmer managed ponds was not practical and even when attempted, failed to reduce levels of SRS within systems significantly due to the semi-permeable nature of ponds.

A balanced view of intensification of aquaculture and consideration of livelihoods benefits for the poor is important. IFRI (1996) emphasized maintaining a natural harvest while sustainably increasing aquaculture production. However, encouraging SRS within formal aquaculture was believed to undermine the success stocked species. This study suggests that further understanding is required regarding species interaction and level of intensification of aquaculture.

Conventional aquaculture appears to have relatively little impact at certain seasons on meeting nutritional needs. Stocked species do not contribute much from April to September, as marketable size is usually reached only in October when rural people highly depend on SRS. Even partial harvest and thinning started in September in many areas. Roos (2001) mentioned Bangladeshi diet is dominated by rice which contributes majority of energy and protein and other essential nutrients contributed from mainly vegetables, fish and pulses. Vegetable and fruit are the main source of vitamin-A and fish in the diet is dominated by small indigenous fish species. The 1981-82 national survey revealed that fish made 53% of the raw animal food intake with an average intake of 23g/capita/day which is around 2.5 times lower than the current study findings. Current study findings is close to the Roos's (2001) fish intake findings in Kishorgonj.

Greater commercialization in fish culture may have negative impacts on household nutrition, especially in the case of poor households (Barman 2000). Fish is a cheaper animal protein source than pork, chicken or meat particularly for rural poor in Northeast Thailand. Wild fish played an important role for an average consumption per caput of 16.6 kg per year and provided 4% of the total household income (Saengrut 1998). When fish supplies are short and prices go up, poor consumers are forced to shift to inferior foods (Kent, 1997).

It is important to note the importance of other food items apart from fish to the diet of people regionally.In Southeast Asia SRS consumed regularly are much more diverse. In flooded rice fields, living aquatic resources such as fish, fresh water prawns and crabs, sails, mussels and frogs occur naturally. These were regularly caught or collected and have played an important role in the diet of rural farm households (Prein, 2002). Gregory and Guttman (2002) highlighted the importance of rice field fisheries as an important source of fish for household consumption in Cambodia. The diversity of SRS species in the diet was significantly affected by zone in this study which indicates a need to implement conservation principles within both capture fisheries and aquaculture. The potential biodiversity benefits of promoting SRS were clear ; the study recorded more than 25 non-stocked species in the yearly diet and indicated that more diverse diets led to grater consumption of aquatic animals. A recent study recorded 51, 29 and 15 type of fish species in the rural diet in Northeast Thailand, Southeast Cambodia and Red River Delta, Vietnam respectively (Morales et al. 2006) which suggest the potential of farming AA with biodiversity in the region. Maintaining biodiversity within both FMAS and other aquatic systems is also important for long term food and environmental security particually in developing countries.The disparity of aquatic animal consumption particularly between poor and better off was greater in the northwest than south-central zone which suggests location specific intervention to address malnutrition and consumption poverty are required. Finally, the study indicates that formulation of an integrated approach to water, agriculture, environment and fisheries management is required to sustain SRS for current and future nutritional and livelihoods security of the poor.

6.5 Critique on methods

The research approach or the methodological context used a range of tools based on both quantitative and qualitative approaches. It balanced ‘quick and dirty’ approaches, participatory with longer term observational and anthropological methods and structured longitudinal panels for collection of quantitative data. Several levels of analysis (household, group, area, special social group) were used and triangulation between methods and levels of analysis ensured. The status of households defined by well-being, involvement in aquaculture, gender of head and zone were the key factors underlying the analysis.

Questionnaire survey and PCA

The strengths and weakness of both survey and PRA tools understood, the current study sought to optimise the use of both. Hussein (2000) and Westley & Rashid (2001) emphasized that a wide variety of information needed to be collected by means of a large number of methods.

To generate sufficient contextual information the study followed Participatory Community Appraisal at the beginning (Step1) which not only used FGD group level scoring to construct several matrixes but also captured individual level opinion within a PRA or focus groups which allowed the application of conventional statistical tests. Kanji (2003) pointed that the conventional approach to participatory research tends to homogenize communities and ignore a range of differences between people. The identification of distinct groups and triangulation with information from individuals sought to overcome this shortcoming. During the current research some issues were scored at a group level after discussion and some individually to preserve independence of opinion. Both individual and group opinion and scoring led to real insights. PRA tools applied within a sound sampling framework of the wider population was a strength that allowed some level of extrapolation to be possible as opposed to narrative PRA case studies. More analytical and numeric analyses were possible. The PRAs in 18 communities were conducted over a few months and led to a broad community level understanding which led to, subsequently, a better focus on some specific areas for further investigation. A household survey allowed an understanding of the relationship between SRS and livelihoods but its structure was highly informed by the previous PCA

Gladwin et. al. (2002) suggested that PRA tools (quick and dirty) could be trustworthy and scientific. The current study employed various PRA tools in the light of recommendations from Pretty et al. (1995). The critical checkpoints are given in then Table (6.1) below.

Table 6.1: Checkpoints of PRA investigation

Check points	Comments with current study
Intense engagement between various people	Wide range of households, participants covered over a 4-5 months period. Gender, well-being and social groups in two region.
Persistent and parallel observation	PCA findings consulted with communities and macro level stakeholders
Triangulation/compare with multiple sources	PCA findings triangulated/compared with back ground survey, field trial, longitudinal study
Analysis of difference by multiple participants	4 groups of gender well-being segregated participants analysed the findings
Negative case analysis	
Peer checking	Compared with parallel similar works in other 3 countries
Contextual description and visualisation	Used resource map, seasonal calendars
Inquiry audits and validation by others	Results were discussed district level with others.
Impact on stakeholders	Able to hold the interest for a long period of study as they got continuous feed back, participated in direct intervention

Adopted from Pretty et al. (1995)

The household survey that built on the outcomes of the PCA enabled the collection of more focused information regarding specific areas. Questionnaire surveys are still the most commonly used method (Chambers, 1997), but may miss local complexity and diversity (Guijit and Pretty, 1992). Personal interviews have the highest response rates and permit the use of long questionnaires. They also enable researchers to use extensive probes (Neuman, 1994). All these aspects were considered in the current study.

Longitudinal study

Intensive PCA and one-off household surveys are efficient at capturing past experience and current issues but less useful for understanding longer term trends or the detail of seasonal complexity. Poverty and many other livelihood issues are subject to seasonal variation. Life cycle experiences or year round aspects are best understood through regular sampling of selected households. Such frequent interactions with participating households can be challenging in terms of their time and interest. The process may easily become researcher centered and needs to recognise that poorer households typically expect immediate benefits from participation. Building an understanding of the studies aims and good relationships with respondents was important. Moreover the timing and type of questioning should be sensitive, especially for individuals subject to time pressure. For example restricting recall questions is important or data validity is at risk

Worseley et al. (1984) found that monitoring intakes of certain foods (fresh fruits, vegetables, and sweet foods) was susceptible to social desirability biases. Such as respondents may show bias to mention some popular, prestigious food items. Hackett et al. (1985) found that survey fatigue, learning effects (eg. respondents may biased of mentioning consumption of some food items that they learnt as very important to their health), season of the year, day of the week and the subject's knowledge of the study's purpose influenced the measurement of food intake. Kim et. al. (1984) indicated that longer study periods and continual contact with the investigators contributed to the accuracy of reports. Witschi (1990) reported five general approaches to validate dietary methods are: 1) observation of intake, 2) weighting food before selection and consumption 3) comparing two approaches of reporting intake, 4) laboratory analysis of duplicate meals or food portions 5) biochemical determination of a physiologic variable related to a specific nutrient. Current study took account of 1-3 approaches. Sometime both husband and wife of a household were asked the intake amount of a same day to cross check. The surveyors of the current study were aware of various kinds of biases of the respondents.

