Decentralised Fish Seed Networks in Northwest Bangladesh: Impacts on Rural Livelihoods

A Thesis Submitted for the Degree of Doctor of Philosophy

By

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Dedicated to
My Parents

Declaration

I hereby declare that this thesis has been composed entirely by myself. The work presented in this thesis has not previously been submitted for any other degree or qualification. The nature and extent of my work carried out by, or in conjunction with others, has been specifically acknowledged by reference.

Mohammad Mahfujul Haque

Abstract

Ricefield based fish seed production (RBFSP) in irrigated spring (*boro)* ricefields after initial introductions by external promoters has spread among farmers in parts of Northwest Bangladesh. This approach to producing juvenile fish, rather than by specialised geographically clustered hatchery and nursery enterprises, has been recognised as a strategy for decentralised production that makes large high quality seed available locally and supports food fish production. RBFSP has been promoted by the international NGO CARE as part of a process to improve rice-based livelihoods of farming households using a farmer field school (FFS) approach in two consecutive projects between 1993 and 2005. The approach is technically simple and is based on the stocking of common carp (*Cyprinus carpio*) eggs and Nile tilapia (*Oreochromis niloticus*) broodfish in ricefields. As a new approach to farmer level fish seed production, its livelihood impacts on the farming households as well as associated actors; its adoption, adaptation and rejection process in farming households; and its cost-effectives for dissemination at farmer level were not well understood.

This thesis mainly applies the concept of the sustainable livelihood approach (SLA) using tools and processes of the growing family of participatory research. A systems approach was used to ensure that the key stakeholders including households, community and extension organizations were included. The study was initiated with a well-being analysis of community households to identify poorer households before exploring impacts of RBFSP on poorer producing households (RF) compared to non-producing (NRF) households based on one-off and longitudinal surveys. Livelihoods impacts on other actors linked directly and indirectly with RBFSP were also investigated. The adoption process of RBFSP at the household level and the cost-effectiveness of its promotion were assessed.

Impact studies at the household level showed that RF households were significantly larger and had lower levels of formal education than NRF. Adoption of RBFSP had improved practical skills and hence substantially improved human capital in RF households. RF households tended to have more of their ricefish plots located adjacent to their households. Poor and intermediate adopters had smaller riceplots than better-off households but higher seed production efficiencies (poor-315.1 kg fingerlings/ha; intermediate-419.1 kg fingerlings/ha) than better-off households (294.6 kg fingerlings/ha). In addition to direct consumption of large fingerlings, RF households restocked them for further growth in their household ponds in doing so increasing yields by 60%. Fish consumption increased substantially in RF households based on their own production reducing their dependency on purchase from markets. The year round longitudinal survey revealed that activities for RBFSP were compatible with their existing rice-based agriculture activities for household members including men, women and children. The relatively limited income from fingerling production improved cash flow in the low income months. Consumption of large size fingerlings from ricefields provided nutrient dense food in the 'hungry gap' months when supplies of wild fish were poor, smoothing consumption. Apart from RF households, RBFSP extended its livelihoods impacts to a wide range of actors in and around the seed producing community. Poor fry traders were found to be key actors in the spread and support of RBFSP. On average fry traders supplied fingerlings to 35 foodfish producers within a mean distance of 5 Km from producing households in a community where RBFSP was well established. The end users (foodfish producers) included households with their own ponds, ponds with multiple ownership and larger waterbodies leased by small groups. Locally available RFBSP juveniles were attractive to each of these groups, supplementing hatchery derived seed.

A large number of complex socio-cultural and technical factors were related to household level adoption of RBFSP. The major factors included use of cash generated to prevent distress sales of rice; lack of requirement to use pesticide in ricefields; meeting the household consumption demand; capacity to restock fingerlings in ponds; lack of any negative effects on rice production; increased non-stocked fish production in riceplots; simplicity of the technology; ease of fish harvest from riceplots; increased ability to gift fingerlings/foodfish to relatives and neighbours; more efficient use of both riceplot and irrigation pumps. The most important reasons for households not attempting or quickly rejecting RBFSP were labour conflicts with other activities. However, lost access to the riceplots through changes in tenure was the most common cause of late rejection by households who had practiced RBFSP for several years after withdrawal of CARE support. Location of fish seed producing plots close to the homesteads facilitated household women to contribute to seed production activities through feeding and looking after fish. Women were able to decide and control resources generated from fingerling sales as well as choosing to gift fingerlings to their relatives. Informal transfer of fingerlings in this way stimulated spread of RBFSP.

Decentralised fish seed production was promoted through FFS very cost effectively. The introduction of an improved strain of Nile tilapia (GIFT) broodfish greatly enhanced the returns from decentralised seed production based on common carp alone. High levels of secondary adoption improved benefits from promoting RBFSP. The major benefit derived from the improved returns to food fish farmers using locally produced seed. Higher levels of net present value (NPV) and benefit cost ratio (BCR) were achieved based on promotion of mixed-sex tilapia in RBFSP than mono-sex tilapia produced in a large scale central hatchery. Cost-effectiveness in terms of multiplier development impacts on ramification of secondary adopters and, income of fry traders and foodfish producers, RBFSP also showed better performance than a mono-sex tilapia hatchery.

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Acronyms and Abbreviations

Abbreviation/Acronymes	Term
ADB	Asian Development Bank
AFGRP	Aquaculture and Fish Genetics Research Programme
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCR	Benefit Cost Ratio
BRAC	Bangladesh Rural Advancement Committee
CARE	Cooperative America Relief for Everywhere
CBO	Community Based Organization
CEA	Cost Effective Analysis
DAE	Department of Agriculture Extension
DFID	Department for International Development
DoF	Department of Fisheries
DoL	Department of Livestock
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
GIFT	Genetically Improved Farmed Tilapia
Go-Interfish	Greater Opportunities for Integrated Rice-Fish
IMOF	Improved Management of Openwater Fisheries
Interfish	Integrated Rice-Fish
IPM	Integrated Pest Management
KI	Key Informant
MDG	Millennium Development Goal
MOA	Ministry of Agriculture
NADP	Northwest Aquaculture Development Project
NAEP	National Agriculture Extension Policy
NFEP	Northwest Fisheries Extension Project
NGO	Non Government Organization
NPV	Net Present Value
PAR	Participatory Action Research
PRA	Participatory Rural Appraisal
RBFSP	Ricefield Based Fish Seed Production
RDRS	Rangpur Dinajpur Rural Service
SLA	Sustainable Livelihoods Approach
SRS	Self Recruiting Species
SUFER	Support for University Fisheries Research and Education
UNDP	United Nations Development Programme
UoS	University of Stirling
WB	World Bank

