Livelihood Analysis of the Importance of Self-Recruiting Species in Northwest Bangladesh, and the additional Effects of 'Rotenone®' Usage on this

MSc Aquaculture Thesis

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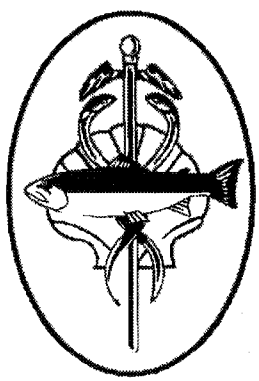

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Figure 1 Market stall trader at Dinajpur district market, Northwest Bangladesh

Abstract

Aquaculture within Bangladesh is rapidly on the increase due to the wide availability of small waterbodies (<0.2ha) appropriate for small-scale development. Aquaculture on average represents 15% of a pond owner's income and therefore has an impact on the livelihoods of themselves and their family. Extension efforts to expand aquaculture concentrate on the exclusion of Self-Recruiting Species (SRS) through flood control, draining ponds or adding piscicides.

Analysis shows livelihoods, within the region, rely on aquaculture as a form of social, financial, natural and human capital. SRS constitute on average 10% of pond production and income but are much more valuable to the owner primarily as a source of nutrition with added social and financial bonuses. SRS are often eaten whole (providing a bounty of vitamins and minerals), they are also used as a gift source to maintain / boost social status. Some SRS can actually provide a large income source, especially when sold at district markets and boost the households financial income (some species being sold at more than double the price of stocked species per kilogram). Current exclusion efforts, recommended by the Northwest Fisheries Extension Project (NFEP) through piscicide use (Rotenone®) have proved ineffective, partly due to poor extension services and the pond owners unwillingness to remove a 'free' income source, concerned more with encouraging SRS into the pond.

Results show no impact of SRS on pond yield at the levels studied and are viewed by the entire community as by far the most nutritious fish source. They are seen to have the greatest impact on the poorer community through providing them with a numerous and affordable food source, also reducing the countries malnutrition problems ensuring a food source available for all.

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Glossary

ANOVA = Analysis of Variance (a statistical parametric test)

Bazaar = Local rural / urban market (daily)

Beel = A perennial closed reservoir / body of water

Decimel = A unit of area used to describe pond size and other areas, one decimel = 40.47m^2

DFID = Department For International Development (UK Government)

District = An area containing several *Thanas*

Division = One of the 6 separations of Bangladesh's landmass containing several districts

DoF = Department of Fisheries

Haat = A village market day (often twice weekly), a bazaar can be open 5 days a week with 2 haat days

MV = Model Village

NFEP = Northwest Fisheries Extension Project

NGO = Non-Governmental Organisation

NMV = Non-Model Village

Para = A cluster of houses within a village

PRA = Participatory Rural Assessment

RRA = Rapid Rural Assessment

Rotenone® = A chemical used as a piscicide / insecticide (see Introduction)

SIS = Small Indigenous Species

SRS = Self-Recruiting Species

TFO = Thana Fisheries Officer

Thana = The smallest administrative unit in Bangladesh, a collection of several unions

Union = A collection of 5-10 villages

SRS and Stocked Fish

(Latin & Local names)

Local Name	Latin name	SRS, Stocked species, or River species
Ayre	*Mystus aor*	River
Baim	*Mastacembelus armatus*	SRS
Bata	*Labeo bata*	SRS
Batashi	*Pseudotropius atherinoides*	SRS
Bhagna	*Cirrhinus reba*	SRS
Bighead carp	*Aristichthys nobilis*	Stocked / SRS (flood)
Boal	*Wallago attu*	SRS
Catla	*Catla catla*	Stocked / SRS (flood)
Chanda / Chandra	*Chanda* sp.	SRS
Chingri	Local freshwater shrimp sp.	SRS / Stocked
Chital	*Notopterus chital*	River
Common / Mirror carp	*Cyprinus carpio*	Stocked / SRS (flood)
Darika / Darkina	*Rasbora daniconius*	SRS
Dhela	*Rohtee cotio*	SRS
Foli	*Notopterus notopterus*	SRS
Frogs	Various sp.	SRS
Gajar / Gajal	*Channa marulius*	SRS
Gossi	*Nandus nandus*	SRS
Grass carp	*Ctenopharyngodon idellus*	Stocked / SRS
Gucchi	*Mastacembelus pancalus*	SRS
Gutum / Puiya	*Lepidocephalus guntea*	SRS

Local Name (contd.)	Latin name	SRS, Stocked species, or River species
Ilish	*Hilsa hilsa / ilisa*	River
Japani / Common carp	*Cyprinus carpio*	Stocked / SRS (flood)
Khalisha	*Colisa* sp.	SRS
Koi	*Anabas testudineus*	SRS
Magur (Indian)	*Clarius batrachus*	SRS
Magur (African)	*Clarius gariapenus*	SRS / River / Stocked
Mola / Moya	*Amblypharyngodon mola*	SRS
Mrigel	*Cirrhinus mrigala*	Stocked / SRS (flood)
Pabda	*Ompok pabda*	SRS / Stocked
Pangas	*Pangasius pangasius*	SRS / Stocked
Puti (Local / deshi)	*Puntius sophore*	SRS
Rani	*Botia dario*	SRS
Rita	*Rita rita*	SRS
Rui	*Labeo rohita*	Stocked / SRS (flood)
Sharputi (culture)	*Puntius gonionotus*	Stocked / SRS (flood)
Sharputi (wild)	*Puntius sarana*	SRS
Shillong	*Silonia silondia*	River
Shing / Shingi	*Heteropneustes fossilis*	SRS
Shol	*Channa striatus*	SRS
Silver carp	*Hypopthalmichthys molitrix*	Stocked / SRS
Snails	Various sp.	SRS
Taki / Shati	*Channa punctatus*	SRS
Tara baim	*Macrognathus aculeatus*	SRS
Tengra	*Mystus* sp.	SRS

Local Name (contd.)	Latin name	SRS, Stocked species, or River species
Tilapia (GIFT)	*Oreochromis niloticus*	Stocked / SRS (flood)
Tora	*Macrognathus aral*	SRS

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1. Introduction

Introduction

1.1 Bangladesh as a country

Bangladesh is a country in South Asia surrounded by India (on its North, West and East borders), with its south coast sloping calmly into the Bay of Bengal. The country covers an area of about 144,000 square kilometres and is segmented by mighty rivers, such as the Padma, Meghna, Jamua and their numerous tributaries. This is one of the misfortunes of Bangladesh as, due to its rather flat landscape the country is prone to flooding, water can cover up to 70% of the landmass for 4-6 months each year. Located in one of the wettest areas of the world, Bangladesh has a tropical monsoon climate characterised by rain bearing winds, high temperatures and a high humidity (Felts, Rajts & Akhteruzzaman, 1996). The monsoon season is between June and September, and the flooding can have a both devastating and beneficial impact, on fish production. Whilst attempts to culture fish and shrimp can be devastated by flooding, natural floodplain fisheries are supported by the process. The flood plain of Bangladesh contains one of the most productive and diverse freshwater faunas of any country in the world, this can produce the very fertile soils of deltas etc. and wash away pollutants, all culminating in the continued fuelling of the intertwined food webs that support fish production.

The country's population consists of approximately 124 million people, comprising of 85.9% Muslims, 12.1% Hindus, 0.8% Buddhists, 0.7% Christians and 0.5% others. Over 65% of the total population are employed in agriculture, and Bangladesh therefore has a large agriculturally based economy – accounting for nearly 46% of the country's GDP. The major industries of Bangladesh are the processing of jute, leather, clothing, pharmaceuticals, frozen fish and frogs legs (NFEP-2, 2000). Therefore two of these can in fact be seen to be major

incomes for the country based on aquaculture / fisheries and may in fact benefit / impact from any information or results provided by this study.

Bangladesh is divided into six administrative divisions; divisional commissioners head administration to the districts of Dhaka, Chittagong, Khulna, Raj Shahi, Barisal and Syllhet. The community level divisions are given below in Table 1.1.

Table 1.1: Administration divisions of Bangladesh

Country (Bangladesh)	6 **Divisions**
Division (Raj Shahi)	Several **Districts**
District (Dinajpur)	Several **Thanas**
Thana (Parbatipur)	Several **Unions**
Union (Bauchundi)	Several **Villages**
Village (Mitrabati)	Several **Paras**

Bangladesh has been classified by the United Nations as a low income food-deficit country, i.e. with a GNP per capita of < US$ 160, and a calorie consumption which is 80% of the calculated requirement (Intermediate Technology 1998). Fish provide the main source of animal protein in Bangladesh (60-80%), but it is thought that animal protein only contributes 10-15% of the total protein intake with rice, lentils etc. constituting the majority. Bangladesh has the highest level of malnutrition of any country in the Asia and Pacific region. This affects most dramatically 70-80% of the children in a country with a very high infant mortality rate (over 1 in 10 for those <1-year-old). Freshwater fish as a dietary staple play a key role in alleviating this problem, and expanding their production could remedy this further.

1.2 Conventional pond culture in Bangladesh

Small-scale aquaculture is by far the most practised form of aquaculture in Bangladesh, especially in the poorer communities of the Northwest (personal comment – M. Islam, NFEP 2000), and will be concentrated on in this study, being defined below:

'The term 'small-scale aquaculture' refers to operations run by an individual smallholder and a family, or a village community group'

Pullin, 1993

Bangladesh's millions of small-scale farm families must generate more food and livelihood opportunities from their land and aquatic resources in order to be capable of economic development (Ahmed *et al.*, 1993). Freshwater fish are seen as critical to meet the food needs of the densely populated country of Bangladesh. Extensive seasonal flooding ensures that wild fish stocks and rice-based agriculture support most people's livelihoods, rice and fish remain the preferred foods. Most fish culture in the region occurs in seasonal ponds, requiring annual stocking of fish seed at the beginning of the rainy season. The ponds are filled with water through the monsoon season due to rain and flooding, the flooding bringing with it SRS and so these are seen to be a factor in most aquacultural systems in the country. Most ponds are less than 2400m^2 (60 decimels), although these can get larger. Farmers who have raised fish longest tend to have larger ponds. Although fish culture is more commonly associated with wealthier farmers, previous surveys have shown that both poor and better-off farmers in Northwest Bangladesh began fish culture more than ten years ago, possibly due to aquacultural extension services i.e. DFID, CARE, DoF etc. It also appears that both the poorest and wealthiest groups have adopted fish culture over the last ten years (AIT / NFEP, 1999).

Information about fish culture and seed production technologies or access to seed has been slow to penetrate the Northwest, which is considered the least developed area within Bangladesh. Although trading networks have been established for numerous years, their coverage and supply is insufficient for increasing demand and therefore development of these is also occurring. Farmers commonly stock fingerlings between April and June since seed is more available and their ponds have enough water. Carp are by far the most popular fish used for aquaculture in Northwest Bangladesh, in particular the Indian Major carp and Silver carp along with Common and Grass carp.

Conventional aquaculture in Northwest Bangladesh is currently promoting the use of piscicides for the removal of fish previously found in the pond. One such piscicide that is currently being promoted in Northwest Bangladesh is Rotenone®, although others exist (many of which are used illegally), such as Phostoxin®, Thiodine® etc. The use of Rotenone® theoretically then enables the entire pond to be devoted to one or several key species that the owner wishes to stock. The current theory is that if wild / unwanted species are removed from the pond then there will be a reduced amount of competition for resources, lack of predators or possible disease / pathogen hosts. This then can lead to increased growth in the preferred stocked species due to more food and living space being available and reduced predation / disease risk. Numerous papers have been written in the past to justify and determine this fact, with which I will not disagree. The study aims to see if this method of aquaculture is suitable for Northwest Bangladesh in terms of the environment both biologically and socially. The social aspect is the main area of concern in this study concentrating mainly on livelihoods to see if the exclusion of these natural SRS is in fact a benefit for the pond owners and communities of this area. Is there an increase in the stock produced using Rotenone® or is there a loss of a currently unforeseen benefit. The environment of Northwest Bangladesh is noted for it's high risk of flooding and the high degree of poverty amongst the communities

contained, previous exemption of SRS has not been properly assessed in such an environment therefore Rotenone® application could be inappropriate. A sub-section of this study will briefly assess this.

Rotenone® is a poison that is used to kill off 'weed fish' before the pond is stocked, in order to reduce competition and predation. It is a piscicide / insecticide that has been used for centuries to obtain fish for food in several parts of Asia as well as Africa and the USA. Rotenone® is used as a compound or liquid, it is effective over a wide range of temperatures (1.5 to 30°C), and can work equally well in acid or alkaline waters. Rotenone® works by decreasing the oxygen consumption of organisms due to the breakdown of epithelial tissue. This is due to its ability to inhibit the mitochondrial respiratory enzyme NADH-ubiquinone reductase, which eventually kills the animal. Rotenone® also acts as a vaso-constrictor, working by narrowing the blood vessels in the gills and prevents normal oxygen uptake from water (blocking the cellular use of oxygen for respiration). Rotenone® inhibits aerobic metabolism and subsequent anaerobic metabolism would result in increased production of lactic acid and a decrease in plasma pH (Morrison, 1988). Biochemically, Rotenone® prevents the transfer of electrons along the respiratory pathway, it's molecular nomenclature being $C_{22}H_{22}0_6$ (Marking, 1992).

Rotenone® is efficient as a piscicide / insecticide as well as its fish killing abilities, also to it's high toxicity to amphibians, especially gill breathing ones, and to invertebrates i.e. insects (and their larvae) and zooplankton. It is possible to detoxify rotenone with the use of aerators or chemically, using an oxidising agent such as potassium permanganate ($KMnO_4$). Although in Bangladesh where aerators and chemicals are a luxury for the wealthier minority, it is possible to just leave the pond for a few days after application before the concentration of Rotenone® becomes undetectable, i.e. <4 days in water at 24°C (Marking, 1992). In Asia it is one of the only chemicals which is legally allowed to be used as a piscicide, due to a long

tradition (the only other piscicide I could find that is, is Antimycin®). Rotenone® is often thought to be too expensive by some fish managers, and isn't widely used in Bangladesh. It is also known in many different forms / names depending on the exact content, manufacturer or country sold in i.e. Noxfish®, Nusyn-Noxfish® etc.

1.3 Livelihoods

The livelihood approach is concerned first and foremost with people. Livelihoods are described as built upon Natural, Social, Human, Physical and Financial capital assets vulnerable to trends, shocks and local cultural practices (DFID Sustainable Livelihoods Information Resources, 2000). People require a range of assets to achieve positive livelihood outcomes; no single category of assets (i.e. aquaculture) on it's own is sufficient to yield all the many and varied livelihood outcomes that people seek (DFID sustainable livelihood guidance sheets). Therefore a more general view of livelihood income will be looked at. For this study I intend to use the livelihoods framework in order to understand the importance of SRS for each wealth class in the community, especially the poor. Many people are seen to live in rural areas, and as a result there is a high degree of dependency on natural resources and agriculture / aquaculture for food, income and livelihoods (Intermediate Technology Bangladesh, 1998). By far the majority of livelihoods undertaking / involved in aquaculture within Northwest Bangladesh are connected to it on a small scale. Small scale farmers produce primarily for subsistence; these small scale farmers are found in rich, middle and poor income socio-economic groups (Cheftel & Lorenzen, 1999). When choosing pond owners and households for interviews (through wealth ranking) the respondents, when wealth ranking, immediately focused on those who had land and were well known amongst the community. The pond owners are wealth ranked within the local village community, not necessarily on a

district or national scale, and these are almost certainly going to be reasonably wealthy to own the land the pond is on.

As well as providing an important source of nutrition, fishing and eating, SRS and other species are an important source of income. They also provide the basis for one of a number of diverse livelihood options which landless people can fall back on. This is particularly important when other livelihood options fail. Even under commercial culture conditions small 'trash fish' (many of which may be SRS), which are available to workers as payment in kind or sold at low price may contribute to the livelihoods of poor non-fish farmers in rural and urban areas (Cheftel and Lorenzen, 1999). SRS may contribute to the livelihoods of farmers, labourers, traders and others; and much of this contribution will be characterised within this study with particular reference to it's differentiation along socio-economic and gender lines.

Fish caught from ponds in addition to household requirements are sold through markets, middlemen or used as gift items, although with more and more information and guidelines being available for pond owners production levels are increasing meaning that there is more surplus available to sell. The aims of many of these extension services are to improve the capacity of local development institutions to promote sustainable systems of aquatic resource management that will improve the livelihoods of the poor. One such extension project the Northwest Fisheries Extension Project (NFEP), funded jointly by the Department For International Development (DFID) and Department of Fisheries (DoF), will be sub-assessed in this thesis in order to analyse the current effectiveness of it's methods.

1.4 Northwest Fisheries Extension Project

The NFEP is a development project implemented in 1988 to alleviate some of the constraints to fish culture development in the area and thus stimulate aquaculture development. The general objectives of the project were:

1. To increase the amount of fish available for consumption in the Northwest region.
2. To improve the livelihoods of the rural poor in the area.

The project is jointly funded by the Department of Fisheries (DoF), of the Government of Bangladesh, and the Department For International Development (DFID) of the Government of the United Kingdom. In addition to developing appropriate applied aquaculture technologies, NFEP Phase 2 is testing new extension methodologies to spread technologies throughout the project area. In collaboration with the Department of Fisheries one of the main extension programmes is the 'Model Village' (MV) programme. According to an NFEP source this is 'a community approach to aquaculture development targeting all pond owners, regardless of economic status, in villages with more than 15 ponds. Following a motivational meeting all pond owners are given three one day training sessions at appropriate times in the fish culture cycle on a) pond preparation b) pond management and water quality and c) disease prevention, partial harvesting and marketing.' (NFEP-2 Diary, 2000). So the comparison in the project is to compare those villages / pond owners with NFEP training on aquaculture to Non-Model Village (NMV) ponds who have received no training (or assistance from extension services involved with aquaculture).