Qualitative and quantitative

The use of both quantitative and qualitative approaches to understanding complex situations is increasingly considered most appropriate (Langworthy et al., 2001)'The quantitative data provided the basis for showing *what* and emphasizing what was representative, while the qualitative was able to reveal *how* and *why* and to highlight differences and variety within the range of human experiences in the areas studied - experiences that could help explain, problematise, and contextualize differences and changes in average values of variables from the quantitative survey' (Bagchi et al. 1998). Qualitative investigation was the focus at the beginning and end of the research mainly at community level. However, individual case studies, field visit reports, monthly meeting reports were critical to 'filling in' a complete picture. Moreover informal collection of information through working, directly with participants and frequent observation of their actions helped gain in depth understanding, particularly of the subtle and unstated relationships between variables in the current study. It was found that qualitative information can bring very powerful explanations which can be later triangulated with quantitative data.

Levels or steps of the investigation

Working from a macro to micro level inquiry is important for developing a sound understanding of any critical facts. However, it may not always necessary to follow a linear approach. The strength of the current study was to explore information first from the community level (meso) which was brought at macro level stakeholders prior to further in depth investigation at household (micro) level. It aimed to explore community level perspectives at the beginning which was validated by national level decision makers in a national workshop then explored household's perspectives through survey and directly working with farmers. However, it was felt that the beginning of the investigation may not have to follow a fixed direction from macro to micro level, rather can start at any level as necessary and then move to other levels.

6.6 Further research

The current study focused mainly on livelihood issues related to aquatic animals and SRS. However, more research can be directed towards innovative SRS management strategies to assist farmers to maintain sustainable natural harvests of SRS. This is particularly important given the process of privatisation and intensification underway throughout the country (Gregory et al.2007). More commercialised production may limit options for resource poor producers, though niche opportunities may expand (Muir, 2003).

Based on the current findings some follow up researchable issues can be addressed such as 1) investigation on environment and water management policy in favour of SRS and broader aquatic resource management 2) study on the small and medium size water body leasing systems and access for the poor 3) village and household level planning tools for SRS management in a village. Important technical issues are 4) flood and drought time management of SRS including refuge management in dry season, prey-predator management 5) comparative advantage of SRS brood management, use of over wintered carp seed and other competitive SRS 6) prospect of high value and low value SRS management particularly during lean SRS fish consumption period. Finally, greater attention should be given to the farming approach that do not exclude and damage SRS, sensitive to diverse aquatic biodiversity, ecosystem services and social basis (access, equity, ownership, lack of disparity in consumption) for sustainable aquatic resource management. Managing SRS is importnat for food and nutrtion security of the poor and for ecological sustainability. Management (including conservation, market intervention) of SRS in FMAS particually in low AA consumption and income months is a 'safety net' to the livelihoods of the poor. Protection of over expoitation of such species in FMAS is also an importnat concern (FMSP-1, 2006). Factors such as gender, well-being and zone/place of origin influence access to natural resources. Awareness of these factors should be reflected in the formulation and implementation of policy (NRSP-1, 2006)

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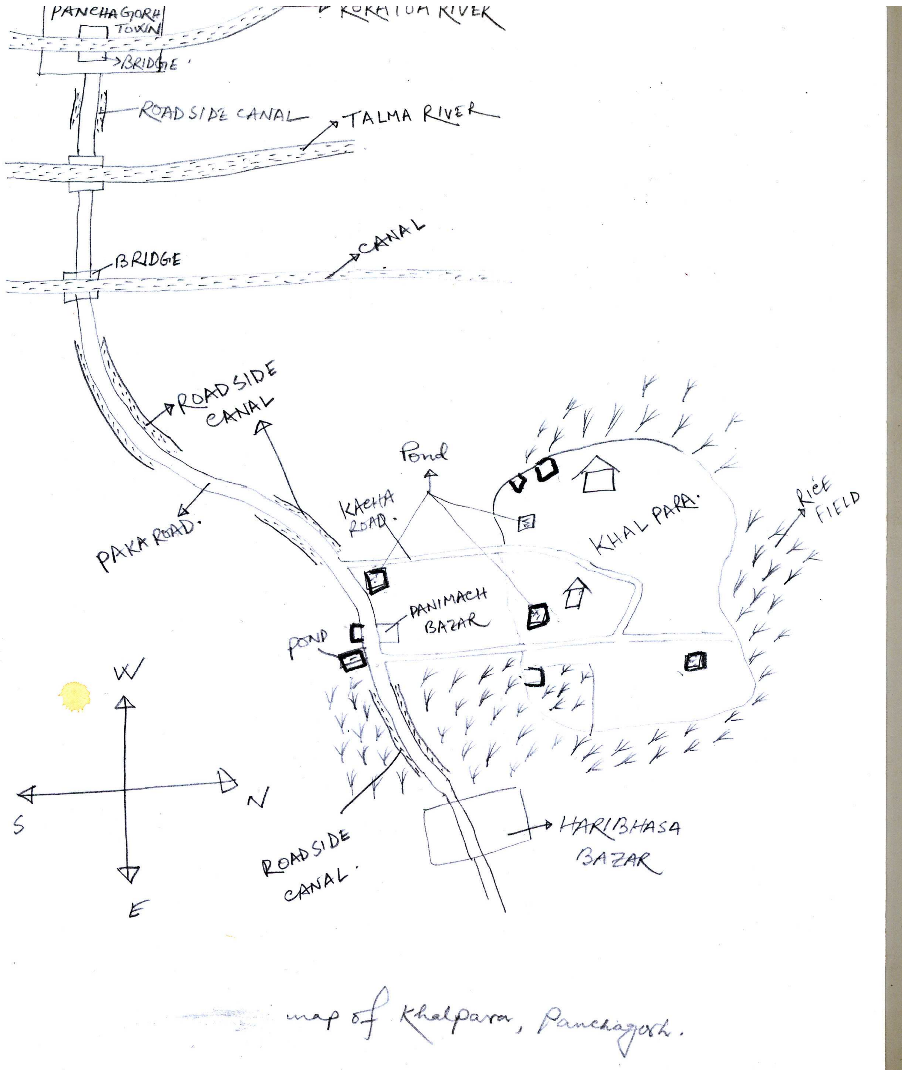
Appendices

Appendix 1: Example of a village resources map (Khalpara, Panchagohr) at PCA stage