Glossary of Terms

Local term	English
Amon	Rainfed rice crop
Arat	Auction market of fish
Bazar/Hat	Village market
Beel	Seasonally inundated water body
Boro	Irrigated rice crop
Community	A cluster of households within a village
Decimal	Unit of land area, 1 decimal = 40.48 m^2
DTW	Deep tube well
Eid	Muslim religios festival
Hectare (ha)	1 hectare = 10,000 m^2
Kacha road	Earthen road
Paiker	Fish retailer
Paka road	Hard bitumen surfaced road
Puja	Hindu religious festival
Shalish	Local informal court
STW	Shallow tube-well
Thana/upazila	Sub-district level of local government
Union	Local government unit comprising several villages

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Chapter 1: General introduction

1.1 Background

Development requires the removal of 'poverty' which is one of the major sources of 'unfreedom' as eloquently stated by the veteran economist and Nobel Laureate Amartya Sen (1999). Poverty occurs the world over and out of its 6 billion people, 2.8 billion, almost half of the total population live on less than US$2 a day, and 1.3 billion live on less than US$1 a day (World Bank, 2004). Approximately 70% of the world's 1.3 billion poor people live in Asia are generally characterised by under-nutrition, a low asset-base, inadequate access to education, vulnerability and a crisis in coping strategies (World Bank, 2004).

In order to enable millions of poor people to improve their livelihoods, the Millennium Development Goals (MDG) have been adopted by 192 member states of the United Nations (White, 2005). Out of eight MDGs, the first one is to 'eradicate extreme poverty and hunger' which has been demonstrated as very strongly linked with agriculture. Moreover, the seven other MDGs demonstrated are also linked directly and indirectly with agriculture (Rosegrant et al. 2006). In agriculture however, unstable and limited crop yields have been identified as important vulnerability factors for poorer households acting as poverty traps (Barrett et al. 2001; Zimmerman and Carter, 2003). Crop yields are risky because they depend on weather, biotic stress and optimal timing of inputs. In terms of inputs, agriculture productivity depends to a great extent on the availability of quality seeds. All other inputs like fertilizers, pesticides and improved implements will go for naught unless accompanied by quality seed (Ray et al. 2001).

Since the Second World War advances in seed production have contributed significantly to the worldwide increase in crop yields. More specifically, in developing countries, seed production lies at the heart of the 'Green Revolution' which has been successful in raising grain production in areas of medium and high potential for arable farming[1] (Wiggins and Cromwell, 1995). The 'Green Revolution' tripled food production in tropical areas of Asia, particularly through increasing yields in rice, wheat, and maize, thereby relieving hundreds of millions of people from hunger (IYRS, 2003). The Asian Green Revolution in other words has been termed as a 'seed-fertilizer' revolution (Otsuka and Kalirajan, 2006). Despite a considerable improvement in rice seed, the open-pollinated nature of nearly all rice in Asia led farmers themselves to produce, preserve and maintain high yielding varieties of rice seed year after year (ISIS, 2004). In terms of maize cultivation, open pollinated local and improved varieties together occupy the major part of seed supply to the farmers in developing countries. Open pollinated seed production is simpler and relatively inexpensive, and subsistence farmers who grow them can save their own seed to plant in the following season, reducing their dependence on external sources (The Maize Program, 1999). Saving seed at the household level is not only a viable option for poor rural farmers but as a result improves stability of cereal production across the world (Louwaars, 1997). This is because, although physical access to an appropriate quantity of quality seed is critical, the timing of availability, and information about seed are often more important (Rohrbach and Malusalila, 2000; Tripp, 2001). Thus traditional seed production and preservation is the most important method of seed supply and seed multiplication for small-scale farmers in developing countries with approximately 70% of all seed stored by small-scale farmers drawn, principally from on-farm seed production (Delouche, 1982; Lewis and Mulvany, 1997).

[1] The general defining criteria for medium and high potential arable land is wetness class - slight and nil; effective soil depth – 60 and 150 cm; soil texture – sandy loam to clay and sandy clay loam to clay; permeability – rapid to slow and moderate; and available water capacity – 15 and 25 cm respectively (Young, 1976).

In Bangladesh in 2002, almost 90% of rice seed planted was obtained from on-farm production or through exchange with neighbours (Hossain et al. 2006). Production and preservation of open-pollinated seed continues to be an important activity of rural households where household members, particularly women, keep seed from cereals, vegetables, fruits and many other crops. Knowledge regarding seed saving has typically been transmitted from mother to daughter, from sister to sister, from mother-in-law to daughter-in-law, or from village sister to others (Akhter, 2001). Saving their own seed offers several clear advantages to farmers in developing countries as described by Lewis and Mulvany (1997). Firstly, most seed saved is the farmers' own seed and is of known quality. Secondly, small quantities of seed can usually be obtained from neighbours, if necessary. Thirdly, seed is usually readily available at the required time. Fourth, if seed is purchased, payment can be made by a variety of means other than cash. Finally, locally adapted varieties of seed unavailable elsewhere can be retained and used (Lewis and Mulvany, 1997).

In comparison to the agrarian history, aquaculture has been regarded as an infant (Kongkeo, 2001). But aquaculture as a sector is the most diverse of all animal food production sectors due to the great variety of "culturable species", a wide range of "aquatic environments" (e.g. fresh, marine, brakish, cold, temperate, and warm water), a wide range of "containments" (e.g. pond, ricefield, pen, cage etc.) and different degrees of "culture intensity" (extensive, semi-intensive and intensive practices (Tacon et al. 1995). Aquaculture in its many forms began to make a significant contribution to overall food as well as animal protein supplies in the later part of the 20th Century (De Silva, 2001). In particular, Asian aquaculture has evolved over the past 20 years from a traditional practice to a science-based activity and grown into a significant food production sector, contributing more to national economies and providing better livelihoods for rural and farming families (FAO/RAP, 2000). Over the years, the development of aquaculture has occurred as a peri-urban practice in terms of its information flow to the farmer level, commercial and vertical integration, multipurpose use of ponds and broad range of benefits to the poor through service and consumption (Little and Edwards, 2003).