1.5 What is a Self-Recruiting Species (SRS)?

One of the first areas of this project that needs to be fully comprehended, so the project can actually set certain boundaries, is to categorise SRS. After numerous searching through associated literature I was unable to find an accurate or appropriate definition for this project

and so decided that the best option would be to research further into this area and then set the definition myself. This then allows possible future researchers to categorise the freshwater fish of the Northwest as SRS or stocked fish etc, and myself. A SRS can in fact be:

'Any sized organism, though usually small (<25cm), which is able to enter a system naturally and spend all or part of it's life cycle here, which farmers / local people are then able to harvest or utilise, without the need for stocking'

Livesey, 2000

The SRS can either be those which are capable of reproducing in a pond / small closed water body system, therefore completing it's reproductive cycle here, or those which enter the pond during flood periods and live out the remainder / part of their life cycle here. So in this study, the SRS featured will be aquatic organisms.

In my view, it would have been much more valuable to define SRS even further into those species that were capable of reproducing in the dynamic floodplain environment, whilst at the same time being important in the still shallow, stagnant water of ponds. Unfortunately there was not the resources, time or available information to deduce which species were capable of this, a much longer study is required, and so I have decided on the above. Though both definitions include species which can be exploited by the pond owner and so the one decided upon becomes more than acceptable.

For example organisms I will concentrate on as SRS are those that can occur naturally in the pond throughout all or part of the year (not removed by the farmer). Those species which can survive in ponds and enter after flooding (being sourced from beels or other large perennial water bodies / rice fields) will be included also. Along with those capable of crossing land or possibly even entering the pond through artificial methods (pond owners catching SRS from nearby canals and adding them to the pond to grow further or store until

food / an income source is required). It was also discovered in the literature review and through enquiries that many pond owners in fact catch fish from the local beel / freshwater body and place them in their ponds. These will also be suggested if they could have also reached the pond through natural methods i.e. floods, or maybe moving over land i.e. frogs / snakes, and survive here. It is important when reading this study that the reader does not confuse SRS with Small Indigenous Species (SIS) which have been researched on numerous previous studies. SIS of Bangladesh can be seen as:

'.....generally considered to be those fish which grow to a length of approximately 5-25 cm at maturity'

Felts, Rajts and Akhteruzzaman, 1996

SIS are organisms which are defined only by their size and country naturally found in (endemic to), for this example the definition is fish between 5-25cm at maturity and indigenous to Bangladesh (not an exotic species). Previous work on SIS has shown that they can be dried more easily than larger fish, and have a very high calcium content in this form. SIS can be mixed easily with other foods; larger fish may require special preparation and a different cooking pattern (Intermediate Technology Bangladesh, 1998). SIS are a food source that can be eaten daily in low-income households, larger fish are only eaten at festivals and on special occasions (if at all). As the SRS are often small and of a low price, every member of a household is often able to get a share. According to Villif and Jorgensen (1993), Puti contained twice the amount of iron than Silver carp and Rui. They also found that Mola contains three times as much calcium and fifty times as much Vitamin A as Silver carp and Rui taken from aquacultural ponds. Mola can breed three times a year – April, July and October (Mustapha 1997). The nutritional and continual breeding cycle of several species,

offer themselves as ideal stock for stocking or as a savoured resource, which can help against malnutrition for protein deficiency in Bangladesh. It is not just these key species but research has shown that SIS have a high nutritional value in terms of protein content and the presence of micro-nutrients, vitamins and minerals which are not commonly available from other foods in Bangladesh. SIS provide the basis for one of a number of diverse livelihood options which poorer people can fall back on, i.e. catching them wild for food and / or income. Whereas this study, on SRS, is concerned with all species of fauna (fish, amphibians, molluscs) which are of varied size, not necessarily endemic to Bangladesh (e.g. African catfish – *Clarius batrachus*), but capable of surviving in the wild and naturally entering into and surviving in the pond. There is probably going to be a great deal of overlap between SIS and SRS with numerous species occurring in both categories but the idea of this project is to study and define SRS.

The barrier set here for SRS is that it makes some river-living species, marine species and deep water species exempt from the study, that are incapable of surviving in the relatively shallow and still (often stagnant) freshwater environment, the pond. Stocked species of carp i.e. Common carp, Rui, Catla etc. can technically be considered as SRS if they are able to escape from one pond and enter another due to flooding. Although for the purpose of this study they will excluded, as they are near impossible to quantify and estimate in this form. It is unknown how much of the farmers initial carp stock is just from his / her stocking if the pond has flooded and the same species enters as a SRS. Also it is unlikely that many stocked species are able to reproduce naturally in the local environment and so they will be discounted.

A factor considered in this study and affecting possible results, is that many stocked fish species, in particular carp, take at least 4-6 months to reach marketable size, whilst many SRS may mature at a quicker rate and reproduce throughout the year which allows them to be continually harvested. This study concentrates on a newly defined area of the organisms

present in and around the aquaculture system – SRS, therefore this study is also going to be used in an attempt to define SRS. SRS may grow quicker, possibly due to their adaptation and evolution in this, their natural habitat, where over centuries they have mastered optimum feeding strategies, survival and growth as well as appropriate / evolved reproductive rates adapted for the environment i.e. temperature, water levels, food availability etc. Traditionally, many fish people in communities have depended on the biodiversity of local aquatic species, as a means of increasing their survival strategies. So therefore seeking to conserve this variety of freshwater species in order to conserve their food source and possible income source, in a sustainable manner. Although it is currently unknown whether this is still practised, and if so to what degree. Farmers may in fact encourage the recruitment of SRS during the flood / monsoon period in Bangladesh. The seasonal floodwaters renew natural and cultured aquatic life support systems, enriching populations, soils and washing away pollutants. The diversity of seasons and habitats of Bangladesh provide for a large seasonal diversity of available fish species.

When studying local knowledge and past literature on the aquatic organisms of Bangladesh, both flora and fauna, little was found on any flora that was harvested from closed water bodies. The only exceptions being large perennial water bodies i.e. beels, which sometimes contain wild plants (i.e. water hyacinths and duckweed) which are occasionally harvested as food for cattle or human consumption, another rarity is the wild rice which can be harvested from these. As these are seen as rare and not important nationally I intend to focus on smaller closed water bodies owned by one / several farmers, so will discount flora and concentrate mainly on aquatic fauna i.e. fish, molluscs, amphibians etc.

Along with the use of SRS as a food source, SRS also contribute to an aquatic ecological balance and play a key part in maintaining nature's balance, i.e.:

- they help to clean the water they live in by consuming organic debris

- they enrich soils with their excreta
- they grow and graze in open water, feeding from nature, and are rumoured to be tastier than any cultured organism (this will be investigated during the study)

Most of the SRS breed naturally in perennial ponds, beels or amongst rice fields and enter ponds during flooding in the Monsoon (Amon) season. Therefore the vulnerability of the ponds to perennial water bodies will also be taken into account during this study, and their flooding frequency (if this is a factor). The floodplain of Bangladesh contains one of the most productive and diverse freshwater faunas of the world and therefore it is thought that the production of SRS will be great and so influence the livelihoods of pond owners and general consumer (non-pond owning households). During the Monsoon season many dams flood, increasing the diversity and number of fish available, opportunists can then catch fish (being mainly if not totally SRS) using numerous methods as the water level rises.

In the past, many SRS of fish have had a low market value, partly because of their abundance, and partly because larger fish were preferred as a food source by those who can afford them. For these reasons there has been little attempt to raise and culture these species commercially. However, the open water fishery of Bangladesh is no longer able to satisfy the market demand for small species, possibly due to extensive flood control projects, aid work and over-exploitation. Therefore the SRS collected in the pond could, and probably does, tap into an area of the market which substantiates current requests / demand.

1.6 SRS in the project contents and coverage

The availability and stocking of fish seed from hatcheries has been an important aspect of promoting rural aquaculture in Asia. However seed from indigenous and exotic species of fish and other aquatic animals that recruit in the system is believed to be important, especially

to poorer people. So I will be determining the importance of SRS to each type of household. This project will pilot test a range of techniques within the NFEP project in Bangladesh for a DFID research project in Indochina to assess the importance of these animals on livelihoods of the poor.

Published literature states that most fish come from inland open waters and are marketed domestically, unprocessed (M. Ahmed 1992). This study will attempt to verify this in further detail. It is currently known that people within Bangladesh consume SRS, the idea of this study it to assess how important these are to livelihoods. Also to analyse whether current aquaculture programmes to exclude SRS is an effective process for these communities with the available resources.

The role of SRS in aquaculture systems and livelihoods will depend on socio-economic / institutional (e.g. assets, access to capital, access to common property aquatic resources), technical (e.g. pond sanitization) and environmental (e.g. degree of water control) factors.
The best way to define a livelihood is that it:

'...comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance it's capability and assets both now and in the future, while not undermining the natural resource bias.'

Adapted from Scoones, 1998

1.7 Rotenone® in the project contents and coverage

The aims / objectives of this part of the study are to discover the impact that Rotenone® does / could have on the pond owners and possible community. By comparing the findings of the first section of the study, with data collected from ponds which have applied Rotenone® as

a clearing / sterilising treatment. For example the Net output from a similar sized pond of stocked species and SRS (after knowing inputs) compared to one which has been cleared (theoretically all the existing species killed off) by Rotenone®. To see if negative social and economic impacts on livelihoods are reduced because of this (or *vice versa*), and which method benefits the pond owners in this region the greatest (Rotenone® use or SRS exploitation / tolerance).

In a way, this section aims to assess & analyse whether the recommendation of Rotenone® usage, as a piscicide / insecticide, is worthwhile (particularly within the NFEP projects in Northwest Bangladesh). Over the last eight years the NFEP has been training extension workers (male and female), implementing a poverty focused extension and training program in Dinajpur, in order to introduce new technologies / methodologies into the fisheries industry of Northwest Bangladesh (on varying scales). As well as communicating with the inhabitants of the area to identify their concerns, views and ideas in order to adapt techniques / methods to cope with the needs of fisheries / aquaculture to grow with the demands of an ever increasing population. This then creates a boost to the area economically, technologically, nutritionally etc. One of the techniques introduced by the NFEP to certain ponds in Model Villages (MV) was to implement the use of Rotenone at the beginning to kill off / reduce all other species. These may act as competitors, predators or host to disease etc., so having a negative impact on fish production.

The basis for the methodologies involved in this study / project, were created within and around Participatory Rural Assessment (PRA). PRA is in fact a recently updated / modified version of Rapid Rural Appraisal (RRA), growing out of the combination of RRA with an emphasis on participation, so there is a large amount of overlap between the two. With RRA it assumes that a team of specialists are responding to a problem identified in a local community. RRA is essentially a process of learning about rural conditions in an outside team.

With PRA the goal is to shift the leadership of the project, and as much of the research work as possible, from the visiting experts to the local people themselves. The best way to think about this method and to summarise it, is to use a definition, PRA is:

'a phenomenological method of enquiry, and is about research with people rather than on people'

Hussey & Hussey, 1997

PRA methods emphasise group discussions and diagramming by rural people and pay special attention to outsider's behaviour, attitudes and interactions with them. In this way the power to initiate and implement should shift away from the development agency towards the local community.

1.8 Hypotheses

To start this study, after numerous literature collection and assessment (as listed under References), I have decided upon the following hypotheses to test as well as any other data patterns / correlation's which may occur throughout the duration:

1. To examine the importance of SRS as part of the diets of the poor homeless section of the communities in Northwest Bangladesh, so being a nutritional advantage.
2. SRS constitute an important source of income for pond owners, especially as a 'free' input to the pond, so being an economic advantage (when sold at markets), especially with the poorer section of the aquacultural population.
3. SRS are an important social item in the community for wealthier pond owners as a source of gifts, creating a status in the village.
4. SRS constitute a larger proportion of the pond owner's diet than the non-pond owner's diet, in terms of fish consumption and therefore animal protein intake.

5. Farmers actively encourage the recruitment of SRS.
6. Farmers see SRS as a desired income in terms of food and a profit-making resource, due to their 'free' status as a no input stock.
7. SRS are not available to the farmer continually throughout the year and may in fact only become an exploitable resource after flooding occurs in the Monsoon season.
8. Many SRS have a higher market value and demand to those of the community able to afford them, due to their tradition as a food source (people being used to eating it and less so for stocked species).
9. SRS will vary considerably in price, depending on their feeding habits. For example predatory SRS will have more of a value and appeal than herbivorous SRS.
10. The approach used by the NFEP Project to eliminate or reduce SRS is ineffective.

2. Materials & Methods

Materials and Methods / Methodologies

The project target area is set in the Northwest area of Bangladesh in the Raj Shahi Division. This area contains sixteen districts, although the project will only target one of these due to access and time constraints, this being Dinajpur. Dinajpur contains thirteen Thanas and the target villages would be selected from one, two or three of these. The base for the project work is at the NFEP hatchery in Parbatipur (Dinajpur), where I worked for eight weeks. From here field expeditions took place to target villages to collect information for the study, including conversing with NFEP staff of varied areas of expertise. Apart from the obvious reason of the research centre based in Parbatipur (Northwest Bangladesh), another good reason for this location is that this area contains a more highly differential class structure which may give a more representative and general view of impacts, practices, preferences etc. (personal comment – D. Little, 2000).

The total number of ponds >0.032 ha in 1989 in Northwest Bangladesh was 88,940 and covered a total of 13,322 ha (BBS 1992). Of these, 54% were classified as derelict or culturable, yielding only wild fish and 46% cultured by traditional methods. Rainwater and groundwater are the two main sources of pond water in Northwest Bangladesh, few ponds are drainable. There are large tracts of seasonal and perennial water-bodies that exist along the roadside created by soil excavated to build roads and houses. Traditional aquaculture is extensive and usually not the main income for the pond owner/s (who are usually farmers), where pond owners rely either upon a natural supply of fish (SRS) or purchase fingerlings from traders (e.g. Rui, Catla, Silver carp etc.). Note that I will refer to fish though out this project by their common name in Northwest Bangladesh and a list of these with their species name can be found in the previous Glossary section.

Several variations of livelihood were analysed in this study and within these groups several respondents were taken from each. For example, apart from speaking to the numerous NFEP project staff and villagers in target areas, I spoke to pond owners, households (without ponds), market traders and Rotenone®-applying ponds. This is in an attempt to fulfil my objectives and to get more than one view on certain areas, allowing triangulation.

2.1 Secondary data collection

This was completed with the use of files, reports, databases, maps, interviewing / conversing with locals and experts in the field, and from articles and books for the initial collection of key data (from the library at Stirling University). Along with the Internet and other computer facilities and the small library kept at the NFEP hatchery in Parbatipur. Also a main source of secondary data was collected from previous NFEP studies when constructing 'Model Villages' which had already collected lists of pond owners allowing us to use these to quickly double check names with local villages and possibly adding names to / removing names from, the list. Secondary data helped to suggest avenues of enquiry that respondents themselves would not bring up unless asked. Also assisting me to modify and adapt the inclusions of the study and methodologies required in order to collect the required data.

2.2 Village selection criteria

As well as government controlled extension efforts, there are many Non-Governmental Organisations (NGO's) in Bangladesh that are helping to accelerate the adoption of more sustainable farming systems and natural resources management. The Model Villages were already chosen being those which had no previous NGO assistance in aquaculture, to prevent any variation the Non-Model Villages which I chose for the study. This was achieved with the assistance of the Thanna Fisheries Officer's (TFO's), looking through secondary data, and by

validating this by also asking pond owners within the village. The village selection had to try and be representative of Northwest Bangladesh and reduce any bias, but remain mutually exclusive and within the following criteria:

- Accessibility = We were able to visit the villages via our transport method (motorbike) to give sufficient time to complete the study, the villages were both within an 1-2 hours travel (radius) from the NFEP hatchery. The off-road motorbike expanded the accessibility factor.
- Typical / representative intervention = To give an example of what the study is researching, will the study sites be able to provide the information required.
- Maturity of the programme = Ensuring that in each Model Village, that the model village scheme was set up in the same year to avoid any bias / variation from initiation period, i.e. loss of interest etc.
- Number of households in the village = If the target village is able to provide enough representative households to give enough variation and quantity for data retrieval and range of variation in the population.
- Agro-ecological region = To sample areas that actually rely on a sufficient amount of their yearly income / food supply (nutrition) / gift supply from aquaculture, both cultured and SRS. Also in an area with the same kind of habitats and environment for equal growing conditions etc.
- Number of ponds in village = If the village is able to provide enough ponds in terms of quantity for accurate data retrieval and range of variation in the population, that can then be statistically analysed.
- Mixed socio-economic grouping = That the village is able to supply a variation in the socio-economic status of pond owners and households to analyse if there is any variation in this key area of the study.

2.3 Field observations - markets and villages

This was involved in the criteria for village selection and to observe the general pond conditions / location which questions would be asked about in interviews and discussions. This mainly helped with setting the scene for me in terms of understanding the ponds place in each households lifestyle (importance); how they fished the pond, how the ponds were constructed, where the ponds were constructed etc. The inputs and outputs from the pond were looked at, and then further down the line the trading of pond outputs in the market environment examined.

Observation was also required at the market level to observe the trading of fish, it's methods, how the fish were sold and the bargaining that exists to gain the fish required at the chosen price. The markets also gave me the opportunity to actually view the diversity of fish that are traded / consumed in this region of Northwest Bangladesh. Therefore an idea of size, quantity, traded status (alive / dead, processed / fresh), and a personal view of the features of fish and any other SRS that could be seen in the market place.

2.4 Structured pond observation

This included the undertaking of transect walks, systematically walking through an area with locals / extension workers for general observation of land use and the features that exist and their position in respect of the rest of the land use areas i.e. house, cattle shed and others. As I was completing this I would note key resources, features and constraints, to identify possible flood sources and areas more / less prone to flooding i.e. beels. Also to allow an increased understanding of the house and pond layout and the part it plays in the households (pond owners) livelihood.

2.5 Wealth / poverty ranking

Wealth ranking is a very useful technique that can be utilised in order to allow us to:

- lead into other discussions on livelihoods and vulnerability,
- produce a baseline against which future intervention impact can be measured,
- provide a sample frame to cross-check the relative wealth of informants who will be interviewed, so biases against the poor and vulnerable can be offset,
- produce key local indicators of welfare and well being.

(Pratt and Loizos, 1992)

Advantages include ease of use, i.e. farmers may not be well educated or may be illiterate, and it allows participation that most people are keen to get involved in (allowing opinions to be included). The wealth score is relative to the people in the selected villages; also taking averages can reduce bias. The wealth / poverty ranking system is effective in that it allows me to separate the pond owners and households in terms of their economic status. I am then able to use this to gain a number of different perspectives and to analyse whether livelihoods of a certain wealth strata are more effected by SRS than others, allowing me then to explore further reasons for this.