Appendix 2: Some PRA tools and qualitative information collected at PCA stage

(Some of tools already presented in the respective chapter)

Appendix 2.1: Some qualitative information of a community

Surjanagar village at a glance where the community located

Village- Surjanagar
Community- Surjanagar
Union – Mizanpur
Thana – Rajbari Sadar
District – Rajbari
Number of household ……………………………. 80
Population …………………………………………200
Literacy rate ……………………………………… 45%
School (Primary)………………………………….. 01
School (High) …………………………………….. 01
Household used Sanitary latrine ………………… 80%
Wealth rank category …………………………….. Rich, Medium and Poor
Railway station …………………………………… 01
Post office ………………………………………… 01
Market ……………………………………………. 01
Ponds ……………………………………………… 30

Background information

Surjanagar situated in Rajbari Sadar Thana of Rajbari district. It is 12 Km from Rajbari town. At the north of village is Nayandia village and south is Mohadebpur village. At the east of this village is Durgapur village and at the west is Dayalnagar village. The general topography of the village is undulating. It has three type of lands likes upland, low land and homestead land. The distribution of land holding is not equal. Very small group of farmers have maximum land and the maximum farmers are medium and poor. It is very close to river of Padma. It is 3 Km far from the river of Padma. In this village there is a primary school, a high school, one railway station, one post office and a village market. Some of the roads of this village were pucca. So we can tell that it is an ideal village. In this village, apart from cooking women do other domestic works likes cleaning their house, looking after their children, doing homestead gardening, rearing domestic animal, take care of poultry and some of the women are day labor. Villagers cultivate in their land three type of paddy (*Aush, Amon and Boro*). It is their main crop. Some of the villagers cultivate in their land jute, wheat, banana, papaya, fodder, pulse, spice, vegetable, etc. There are about 30 ponds in this village. Most of them are perennial ponds. Villagers culture fish in all of these ponds. There are some people who have also do fish nursery in their ponds. At the rainy season the villagers take part to capture fish from adjacent *beel* or paddy field, which is situated in the village. Poor women also take part in fish capture. Some time women angling fish from their ponds.

Appendix 2.2: Well-being narrative

Rich: Have more land**,** able to land money, provide their children in good school, can spend more money for physician when necessary, have good house (half building, strongly made by tin) with good furnishers and television & cassette player, have milk cow for household consumption, some one have business or service.

Medium: Have land not more then 2.0 acres, provide their children in local school, can not spend so much money for physician, have tin roof house and in some cases television or cassette player, have good no. of livestock, in some cases have small business or service

Poor: Have land less then 1.0 acre including homestead, unable to provide their children in school, borrow money, can not take meal with full plate three times a day, at the time of illness they go to village doctors (*Kobiraz*), have thatched house and always feel tension for food.

Appendix 2.3: Time line Surjanagar, Rajbari

1971 ------- Freedom fight

1974 ------- Famine

1975 ------- IRRI rice, deep tube well started

1983 ------- Pesticide, fertilizer use started

1988 ------- Flood

1989 ------- Flood protection barrage build up

1990 ------- Abundance of SRS are decreasing due to barrage

1998 ------- Poultry farm start

Appendix 2.4: Sources of SRS: Mixed group, Surjanagar, Rajbari

Name of SRS		Pond	Canal	*Beel*	Rivers	Rice field / Flood plain
Shrimp	A	3	6	4	5	2
	F	3	6	4	5	2
Puti *(Puntius sophore*)	A	2	6	7	1	4
	F	2	6	7	1	4
Koi (*Anabas testudineus)*	A	1	4	7	-	8
	F	1	7	8	-	4
Magur (*Clarius batrachus*)	A	1	6	9	_	4
	F	1	6	9	_	4
Shing (*Heteropneustes fossilis*)	A	1	6	9	_	4
	F	1	6	9	_	4
Kajoli (Ailia coila)	A	-	1	2	17	_
	F	-	1	2	17	_
Pabda (Ompok pabda)	A	_	1	2	17	_
	F	_	1	2	17	_
Tara Baim (Macrognathus aculeatus	A	1	6	9	2	2
	F	1	6	9	2	2
Batashi (Pseudeutropius Atherinoides)	A	_	1	2	17	_
	F	_	_	_	20	_

A=adult, F= Fingerling/juvenile

Appendix 2.5: Information on livelihood options and trend, Surjanagar, Rajbari

Sl. No.	Livelihood options	Score			Trend	Causes
		M	F	T		
01.	Service holder	15	05	20	↗	(i) Educated people is increasing (ii) After the end of month they got salary (iii)Honorable job (iv) Can marriage in good family
02.	Small trading	60	-	60	↗	(i) More profit (ii)Can live well (iii)Those who start once –they try to continue
03.	Day laborer	06	10	16	↘	(i)Low income (ii)Income is higher on other trade (iii)Laborious work (iv)Don’t get work all over the year (v)They have need to work in rain and sunlight
04.	Fishermen	02	-	02	→	(i) Laborious work (ii) Have need to work in sunlight and rain (iii) don’t get honor in the society (iv) Now they don’t get more fish from the open water bodies
05.	Blacksmith	02	-	02	→	(i) Highly laborious work (ii)Profit is not sufficient (iii) Problem to sell the making goods (iv) Order gating from the people is not sufficient
06.	Khata making	-	03	03	→	(i) don’t get work all over the year (ii) laborious work (iii)Don’t get from the community people (iv) Low income
07.	Handicraft	-	17	17	↗	(i) High income (ii) Can work all over the year (iii) Demand of the work is high (iv)Rain and sunlight is not problem for the work
08.	Tailoring	50	3	53	↗	i)High income (ii)Can save himself from rain and sunlight (iii)Can work all over the year (iv)Rain and sunlight is not a problem for the work (v)Less energy consuming
09.	Village doctor	06	-	06	↗	(i)High income (ii)Prestigious work (iii)Some of the people are under training who will come in this work
10.	Carpentry	03	-	03	↗	i)High income (ii)Can save himself from rain and sunlight (iii)Can work all over the year (iv)Rain and sun is not a problem for the work
11.	Painter	02	-	02	→	(i) do not get sufficient work at the rainy season (ii)Laborious work (iii) lack of technical knowledge (iv) Have need to work in the sunlight
12.	Masonry	04	-	04	↗	i)High income (ii)Can save himself from rain and sunlight (iii)Can work all over the year (iv)Rain and sun is not a problem for the work
13.	Break field worker	05	-	05	↗	(i)High income than daily labor (ii)If they could not manage any work in his village than go to the break field (iii) Can do work during the dry season
14.	Washerman	02	-	02	→	i)Labor intensive (ii)Low income (iii)Electricity problem

Appendix 2.6: Information on seasonality of livelihoods activities Surjanagar, Rajbari

Sl. No	Livelihood options	B	J	A	S	V	A	K	A	P	M	F	C
01.	Service holder (Rich, Medium)												
02.	Small trading (R, M)												
03.	Day laborer (Poor)												
04.	Fishermen (P)												
05.	Blacksmith (P)												
06.	Khata making (P)												
07.	Handicraft (P)												
08.	Tailoring (M)												
09.	Village doctor (M)												
10.	Carpentry (P)												
11.	Painter (P)												
12.	Masonry (P)												
13.	Break field worker (P)												
14.	Washerman (P)												