As with crop seed in the global context, the availability of quality fish seed is a prerequisite for the adoption of sustainable aquaculture (Little et al. 2002b). The wider involvement of poorer households in aquaculture was reported to be constrained by a lack of fish seed/fingerling in many countries (AIT, 1997; Edwards, 1999b). Over the recent decades, aquaculture development has increased demand for quality seed and consequently exposed the shortcomings of wild seed resources. Seed production from hatcheries has therefore expanded rapidly in many parts of Asia. Although the techniques for mass production of fish seed were successfully introduced through the public to private sectors, the distribution of quality seed to rural remote and peripheral farming households has often remained constrained. Private sector entrepreneurs, characterised as networks of ‘actors’ now produce and distribute the bulk of seed in different countries such as Bangladesh, India, Thailand and Vietnam but typically production is centralised in certain geographical areas (Little et al. 2002b).

The centralised hatchery-based seed production common in many parts of Asia appears to result in poor or erratic quality of seed reaching farmers (Little et al. 2002b). The most obvious and common conception of poor ‘quality’ is the very small size of seed reaching farmers. The stocking of undersized fingerlings or even fry results in sub-optimal and inconsistent yields and returns to on-growers. This reality is related to the majority hatcheries having inadequate facilities for fry to fingerling rearing and difficulties of distributing live fry or fingerling to the farmer level (De Silva, 2001).

Competition among nursery producers and traders, and typically long distance transportation appear to result in poor quality seed reaching farmers in Vietnam (Demaine, 1996). The co-location of many small producers is a characteristic feature of Asian fish seed networks that derives from their proximity to natural sources of riverine seed and/or the location of government and private hatcheries (Little et al. 2002a). Such 'clusters' of enterprises have implications for seed quality; while the high density of such operations can lead to easy transfer of pathogens, it can also lead to high levels of information exchange and sharing at minimum transaction costs. Additionally, such clusters lead to improved availability of materials and equipment, attract traders/distributors and improve linkages among service providers (Little et al. 2002a).

The usual approach of donor-funded development projects was to set up large, centrally based, government hatcheries to provide farmers with fingerlings which are rarely sustained following withdrawal of financial support (Van den Berg, 1996). These hatcheries are expensive to build and operate and typically only distribute seed over a limited area. This can limit the involvement of poor farmers in remote areas in rural aquaculture (Edwards, 1999b). Seed production and distribution of fish such as carp and catfish from government hatcheries have proved less sustainable in different regions of the world (Little and Edwards, 2003). A similar scenario was reported in the case of reproductive health services offering artificial insemination for cattle being operated by a conventional traditional centralised veterinary hospital in Bangladesh. This approach does not ensure that farmers in remote agriculturally marginal areas can benefit from the service at the proper time resulting in low conception rates and economic loss. In order to ensure that such services reach rural farmers, local level artificial insemination services have been developed and promoted with encouraging livelihood benefits (Shamsuddin et al. 2007). Lessons learnt from the Green Revolution, as well as from livestock development, could be applied to aquaculture development i.e. promoting local production and availability of quality fish seed. The concept of local level fish seed production could greatly strengthen sustainable development of quality fish seed supply. Fish seed is extremely perishable and the importance of 'timeliness' of production and delivery for rainfed aquaculture systems is critical. From this background the main hypothesis of the present study was framed as 'local production of fish seed in irrigated ricefields has positive, diverse and subtle impacts on rural livelihoods in Northwest Bangladesh'.

1.1.1 The concept of sustainable development

The concept of sustainable development has resulted from perceived inadequacies of earlier models of economic growth and development. Relating to sustainable development, the shift from economic development to people-first development has come to the fore, putting greater emphasis on human and social aspects (Chambers, 1997). This is due to previous economic models did not provide a broad enough base on which to make balanced judgements on the costs and benefits of various policies which tended to focus on short-term gains at the expense of longer term aspirations (FAO, 1999). There has been some debate over the concrete definition of sustainable development. Williams and Millington (2004) argued that sustainable development is a notoriously difficult, slippery and elusive concept to pin down. Fowke and Prasad (1996) have identified at least 80 different, often competing and sometimes contradictory, definitions of sustainable development. The best known, however, is that given in the Brundtland Report, where it is suggested that sustainable development means 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). The interpretation of the Brundtland definition is as follows:-

A commitment to meet the needs of present and future generations has various implications. "Meeting the needs of the present" means satisfying (WCED, 1987):

- Economic needs – including access to assets providing an adequate livelihood or productive economic activity; also economic security when unemployed, ill, disabled or otherwise unable to secure a livelihood.

- Social, cultural and health needs - including a shelter which is healthy, safe, affordable and secure, within a neighbourhood with provision for piped water, drainage, transport, healthcare, education and child development, and protection from environmental hazards.

- Political needs - including freedom to participate in national and local politics and in decisions regarding management and development of one's home and neighbourhood, within a broader framework which ensures respect for civil and political rights and the implementation of environmental legislation.

Meeting such needs "without compromising the ability of future generations to meet their own needs" means (WCED, 1987):

- Minimising use or waste of non-renewable resources - including minimising the consumption of fossil fuels and substituting with renewable sources where feasible. Also, minimising the waste of scarce mineral resources (reduce use, re-use, recycle, reclaim).

- Sustainable use of renewable resources - including using freshwater, soils and forests in ways that ensure a natural rate of recharge.

- Keeping within the absorptive capacity of local and global sinks for wastes – including the capacity of rivers to break down biodegradable wastes as well as the capacity of global environmental systems, such as climate, to absorb greenhouse gases.

Alongside the development of this definition of sustainable development, the World Commission on Environment and Development (WCED), acknowledged the concept of 'sustainable livelihood approach (SLA)' when it first appeared in the report of an advisory panel of the WCED in 1987 (WCED, 1987). This wider concept of sustainable development made SLA an important guide for many nations and the international development communities which is increasingly being adopted in a wide range of fields (Williams and Millington, 2004).