The wealth / poverty-ranking method used (Gregory, 1990) is a technique used by the NFEP to poverty rank villages and villagers. The technique used was slightly modified and is described (as we carried it out) below:

1) Firstly Giazi (my translator and extension assistant) and I visited the target village (after village selection was completed) and a list of pond owners was drawn up through interviewing several villagers, one being a dominating figure in that society leader, or through consulting secondary data collected from the Model Village (MV) projects, and checking this through with a village leader and other locals.

2) We then made up a set of cards and on each was written the name of one pond owner and a serial number, 1, 2, 3, etc.

3) Then we found a permanent resident of the village, (she / he did not need be a pond owner) and the extension worker then began his interview. Although the interview was easier in some ways with an educated villager, good memory / social knowledge was found to be more important than literacy.

4) The respondent was given two cards and asked which of the two pond owners 'lives more comfortably'. We read out the names, as they were given to the villager. The respondent then places the cards down on the floor with the 'living more comfortably' farmer to the left. A third card was then given to the respondent who could then either place the card on top of one of the other cards or make a third pile. This process was continued until all the cards had been dealt. A note was made of where the interviewee placed his / her card and the score discounted (if a pond owner). The respondent was encouraged to make more than four piles yet less than eight, concentrating mainly on the biggest piles and we asked if there was any difference in lifestyle between the villagers in that pile.

5) Once the respondent had laid out all the cards, each pile was read back to the respondent, to double check the ranking of each individual, as it was found likely that a few minor changes were to be made.

6) Once the villager has departed, each pile was turned over and scored at the back. For example, if there were five piles of cards, then each card in the pile at the extreme left was numbered 1/5, cards in the second pile numbered 2/5, and so on to cards in the fifth pile numbered 5/5.

7) The cards were then shuffled and a second respondent, who has not witnessed the first interview, was found. The process was repeated a second and then a third time. At the end of the interview the cards each had three scores on the back.

8) The respondents were thanked, in turn, and the interview completed.

9) Then in the field, or back at the centre, we calculated the scores by turning the figures into scores out of 100, so 1/5 becomes 1 divided by 5 multiplied by 100 = 20. A simple average was then calculated for the three calculated values.

10) The pond owners are then arranged sequentially in the same table with the highest average scores at the top. Farmers with high average scores (e.g.87) are considered by their neighbours to be struggling to survive. Farmers with low scores (e.g.24) are regarded as living fairly comfortably.

11) The project relies on getting a sample of each wealth strata in the community (allowing the analysis of the degree that SRS effect different wealth classes, in turns of importance). With the help of several extension workers I chose to set the boundaries of the strata as follows:

Rich = 0 – 33 (closest to 0)

Middle = 34 – 66 (closest to 50)

Poor = 67 – 100 (closest to 100)

I took the lowest figures for individuals as the Rich wealth strata, the highest figures for individuals as the Poor wealth strata and those centring on 50 as the Middle wealth strata, in an attempt to get the best representatives.

The wealth ranking was completed for all the pond owners in the target village.

Figure 2.1 Giazi (assistant extension officer) partaking in a wealth-ranking exercise with a pond owner

2.6 Semi-structured interviewing / questioning

This contained several key areas and shall be mentioned separately below.

Pond Owners:

The first key area was the interviewing / questioning of six pond owners in the village (two from each wealth strata – calculated previously) and an example of the interviewing questions can be found in the Appendix. The questionnaire was developed with the use of numerous sources of secondary data and using the main livelihood framework to look at SRS as a Human, Physical, Financial, Social and Natural resource. This was reasonably general attempting to introduce and bring up new areas so that the questions could be thought through by the pond owner before he / she answered them. Although it included several key questions providing me with information on pond size, pond inputs (weight and cost), pond outputs (weight and cost of SRS and stocked species) and the use of the pond outputs. A subsection also dealt with the various income sources of the pond owner and the percentage of their

yearly income supplied by these. The results are tabulated and graphed in various forms within the Results section and can be found analysed within the Discussion.

Data was required in order to compare and contrast the pond owners for each wealth strata to see the quantity and significance that aquaculture as a whole contributes to their livelihoods. Pond owners were asked to participate in an income ranking exercise where they were asked to rank their incomes in terms of the greatest and least proportion of their yearly income. The pond owners were given the following categories to number for importance:

- Agriculture – rice, bananas, sugar cane, fruit, vegetables, cereals etc.
- Aquaculture – fish, molluscs, amphibians etc. sold for profit
- Labour – being paid for manual work i.e. road building, fishing, construction etc.
- Services – rickshaw etc.
- Business – hotel, rice mill, restaurant etc.
- Livestock – cows, goats, chickens, geese, milk, eggs etc.
- Others – any which don't fit into the above categories

After ranking those categories for income, they were then asked to quantify this by putting a percent of their yearly income to each, i.e. asking them to give each as a proportion. When pilot testing this technique in the field, many people were unaware of the use of a percentage in terms of quantifying, so the method constructed was to theoretically present them with one hundred Takka and inform them that this was to be seen as their yearly income. Then I asked (through my translator) if this was true how many Takka would be made from Agriculture, then Aquaculture and so on, for all the categories they had ranked. These figures could just be converted straight into percentages by changing Takka to percent, and was seen to be very effective in the field and less time consuming than other possibilities. With the rest of the information gained through questionnaires / interviews the aquaculture contribution

could then be broken down into SRS and stocked species for analysing their contribution to livelihoods of each wealth and area. Attempts were made to get an accurate income figure but interviewees were seen as unprepared to divulge such information, and even if this was given great variation was noted and numerous inaccurate bias through people lying in an attempt to boost their social wealth status.

Non-Pond Owning Households:

This was completed by firstly drawing up a list of the non-pond owners in the target village and these were listed as 'households'. It was found that there were very few households who didn't have their own pond or share a pond with others and so the decision was made not to complete a wealth ranking in the same method as described above with these individuals. Instead an individual from each of the wealth strata of pond owners was asked to comment on which strata each of the households fit into, by asking about family size, income, housing, cattle owned etc. The wealth strata of the chosen named households, were deduced speaking to TFO's, leaders in the local community and surrounding paras who new of the householders, and combining the results gained. Two were taken then from each wealth strata to be interviewed, an example of the interviewing questions can be found in the Appendix. Key information was collected comparing SRS, stocked species and river species, on the fish the households bought and from where, the fish preferred and why, and numerous other data. The key issues are summarised in tables and various graphs within the Results section and these results analysed in the Discussion.

Markets:

The third key area was the interviewing of market traders in a range of different market sizes / settings, i.e. the small roadside markets, larger haats / bazaars and biggest district markets. Roadside markets are small retail gatherings with usually less than five fish stalls (often several roadside markets to one village). Bazaars are village markets where there are up to ten fish stalls (one market per village), these were also expanded on haat days that occurred twice a week, and both were sampled and averaged as one category. The district market is a large, daily, central retail event servicing the retail outputs of the several villages contained within the district.

These were sampled to discover if there was more of an impact of SRS in a certain market type, also the opportunity was used to briefly interview / question fish market traders and an example of the questions which were asked can be found in the Appendix. Key information required was on trader age, the species of fish they sold (then categorising these into SRS, stocked species or river species).

These three areas (pond owners, non-pond owners and market traders) were chosen to allow me to 'triangulate' data. Triangulation was used as a way of validating data received, by using several variables, i.e. different livelihoods, sexes, ages, and wealth to give varied and less biased findings. An example of this can be given when looking at the price / preference of fish, both householders, pond owners and market traders can be asked. Or just using one of these variables and asking poorer respondents, middle respondents and richer respondents to get several views on the same area and most importantly reducing, if not removing, bias.

As a result of preliminary interviews it was discovered that the poorer strata needed to be concentrated on, also to probe further into an area to validate my hypotheses. After careful enquiring with locals and extension workers, it was discovered that some of the poorest people are the manual workers (the men breaking up stones and bricks for aggregate - see Figure 3.14

in the Results section) and female manual workers carrying the aggregate (see Figure 3.15). A questionnaire similar to the one of the households, an example of which is found in the Appendix, was used to identify the importance of SRS on their livelihoods both socially and economically. Key information collected was on fish bought and from where, fish preferred and why, how often they consumed fish and numerous other forms of information.

Rotenone:

A sub-section of this project / case study is to assess the current NFEP extension service recommendations on the exclusion of SRS (along with numerous insects) from ponds with the use of the piscicide / insecticide Rotenone®. This will allow me to then briefly quantify the effectiveness of Rotenone® in Northwest Bangladesh from a livelihood point of view, assessing its effectiveness within the community in which it is being used. Information was collected again in the form of a questionnaire from pond owners, who applied Rotenone® to their ponds as part of the NFEP recommendation / project, and semi-structured interview (see in the Appendix), similar to that of pond owners. Information was collected on pond inputs and outputs (cost and weight), if SRS are excluded, then allowing me to compare this data with previous pond data for similar wealth classes for any differences.

The semi-structured interview / questioning involved discussing issues (written down and mentally noted / constructed at the time) from a checklist which were raised during the interview process. This forms the basis for Rapid Rural Appraisal. The questions asked are open- ended and certain themes are explored further in more depth or discounted and a new subject approached. The questioning / discussions also allowed for new topics to arise which may well have not been previously thought of and so this could be integrated into future questions or discussed at a later time.

Pilot testing of the questionnaire showed that the most accurate and helpful results were given when the interview was kept within 15-25 minutes so not using up too much of the respondents valuable time and preventing him / her from becoming bored (impatient to leave) and inaccurate.

Each questionnaire was pilot tested on villagers in the field and the form and direction of answering was noted and looked at to see if the key points that I wished to study were being answered. Needless to say modifications were made to adapt the questioning (such as asking more general questions about total fish bought, then asking which are bought the most to give a more accurate and specified view and response). This was to gain the required information before complete data collection was undertaken, allowing the respondent to understand the question fully and give an appropriate answer.

2.7 Significance:

Before statistics can be carried out on the data collected, the data sets were checked for Normality and Homogeneity of Variance. If the data showed a deviation from these, then non-parametric statistics had to be performed, although the data collected in these studies was parametric (residual and fitted plots showed not deviation from Normality or Homogeneity of Variance) and statistics could be carried out using ANOVA's on the General Linear Model. Statistical analysis was performed using the computer package MINITAB® version 12.1. comparing all of the variables within each data area, i.e. Pond owners, Households, Markets, Manual workers and Rotenone® applying pond owners. Admittedly some of the variables are ludicrous to compare but this allows me with my wealth of data to analyse everything and possibly discover some factor that I haven't previously considered.

3. Results

Results

3.1 Village selection criteria

With the help of the Extension officer at NFEP hatchery in Parbatipur (Mr. Mehrul Islam) I decided upon three thanas to visit to select the target villages. After meeting with the Thanna Fisheries Officer (TFO) of each Thana it was decided that regarding the criteria decided upon in the Materials and Methods / Methodology section, to select the Thanas Chirirbandar and Badarganj. After continued discussions with the TFO and visiting the Thana areas themselves we were able to pick out a Model Village (MV) and Non-Model Village (NMV) from each thana. It was decided that the villages used should have become MV's in the same year (1996) in an attempt to reduce any bias, as it is documented that the earlier a village became a MV, the less practised and efficient the NFEP culture practices would be. The villages chosen were as follows:

Chirirbandar Thana = MV – Magina

NMV – Mitrabati

Badarganj Thana = MV – Rajarompur

NMV – North Bauchandi

We visited each village in the chosen Thana, and constructed a list of pond owners in the area or confirmed the existence of the owners on the NFEP pre-constructed list (in MV's only). We wealth ranked the pond owners of each village and households (using the method described), and interviewed 6 respondents of each. Then also decided to interview manual workers (road builders / aggregate makers) within these villages, as a section of the community divided by wealth class to concentrate on. The results are shown below in the form of graphs and tables with a small summary paragraph on each in the Results section, the bulk of the main findings will be covered in detail within the Discussion.

3.2 Systems

The first step to take in the study was to fully understand the movement of stocked species and SRS naturally and artificially between perennial refuges, often community managed, and to ponds under the management of individual households. This was then further explored to understand the position of stocked species and SRS as an asset; involving the market routes, different types of market and consumers affected. A diagrammatical representation is given in Figure 1.1 & Figure 1.2 respectively.

3.3 Pond-owning households

The data collected on pond owners is best shown firstly as an average to summarise the 24 pond owners interviewed and their respective averages as a percent harvested from the pond of SRS and stocked species, to give an overall view of the divided output from the ponds. Table 3.1 firstly shows the value of individual pond inputs that were used when calculating total pond inputs and net pond outputs (Morrice 1995, Griffiths & Mannan 1996).

Table 3.1 The price of pond inputs mentioned in the study in Takka per kilogram (Morrice 1995, Griffiths & Mannan 1996)

Pond Input Prices per Kiliogram	
Input	**Price in Takka per Kilogram**
Cow dung / Manure; available on farm	0.5 Takka
Duckweed; available on farm	0.5 Takka
Lime; occasionally available on farm	5.5 Takka
Mustard Oil Cake (MOC)	8.5 Takka
Murata Potash (MP)	10 Takka
Rice bran; available on farm	3 Takka
Rotenone®	300 Takka
Triple Super Phosphate (TSP)	8 Takka
Urea; available on farm	6 Takka
Wheat bran; available on farm	6.5 Takka

*Note at the time of writing 78 Takka = £1 or $1 = 51 Takka (08/05/2000)

Figure 3.3 shows the average pond production of SRS compared to stocked species in terms of the amount of production in Takka per decimel of pond area. The average yearly pond production is shown below in Table 3.2.

Table 3.2 Mean annual pond production in kilograms per decimel (n=24)

		Wealth		
		Rich	Middle	Poor
SRS	%	8	10	11
	Kg	1.11±0.96	1.48±1.2	1.71±1.96
Stocked	%	92	90	89
	Kg	10.23±4.84	12.51±10.68	8.64±4.13

The pie chart (Figure 3.3) shows how on average stocked species account for 88% of the total pond production (Kilograms of weight) and SRS only 12%, economically (if all species were sold, which they are not) stocked species account for 90.3% of gross annual pond output value and SRS 9.7%. When analysed this showed a significance ($P = 0.002$, $df = 4$, $f = 6.38$).

There were no significant differences ($P > 0.05$, $df = 2$, $f = 0.00$) in annual production in kilograms from the pond to the wealth of the household (see Figure 3.4). Figure 3.5 shows this on a more specified scale to each of the ponds analysed. From this, SRS are seen to be harvested in the majority of both MV and NMV. SRS were absent in only three of the twenty-four ponds surveyed. The ratio of stocked fish to SRS harvested is similar in all villages receiving aquaculture extension inputs (MV) or not (NMV).

Figure 3.6 looks further into the production of SRS and stocked species in terms of the ways pond owners dispose of these two products. The histogram shows the percentage disposal of these in terms of the percent eaten, sold off and given away. This clearly shows that the majority of both products are consumed by the pond owner and his / her family ($P < 0.001$, $df = 6$, $f = 34.92$), when compared to disposal percentages and amount eaten. Also

similar proportions of both products is used as a gift item. Further statistical analysis shows an interaction between the product type (SRS or stocked) verses percent eaten against disposal. The graph shown in Figure 3.7 shows the interaction plot for the data means on percent disposal of SRS and stocked species in a clearer form.

Figure 3.8 shows a scattergraph of the comparison between SRS yield and total net pond income in Takka per decimel. This clearly shows no significant pattern between the SRS yield and the total net pond yield ($r = 0.087$ where $P > 0.05$).

Another area analysed when collecting results for pond owners was the dominance of aquaculture economically as part of their yearly income. This is represented in the bar chart in Figure 3.9, showing how agriculture is the main dominant income source for each of the three wealth ranks analysed. Aquaculture contributes between 6.5 and 21.1% of the yearly income, depending on the pond owners wealth (total average for all wealth's is aquaculture contributing 15.8% of yearly income). Aquaculture appears to be more important in the incomes of poor people, although there was great variability in how households of different wealth ranked this and other activities. Very few people showed labour as an income source. Although as can be indicated by the standard deviation bars and when completing a statistical data comparison (ANOVA) with standard deviation there was seen to be no significant difference between the wealth ranks or income sources.