Appendix 2.7: Seasonal calendar by Rich men at Surjanagar, Rajbari

Sl. No.	**Activites**	B	J	A	S	V	As	K	A	P	M	F	C
01	Rice: IRRI												
	Amon												
	Aush												
02	Jute cultivation												
03	Wheat Cultivation												
04	Vegetable cultivation												
05	Fish culture												
06	Social work												
07	Households												
08	Prayer												
09	Cow/ goat rearing												
10	Service												
11	Business												

Appendix 2.8: Seasonal calendar by poor men at Surjanagar, Rajbari

Sl. No.	Activites	B	J	A	S	V	As	K	A	P	M	F	C
01													
	Rice: Amon												
	Aush												
02	Rickshaw pulling												
03	Households												
04	Vegetable cultivation												
05	Day labor												
06	Social work												
07	Catching fish												
08	Prayer												
09	Cow/ goat rearing												
10	Spice												

Appendix 2.9: Seasonal calendar by Rich women at Surjanagar, Rajbari

Sl. No.	**Activites**	B	J	A	S	V	As	K	A	P	M	F	C
01	Rice: IRRI												
	Amon												
	Aush												
02	Jute cultivation												
03	Wheat Cultivation												
04	Vegetable cultivation												
05	Poultry												
06	Households												
07	Prayer												
08	Cow/ goat rearing												

Appendix 2.10: Seasonal calendar by Poor women at Surjanagar, Rajbari

Sl. No.	Activites	B	J	A	S	V	As	K	A	P	M	F	C
01													
	Amon rice												
	Aush Rice												
02	Catching fish												
03	Wheat												
04	Vegetable												
05	Poultry												
06	Households												
07	Prayer												
08	Cow/ goat rearing												
09	Cloth sewing												

Appendix 2.11: Seasonal Calendar (Farming Option), mixed group Surjanagar, Rajbari

Sl. No.	**Farming option**	B	J	A	S	V	As	K	A	P	M	F	C
01	Agriculture : IRRI												
	Amon												
	Aush												
02	Jute cultivation												
03	Sugarcane cultivation												
04	Maze cultivation												
05	Vegetable cultivation												
06	Fish culture												
07	Groundnut cultivation												
08	Poultry farm												
09	Pulse cultivation												
10	Papya cultivation												
11	Banana cultivation												
12	Sweet potato Cultivation												
13	Nursery (Plant)												
14	Spice cultivation												

Name of vegetables grown: 1. Indian 2. spinach 3. Red amaranths 4. Dante Spinach 5. Cauli-flower 6. Cabbage 7.Tomato 8. Bringal 9. GourdMatrix –Income & Expenditure:

Appendix 2.12: Matrix – Income & expenditure, Surjanagar, Rajbari

		B	J	A	S	V	A	K	A	P	M	F	C
INCOME	RICH	***	******	***	***	***	***	***	******	***	***	***	***
	MEDIUM	*	******	*	*	**	*	*	****	**	**	*	****
	POOR	**	****	*	**	***	*	*	***	*	*	*	*
EXPENDITURE	RICH	***	******	***	***	***	***	***	***	******	****	***	***
	MEDIUM	***	****	**	**	****	**	**	**	******	****	**	**
	POOR	**	**	**	**	**	**	**	**	**	**	**	**

Note: Score six means that is highest income or expenditure month
Score one means that is lowest income or expenditure month

Appendix 2.13: Seasonal Matrix: Some aquatic animal harvesting, by mixed group, Surjanagar Rajbari

Name of the fish		B Ap-May	J May June	A June July	S July Aug	V Aug Sep	A Sep Oct	K Oct Nov	A Nov Dec	P Dec Jan	M Jan Feb	F Feb Mar	C Mar Apr
Shrimp	**No.**												
	Eq.	Ghuni , Khoya Jal (Moshari Jal),Push net											
	Who	Mainly fishermen , Some time community people and children											
Puti	**No.**												
	Eq.	Vashal , Dry out of water ,current jal ,Ghuni ,Cast net											
	Who	Mainly fishermen and poor people , Some time all of the community people											
Koi	**No.**												
	Eq.	Barsha (one kind of hook) ,Koi Jal ,Khadon (Ghuni) ,Hook, Dry out of water											
	Who	Mainly fishermen and poor people , some time general people											
Magur	**No.**												
	Eq.	Barsha ,Hook , Current Jal ,Dry out of water											
	Who	Mainly fishermen , Foria , Some time general public											
Shinghi	**No.**												
	Eq.	Barsha ,Hook , Current Jal ,Dry out of water											
	Who	Mainly fishermen , Foria , Some time general public											
Kajoli	**No.**												
	Eq.	Ghono ber Jal (Naghani Jal)											
	Who	Fishermen											
Pabda	**No.**												
	Eq.	Ghono ber Jal (Naghani Jal)											
	Who	Fishermen											
Tara Baim	**No.**												
	Eq.	Ghoni , Koi Jal , Vashal , Dry out of water											
	Who	Mainly fishermen and poor people ,Foria , Some time general people											
Batashi	**No.**												
	Eq.	Ghono ber Jal (Naghani Jal)											
	Who	Fishermen											

Appendix 3: Aquatic system and livelihoods context survey (background) questionnaire

Self-Recruiting species in Aquaculture-their Role in rural livelihoods

Purpose:

To identify households for the long-term monitoring on the basis of:
Their character, management of aquatic resources
Aspects of their livelihood

QUESTIONNAIRE 2 : HOUSEHOLD LEVEL

ii Country: ________________
iii Province/District: ________________
iv. Zone ________________
v Commune: ________________
vi Village name: ________________
vii Group Name: ________________

viii Name of Respondent: ___________________________________

ix Age:___ x Sex :_(__)_(Male) xi Civil Status:_ (__)_Single

_(__)_(Female)

_(__)_Married

__(__)_widow

__(__)_divorce
__(__)_Others specify: _______

xii Relationship with the household head:
_(__)_Wife _(__)_Husband _(__)_Parents _(__)_Children
_(__)_house head

1. Profile of Household Head

1.1 Classification of the Household:
1.2 Well being Ranking from PRA: ____ ____ ____

1.3 Name: _________________

1.4 Age:___ 1.5 Sex :_(__)_(Male) 1.6 Civil Status:_ (__)_Single
_(__)_(Female) _(__)_Married

__(__)_widow__(__)_divorce __(__)_Others specify: _______

1.7 Education: _(__)_ (1) Primary (Level 1).............................
_(__)_ (2) Secondary (Level 2) ....
_(__)_ (3) High School (Level 3).......................
_(__)_ (4) Technical/Vocational.......................
_(__)_ (5) Bachelor...
_(__)_ (6) Higher Education.............................
_(__)_ (7) Did not go to school.........................