1.1.2 The concept of the SLA

The most well known definition of a SLA comes from Chambers and Conway (1992) and a modified version of this definition has been generally adopted, with minor differences between authors and organisations:

"a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets…."

"... both now and in the future (Carney, 1998)" or

"... while not undermining the natural base (Scoones, 1998)" or

"….including both these last statements (Farrington et al. 1999)".

Ellis (2000) in his definition of a 'livelihood' has placed more emphasis on the 'access' to assets and activities that is influenced by social relations (gender, class, kin, belief systems) and institutions. He has however, excluded any reference to capabilities or sustainability. The most well known sustainable livelihood framework has been documented by DFID (Figure 1.1) (Carney, 1998; Carney, 1999; DFID, 1999).

Assets

The SLA is based on the premise that understanding the asset status of the poor is fundamental to understanding the options open to them, the strategies they adopt to attain livelihoods, the outcomes they aspire to and the vulnerability context under which they operate (Ellis, 2000). DFID distinguishes five categories of assets (or capital) – natural, social, human, physical and financial (Carney, 1998). In aquaculture, natural assets include fish species raised; physical capital includes constructed ponds, human capital includes knowledge of fish culture; financial capital includes income from selling fish; and social capital includes the use of pond water for washing, bathing etc. by other community households (Little et al. 2007). An analysis of assets is a review of what people have (and recognition of what people do not have) rather than an analysis of needs (Helmore, 1998).

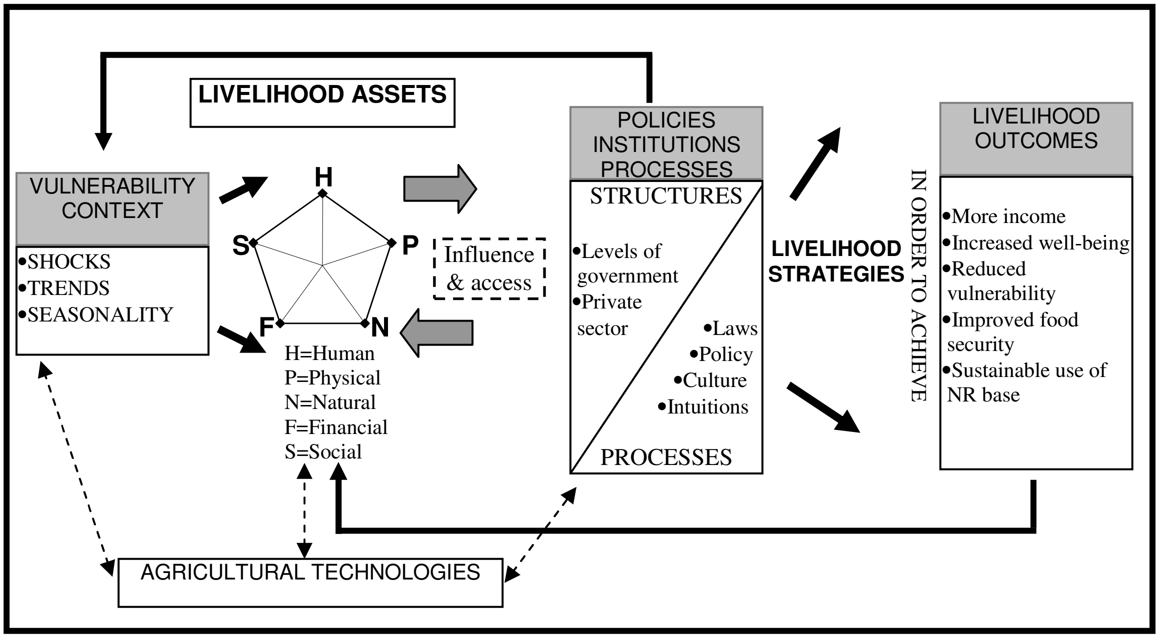


Figure 1.1: Sustainable Livelihoods Framework (source: Adato and Meinzen-Dick, 2002).

Transforming structures and processes

It is important to understand the structures or organisations, and the processes such as laws, policies, societal norms and incentives. Access, control and use of assets are influenced by the institutional structures and processes. For instance, in Bangladesh, earlier aquaculture extension organizations tended to exclude poorer households. However, recently broader development and effort by promoters appear to be increasing pond culture as an opportunity for the poorer through enhancing access arrangements (e.g. sharecropping, lease arrangements etc.) (Little et al. 2007). An understanding of structures and processes provides the link between the micro (individual, household and community) and the macro (regional, government and powerful private enterprise) level (Scoones, 1998; Carney, 1998; Ellis, 2000).

Livelihood strategies

The term 'livelihood strategy' is used to denote the range of combination of activities and choices that households make in order to achieve their livelihood goals. Livelihood strategies include: how people combine their income generating activities, the way in which they use their assets; which assets they chose to invest in; and how they manage to preserve existing assets and income (DFID, 2000). For instance in aquaculture, both producer and non-producers carry out versatile activities as part of their livelihood strategies. At the producer level, integration of pond aquaculture with vegetable cultivation on the pond dikes using pond water and mud for irrigation and fertilization respectively has been adopted by poorer households as part of their livelihood strategy in Bangladesh (Little et al. 2007). Whereas at the non-producer level, fry traders generate income by trading fish seed from hatchery/nursery to pond farmers (Barman et al. 2002) and fish traders generate income by trading fish from pond farmers to markets (Faruque, 2007).

Livelihood outcomes

Livelihood outcomes are the achievement or results of livelihood strategies. Outcomes can be examined in relation to the sustainable use of resource-base, improved food security, more income; increased well-being; improved social relation and status; improved dignity and respect; and reduced vulnerability (DFID, 2000). In aquaculture practice, use of ponds in a sustainable manner, increased fish consumption, additional income from fish, consumption of fish in the month when fish are less available in market or from wild sources have been identified as important livelihood outcomes in Bangladesh (Little et al. 2007).

Vulnerability context

Vulnerability is a key component in the SLA. The vulnerability context refers to the shocks, trends and seasonality that negatively affect people's livelihoods. The key feature of all factors within the vulnerability context is that they are not controllable by local people in the immediate or medium term. Vulnerability or livelihoods insecurity resulting from these factors is a constant reality for many people in the world (DFID, 2000). Households however often try to reduce the consequences of vulnerability factors such as shocks, trends and seasonality. In the case of aquaculture, households were reported to increase fish consumption from their own ponds to cope with seasonal shortages wild fish (Karim, 2006).