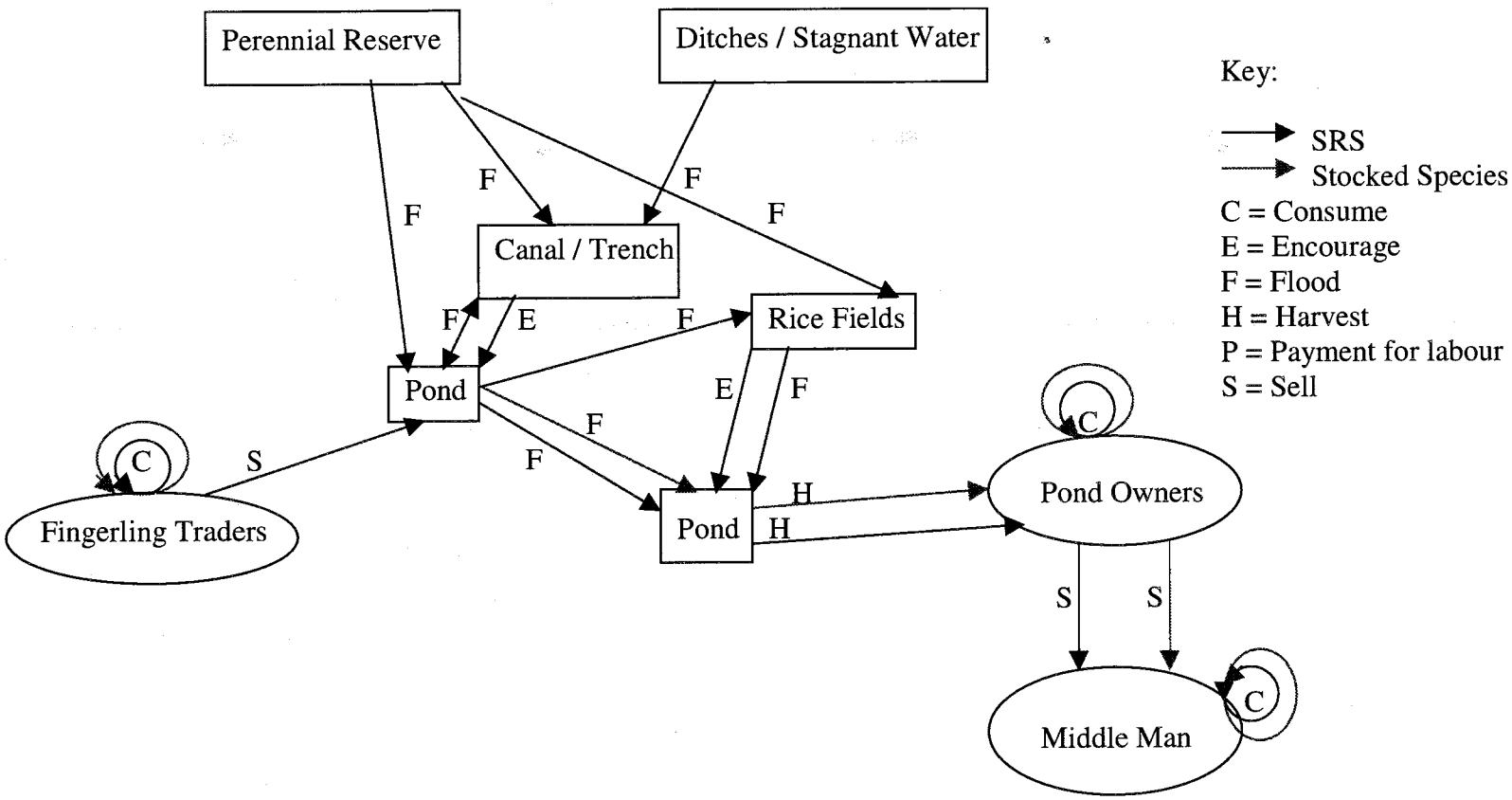

Figure 3.1 A summary of aquatic resource systems and their use in four communities in Northwest Bangladesh

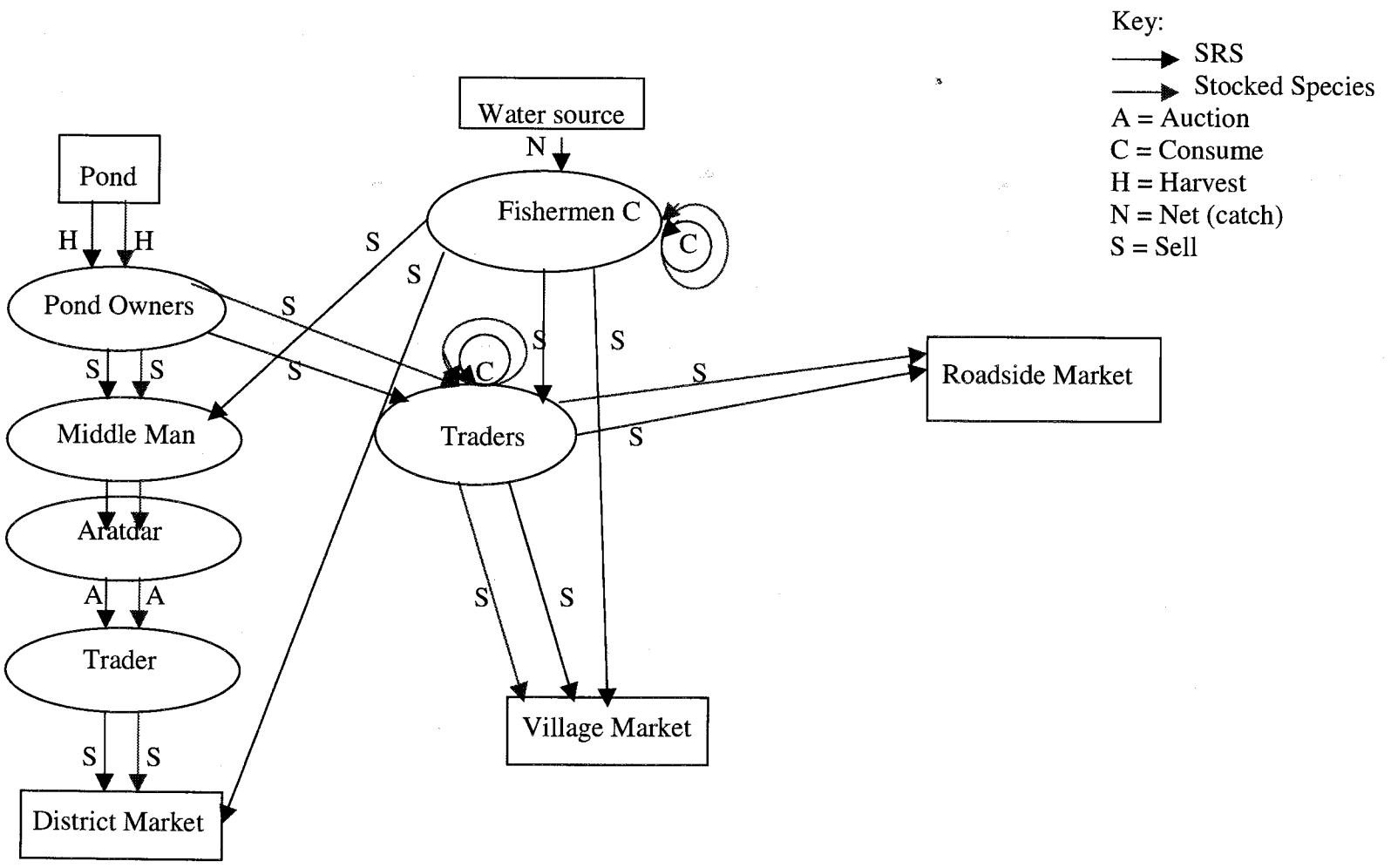

Figure 3.2 A summary of market systems and the movement of aquatic species within them in Northwest Bangladesh

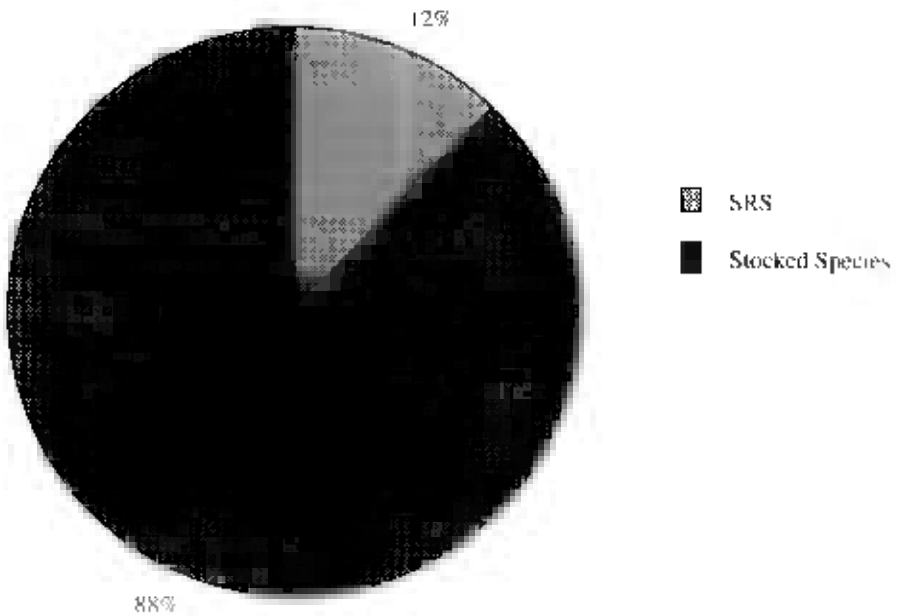

Figure 3.3 Mean annual pond production in kilograms per decimel of SRS compared to stocked species as a percentage

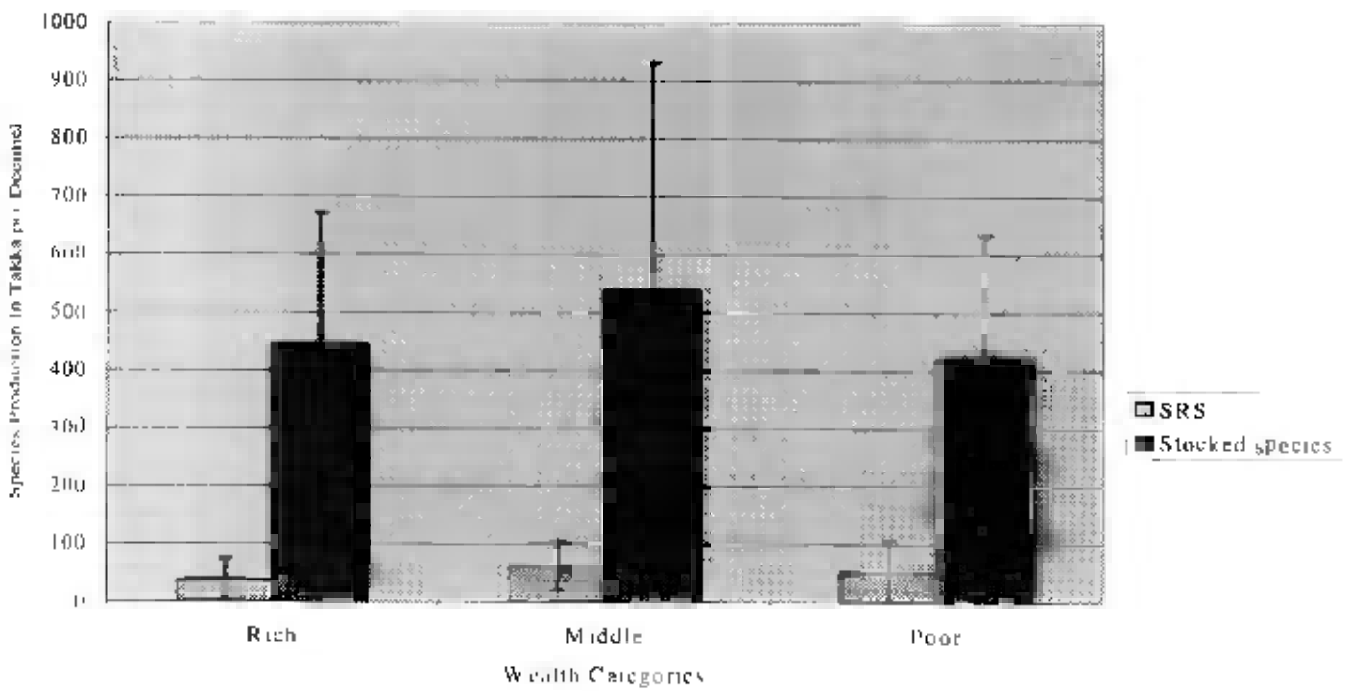

Figure 3.4 Mean pond production for different wealth-ranked pond owners of stocked species verses SRS in terms of Takka per decimel (showing standard deviation bars)

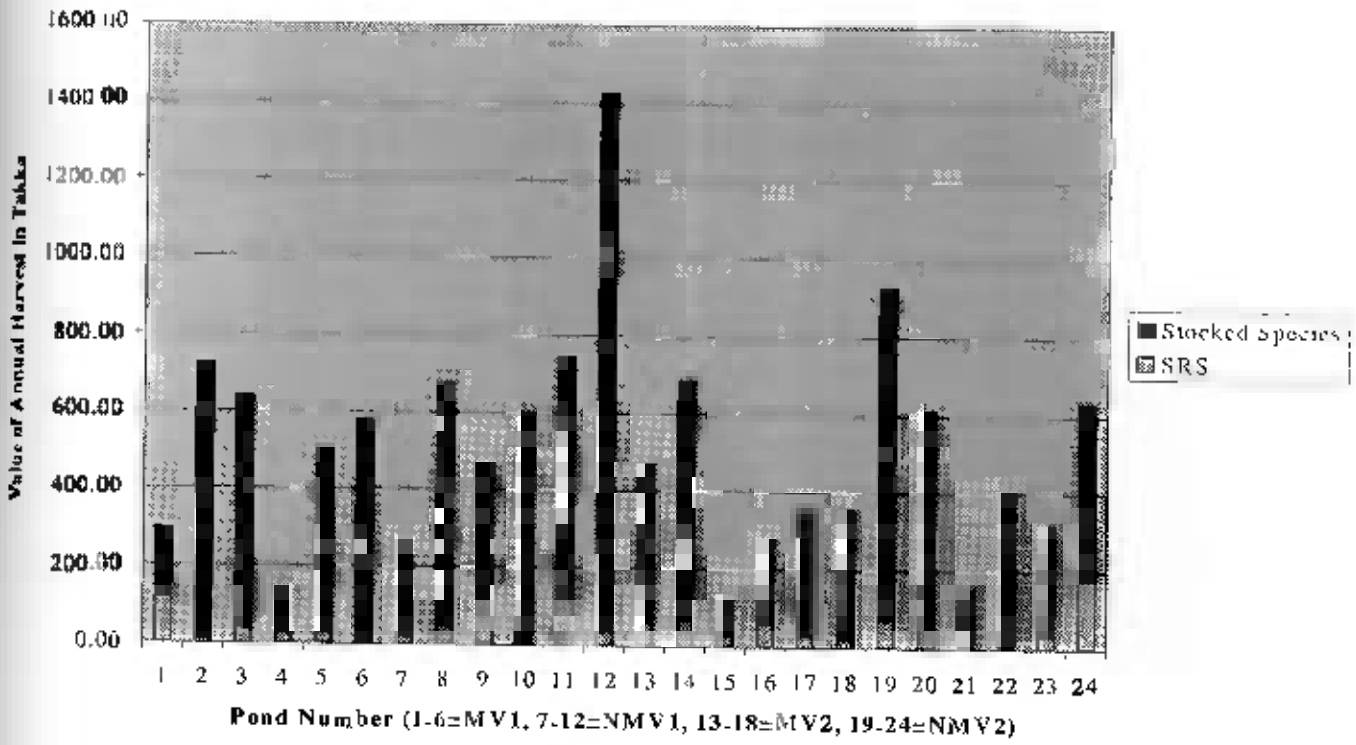

Figure 3.5 Annual outputs from each sampled pond in terms of production value for SRS and stocked species in Takka per decimel

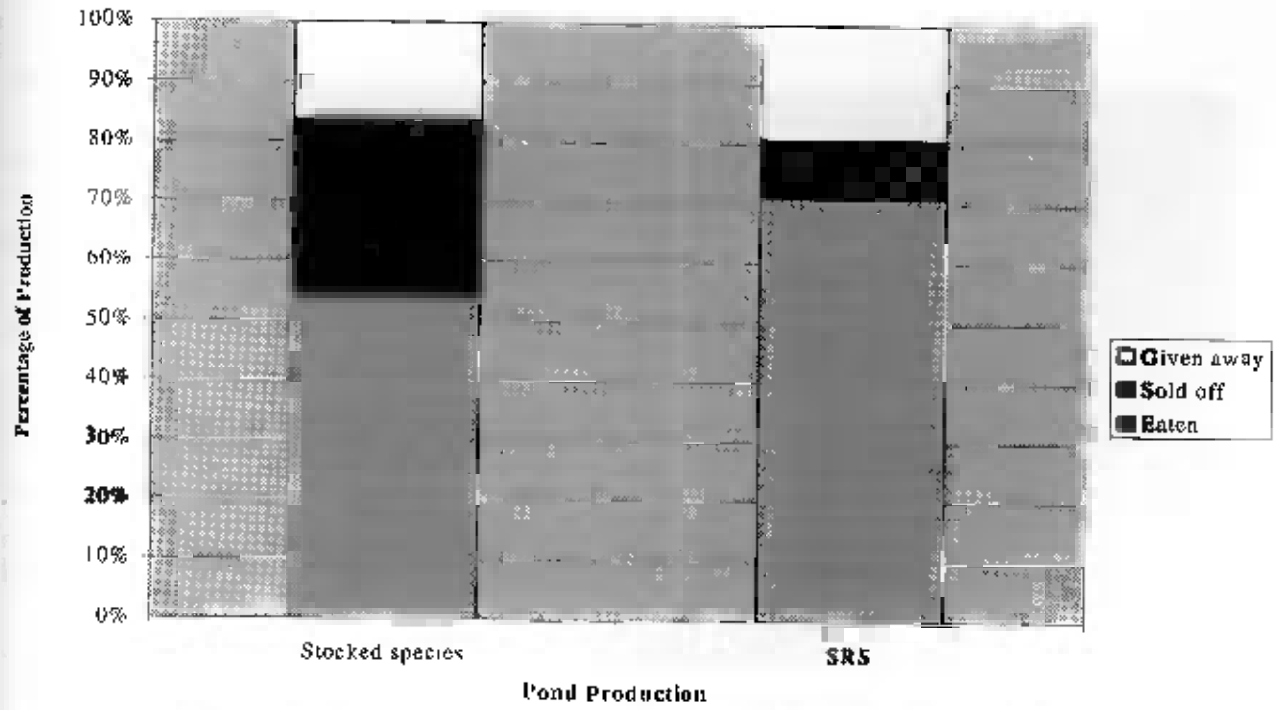

Figure 3.6 Mean disposal of fish amongst pond owners as a percentage of total produced