1.8 Occupation: (Rank)
____
____
____
____

1.9 Other skills________________
____

2. Profile of Household Members

2.1 Total number of household members: ___________
2.2 Visiting regularly (How many members?): ___________
2.3 Sending financial support (How many persons help) :__________

2.4

Age	Sex	Education	Health	Occupation	Other Skills Where?

2.5 Do you receive financial support from relatives or friends? _(__)_Yes _(__)_No
If yes, from whom?: ________________________

3. Household Assets

3.1 Land area:

Residential area: ________ m^2 Total Farm Area: _________ m^2
(= house + garden) = (ricefields)

Share, lease in: _________ m^2
Share,lease out: _________ m^2
Rent: _________ m^2

3.1a If you are renting land, for how long and on what terms (frequency of payments)?:

____

3.2 Livestock:

Livestock/poultry	Number
_______________	_________
_______________	_________
_______________	_________

3.3 House
Owned_(__)_
Rented_(__)_
Shared _(__)_

3.3.1 House material
Concrete _(__)_
Semi-concrete _(__)_
Wood _(__)_
Bamboo _(__)_
Leaves _(__)_
Other _(__)_ specify: _______

3.3.2Home Appliances: Refrigerator ( ),TV ( ), Radio ( ), Fan ( ), Flat iron ( ), Rice cooker ( ).
3.4 Farm equipment: ____
3.5 Fishing gears: ____

3.6 Other assets, do they have:
Ricemill _(__)_
Shop _(__)_
Bicycle _(__)_
Motor cycle _(__)_
Other business _(__)_ , specify: __________

3.7 Access

3.7.1 Do you have access to irrigation? _(__)_Yes_(__)_No

Water coming into your system is from:
Lake _(__)_
River _(__)_ Dam _(__)_
Reservoir _(__)_ stream _(__)_
Rainfed _(__)_ Others _(__)_ , specify: ___________

3.7.2 Do you use common land to:

Collect Food _(__)_ Collect Wood _(__)_
Crops _(__)_ Fishing _(__)_
Graze livestock_(__)_ Others _(__)_, specify:_________

3.7.3 Can you get credit from the following and in what form:

_(__)_Commercial bank __________
_(__)_Government bank __________
_(__)_Gov't organization __________ specify the name:___________
_(__)_Private lenders __________
_(__)_Cooperatives __________
_(__)_Others __________ specify the name:___________

4. Physical Characteristics of Aquatic System

	Number	Area m^2	Flooded	Polluted	Stocked	Depth (m) Wet season	Depth (m) Dry season
Ponds (in ricefields)	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________
Other ponds	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________
Rice fields	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________
	____	_____	_( )_	_( )_	_( )_	_________	_________

If the system is polluted, what is the nature of pollution? ____________________

5. Farming

How many cropping per year?
Rice __________
Crop __________

6. Management

6.1How long have you been managing the system?
In rice paddy: _____ in ponds:_____in ponds in ricefields:______

6.2 Do you ever stock fish? Yes_( )_ No_( )_
6.2a If yes, how often do you stock:
in rice paddy: _____ in ponds:_____ in ponds in ricefield:______

6.3 Source of Seed Species

Trader	_( )_	____________________
Government	_( )_	____________________
Neighbour	_( )_	____________________
Private hatchery	_( )_	____________________
Others	_( )_, specify:	__________________

6.4 How did you avail of the seed?

Given free _( )_
Purchased _( )_
Catch _( )_
Other _( )_, please specify: _______________

6.5 Do you allow/attract aquatic organisms to enter into your system?

6.5.1 If yes, what do you do to accomplish this?

_( )_Digging ponds or ditches
_( )_branches/brish parks
_( )_retain water
_( )_feed fish
_( )_fertilise
_( )_others, please specify: ______________

6.5.2 If no, what do you do to prevent them from entering:

_( )_putting screen
_( )_other, please specify: ______________
_( )_none

6.6 Do you eliminate SRS in your system? _( )_Yes_( )_No

6.6.1 If yes, what do you do to eliminate SRS?

_( )_application of pesticide
_( )_drying of the system, when? ___________ method? ______________
_( )_others, please specify _____________________

6.6.2 If no, why? ______________________________

6.7 Harvesting

How often do you harvest in your own systems?

_(__)_ Regular Specify__________
_(__)_ Seasonal Specify__________
_(__)_ Occasional Specify__________
_(__)_ Fishing day Specify__________
_(__)_ Others Specify__________

6.8 Do you sell fish? Yes _(__)_No _(__)_

6.8.1 If yes, where do you sell?

Place Species

__________________ __________________
__________________ __________________
__________________ __________________

6.8.2 How do you compare the amount of fish you sell ?

		More	Same	Less
Ponds in ricefields:	Stocked	_(__)_	_(__)_	_(__)_
	Wild	_(__)_	_(__)_	_(__)_
Other ponds:	Stocked	_(__)_	_(__)_	_(__)_
	Wild	_(__)_	_(__)_	_(__)_
Rice field:	Stocked	_(__)_	_(__)_	_(__)_
	Wild	_(__)_	_(__)_	_(__)_

6.9 Give the 6 most important species (local name) of SRS which you harvest:

Ponds in ricefields	Other ponds	Rice field
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

7. Will you be interested to join our project research of one year monitoring (visit one time per month)?

WE WILL BE MONITORING MORE ON LIVELIHOOD ASPECTS, AQUATIC RESOURCE USE, AND
ECOLOGICAL PARAMETERS

Appendix 4: Household level year round monitoring

Questionnaire for monitoring of household livelihoods

DATE: _____________ Village:________________ HH code:___________

Household Activities

1. Agricultural activities on household land ***IN THE LAST SEVEN DAYS***

Household member	**Agricultural activities**	Where (code)	Frequency	Time spent (Total)

Major other agricultural activities on HH land during the last month:

____

____

2. Agricultural activities on other people's land ***IN THE LAST SEVEN DAYS***

Household member	Agricultural activities	Where	Frequency	Time spent (Total)	Remarks

Major other agricultural activities on other's people land during the last month:

____

____

3. **Aquatic Animal management** ***IN THE LAST SEVEN DAYS*** **on all land - use the 1st set of map 1,2,3**

Household member	Activities	Where	Frequency	Time spent	Remarks

Other AA management activities in the last month:

____

____

4. Aquatic animals collected IN THE LAST SEVEN DAYS (use the same first set of the 3 maps)

Who collected	Species	Size						Location	Gear used	Frequency and time spent	What do you do with them				Why and where if sell
		Big			Small										
		Type of stick	Nb	Kg	Type of bowl	Nb	Kg				Sell	Con	Give	Proc	

Comparison for the last month:

AA Species	Week 1	Week 2	Week 3	Week 4	Total number of beans
					20
					20
					20
					20
					20
					20
					20
					20
					20
					20
					20
					20
					20
					20

5. Life history information for the last month : use the 2de set of map 1, 2 ,,3

5.1 Have you seen any aquatic animals with eggs in any place you used to go (within the 3 maps) Species? Where?

Indicate on the most appropriate of the 3 maps the precise location (if possible) where they saw AA with eggs (perhaps they ate AA with eggs and remember where they caught them), indicate the species name and a code to know that it is about egg exp: * Eg-Anabas testudineus

5.2 Have you seen any movement of aquatic animals from one place to another?

Indicate by simple arrow the direction of the animal they saw moving, and the name of the species if possible.