During the past decade, the SLA has been adopted by a number of government, non-government and multilateral organisations, such as the DFID, UNDP, OXFAM and CARE as a basis for natural resource based development and research (DFID, 1999; UNDP, 1999; NZAID, 2002).

1.1.3 Sustainable natural resource (NR) based development for the poor

About 70% of the MDG targeting poorer people live in rural areas, where their immediate livelihood benefits can be achieved through the development of agriculture using existing NR base (e.g. land, waterbodies etc.), which could help the poor to overcome some of the critical constraints they face in meeting their basic needs (Rosegrant et al. 2006). In 2000, the member states of the United Nations adopted the Millennium Declaration as a renewed commitment to human development. The Declaration includes eight MDGs, each with quantified targets having direct and indirect linkages with agriculture, to motivate the international community and provide an accountability mechanism for actions taken to enable millions of poor farmers to improve their livelihoods. Considering rural communities with their existing ecosystems, a necessary component in meeting the MDGs by 2015 in many parts of the world is a more sustainable productive and profitable agricultural sector (Rosegrant et al. 2006).

Among the MDG's target countries, Bangladesh is the most densely populated country in the world excluding Singapore (Sen, 2003). Agriculture provides livelihoods to more than two-thirds of the rural population in Bangladesh (FFYP, 1998). However, due to its dense population, Bangladesh has one of the lowest land/person ratios (Rasul and Thapa, 2004). Population growth (around 2% annually) further reduces the availability of land for agriculture by creating increased demand for land for settlements, roads, industry, and other non-agricultural uses (FAO, 2000a).

There is therefore, a growing emphasis on sustainable agriculture in response to concerns about the adverse environmental and economic impacts of conventional agriculture (Hansen, 1996). Sustainable agriculture should be considered from the perspectives of ecological soundness, economic viability, and social acceptability. Ecological soundness refers to the preservation and improvement of the natural environment. Economic viability refers to maintenance of yields and productivity of plant and animal, and 'social acceptability' refers to self-reliance, equality and improved quality of life (Yunlong and Smith, 1994). The diversity and abundance of literature written over the years to conceptualize sustainability has formed a consensus on three basic features. These are: (i) maintenance of environmental quality, (ii) stable plant and animal productivity, and (iii) social acceptability (Rasul and Thapa, 2004). As an important part of agriculture, aquaculture development in particular strives to be sustainable, to all intents and purposes (De Silva, 2001).

1.1.4 Sustainable aquaculture development

The broader definition of aquaculture put forward by Beveridge and Little (2002) based on the key criteria of i) some form of intervention to increase yield; and ii) either ownership of stock or controls on access to and benefits accruing from the interventions. Aquaculture systems may be characterized by their degree of intensity of farming as intensive, semi-intensive and extensive (Edwards, 1999). Intensive aquaculture systems depend on relatively high-cost, nutritionally complete diets. In semi-intensive systems natural food within the system is increased by organic (manures) or inorganic fertilizers and/or is complemented by usually low-cost supplementary feed. Extensive aquaculture relies on natural food such as plankton for fish in the culture system without intentional human intervention (Edwards, 1999b). There have been however, many efforts to create a conceptual framework for understanding and defining sustainable aquaculture (Wurts, 2000).

A stakeholder survey was conducted by Caffey et al. (1998) in an attempt to develop a consensus assessment of sustainable aquaculture in the south-western United States. Respondents were polled to determine measurable indicators of sustainability in three different areas: sociological, economic and environmental. Sociological interests centred on employment, local concerns such as residency/ownership and aesthetics, and regional sources of inputs. Economic issues focused on profitability, market demand and improved feeding efficiency. Environmental concerns dealt with the quantity of land, water and energy used; water quality; and effluents (Caffey et al. 1998).

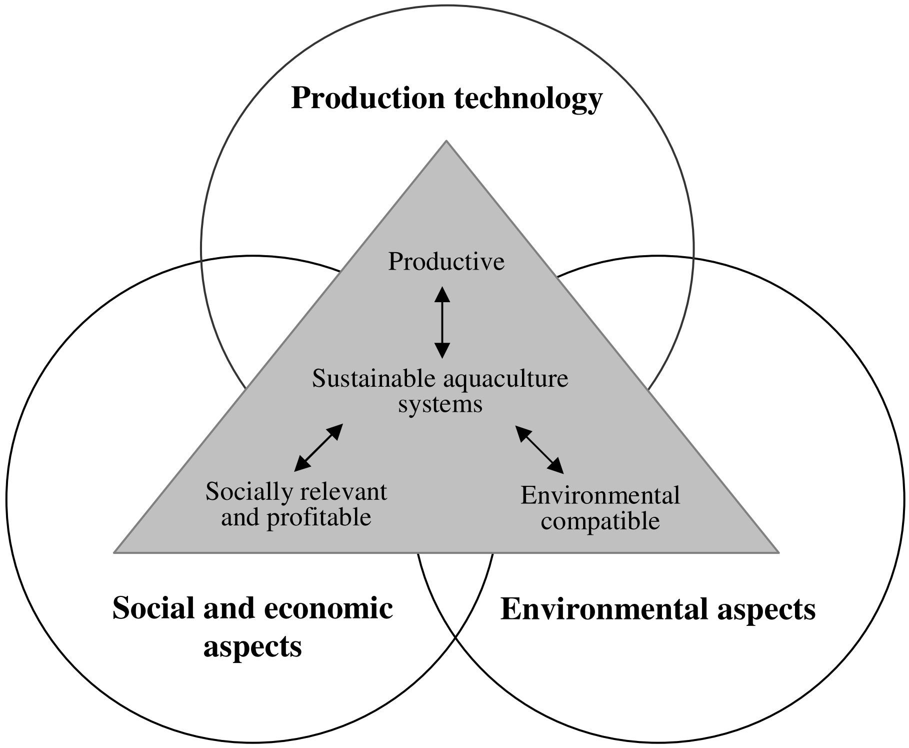


Figure 1.2: The three inter-related aspects of sustainability of an aquaculture systems: production technology, social and economic aspects, and environmental aspects, source : AIT (1994).