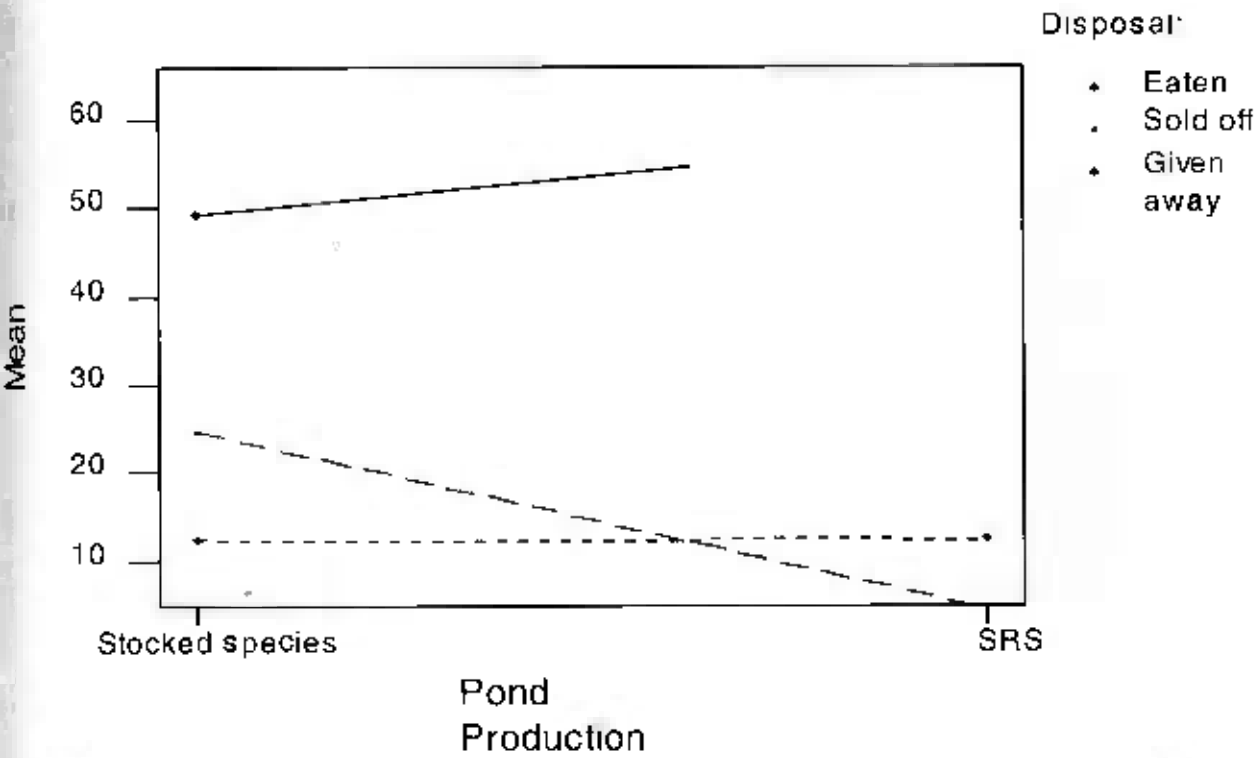

Figure 3.7 Interaction Plot - Data means for percent disposal of SRS and stocked species

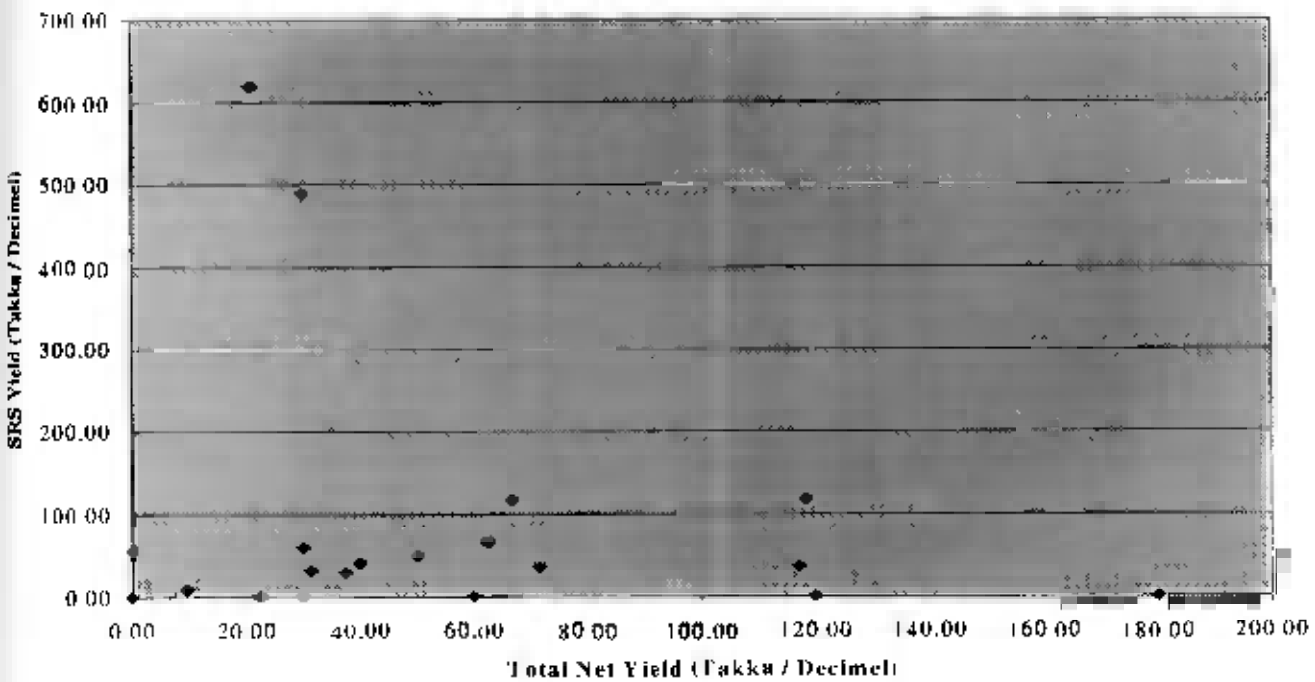

Figure 3.8 Scattergraph show the relationship between SRS output and net pond yield in Takka per decimel

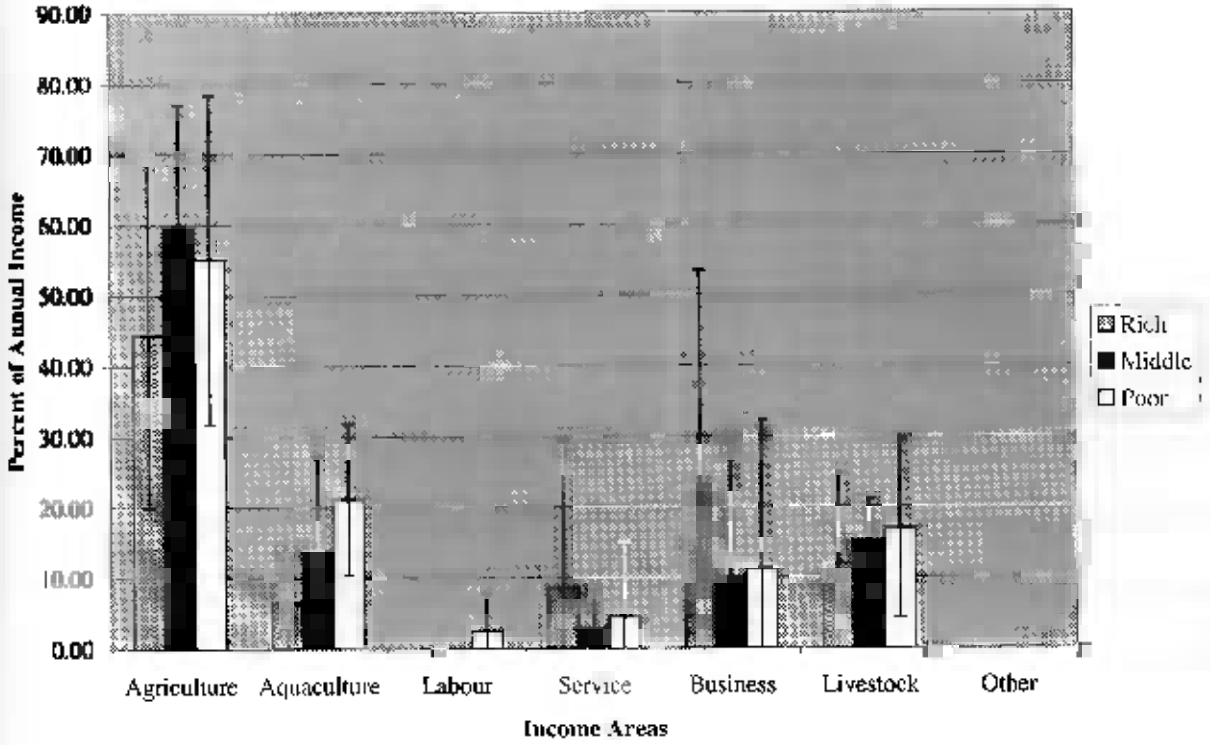

Figure 3.9 Importance of sources of income as a proportion of annual income, as assessed by pond owners of variable wealths (showing standard deviation bars)

3.4 Households (non-pond owners)

Figures 3.10, 3.11 & 3.12 are histograms displaying the preferences of households (without ponds) in terms of fish bought and consumed which can be compared by the differing wealth ranked classes of rich, middle and poor shown. Numerous results can be obtained from these figures, firstly it is obvious that rich households are more likely on average to purchase more culture species than river or SRS, whereas the poor and particularly middle households have SRS as the majority of their fish purchased. When analysing this using ANOVA's it was found that there was a significant difference between fish bought most and category of fish ($P < 0.001$, $df = 2$, $f = 7.88$). This came up again when analysing the interaction between wealth of household and fish category bought when looking at those fish 'bought most'. This tells us that rich middle and poor wealth-ranked classes purchased similar quantities of SRS, stocked species and river species, but that there were differences in the amount of SRS, stocked and river species.

One of the main noticeable points is that each wealth ranked household on average perceived SRS to be the most nutritious fish category (no significant difference between them, $P > 0.05$, $df = 2$, $f = 4.71$); particularly mentioned were Shol, Koi and Magur. Other observations show that the poor are given more stocked species as a proportion than the rich and middle wealth-ranked classes (significant, $P < 0.001$, $df = 4$, $f = 6.24$). Also the middle wealth rank is seen to buy more SRS than the rich or poor (not significant, $P > 0.05$, $df = 4$, $f = 2.00$). The charts also show that the rich wealth ranked class think that stocked species are tastier, than river and SRS, when compared to the middle and poor wealth classes (being significant, $P = 0.004$, $df = 4$, $f = 4.36$).

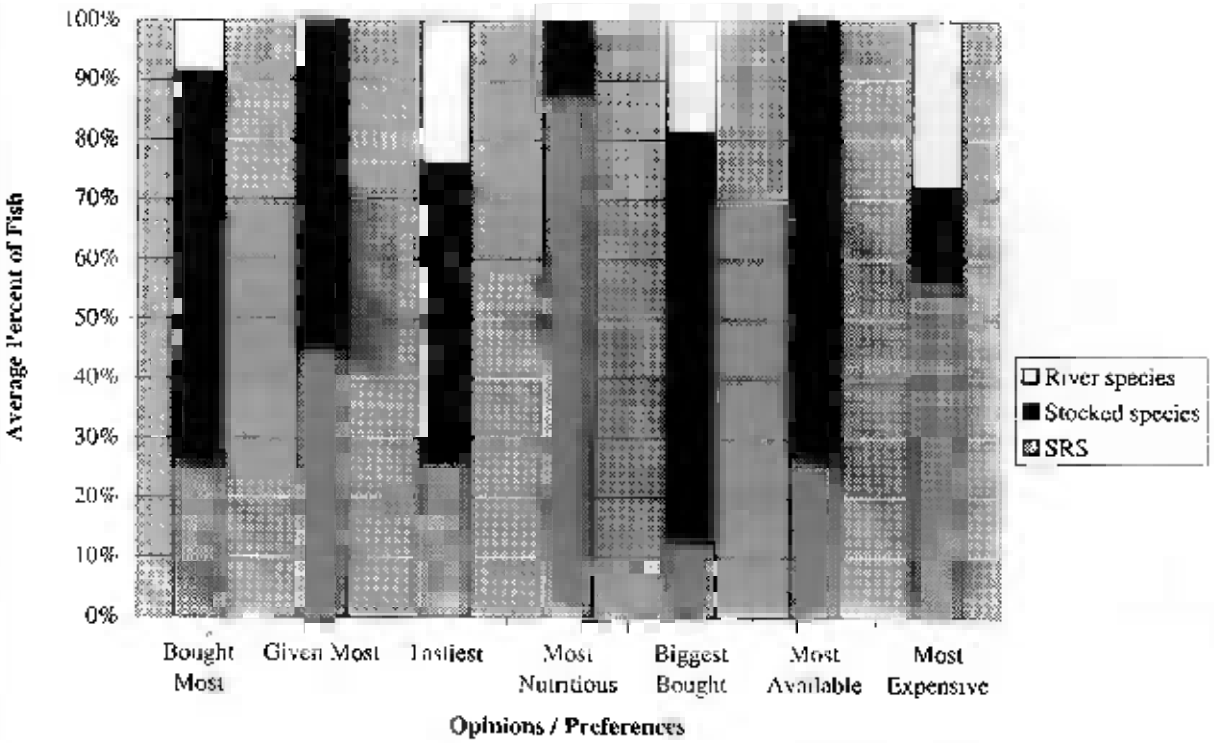

Figure 3.10 Preferences and opinions of rich wealth-ranked households (non-pond owning) in terms of fish bought and consumed

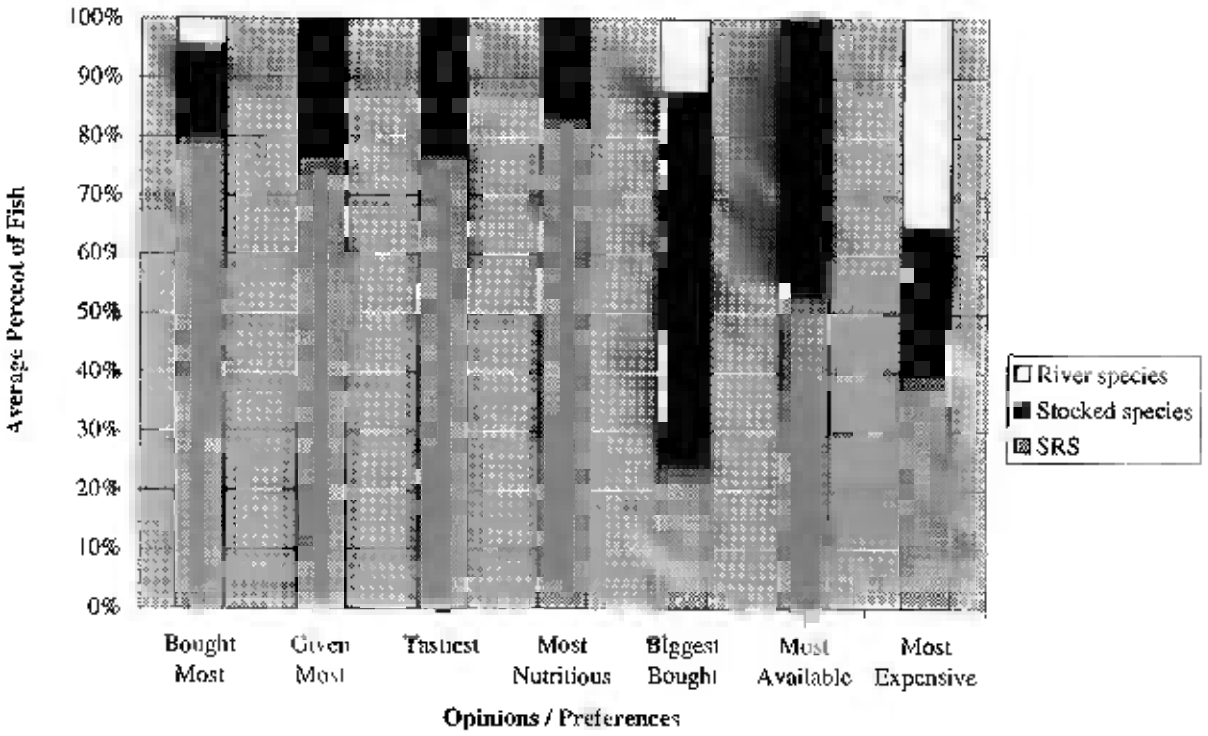

Figure 3.11 Preferences and opinions of middle wealth-ranked households (non-pond owning) in terms of fish bought and consumed

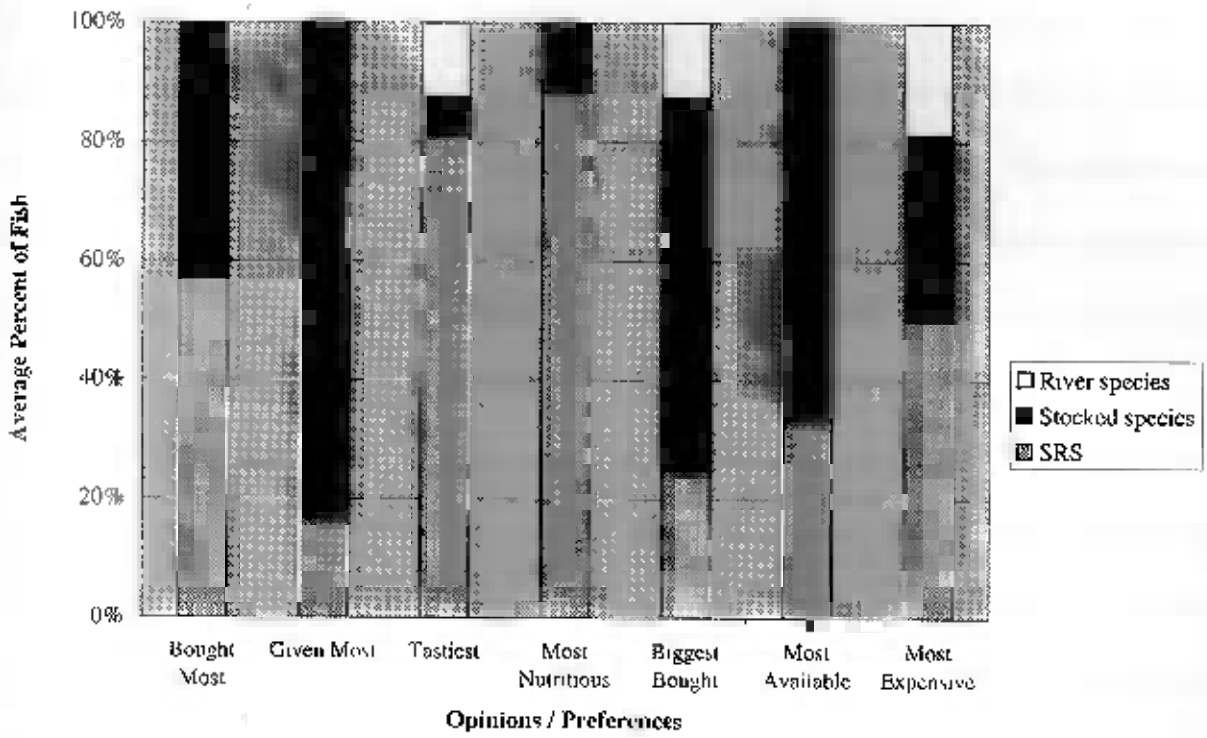

Figure 3.12 Preferences and opinions of poor wealth-ranked households (non-pond owning) in terms of fish bought and consumed

3.5 Markets

When visiting the large district market at Dinajpur, i.e. Bahadur bazaar, it was discovered that the traders / market sellers had very little if any knowledge on the fish. As far as I could work out from observing the market processes, speaking to my extension colleagues and asking the traders themselves, the majority of the system is set up such that the fish are usually bought from the farmer at the pond by a middleman or business man. This middle man then took these fish on to the district bazaar and sold them to the Aratdar (a central auctioneer) who then auctioned them out to traders / market sellers who sold them in the surrounding market.