5.3 Have you seen any offspring (larvae, juveniles) aquatic animals in the system? If yes can you give an idea of the quantity you saw (few or large)

Indicate on the map where they saw them, use a code exp: * L-Anabas few; * J-*Channa striata* large

5.4 Have you seen any reproductive or spawning behavior in aquatic animals?

Indicate on the map where they saw reproductive behavior (some species are going in a special shallow place for reproduction) : * R-*Esomus metallicus*

And spawning location where AA release eggs: *S- *Esomus metallicus*

5.5 Have you seen any sign of diseases or parasites on the aquatic animals?

Where	Species	Sign of disease

General questions:

5.6 Have you ever noticed some AA that feed (eat) some other AA? If yes explain which one

5.7 Did you ever notice certain frequent association of AA? If yes, which one

6. Non-farm activities (both in the village and outside the village) *IN THE LAST SEVEN DAYS*

Household member	Activities	Frequency	Where	Time spent	Remarks

Other major non farm activities during the last month:

____

7. Food consumption *IN THE LAST three DAYS*

7.1 Types of food eaten

Types	Frequency	Quantity	Source	Preparation	Who eats	Remarks

Any other special food eaten during the last month?:-

____

7.2 Types of aquatic animals eaten ***IN THE LAST SEVEN DAYS***

Species	Quantity	Frequency	Source	Preparation	Who eats	Remarks

Any other special AA eaten during the last month:

____8. Income *IN THE LAST SEVEN DAYS*

Source	Y/N	Who	Frequency	Amount
Wages				
Income from rice				
Sales from farm production				
Livestock				
Selling aquatic animals				
Selling aquatic plants				
Services (rental of land, equipment)				

Any other important income during the 3 preceding weeks?:

9. Expenditure *IN THE LAST SEVEN DAYS*

Expense	Y/N	Who	Frequency	Amount	Remark
Rice					
Other food					
Farming needs					
Livestock					
Buying aquatic animals: 1: 2: 3:					
Buying aquatic plants					
Services (school, clothes)					

Any other important expenses during the 3 preceding weeks?:

---

10. Visitors/helpers <u>in the last month</u> Y/N: ____

Relationship	Purpose of visit	Frequency	Time spent

11. **Other questions regarding the last month**
   a. Has anyone been ill in the last month? Y/N:____ if yes, who?:______

   b. Has any livestock been born or died in the last month? Y/N____
      if yes what:_______

   c. Did any special occasions happen in the last month? (Festivals), Y/N? ____
   If yes, precise: ________

12. Questions regarding the next month

   a. Will there be any big aquatic animals harvests in the next month (e.g. from your ponds, cultured ponds?) Y/N? _________

   If yes, please precise where and when: ____

   b. Will any special occasions happen in the next month? Y/N? : _______
   If yes, precise: ____

   And will any aquatic animals be required for these special occasions? Y/N? ____
   If yes, precise: _______________________________________

Physical parameters:

Every 2 months, we should inspect the aquatic systems and record on the map 1(from the 2de set)

- Actual water depth of the systems (F, P.)
- Flow communications
- Permanent shade area (plants on the surface of the ponds)
- Flooded area (actual)
- Temperature of the water
- Turbidity (Secchi disk)
- Soil (only one time, unless it changes during the year)

Interviewer's signature (when questionnaire is complete, all the missing answer are explain:

Appendix 5: Village information: Farmer participatory trial

Social context of the village collected during site selection

Indicators	Shakerhat Village	Shamshernagor Vill	Chandanbari Vill.
Location	7km from the Thana/District town	2.5 m from Thana town, 15 km from district town	4 km from Thana town,14 km from dist town
Population	125 household(hh) very few fisher	160 hh	160 hh
Soil	Dry area, sandy-loam,	Moderate water holding capacity, 45% sand, 55% clay	Moderate water holding capacity,60% clay, 40% sandy
Water	Most ponds dries up by Feb, 6-7 months water for fish culture, rice fileds: 2-3 months	Same as Chandanbari	In ponds : 7-8 on ths, in rice fields 2-3 months
Institutions	One High School,1 non-formal primary school, 1 Mosque,	One Primary School, 3 Mosque, 1 Religious school/madrasha, one local market	One Primary School,1 High School, 1 Religious School/madrasha, 1 Community Clinic,2 Mosque, 1 Union Council
Literacy	47%	41%	47%
Poor hh	60%	65% hh poor	61% hh are poor
Food insecure period	Same	Same as Chandanbari	March, April, Sep, Oct
Less income period	Aug and October	same	Aug, Sep, Oct
Flood, drought	Not largely flood affected, affected by drought, some time affected by long winter	Not largely flood affected, affected by drought, some time winter	Not flood affected but affected by drought, long winter (Nov- April)
Main aquatic systems	32 ponds, one river flows nearby the village	38 ponds, one small river flows close to the village	35 ponds, rice fields, a small river, some low lands
Wage rate	same	Varies by season and gender, male : 50-80tk./day, female : 30-60Tk/day	Male :60-80Tk/day, Female: 30-50Tk/day
Main crop	Ground nut, nut, sesame, wheat, vegetable, rice Watermelon, tomato are cash crops	Ground nut, nut, sesame, wheat, vegetable, rice, recently HYV rice and jute.	Ground nut, nut, sesame, wheat, vegetable, rice

Appendix 6: Monthly meeting record with trial farmers

<u>Monthly meeting report</u>
July, 2003
Shakerhat

Panchaghar

Objective of the monthly farmer workshop:

1. Collect qualitative evidence (individual, group) on SRS management strategies tried by the farmers last month
2. Record practical information on SRS conservation measures in ponds and rf ponds last month
3. Record on going changes as a result of project facilitated works last month/cumulative effect

The meeting at Shakerhat started at 10.00 am at Md. Tamiz's house and ends at 1:30 PM.. It is an important time when farmers completed their carp stocking and stocked Shing brood in 12 SRS positive ponds and 40% SRS positive ponds were stocked with Koi, Shing, Magur finerling. Although stocking of brood was late, farmers observed shing breeds in 2 ponds (out of 8). Framers realised that SRS (#3) broods could be stocked little earlier although they faced problem to manage brood fish from natural sources.
Thirteen farmers were present in the meeting. The participants were: tamiz uddin, Chahir Uddin, Hasen Ali, Iazul Haque, Rafizul Haque, Anarul Islam, Rasida Begum, Khoir Uddin, Ashraful Haque, Mokhlesar Rahman, Fazle Alam Minto, Md. Kaium, absent- Nozmol Haque, Mosharof Hossain, Tuzammel Haque, Hasibul Islam.