The semi-intensive and extensive aquaculture have been characterised as rural aquaculture systems (Edwards, 1999a), which greatly depend on locally adopted technologies and limited household resources (Edwards and Demaine, 1997). Sustainability in respect of rural aquaculture, has been expressed schematically (AIT, 1994), where it was considered in terms of three interrelated aspects viz. production technology, social and economic aspects, and environmental aspects (Figure 1.2). Definitions of the inter-related aspects required in general for aquaculture technology to be sustainable in the poor farming households are (AIT, 1994):-

- Production technology – a technology needs to be sufficiently productive for aquaculture to be an attractive option to possible alternative and/or competing uses of resources.

- Social and economic aspects – low-unit cost input systems may be most appropriate for the limited resource base of most poor farming households; and low production costs mean that fish can be sold at a relatively low market price and be affordable to poor consumers.

- Environmental aspects – a technology needs to fit into the limited resource base of the poor, not use resources that may be used more productively in other ways, and be environmentally friendly.

The basic intents and purposes of this definition of sustainable aquaculture are more or less similar to those in the definition of sustainable development given by WCED (1997). It is however, essential that aquaculture not be considered only in narrow technical aspects, in isolation from crucial social, economic and environmental contexts. Rather sustainable aquaculture technologies need to be characterised with respect to their ability to contribute to the improved welfare of the poor in each and every local situation or context in which they have potential (Edwards, 1999a).

Recent aquaculture research began to assess on the livelihoods of the poor and embrace non-producers as beneficiaries through the emergence of complex marketing and service networks (Faruque, 2007). Additionally, benefits of aquaculture may relate to the integrated use of water rather than simply fish production alone (Prein, 2002; Karim, 2006; Turongruang, 2007). It may also be extended to include the management of unstocked aquatic animals and food security of poorer households in Asia (Morales, 2007).

1.2 Aquaculture potential for food security and poverty reduction

Poverty is a multidimensional concept, and viewed as pronounced deprivation in wellbeing (World Bank, 2001). The most common identified causes of poverty in rural areas are related to living in remote areas and unfavourable agricultural environments, limited access to transport, power and infrastructure, illiteracy and having very few agricultural and non agricultural assets (Sen, 2003). The typical means of poverty reduction emphasise food production, agricultural diversification, creating access and human development in terms of education, health and nutrition (Sen, 2003).

In spite of continued efforts by development promoters to provide a more stable, sustainable food supply including provision of an adequate nutritional quality for poorer people, a great proportion of the population in the developing world still suffers from chronic under-nutrition and poverty (Ahmed and Lorica, 2002). Agricultural policies in developing countries, while continuing to focus on ways of increasing supply from traditional crop farming, have overlooked the role of diversified production, employment and income generation on farms in achieving food security (Ahmed, 1999). Recognition is given to the role of balanced nutrition, including critical vitamins and minerals in the diet, and the need for improvements in sanitation, hygiene and living environments, which are related to income and purchasing power, rather than just food production and consumption (Ahmed and Lorica, 2002). Technological development, the revolution in information and communications and the current trends towards increasing globalization have created new opportunities and challenges for developing countries to improve the food security of low-income poorer section of the population (Pinstrup-Andersen, 1999). Further, the cereals and crop commodity supply perspective of food security has now changed to include products such as fish and livestock (Ahmed et al. 1999; Delgado et al. 1999).

Of the different global food production systems, aquaculture is widely perceived as an important weapon in the global fight against malnutrition and poverty, particularly within developing countries (Tacon, 2001). Aquaculture is regarded as an important domestic provider of much needed high quality animal protein and other essential nutrients (generally at affordable prices to the poorer segments of the community) and/or a provider of employment opportunities and cash income. In view of these positive characteristics, that aquaculture has been the world's fastest growing food production sector for nearly two decades (Tacon, 2001) and over this time scale the relative contribution of aquatic products to global animal production has increased. Aquaculture production in the developing countries has been growing more than five times as fast as in developed countries since 1984 (FAO, 2000c). Between 1990 and 2000, the annual growth rate in aquaculture was 11.4%, compared to 4.9% for poultry, 2.5% for pork and 0.5% for beef (FAO, 2004), and it is expected that this trend will continue over the coming decades (Ahmed and Lorica, 2002).

Continued growth in the aquaculture sector has also resulted in an increasing contribution to total world fishery production, which historically has been dominated by capture fisheries (New, 1999). Estimates for 2003 showed a total aquaculture production (excluding seaweed) of 41.9 million tons, constituting about 31.69 % of total world fishery production, compared with 30.6 million tons (25.88%) in 1998 (FAO, 2005). Of global aquaculture production, 15.54 million tons (37%) originated from freshwater of which the major share (42%) was Chinese and Indian carp species (FAO, 2005).

In most of the low-income food deficit countries finfish aquaculture production is based on the culture of low-value herbivorous/omnivorous freshwater finfish in inland rural communities, within semi-intensive or extensive farming systems that use moderate to low levels of production inputs. These systems produce large quantities of affordable food-fish for home consumption and purchase by low income people in domestic markets (Tacon, 2001; FAO, 1996). In 1998, nearly 90% of the total world aquaculture production came from developing countries, mainly from low-income food deficit countries, with China as the world leader contributing two-thirds of world production (Tacon, 2001). The share of aquaculture in total fisheries production has likewise grown in low-income food deficit countries, especially against the backdrop of over-fishing and declining productivity from capture fisheries.

A steady growth in the production of fish species grown on agricultural farms in low-income food deficit countries and consumed domestically has occurred (FAO, 1996; New, 1999; Laureti, 1998). Thus, considerable adoption of aquaculture on traditional agricultural farms in a number of countries, such as Bangladesh, China, India, Indonesia, Thailand and Vietnam, have shown some early signs of aquaculture's ability to improve productivity and food security, contribute to the diversification of farm operations, poverty reduction, and create additional employment and income (Ahmed and Lorica, 2002). The linkages between the traditional and cultural consumption habit of fish-based diet, declining wild stocks of fish and increasing year round demand and supply of low priced cultured fish (e.g. tilapia culture in Thailand) has reinforced the importance of aquaculture for the poor in developing countries (Belton et al. 2007).