Prices for fish varied according to the season, size and species. Table 3.3 below shows the perspectives of market sellers in terms of the fish category / type bought mainly by customers of variable wealth. It indicates the rich mainly buy key culture species, e.g. Rui and Common carp. Also showing many SRS bought by everyone but a few key species such as Puti and Tengra are purchased more by the poor.

Table 3.3 Estimated percentage of customers of differing wealth categories purchasing certain species from the market traders perspective (n=36):

Species (local name)	SRS / Culture	Rich	Middle	Poor
Ayre	SRS	100	0	0
Baim	SRS	92	8	0
Bata	SRS	60	40	0
Batashi	SRS	95	5	0
Bhagna	SRS	94	6	0
Bighead carp	Culture	55	45	0
Boal	SRS	85	10	5
Catla	Culture	80	15	5
Chanda / Chandra	SRS	77	22	1
Chingri	SRS	40	40	20
Chital	River	90	10	0
Common / Mirror carp	Culture	55	40	5
Darika / Darkina	SRS	10	15	75
Dhela	SRS	70	30	0
Foli	SRS	96	4	0
Gajal / Gajar	SRS	80	17	3
Gossi	SRS	88	22	0

Grass carp	Culture	45	45	10
Gucchi	SRS	75	22	3
Gutum / Puiya	SRS	68	27	5
Ilish	River	85	9	6
Khalisha	SRS	40	35	25
Koi	SRS	85	15	0
Magur (Indian)	SRS	85	10	5
Magur (African)	SRS	100	0	0
Mola / Moya	SRS	50	40	10
Mrigel	Culture	65	25	10
Pabda	SRS	95	5	0
Pangas	SRS	95	5	0
Puti (Deshi - local)	SRS	5	8	87
Rani	SRS	82	18	0
Rita	SRS	92	8	0
Rui	Culture	75	15	10
Sharputi (Culture)	Culture	65	28	7
Sharputi (Wild)	SRS	60	35	5
Shillong	River	75	22	3
Shing / Shingi	SRS	60	40	0
Shol	SRS	55	38	7
Silver carp	Culture	5	18	77
Taki / Shati	SRS	12	18	70
Tara baim	SRS	88	12	0
Tengra	SRS	6	19	75
Tilapia (*O.niloticus*)	Culture	5	13	82
Tora	SRS	60	30	10

The dominance of fish types (stocked species, SRS and river species) at markets of various size are given in percent of total fish species sold. The proportion of each fish category sold at the three different markets is given in Figure 3.13. District markets are large multi-village retail events consisting of more than twenty fish stalls. The haat / bazaar takes place in a single village, occasionally haats where more food was sold take place – both consisting of up to ten or so fish stalls). Roadside markets are small retail events occurring sometimes in several areas of a village and consisting of two to five fish stalls daily for a couple of hours.

Table 3.4 Preferences / opinions of non-pond owning households purchasing / consuming fish

Preference / Opinion (%)		Culture species	SRS	River species
Bought Most	Rich	61.3	27	11.7
	Middle	22.2	70.4	7.4
	Poor	33.5	66.5	0
Given Most	Rich	38.9	61.1	0
	Middle	26.6	73.4	0
	Poor	85.6	14.4	0
Tastiest	Rich	38.6	30.7	30.7
	Middle	25.2	74.8	0
	Poor	6.9	86.2	6.9
Most Nutritious	Rich	9.4	90.6	0
	Middle	20	80	0
	Poor	13.8	86.2	0
Biggest bought	Rich	61.3	23.3	15.4
	Middle	72.5	18.1	9.4
	Poor	62.4	24.8	12.8
Most Available at Market	Rich	55.9	44.1	0
	Middle	38.9	61.1	0
	Poor	54	46	0
Most Expensive	Rich	26.6	53.2	20.2
	Middle	25.2	41.7	33.1
	Poor	33.6	44.2	22.2

From Figure 3.13 it is apparent that the categories of fish do vary from differing market types. It is noticeable that SRS are much more apparent in the district market, constituting over 60% of the proportion of fish sold but this figure declines in the haat / bazaar and then roadside market respectively. It is also interesting to note that culture species make up over 70% of the proportion sold at haats / bazaars but less than 20% of the proportion of fish sold at district markets. River fish were seen to be by far the minority in roadside and haat / bazaar markets but actually were sold in a greater proportion in district markets when compared to culture species. When statistically analysed no significant difference was found though, due to the range and non-uniform data collected.

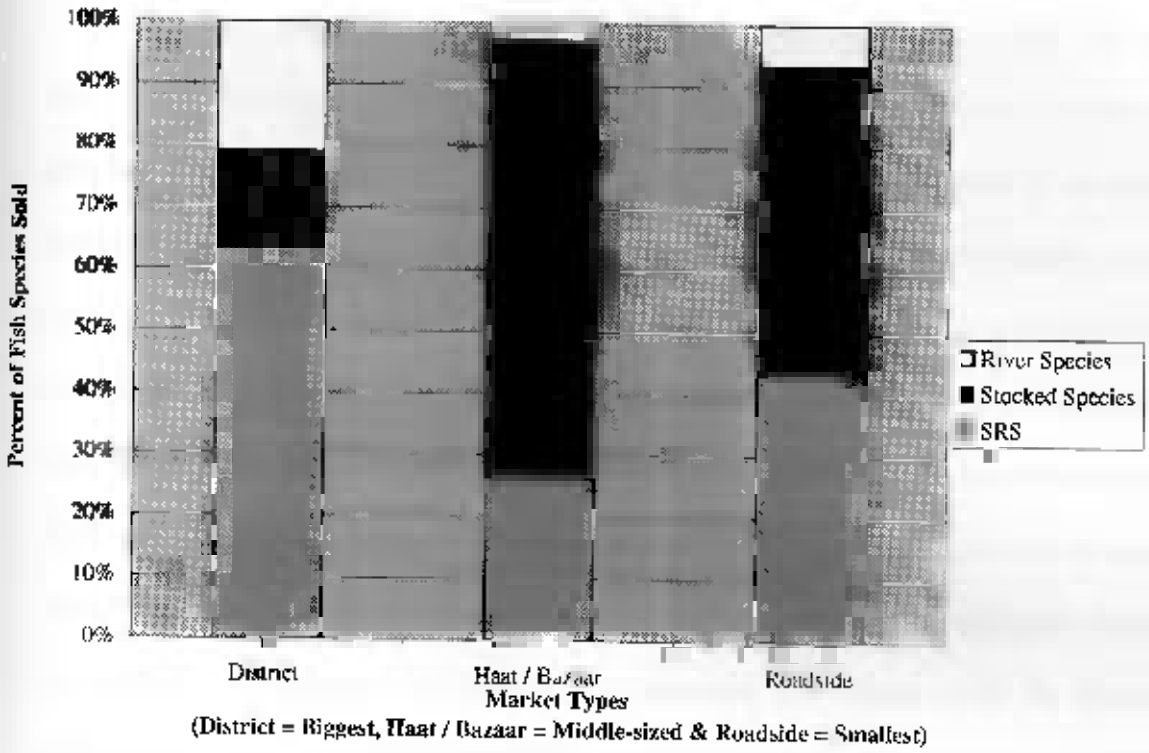

Figure 3.13 Proportion of fish sold at stalls in different market types

3.6 Manual Workers

The first section of results gained through pond owner interviews and non-pond owning household interviews deduced that SRS had the greatest impact on livelihoods of the poorer section of the community. In order to probe further into this section of the community, numerous discussions with respondents of various wealth ranges and colleagues at the NFEP hatchery were used to identify the men and women involved in road construction as being a suitable group. Particularly the men who spent numerous hours breaking up damaged bricks with a small hammer to create aggregate, that is to be used as road foundations (see Figure 3.14). Then to prevent gender bias, and to give an equal view on the poverty situation / fish eaten etc., I also decided to interview those women who carried the aggregate in baskets on their head to the section of the road being constructed (see Figure 3.15). To allow a better response and more open conversation with the women interviewed a female extension worker (Miss Muhammad Meezanur Rahman) assisted, as it was thought better results could be gained.

Figures 3.16 and 3.17 show the average percent preferences and opinions of both male and female manual workers respectively. This in terms of the fish they buy and consume to give an idea of what types of fish appeal or are in the economic range of one of the poorest sections of the community. When comparing the two bar charts it is clear that there are differences between the sexes in terms of preference and opinion. Both state that culture species are generally the biggest they buy (significance / P value of 0.001), in terms of total purchased percentage, and the most available (significance / P value of 0.000) at the markets they visit. Also that SRS are perceived a being more nutritious ($P < 0.001$) when compared to culture and river species. 100% of the female manual workers and over 80% of the male manual workers shared this perception.

Figure 3.14 Male manual workers creating aggregate for road foundations from damaged / excess bricks

Differences arise between the figures when looking at the fish category / type and those bought most, given most and seen as most expensive. The majority of male manual workers' opinions are that the culture species are dominant here whereas the majority of the female manual workers disagree and believe it is SRS, though when comparing the sexes preferences / opinions on 'bought most', 'given most' and 'most expensive' there is no statistically significant difference. Note when looking at those fish given most the figure is nowhere near 100% as the majority of workers, both male and female, were not given any fish.

Figure 3.15 Female manual workers carrying aggregate from the side of the road to areas where it is being placed and compacted

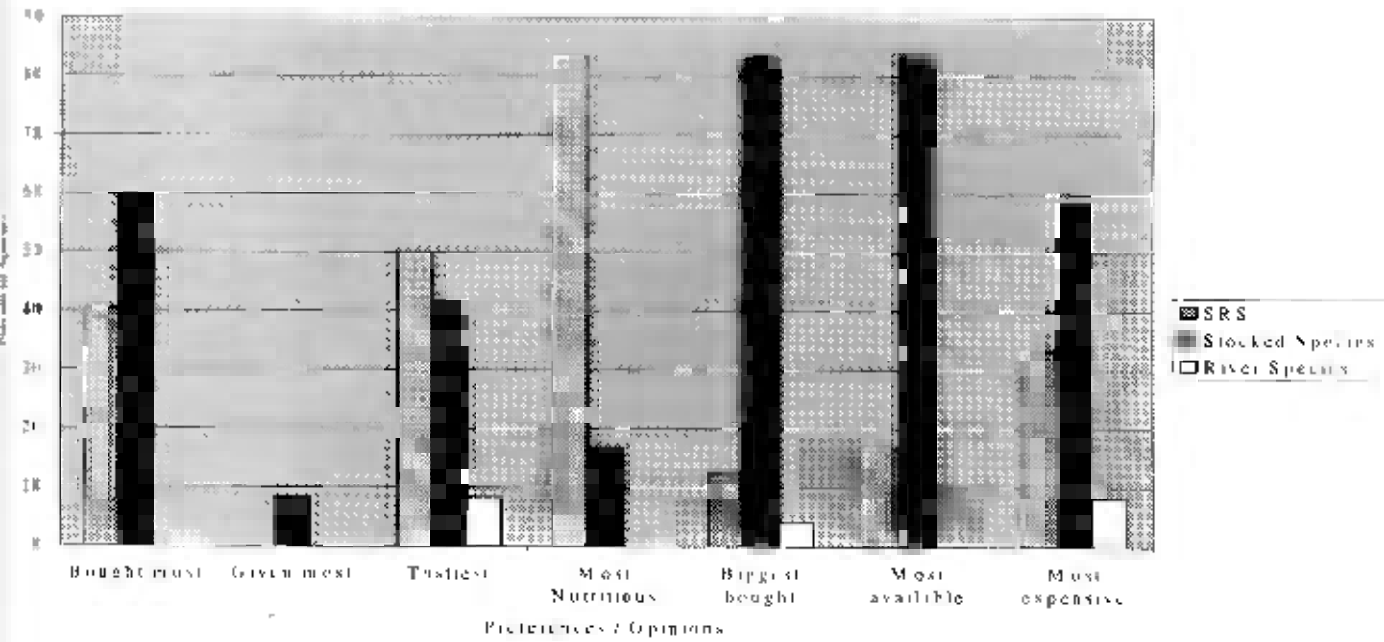

Figure 3.16 Mean percent preferences and opinions of male manual workers in terms of fish consumed and bought

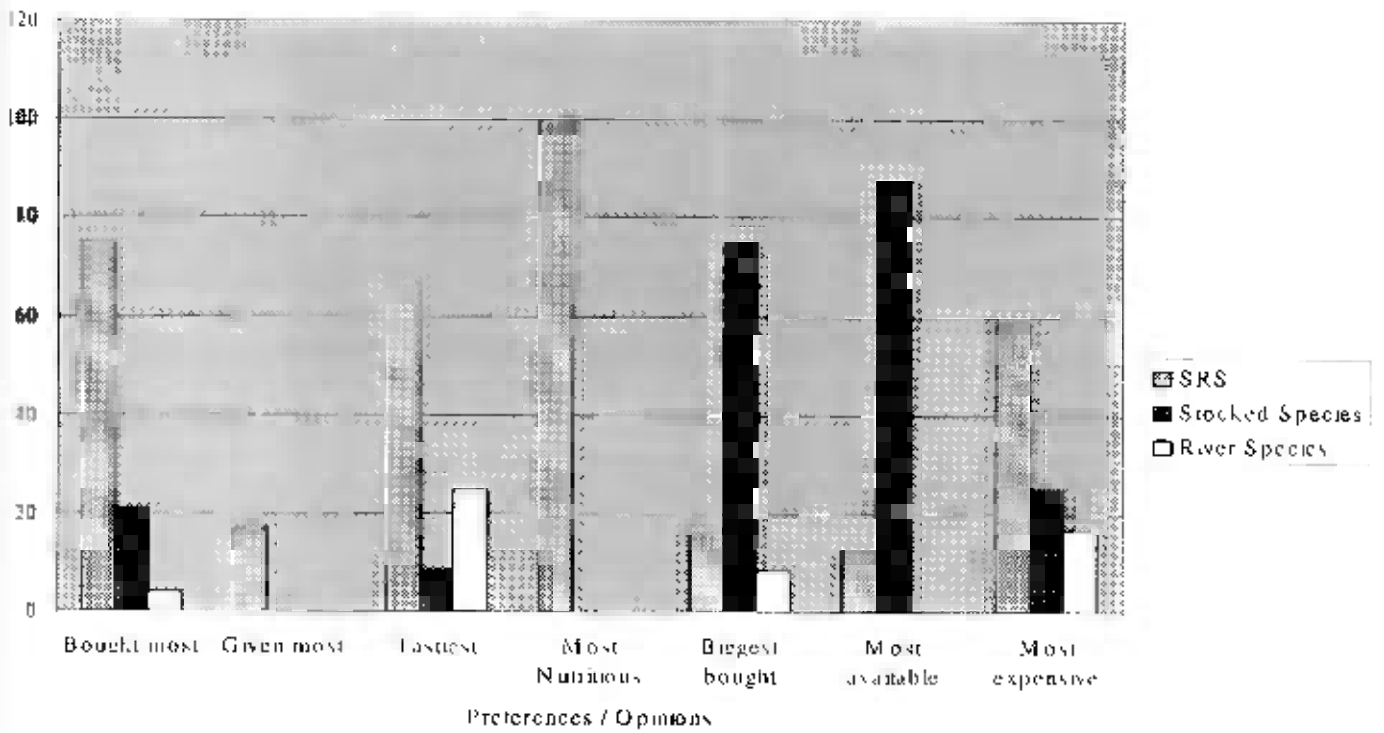

Figure 3.17 Mean percent preferences and opinions of female manual workers in terms of fish consumed and bought

3.7 Rotenone® applying ponds

The general view observed and recorded from the questionnaires and semi-structured interviews with both the pond owners and NFEP project developers was that SRS still occurred within ponds that had applied Rotenone®. Many pond owners actively encouraged SRS into the ponds with the use of trenches / canals and even pipes. The fact that the majority of the ponds examined (62.5%) were prone to annual flooding, meant that SRS could enter the pond with the flood (and the added risk of stocked species loss with this). Figure 3.19 is a bar chart showing that SRS still occur in ponds that have applied Rotenone®, and that they contributed nearly half the output in terms of Takka per decimel when compared to ponds in a MV without Rotenone® application. Figure 3.20 goes on further to show how Rotenone® affects the pond inputs and net outputs in terms of Takka funded or created per decimel of the pond.

This figure shows that the net outputs from the pond without Rotenone® application are much greater ($P < 0.001$) than those with the piscicide added. It should be added that the overall pond inputs are greater in Ponds with Rotenone® even when the value of the Rotenone® input is subtracted. A note to make here is that there may be a difference created by pond size, the ponds applying Rotenone® ranged in size from 2 decimels to 20 decimels (on average 5.75 decimels – reasonably small for a pond). Whereas those without the piscicide ranged from 10 to 250 decimels, on average 38.9 decimels – nearly 7 times larger.