Clarifying the reason of this kind of monthly gathering Faruk highlighted that this process of monitoring would be very useful in participatory decision making on the management techniques. Md. Kaium - a SRS positive farmer expressed satisfaction of close follow up by the project which improved their pond management than last year. He pointed that some of them were reluctant to put feed in the ponds regularly due to other important job like rice planting. But all farmers found to feed sesame/til waste (not seed)- a locally available feed for fish. During *Amon* rice plantation they normally run short of cash in hand and partial project support for trail inputs (loan money) was useful for them to participate in the research. He raised that it would be difficult to separate off springs from the stocked broods as some of the pond may already have few Shing broods that were not stocked. Faruk replied that we could partially solve the problem by sampling. Shams reported that some fishermen observed - Shing breeds later than Koi and Magur. Md. Chahir Uddin – a SRS negative farmer found to stock 6 tilapia brood in his pond collecting from market which breeds now. He also said, his neighbor Rafizul (SRS positive farmer) asked some tilapia seed from him. Ashraful(SRS Positive) expressed that he is still in doubt with the result of stocked broods, faced problem in identifying good fish seeds especially rui, catla, mrigel and commented that we could stock brood 15 days earlier. He suggested to apply more cow dung for better growth of magur and shing. Anwarul – a van puller (SRS negative) said he harvested 6 Shorputi for family consumtion, want to check the growth of fish. Fazle Alam Mintu(SRS positive) reported that shorputi is gowing slowly in his pond and wanted to know the reason.. Then some farmers discussed different types of shorputi feed like –mulberry plant leaves, tender papaya and pumpkin leaves, termite nest, soft leaves and grasses. Some farmer discussed the need of managing net and bamboo fence to protect fish from escaping during flash flood (particularly in September). Moklesur Rahaman (SRS neutral) told that 12 Silver carp died in his pond due to water pollution by a rotten tree branches.

Mr. Shams noted that out of 35 farmers in both sites 9 farmers under SRS negative category able to manage overwintered (30% of the total fingerling) and only 2 farmers of SRS positive category at Shakerhat stocked overwintered fingerlings.

Hope	Fear	Constraint	Lesson	Plan	Coping strategy/stragle
SRS positive: better production than last	brood management escaping of brood,	Less avilability of SRS brood, brood harvesting from deep water ponds Could not estimate all remaining SRS broods particularly catfishes. applying fertilizer in rice field also a priority.	One farmer strongly belive shoal/snake head can be managed in carp polyculture understanding predatory behaviour. Brood could be stocked earlier. Water depth and slope of pond, bushes, special shelter are the factors for breeding, it was only possible to catch shing, magur broods from a prennial pond of 4 feet depth.Sunny and drought days are important to catch broods	Conserve SRS brood for next year, Apply cowdung dose high in SRS pond, Arrange netting/sampling, fertilization regularly, Creating environment for breeding , Emphasise especial feeding for SRS, Arrange net bana to protect SRS and carps during heavy rain	Finally managed brood from a group of fishermen (6) harvested from Union Parishad pond, 8 km away from the study village. 8 pond owners did not vacant remaining fishes from their pond, project assessed remaining fish through several netting.
Negative: let us see the result from SRS positive ponds, will get better carp production than last year. Happy to learn systematic steps of aquaculture. One farmer ask for tilapia seed recruted in his pond.	Short duration of the project. Cannot identify good quality feed seed. Sometimes difficult to record minor harvest done by the children. Few fish escaping was not possible to record in one or two ponds. Growth of sorpunti and catla are slow. Fear from disease.			Supply duck weed/ khudipana, malberi plant leaf, pumpkin leaves, and other tender soft leaves and grasses. Applying lime befor starting winter.	
Neutral Better result from carps	Application(Inappropriate ???)of lime may cause death of fish, few of them are changing towards SRS positive	Resource is not suitable for SRS, have other important activities, not awre of benefits	It is dificult to keep farmers as SRS neutral, one farmers found to stock tilapia from market	Strongly document the reasons of changing in attitude, Encourage them to do carp polyculture properly like other two groups,	Now it is easier for them to motivate for SRS, Geeting more access to knowledge on SRS happening in the same village, learning from neighbour farmers

Common issues:

- More secure information/plan needed on getting (availability/sources) selected SRS broods in May June . Source of SRS fingerling(Koi, Shing, Magur, Tengra) , harvesting and transpoting techniques.
- All category of farmers understood the benefit of over wintered fingerling but it was not accessable for all(cause – sesonal, prennial ponds, lack of cash, availability)
- What type of extra feeding and fertilisation is important for managing Shing, magur, koi and other SRS in their ponds?
- Some small SRS like puti, darika is commonly found in all category of ponds which came naturally. This is good for consumption.
- Many farmers faced problem to identify Rohu, Catla, Mrigel fingerling.
- How to compare production data form 50% seasonal and 50% prennial ponds? This factor affects in variation of stocking dates. Some species were available in the early season and some in July August.
- Many farmer thinks that it would be dificult to keep Koi (Climbing perch) in ponds than magur and shing. Some magur & shing also may escape from the pond during rainy days which need to be protected by creating special shelter(means-keeping some thatch, coconut case, earthern pot, piece of bamboo & nut pipe, branches, bushes, coconut leaves in the shallow slope of ponds) and using net in the pond embank.
- Can shol (snake head) and Puntious would be a suitable species to manage in farmers ponds considering its availability and easy catchability?
- Recording of consumption and harvesting information may become dificult to some extent. Need close follow up.

Key action for next month for the project:

Key Actions	Time	Responsibilty
1. Complete SRS (Koi, Shing, Magur) fingerling stocking	Any how by 15 August	Shams, Fishermen, Tamiz Udding, UP Chairman
2. Share idea of creating breeding environment and shelter for Sing, Magur and Koi . Plan for protecting carp and SRS during flood. Discuss on possible interaction between carps and SRS.	20 Aug	Shams, farmers
3. Refine the monitoring indicators and clarify key research questions and hypothesis	30 Aug	Faruk, Shams, Dave, Wahab
4. Primary analyis on to date(stocking, SRS management, brood stocking,village case study)	30 Sep	Faruk, Shams
5. Share idea and demonstrate SRS feeds. Disburse rest of the refundable loan amount as demanded by the farmers.	20 Aug	Shams, Faruk
6. start to write issue based project discussion paper on 2 issues	Sep	Shams, Faruk
7. 1st round Pond sampling completed	By Aug 20	Shams, Faruk

Appendix 7: Chi-Square test output on education attainment

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
wellbeing * education	119	100.0%	0	.0%	119	100.0%

rank * edulas Crosstabulation

			Education level group				Total
			1	2	3	4	
wellbeing	Low	Count	17	9	2	26	54
		% within rank/wb	31.5%	16.7%	3.7%	48.1%	100.0%
		% of Total	14.3%	7.6%	1.7%	21.8%	45.4%
	Medium	Count	13	11	2	9	35
		% within rank	37.1%	31.4%	5.7%	25.7%	100.0%
		% of Total	10.9%	9.2%	1.7%	7.6%	29.4%
	High	Count	6	16	4	4	30
		% within rank	20.0%	53.3%	13.3%	13.3%	100.0%
		% of Total	5.0%	13.4%	3.4%	3.4%	25.2%
Total		Count	36	36	8	39	119
		% within rank	30.3%	30.3%	6.7%	32.8%	100.0%
		% of Total	30.3%	30.3%	6.7%	32.8%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.834(a)	6	.002
Likelihood Ratio	20.862	6	.002
Linear-by-Linear Association	3.643	1	.056
N of Valid Cases	119		

a 3 cells (25.0%) have expected count less than 5. The minimum expected count is 2.02.