1.2.1 Aquaculture development in Bangladesh

The People's Republic of Bangladesh, a unitary, independent and sovereign country only since 1971, was under Muslim rule for five and half centuries prior to the onset of British rule in 1757. During the British rule it was a part of the British Indian province of Bengal and Assam. In August, 1947 the land of Bangladesh gained independence from the British rule as East Pakistan (BBS, 2003a). Finally Bangladesh emerged as an independent country on March 26, 1971 after a civil war of liberation with Pakistan.

With a total land area of 147,570 km^2, Bangladesh has a large population (123.1 million; 2001 census), with high population density (about 834 persons per km^2), low per capita arable land (0.06 ha low per person) and low per capita income (US$ 461 per year) (BBS, 2003a). The growth rate of the population has been lowered dramatically from about 3.0% in 1960s to 2.4% in 1980s, then sharply to 1.5% in 1990s through the adoption of a National Family Planning programme (Hossain et al. 2005). The current and expected population however are exceedingly high and the increasing number of poor and functionally landless (Hossain et al. 2005) are expected to increase faster in the near future than anywhere else in the world.

Agriculture (including aquaculture and capture fisheries) is a major contributor to the economy of Bangladesh, accounting for 22 % of GDP (BBS, 2003a). Aquaculture and capture fisheries make up 24% of agriculture and 5% of GDP (DoF, 2005). Fish and fisheries have been an integral part of the life of the people of Bangladesh from time immemorial, and play a major role in employment, nutrition, foreign exchange earnings and other aspects of the economy (Alam and Thompson, 2001). The fisheries sector provides full-time employment to an estimated 2 million fishers, small fish traders, fish transporters and packers, etc. and another 10 million people are partly dependent on fishing, e.g. part-time fishing for family subsistence (DoF, 2005). Fish is a natural complement to rice in the national diet, and fish alone supplies about 63% of average animal protein intake, hence giving rise to the adage *mache-bhate bangali*, a Bangali is made of fish and rice (DoF, 2005).

In terms of fisheries resources, the country is very rich in inland water for fish production, being the delta of three major river systems, i.e. the Ganges, Brahmaputra and Meghna. Altogether, a total of 230 large and small rivers (BBS, 2003a) with their tributaries and branches criss-cross the country, with extensive floodplains along their banks. The estimated total floodplain area is 6.3 million ha, of which 0.8 million ha have been permanently dried through flood protection measures. The balance of 5.5 million ha (MPO, 1989) is inundated at various depths ranging from very shallow (0–30 cm) to deeply flooded (more than 1.8 m) during the monsoon season. Additionally, recent expansion of aquaculture through private initiatives, as ad hoc development often for pond construction and rice production have reduced the area of permanent and seasonally flooded land. The estimated total area of freshwater pond is 230,000 ha which contributes the major portion of culture fisheries. Other fisheries resources include oxbow lakes (5488 ha), Kaptai lake (68,800 ha), road side ditches, borrowpits and irrigation canal (500,000 ha).

There are about 300 freshwater species (260 indigenous fish, 12 exotic fish and 24 prawn species) available in Bangladesh (DoF, 2005) of which only a limited number of species are cultured. In 2004, the major bulk (about 80%) of fish production was derived from inland fisheries of which a declining share (45%) was from capture fisheries. The remaining 55% of inland production was derived from culture fisheries based on 16 species of Indian and exotic major carps, catfish and tilapia (DoF, 2005), indicating the increasing importance of aquaculture in food supply.

The distinctive characteristic of aquaculture compared to capture fisheries is that, the growth potential of aquaculture primarily depends on a greater control over seed. In semi-intensive carp polyculture, which still dominates aquaculture in Bangladesh, stocking of fingerlings has been identified as the major input cost per ha production (Alam, 2002). It was also stressed by Mazid (2002) that poor access and cost of quality seed is the single largest limitation to aquaculture in Bangladesh. Moreover, it was realised that inadequate supply of fingerlings with respect to both quality and quality is constraining many pond fish producers in Bangladesh (Alam, 2002; Brown, 2003; Little et al. 2005) .

1.2.2 Context of fish seed in Bangladesh

Before the development of fish seed producing hatcheries in Bangladesh in the 1960's following successful artificial breeding of Indian major and Chinese carps, farmers relied on wild seed to culture fish. Until the 1980's approximately 95% of fish spawn was collected from natural sources (Figure 1.3), currently more than 98% of spawn is produced in the hatcheries (DoF, 2005). Private centralised hatcheries developed in clusters are the main producers of fish seed meeting the major requirement of farmers supplying seed through a complex network of nursery operator and fry traders (ADB, 2005). Increasingly networks of private hatchery producers and traders are dominating the supply of fish seed to the farmers however, poor quality seed, caused by poor genetic management of breeders and accidental hybridization is a common emerging constraint (ADB, 2005). The possible underlying genetic and non-genetic causes responsible for gradual deterioration in yields and individual size of many species of cultured fish were identified (Morrice, 1995). Poor husbandry of fish seed during nursing, holding or transportation is believed to negatively affect their later performance in Northwest Bangladesh (Morrice, 1995).

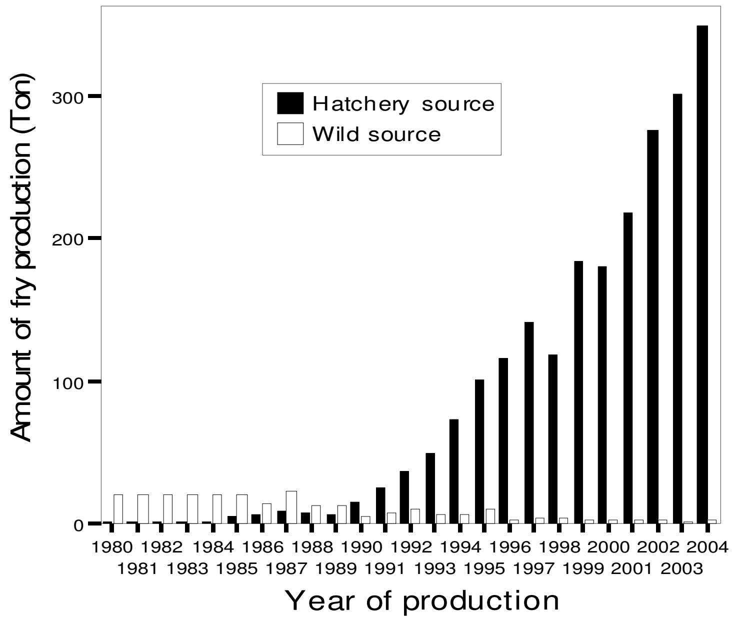


Figure 1.3: Comparative production of fish fry from wild and hatchery over the last two decades in Bangladesh (FRSS, 2003-2004).