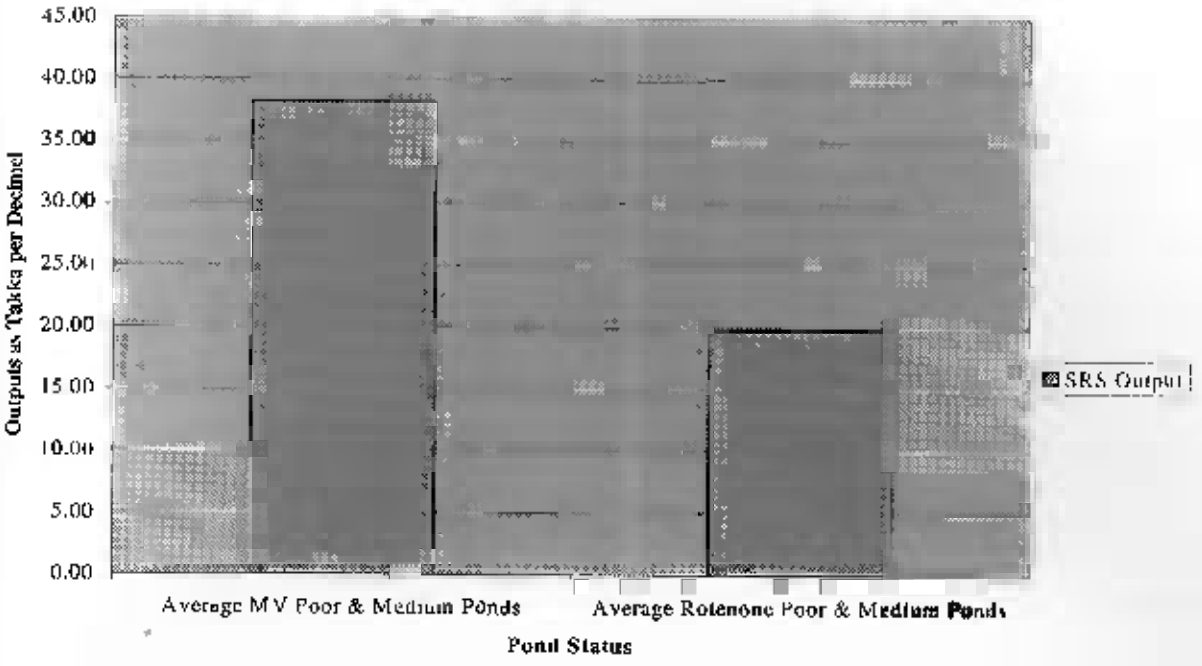

Figure 3.18 SRS output in Takka per decimel from ponds with and without Rotenone® application from similar wealth-ranked owners

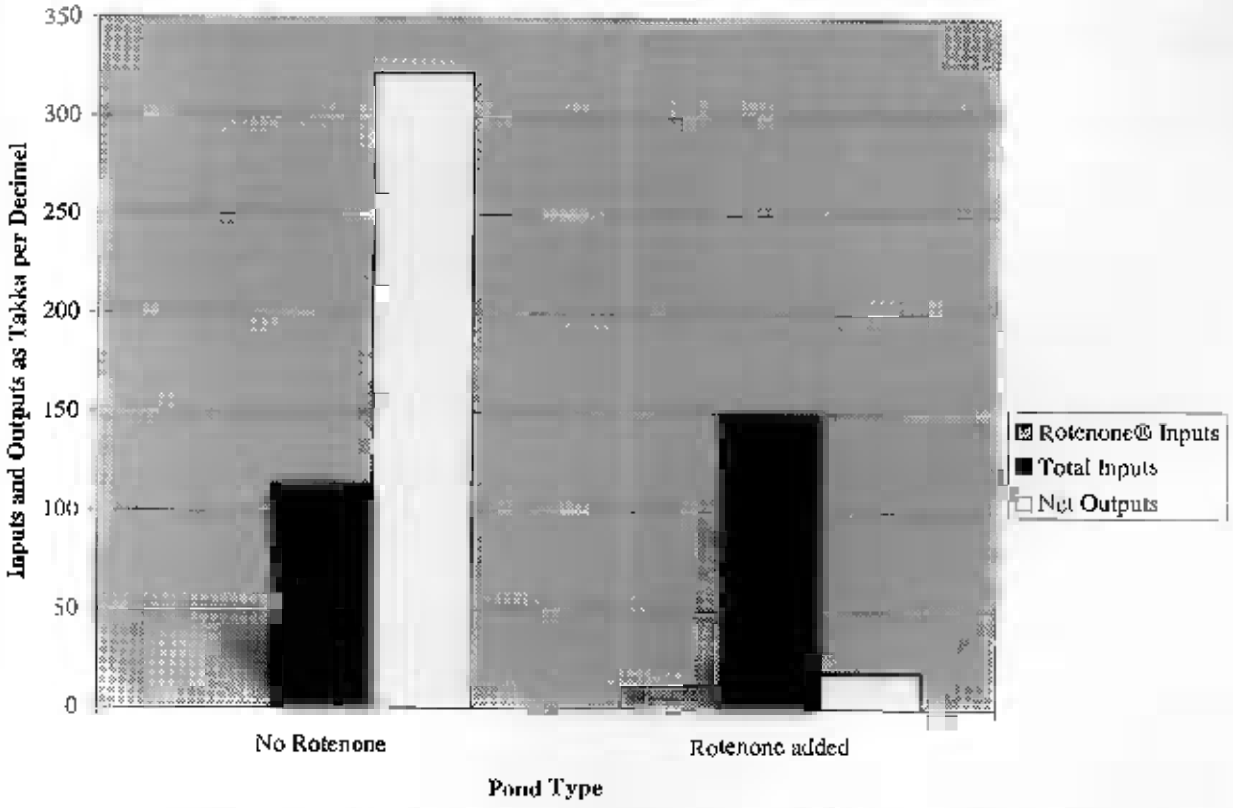

Figure 3.19 Rotenone® addition, average inputs and Net outputs in Takka per decimel from ponds with and without Rotenone® treatment in Model Villages (MV)

4. Discussion

Discussion

I had to be willing to remain ignorant in some areas of this study, spending most time on areas I saw as a major advantage of the participatory approach used, being the communication between the local people and me. It is seen as a better way for me to learn i.e. 'whose knowledge counts', allowing me to learn from rural people and make use of indigenous technical knowledge to assist my analysis. Whenever possible I attempted to use a research framework in which major questions could be asked but was not too prescriptive, relying on PRA methodologies to accelerate learning and meaningful data collection.

In particular the use of PRA allowed a degree of triangulation. Looking at something from only one perspective introduces serious biases into any analysis. If you can introduce two, three or four different points of view into the study, then it allows a more complete and more accurate picture of the situation you're trying to understand. The main aspects of the study, which I aim to triangulate, are the units of observation and the tools and techniques used. The units of observation can be triangulated by ensuring that I don't interview large numbers of people together (but if so, not relying on this alone), a special effort is account for any variation of opinions if present. Using the opinions of differing wealth strata, livelihoods, ages and sexes, is required in order to develop a holistic understanding of the situation. The major tools and techniques used, i.e. group discussions, single semi-structured interviews, transect walks and questionnaires provided information that was supportive or contradictory, allowing a level of triangulation at the methodological level (Gosling and Edwards, 1998).

4.1 Bias encountered and reduced / prevented

This is a very dangerous area within this project especially, it can often (and did several times) creep up on you unawares, and as a result you can end up with a very false

picture of what's going on. There are numerous types of bias which I had to avoid / reduce in this study and a list is given below, along with methods I used to resolve / reduce this:

1. Spatial bias – favouring more acceptable locations (tarmac bias – areas near to or on roads). This was avoided by speaking to the TFO's of each area and asking them to give us a more general view of all areas, and also by commuting between the hatchery and target villages with the use of an off-road motorbike allowing all populated areas to become accessible.
2. Seasonal bias – studies done during more 'comfortable' times of the year (not representative), a village may seem well linked but be cut off during rains / floods. This was not reduced unfortunately as only one season was visited in (late March to late May – just before the monsoon season), although an attempt was made to reduce it's affect by asking about seasonality in terms of prices and availability (see questionnaires in Appendix).
3. Wealth influence – meeting more rich and powerful people (hosted by these people – don't give / show a full perspective). This was avoided by touring the village separately and speaking to a large range of people within the village about their livelihoods and aquaculture. And taking note of the people's position after wealth ranking.
4. Male bias – often using more men in the study than women, possibly due to cultural barriers, women may have less spare time or be working inside and are not immediately noticeable. This was avoided by interviewing several women for the households and female manual workers also, although no women could be found that owned ponds (they all belonged / were controlled by the husband). Although the wives were known to undertake much of the pond labour and upkeep so were therefore encouraged to join the interview and comment accordingly.

5. Politeness – people tend to tell interviewers what they want to hear. This was avoided by ensuring all of the important questions (and in fact the majority of them) were open-ended and giving several options to ask the respondent to define further instead of a yes / no answer.
6. Expectations – where a team is seen to be associated with possible benefits for the individual or village and so people answer reflecting their strategy for capturing these benefits. This was avoided by informing the people immediately that I was a student and was just partaking in some research, also that the topic itself does not tend to suggest any possible benefits to the individual or village (when pilot tested), and no expectations were foreseen.

(Adapted from FAO Fisheries Report No.559, 1997)

A further and perhaps more popular way to define SRS from this study is on two levels, firstly biologically and secondly from the livelihoods perspective which is concentrated on in this thesis. Table 2 below shows both the possible biological and livelihood characteristics of SRS.

Table 4.1 Possible characteristics of SRS biologically and from a livelihoods perspective

Possible Characteristics Of SRS	
Biological View	**Livelihoods View**
A species not stocked in the pond	A free asset entering the pond seasonally
A species capable of naturally entering the pond	A free asset remaining in the pond all year
Can survive all / part of life in pond	Reduces cash outlay (essentially 'free asset') – Financial capital
A species capable of reproduction in pond	A source of 'Natural capital'
A locally occurring species	A daily nutritional resource
A host organism for diseases / parasites	High variety; diversity to diet / incomes
A possible predator / competitor	A numerous, low value resource
Adapted / adapts to the pond environment	A scarce, high value resource especially at district market and home
A variant in the normal stocked diversity	Source of high social value (traditional) – Social capital
Short cycle strategist	Easy to catch; doesn't require specialist gear
	Can be caught by women and children

4.2 Pond owners

All the ponds examined actually practised polyculture, whether intended (with other stocked species), accidentally (with mixed species fingerling supply) or unavoidably / intended with the SRS themselves. It was noticed that when interviewing pond owners (as well as households without ponds), that if any other pond owners or villagers were about (which was likely to be the case, due to their constant curiosity), that the crowd would shout out answers when we were interviewing an individual. This was seen to agitate the respondent as well as provide answers that were possibly inaccurate for the respondent involved, and regardless of how much my assistant and I attempted to prevent this it was still a problem. Therefore we always tried to complete interviews / questionnaires in the respondents home or in secluded areas / teahouses, if this was not possible the crowd were warned previously to the interview and any comments shouted out ignored. When speaking to pond owners and households of various sections of the community it was discovered that many of the SRS are

consumed whole, with their bones in, and so are an important source of calcium and minerals, along with vitamins and animal protein. As many SRS were small (i.e. Puti, Tengra) and of a low price, every member of a household is more likely to get a share. Although there are larger more expensive species of SRS which are mainly purchased by the richer section of the community (i.e. Magur, Shol). Much of the population, in particular children, suffer from malnutrition therefore this food source is seen as a vital part of the diet and due to the cheaper price of several of the SRS this is a more affordable nutritional source for the poorer part of the community.

As mentioned before most SRS enter the pond through floods, although some can be added to the pond which are caught in rivers / flood plains and could enter the pond through floods. There are even several species of fish capable of crossing land to invade another water body, i.e. Koi (the climbing perch) and Magur. Various stocked fish that enter ponds after flooding which are transported from one farmer's pond to the next can be classed as SRS although the problem arises when attempting to do so. It is difficult if not impossible to split the purchased seed culture species from those invading from other ponds through floods e.g. Rui. For the purpose of this study, stocked fish normally purchased as seen will not be classed as SRS.

Aquaculture has often been associated with wealthier households and wealth ranking has been used in recent years to improve the focus of extension efforts towards the poor. There are disadvantages with using the wealth / poverty ranking system, for example the farmers who choose the categories may be biased. Triangulation by using more than one source overcomes this problem to some extent. Also the information obtained is reliant on the opinions of respondents which can and do differ, which is why several respondents were used and each individual had not seen the ranking system previously. The wealth / poverty ranking attempts to overcome problems of using a measure of financial wealth alone, but rather using

the peoples' own perception of well-being. As an outsider though it is also easy to misunderstand the definitions and standards of wealth.

Understanding the production technology used was also a challenge. The pond inputs used are seen to be relatively varied, and similar to that found by other workers. Assigning a financial value to each input (although manure, rice barn, wheat bran, duckweed, urea and often lime are commonly available on the farm) allowed comparison of different pond systems. Also, all of these products can and are bought and sold or have opportunity costs.

Fish were seen to almost completely dominate the SRS viewed as a resource amongst pond owners. Snails were harvested from two ponds and used as a food source for ducks and geese. It was also rumoured that large frogs were occasionally caught in ponds and these were sold for their legs in the export trade. Many smaller frogs, snakes and crabs were also found in ponds but these were killed and discarded (and then occasionally added to the manure heap) as they are viewed as pests which can eat fish and their eggs / fingerlings. This contrasts with aquatic systems in SE Asia in which these animals are rated as human food (Little *et al*, 1996). Many pond owners were also thought to obtain their lime source from the shells of mussels, by grinding them up and using them to lime ponds or adding them to feed livestock; in order to boost the calcium and other mineral contents.

SRS were harvested from 21 of the 23 ponds surveyed, and in all but one of the MV ponds so in the NFEP project to exclude other species and create a controlled more productive environment, SRS are still a viable factor to consider. Attempts to exclude SRS from ponds appear too severe, given current management levels. A significant variation was observed between SRS and stocked species produced in ponds, with nearly 90% of the pond production in kilograms and gross annual income being obtained from stocked species. This ratio was fairly consistent in MV and NMV productions. This raises the question to the value of current extension foci of the project. Most of both the stocked and SRS were consumed by the farmer,

showing that aquaculture is still primarily on a subsistence level and economic income from it being of secondary importance. There was no variation between the wealth of the pond owner and the production amounts in kilograms of stocked verses SRS

The scattergraph in Figure 2.5 and statistical analysis of the results shows no negative effect of SRS on overall net pond yield or income, and in fact the probability of a slight positive effect of SRS on net income if two outer points are removed. SRS appear to pose few risks to pond input price in terms of labour time to net all SRS or draining the pond. The production of stocked fish apart from increased labour to harvest this then appears to be a genuinely 'free' asset for the pond owners.

Income results show that agriculture is still by far the main income area for the pond owners in Northwest Bangladesh, as the main rural communities are viewed to be those whose livelihoods are mainly reliant on subsistence agriculture.

4.3 Non-pond owning households

Results show that the rich wealth-ranked class is more likely to purchase stocked species than SRS or river species, their view is that the stocked species are on average tastier, larger and more available than SRS or river fish. The results indicate that the most expensive fish are cultured species, with high accordance between wealth ranks. This can be reinforced when looking at the species purchased most by the poor and middle wealth classes who have less available money for food and so purchase SRS significantly more than stocked species ($P < 0.05$).

Each wealth class viewed SRS as the most nutritious, yet the rich seem to view taste as more of an important factor when purchasing fish rather than the nutrition it can provide. Malnutrition is less of an important factor for rich people who can afford to spend a large amount of money on food and are less likely to go hungry. This could be explained by there

being a higher level of malnutrition in the middle and particularly poor wealth classes who are more concerned about their diet, and for whom poor diet has more of an impact on livelihoods for survival, illness etc.

The poor were seen to receive gifts of stocked fish more than river or SRS, this seems to contradict my previous points, although further discussions with these respondents informed me that such gifts are typically in the form of small juveniles which have a much lower value at market.

4.4 Markets

For poorer people most stocked fish (with the exception of silver carp) are normally outside their economic reach, and are nutritionally less valuable compared to traditional SRS. SRS are far more popular than stocked fish i.e. carps with this poorer group. Although they are often seen to have a poorer taste than SRS, stocked fish are more popular in the market, where it has been previously suggested that people buy them for social status (personal comment G. Hossaain, 2000).

Fish in markets were seen to be sold almost exclusively by weight during the early part of the day, each trader having his (as all traders seen were men) own makeshift scales. From mid-afternoon as retail opportunities decrease, surplus fish was seen to be sold at discounted rates, although this was infrequent as most traders sold all their fish or replaced the live air breathers, i.e. snakehead (Shol), in water containers to sell at a later date. Drying of unsold fish was heard of though not observed, and represented a salvage operation, rather than for increasing value. The highest value species were noted to be the predatory air-breathing SRS e.g. Shol, Taki, Koi, Magur etc. Whereas smaller herbivorous / omnivorous SRS (the bulk of the mass) enter the market at a lower value.

Figure 4.1 An example of one of the predatory air-breathing snakeheads sold at Dinajpur district market

There is a great deal of seasonal and regional variation in quantity and type of fish in local markets Mainly cheap SRS i.e. Puti and Tengra dominated rural markets, yet SRS as a whole dominated the district market. This is possibly due to the SRS being able to fetch a better price at the district market where more and wealthier people are around to purchase fish. It is therefore worth the trouble for pond owners / middlemen to travel that bit further to get an increased price. The beel harvest peaks between January and April, whereas the river harvest peaks between November and December (Gregory and Kamp, 1999). Declines in the abundance of, and reduction of access to markets could have a negative impact on the food security and nutrition of poorer households. If access to urban markets (i.e. transport, communications, storage etc) is lacking then the selling price of SRS and stocked species may drop Access could be a problem in the monsoon season due to flooding and lack of passage on roads to certain markets or fish sources; research is needed to validate this theory.

Traders discussed how they have little knowledge about the origin of the fish that they sold, especially traders at bazaars / haats and district markets. All traders interviewed agreed that the season, size of fish and species of fish drastically affected its appeal and price. Table 3.3 agrees data from the traders corroborated the results from the household interviews showing that key stocked species (the Major carps; Rui, Mrigel and Catla) are mainly purchased by the rich and that a few key SRS (Puti, Tengra, Darika) are purchased mainly by the poor. Other SRS are purchased by every wealth category however, so have an impact on people drawn from a wider cross-section of the community.

SRS appear to have a higher profile as indicated by a high proportion of fish sold, at the district market. A possible reason for this could be that middlemen, buying from pond owners and selling to traders / Aratdars) realise they can demand a higher price for the SRS when selling them at the district market. Numerous found literature and interviews with NFEP staff also agreed that higher prices on general are be demanded for SRS at district markets. In contrast stocked species contribute over 70% of the proportion of fish sold in haats and bazaars. River species had minimal presence in bazaars / haats and roadside markets, but were more evident in district markets where they sold for a higher price. Reduced availability, due to declining wild stocks or season, of river species may also have an effect on the proportion of fish sold at smaller markets.

4.5 Manual workers

Previous interviews from non-pond owning households, provides us with the information that SRS appear to have more of an impact on livelihoods of poorer people in the community. The focus on one of the poorest rural groups, waged unskilled manual workers seemed to suggest there were gender-based differences, although these were not significant ($P > 0.05$). Male manual workers both purchased more stocked species and were most often

gifted them. Yet female manual workers bought more SRS and valued them for their availability. They also claimed that they received SRS more often as gifts, and that they were most expensive.