Appendix 8: Univariate Analysis of Variance on vegetable consumption

(Household monitoring)

Univariate Analysis of Variance

Between-Subjects Factors

		N
zone	1	312
	2	288
wb	1	264
	2	168
	3	168
months	1	50
	2	50
	3	50
	4	50
	5	50
	6	50
	7	50
	8	50
	9	50
	10	50
	11	50
	12	50
com	1	48
	2	108
	3	132
	4	48
	5	48
	6	48
	7	48
	8	48
	9	48
	10	24
hhid	41101	12
	41102	12
	41103	12
	41104	12
	41205	12
	41206	12
	41207	12
	41208	12
	41309	12
	41310	12
	41311	12
	41312	12
	41413	12
	41414	12
	41415	12
	41416	12
	41517	12
	41518	12
	41519	12
	41520	12
	41621	12
	41622	12
	41623	12
	41624	12
	42801	12
	42802	12
	42803	12
	42804	12
	42805	12
	42806	12
	42807	12
	42808	12
	42809	12
	42810	12
	42811	12
	42812	12
	42813	12
	42901	12
	42902	12
	42903	12
	42904	12
	42905	12
	42906	12
	42907	12
	42908	12
	42909	12
	42910	12
	42911	12
	42912	12
	42913	12

Tests of Between-Subjects Effects

Dependent Variable: vegpc7dg

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	2723541440.678	1	2723541440.678	213.720	.000
	Error	92152717.762	7.231	12743487.847(a)		
zone	Hypothesis	50926520.153	1	50926520.153	3.984	.085
	Error	92004411.691	7.197	12784037.052(b)		
wb	Hypothesis	4679501.155	2	2339750.577	.429	.654
	Error	196265662.789	36	5451823.966(c)		
months	Hypothesis	200935454.105	11	18266859.464	20.539	.000
	Error	430464857.290	484	889390.201(d)		
com(zone)	Hypothesis	95677625.993	8	11959703.249	2.194	.051
	Error	196265662.789	36	5451823.966(c)		
hhid(zone * wb * com)	Hypothesis	196265662.789	36	5451823.966	6.130	.000
	Error	430464857.290	484	889390.201(d)		
zone * wb	Hypothesis	2464603.639	2	1232301.819	.226	.799
	Error	196265662.789	36	5451823.966(c)		
zone * months	Hypothesis	63279663.106	11	5752696.646	6.468	.000
	Error	430464857.290	484	889390.201(d)		
wb * months	Hypothesis	33711534.472	22	1532342.476	1.723	.022
	Error	430464857.290	484	889390.201(d)		
zone * wb * months	Hypothesis	23039459.575	22	1047248.163	1.177	.262
	Error	430464857.290	484	889390.201(d)		

a 1.120 MS(com(zone)) - .120 MS(hhid(zone * wb * com))
b 1.127 MS(com(zone)) - .127 MS(hhid(zone * wb * com))
c MS(hhid(zone * wb * com))
d MS(Error)

Expected Mean Squares(a,b)

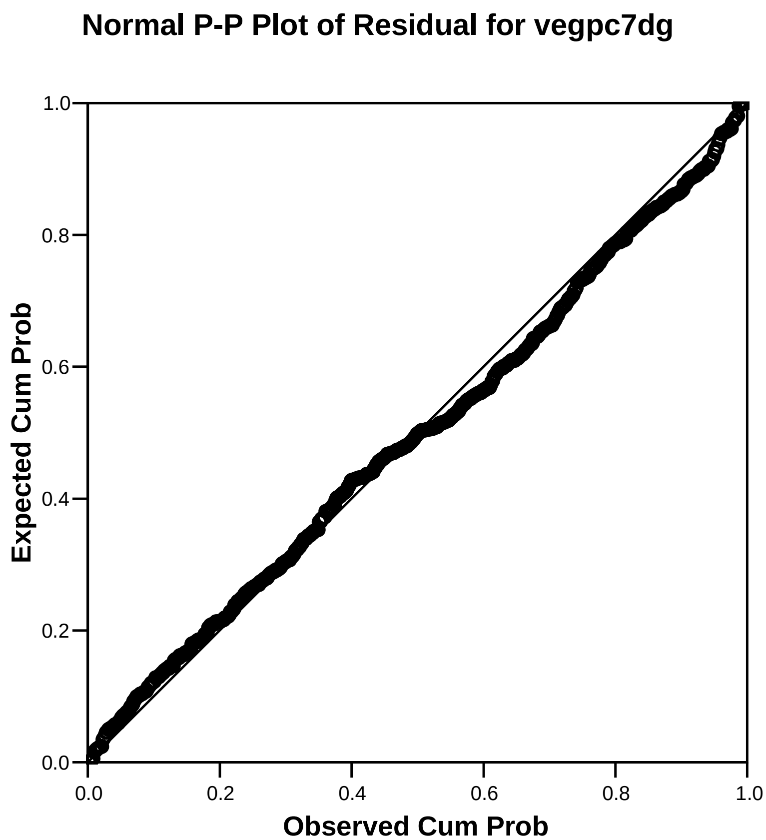
Source	Variance Component			
	Var(com(zone))	Var(hhid(zone * wb * com))	Var(Error)	Quadratic Term

Intercept	53.349	12.000	1.000	Intercept, zone, wb, months, zone * wb, zone * months, wb * months, zone * wb * months
zone	53.646	12.000	1.000	zone, zone * wb, zone * months, zone * wb * months
wb	.000	12.000	1.000	wb, zone * wb, wb * months, zone * wb * months
months	.000	.000	1.000	months, zone * months, wb * months, zone * wb * months
com(zone)	47.615	12.000	1.000	
hhid(zone * wb * com)	.000	12.000	1.000	
zone * wb	.000	12.000	1.000	zone * wb, zone * wb * months
zone * months	.000	.000	1.000	zone * months, zone * wb * months
wb * months	.000	.000	1.000	wb * months, zone * wb * months
zone * wb * months	.000	.000	1.000	zone * wb * months
Error	.000	.000	1.000	

a For each source, the expected mean square equals the sum of the coefficients in the cells times the variance components, plus a quadratic term involving effects in the Quadratic Term cell.
b Expected Mean Squares are based on the Type III Sums of Squares.

Syntax:

```
UNIANOVA
  vegpc7dg  BY zone wb months com hhid
  /RANDOM = com hhid
  /METHOD = SSTYPE(3)
  /INTERCEPT = INCLUDE
  /SAVE = PRED RESID
  /CRITERIA = ALPHA(.05)
  /DESIGN = zone wb months com(zone) hhid(zone*com*wb) wb*zone months*zone
months*wb months*wb*zone .
```


Normal P-P Plot of Residual for vegpc7dg
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0