A possible reason for these differing opinions of men and women is due to their different social position and purchasing power. It has already been agreed that manual workers fit into the poor category of wealth, although there are differing categories of poor people (personal comment, T. Frankenburger, 2000). In Bangladesh traditional culture / religion dictates that the women remains in the household, either their parents or husband. Women working as manual labourers are therefore usually extremely poor, likely to be more exploited and receive poorer daily wage rates than men doing the same job. The male manual workers may have had a wife who can afford to remain in and around the household. Further research is required to validate this statement.

4.6 Rotenone®-applied ponds

The use of Rotenone® supported by the project in the MV – Harirampur was clearly ineffective. All Rotenone® applying ponds showed some level of SRS present, contributing on average half the SRS production in MV ponds. Furthermore the use of Rotenone® was given entirely on a free basis by NFEP, along with information on its usage. Generally Rotenone® unavailable in rural area and sold at a price beyond the reach of poorer farmers (250 – 400 Takka / Kg).

The ineffectiveness of Rotenone®, despite project support, may not be due only to flooding allowing entry of fish into the ponds during the culture period. The majority of the Rotenone® using pond owners interviewed were firstly actively encouraging the entrance of SRS into the pond especially Magur, Shol and Shati, a large amount of which would predate on the fish / fingerlings.

Secondly over half of the respondents interviewed were unsure of why they were actually using Rotenone®. Several points arise from these findings; firstly it could be that the extension work applied in this village was fairly poor, as the farmers seemed to just be conforming to what the extension worker had told them without knowing the reason behind it. Also a large proportion of the ponds where Rotenone® had been and was being applied were particularly susceptible to annual flooding.

The active encouragement of SRS entry by pond owners appears to be related to the perceptions of their value recorded in our survey i.e. their good taste, high nutritional value and market price. Other points could be that the pond owners see the SRS as a free stock, without the need to buy in fingerlings and so are a free benefit to the farmer and pond. One thing to note was that the average size of ponds in which Rotenone® was applied was 5.75 decimels, compared to the average of 38.9 decimels for ponds in which Rotenone® was not used. This may well affect the results in terms of fish production as it has already been noted that Major carps grow poorly in ponds of less than 49 decimels (Ameen, Rahaman and Ahmed, 1986).

The use of Rotenone® and culture of both stocked species and SRS could be effective if carefully timed. If Rotenone® was applied to remove SRS before stocking, to improve early survival of small stocked fingerlings, they could then survive when SRS entered during floods later in the season. Clearly the timing of application of Rotenone® or other piscicide, fish stocking and flooding would be critical.

Current use of Rotenone® in the types of ponds trialed by the project leads to significantly lower net pond incomes. Even when the cost of Rotenone® was subtracted from the inputs, performance in ponds treated with Rotenone® was poorer than non-treated MV ponds. This suggests that ponds treated with Rotenone® were poorly managed. Owners of such small ponds are less likely to invest in inputs and certain species of fish (e.g. Indian Major

carps) that are known to perform more poorly in such ponds. Given their perceptions and management, in retrospect it appears that they were an unsuitable target group.

Although Rotenone®, a chemical made from a plant root extract in India and imported to Dhaka, is difficult to obtain in the Northwest, other piscicides are used. Thiodine® (essentially DDT), Sumithian®, Phostoxin® (commonly known as the gas tablet) etc. are all used despite Thiodine® being a banned chemical. These compounds are all available locally and are much cheaper. Farmers apply Thiodine®, which is a persistent chemical highly toxic to a variety of aquatic life, to the pond once a year before stocking, usually in March. Sumithian® is a poison that is applied after every harvest to kill all the SRS, whereas Phostoxin® (also known as the gas tablet) is usually applied once a year (usually March) but is seen to be less available.

A major problem could arise if zooplankton are wiped out by Rotenone® use in a pond, but fortunately it's unable to destroy the resting eggs / life stages, allowing populations to recover over time. Rotenone® can also change the make up of zooplankton populations, in experiments after application the zooplankton population changed from rotifer dominance and a few grazers, to grazer dominance and a few rotifers (Sonni & Waervagen, 1990). Also after treatment cyanobacterial blooms have been observed, possibly due to the decrease in nutrients after use. The other major benefit of Rotenone® is it's low toxicity to birds and mammals, which, in a world that is becoming even more concerned with health issues and the environment, is a major benefit.

The trialing of Rotenone® in this study seems to have been a relative failure due to its poor effectiveness (even in small ponds), its high cost and poor availability. Most importantly, it appears that the target group valued and encouraged SRS in their ponds.

4.7 Overall outcomes

Disadvantages of SRS:

- have many bones, eaten carefully or whole
- spoil quickly, have to be consumed or sold soon after capture, some contradiction with air breathing carnivores such as Shol, Koi and Magur.

There was also possible demand for certain fish for reasons other than those enquired about in the questionnaires. Several respondents mentioned that Koi and Magur were often eaten due to the belief of their value as aphrodisiacs and often given as a wedding gift. Also Shol and Gajal were occasionally eaten due to the belief that they have medicinal properties, along with Mola which was widely believed to be good for the eyes. It was also discovered that the government has used a major nutrient campaign informing the people of the nutrient quality of Magur in particular which they encouraged people to consume due to it's high nutrient and mineral content. Work by Roos, Islam, Thilsted, Ashrafuddin, Mushedyzaman, Mohsin, and Shomsuddin, (1999) Has shown that Mola has more vitamin A and D than silver carp etc. More recently there has been increased promotion of Rui as a valuable nutritional resource by the Government of Bangladesh (in an attempt to reduce the countries malnutrition), these may have had an influence in the results. Results suggest the poor, most likely to have poor nutrition, are least likely to purchase Rui themselves.

Major efforts are being made to reduce the impact of seasonal flooding, which covers 70% of the landmass, through flood control and drainage projects. This may have negative impacts on SRS. Flood embankments restrict flooding and the seasonal migration of fish, which is essential for their reproduction and growth. Relatively few mature fish are able to migrate from beels into rivers and upstream to spawn, because so many of the beel-river connections are blocked. The Flood Action Plan (FAP) of Bangladesh has been a major donor supported project, designed to transform large areas of Bangladesh's flood plains into dry land

agriculture. The drying out of flood plains has reduced the floods range and fishermen / pond owners have blamed the decrease in SRS on these blockages in migration routes and reduced beel area. Could this affect the SRS entering ponds and having a knock-on effect to livelihoods (Graaf, Born, Uddin, and Huda, 1999)?

The outcomes of utilising SRS depends on their availability, demand and selling price, although if favourable these could lead to increased food security, income security, nutritional security, social network security and environmental security. The current study indicates, moreover, that SRS and stocked species coexist in pond production systems and are complimentary in terms of supporting livelihoods of both pond owners and people without ponds.

Impact of fertilisers, insecticides and herbicides from agriculture, and waste from agricultural processing i.e. jute retting, and industrial discharge - could have an affect on wild fisheries and possibly effect the SRS entering ponds in terms of reducing amount and diversity of species, and having a knock-on effect to livelihoods.

SRS can be summarised from the results to be important in terms of livelihoods by forming different types of capital. Four of the five factors involved in livelihoods are seen to be affected by SRS. SRS can form a financial capital in terms of a 'free' asset, which can be harvested and sold at markets. They also form a source of social capital, as shown by Figure 3.6. Nearly 20% of SRS are given away which is slightly more than stocked species, to friends and neighbours. This could be as a way of increasing or maintaining social status (the more pond owners give, the greater the wealth / social status they have as perceived by the local community) or just helping to support direct and indirect family. To explain this it can be basically be broken down to the view of the community that the more a person gives the wealthier they are and higher they are up the social ladder, society in Bangladesh seems to be drastically segregated by wealth, as it is in most communities. Social capital is particularly

important in societies like rural Bangladesh that are highly stratified. SRS are a good source of human capital in that to harvest them the wealthier pond owners often employ labourers to net the pond. Also friends / neighbours were occasionally found to be able to take a proportion of the smaller SRS when the pond was harvested and after the harvest any remaining SRS were also seen to be available to others so supporting numerous other livelihoods (natural capita).

Livelihood outcomes therefore include; more income, increased well being, decreased vulnerability, increased food security, more sustainable use of natural resource base.

The species diversity of Bangladesh is seen to be under threat, which could seriously diminish the number of SRS available for exploitation by the farmers. SRS have been shown to play a large factor in most if not all livelihoods, especially with those of the poorer (landless, manual workers) population. SRS reduction in the environment is caused by:

- Increased fishing pressure due to population growth,
- Loss of habitat due to the construction of Flood Control Drainage / Irrigation (FCD/I) projects,
- Fish disease,
- Deforestation (rapidly increasing in Bangladesh),
- Use fertilisers and pesticides in Agriculture (Rotenone®, Thiodine® etc.),
- The use of mechanical pumps for fishing by 'Dewatering' (creating only a temporary environment),
- Industrial and domestic pollution (jute retting etc.),
- Siltation of water bodies (construction work on houses, roads etc.).

(Adapted from Felts, Rajts, Akhteruzzaman, 1996)

The reduced biodiversity and availability of SRS could also have an affect on the larger world aquarium fish trade that is another large industry bringing money into the

country. Admittedly this only affect a few people in terms of labour and individual livelihoods, but does boost the nations economy. Many tropical aquarium fish companies rely on their supply of fish from the wild (e.g. goramies, i.e. *Colisa fasciata*) or catch broodstock from the wild. This can impact livelihoods by hiring locals to catch these or purchasing the by-catch from fishermen / pond owner. In any case the reduced availability of a few key SRS will in fact have a direct impact in reduced availability and therefore increases in price and possible loss of trade, or indirectly in terms of genetic variation. The counter affect of this is the increased pressure / demand for these species, increasing fishing which does damage to either the species intended, other affected species and their environments in the process. The broodstock initially taken from the wild will have to be replaced at some stage (probably from the wild) to maintain genetic variation in a population reducing / preventing reduced growth, mutations and generally poorer quality (less attractive) fish, affecting sales. The fact that enough genetic variation is maintained in the wild strains is essential for the fish's future and in livelihoods nutritionally, socially and economically. Effective methods of reducing SRS in ponds i.e. flood control and poisoning (Rotenone®) could affect these.

Ameen *et. al* (1986) has shown that ponds of less than 0.2ha (< 49 decimels) in size are very rarely profitable in the farming of Major carp (Rui, Catla and Mrigel). There are numerous of these ponds stretching throughout Bangladesh and they are mostly seasonal, a large number of them remaining derelict. Many of these ponds in this <49 decimels category could be utilised to concentrate on the production of SRS to boost the livelihoods of the poorer part of the community. The fact that many SRS hatchlings can grow to maturity in about three months and are capable of reproducing themselves is a big advantage for the fish themselves and the community in providing a rapid, staple, usually cheap and continuous supply of food.

Some SRS are being bred and sold in the expanding aquaculture industry of Bangladesh. Although they still remain as a minor section of the aquaculture regardless of

their nutritional capacity and other benefits, due to a larger return on initial investment being gained on larger fish like the Major carps. SRS present many advantages to aquaculture:

- Do not require induced breeding in a hatchery,
- Many of the species can tolerate low oxygen levels and high temperatures due to their habitation of shallow stagnant ponds (a more natural environment for them),
- Have a rapid growth to maturity,
- Several breeding / growth cycles possible,
- Shorter growth cycle; suitable for seasonal ponds,
- Species will occupy their natural habitat,
- Smaller size of water body can be used,
- Variety of available foodstuffs utilised,
- Varied market size accepted and allowed by law,
- Culture of these species often utilises continuous harvesting which facilitates marketing,
- Culture can take place in sites not suitable for other culture species i.e. carps, where there are extremely shallow water areas,
- Many SRS can maintain a high population density through breeding in ponds.

(Modified from Felts, Rajts, Akhteruzzaman, 1996)

4.8 Validating the hypotheses

1. SRS was seen to be an important part of the diets of the poorer section of the communities in Northwest Bangladesh, so being a nutritional advantage.
2. SRS constituted an important source of income for pond owners, especially as a 'free' input to the pond, so being an economic advantage (when sold at markets), especially with the poorer section of the aquacultural population.

3. SRS are more of an important social item in the community for each pond owners, regardless of wealth as a source of gifts, although stocked species featured in near equal amounts.
4. SRS constituted a larger proportion of the pond owner's diet than the non-pond owner's diet of similar wealth ranks, in terms of fish consumption and therefore animal protein intake. Although female manual workers (theoretically much poorer) were seen to eat even more of a proportion of SRS.
5. Most farmers did not actively encourage the recruitment of SRS (except those applying Rotenone®). Although their actions with the pond had secondary consequences that assisted recruitment, i.e. cutting a channel to allow water to enter the pond and having reduced flood prevention.
6. Farmers were seen to regard SRS as a desired income mainly in terms of food and then as an added bonus of a profit-making resource, due to their 'free' status as a no input stock.
7. SRS were seen to be available to the farmer continually throughout the year being harvested continuously mainly as a food source for the pond owner and his / her family.
8. Many SRS had a higher market value and demand to those of the community able to afford them, due to their tradition as a food source (people being used to eating it and less so for stocked species), perception as nutritious and preferred taste.
9. SRS varied considerably in price, depending on their feeding habits (species), size and season. For example predatory SRS such as Magur and Shol had more of a value and appeal than herbivorous SRS such as Puti and Darika.
10. The approach used by the NFEP Project to eliminate or reduce SRS using Rotenone® was ineffective and, given the above, maybe misguided.

4.9 Possible action and follow up work

- promote policies which encourage the sustainable management of freshwater SRS
- enhance the human understanding and knowledge concerning the role of SRS in freshwater ecosystems
- identify research constraints towards the sustainable culture of SRS
- if not completed already, then a study should be undertaken to determine the impact of altered zooplankton populations, nutrient and chlorophyll decreases, and increased cyanobacterial blooms on SRS and stocked species and the local environment caused by Rotenone® application.

Possible follow-up work:

1. The nutritional content of SRS vs. stocked sp., some work already done by Villif and Jorgensen (1993), but work needs to include more species. And the consumption methods of each species i.e. filleted, picked of the bone, whole etc. If eaten whole then examine entire body nutritional content, or parts of body that are consumed examined. Then compare these findings in terms of the nutritional proportion of the diet ingested i.e. how much of the protein eaten constitutes SRS and how much for culture species etc. With continued monitoring of harvest / pond composition.
2. Refining SRS even further by identifying those capable of reproducing in the shallow, stagnant freshwater bodies, for possible future stocked culture potential.
3. Identifying the actual percentage composition of species within the SRS category within the pond. Allowing us to identify the number and size percentage of high income and preferred SRS in terms of taste, cost, nutrition, size etc. So it is possible to get a more accurate picture of the income that SRS can have for certain livelihoods. For example if 1Kg of SRS is dominated by carnivorous air-breathers i.e. Magur, Shol etc. then it is worth

a great deal more than 1Kg of Puti and Darika, both in terms of the size of the fish and their preferred position in society.

4. The effect of flood control projects / Flood Action Plans (FAP's) on SRS availability over the last 10 years to see if this affects abundance / diversity and having a further knock-on effect on livelihoods.
5. Impact of Rotenone® usage on wild populations and environment.
6. Any access restrictions to markets in the monsoon season when roads / paths may be not be passable due to flooding or damage caused through storms etc.

The price of some SRS is now competitive with, if not greater than, that of stocked species (i.e. Rui); for example Rui can be sold at 60 Takka per kilogram, whereas Koi (SRS) is sold at 100-150 Takka per kg. But more work needs to be undertaken to fully understand the nutritional and environmental requirements of SRS if they are to be properly utilised. In a market that seems to only be increasing in terms of price and demand for selected SRS the gaining of them through aquaculture seems a valuable future resource for the country and maybe as an export item to India and other parts of Asia. Therefore having a further boost and adding further sustainability to many of the country's livelihoods.

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6. Appendix

Appendix

Questionnaires used:

Figure … Pond Owners:

Wealth =
No. of owners =
Farmer / respondent name =
Pond size =
Pond seasonal / perennial =
Pond floods annually =
Culture species stocked =
Fingerling cost per year =
Total culture fish output each year =
Culture fish eaten =
Culture fish sold =
Culture fish gifts =
Culture fishes other use =
SSRS present =
Total SSRS output each year =
Use of SSRS = food –
gifts -
sold –
other -
Recruitment encouragement =
Availability of SSRS =
Pond inputs = manure –
food; ricebran –
wheat bran –
others –
TSP –
urea –
lime –
chemicals –
use poison –
Use Rotenone –
Why use / don't use Rotenone? –
Pond income of SSRS (IF SOLD) =
Pond income of culture fish (IF SOLD) =

Figure Non-Pond Owning Households:

Wealth =
Family name =
Family size =
Ages =

Fish eaten =
Fish bought =
Fish bought most frequently =
Fish prices (bought most frequently) -
-
Fish given =
Fish caught =
Purchase / consumption factors (that they buy):
- Costs most =
- Most nutritious =
- Biggest size =
- Tastiest =
- Most available =
Frequency consumed =
Purchasing / gaining place =

Market traders:

Thana =
Market location =
Name of trader =
Sex =
Age =

Fish species sold	Price/kg (Takka) Max. – Min. (yearly)	Source	Wealth	Consumers buy mainly	Reason
Sp.1					
Sp.2					

From own pond or purchase fish =
Source of SSRS (i.e. beel, culture, derelict etc.) =
When SSRS most available =
When SSRS least available =
Fish species most frequently sold =
Opinion of why most frequently sold =

Manual Workers:

Respondent name =
Sex =
Wealth = Poor – previously determined
Landless? =
Age =
Sex / gender =
Family size =
How often eat fish =
Fish species eaten =
Fish bought =
Fish bought most frequently =

Fish given =
Fish given most frequently =
Fish caught =
Fish caught most frequently =
Source of fish (market / beel etc.) =
Fish prices –
-

Purchase factors (fish they buy):
- Costs most =
- Most nutritious =
- Biggest size =
- Tastiest =
- Most available =

How often do you eat chicken?
How often do you eat buffalo / cow?
Who eats most fish in the house?

Rotenone® applying Pond Owners:

(See Pond Owners questionnaire - identical)