A survey on the existing methodology of fry/fingerling production in Bangladesh was conducted by an FAO/UNDP project in 1990. This survey revealed that the production technology was characterized by overstocking of nursery ponds, inadequate pond-preparation, improper manuring and fertilization and use poor quality feed. Also, intermittent thinning of the fry population and unnecessarily prolonging the production cycle were common features in nursery practices (FAO, 1992). Low survival, slow growth, low production of biomass, unnecessary wastage of fry resource and fertilizer, and low profit margin are the inevitable results of inadequate nursery management systems (FAO, 1992). A previous study however, revealed that some large hatcheries have the capacity to satisfy their customers with a supply of good quality hatchlings (Barman et al. 2002).

The single most important indicator of 'quality' of fish seed is the size of juvenile fish that could be supplied to foodfish producing farmers. A larger seed will survive better and grow faster to marketable size than a smaller seed produced under the same conditions (Little et al. 2005). The supply of large size fingerlings for stocking in different types of waterbodies is increasingly being emphasised by policy makers and promoting organizations (Rahman, Undated) as the success of aquaculture operations greatly depends on survival which can be ensured by stocking of large fingerlings. For instance, the Department of Fisheries (DoF), Bangladesh, in collaboration with Non-Government Organization (NGOs) implemented the New Fisheries Management Policy (NFMP) and later Improved Management of Openwater Fisheries (IMOF) to enhance the production of open waterbodies involving the poor with the expectation of improved livelihoods, but the target was constrained by the irregular supply of fingerlings (Lewis, 1997). As a result, the timely and adequate supply of good quality seed has been a precondition in all regions, both for scaling up production and adoption of aquaculture by new entrants (World Bank, 2006). Realising the context of fish seed supply, strategies to decentralize fish seed/fingerling production at the farming household level have been emphasised to ensure the availability of quality fish seed (Little et al. 1999).

1.3 The concept of decentralised fish seed production

The classical concept of decentralisation has a long tradition in political science and is concerned with the extent to which power and authority should be dispersed through the geographical hierarchy of the state, and the institutions and processes through which such dispersal occurs (Smith, 1985). In an organizational management context, the term 'decentralisation' implies more autonomy, whereby authority is vested in those further removed from the centre, while conversely 'centralised' implies the authority to make important decisions lies toward the 'head'(Cummings, 1995). The policies of decentralisation are currently used in a number of different countries in a number of different ways and contexts (Samoff, 1990). In terms of Bangladesh Government policy, it is argued that decentralisation is a more efficient way of meeting the needs of local poor, moreover decentralisation can cut red tape and make government and administration more flexible, accountable and responsive by bringing government closer to the people (Westergaard and Alam, 1995).

Outside of the political arena a decentralised approach is effectively being used to deliver healthcare building satellite clinics (Habib et al. 2000) and to provide electricity facilities through photovoltaic systems (Biswas et al. 2004) in the remote and peripheral areas of Bangladesh. The concept of a decentralised approach does however have some limitations. For instance under a decentralised local government in Bangladesh, local resources (e.g. state own waterbodies) were reportedly controlled and exploited by elites or political factions (Westergaard and Alam, 1995).

As with the classical concept of decentralisation, fish seed production at the farmer level has been regarded as a strategy for the decentralization of fish seed production (Little et al. 2005). Decentralised or farmer level fish seed production can be accomplished in two ways i) through conventional earthen pond nursing; and ii) alternative methods of spawning and nursing of fish seed that generally require a lower level of investment. As an alternative method which is 'less 'risky', a smaller-scale and promising approach is spawning and nursing of small fry in irrigated ricefields (Little et al. 2005). In Indonesia, with limited nursery capabilities, the potential of using ricefields quickly became evident and ricefish farming for fingerling production became popular among rice farmers (Halwart, 1998). In ricefield based decentralised fish seed production system, most success has been achieved to date using small carp and tilapia (AIT Aqua Outreach, 1997; Gregory et al. 1997; Barman and Little, 2006).

1.3.1 Potential of ricefield for fish seed production

'There is rice in the fields, fish in the water'. This sentence inscribed on a stone tablet from the Sukhothai period – a Thai Kingdom that flourished 700 years ago - depicts a scene of an idyllic value (Schuster, 1955). Since long ago, in flooded ricefields, living aquatic resources such as fish, freshwater prawns and crabs, snails, mussels and frogs occur naturally. These were regularly caught or collected and have played an important role in the diet of rural farming households in many parts of Asia (Prein, 2002).

Before the intensification of agriculture in Bangladesh, traditionally rural farmers captured wild fish that entered the rice fields through flooding by excavation of a sump in the low-lying area of their farms (Gupta et al. 2002). There were concerns that intensification of rice cropping was adversely affecting the ecology of rice fields (Pingali, 1992). With the use of pesticides and larger amounts of inorganic fertilisers, the natural occurrence of these living aquatic resources has been reduced considerably (Prein, 2002). The decline in wild stocks, coupled with increasing demand for fish, elicited special attention from researchers in 1970s and 1980s (Gupta et al. 2002). Hence, there has been a move towards diversification out of rice monoculture (Pingali, 1992). In this regard, it was suggested that the area under rice cultivation will have to accommodate crop diversification in Bangladesh as demand for other food items increases rapidly as a result of urbanization and a spectacular growth in per capita incomes since the mid 1980s (Hossain et al. 2006). This leads to renewed interest in research and development on alternatives to rice monoculture. One of these is the age-old practice of integrating fish culture with rice farming (Gupta et al. 2002).

Stocking and culture of fish in ricefields has a long history (Guan and Chen, 1989) which can be traced back to the Eastern Han Dynasty (25-222 AD) in China (Li, 1992) with numerous designs and experiences in experimentation and implementation (dela

Cruz, 1994; Cai et al. 1995; Halwart and Gupta, 2004). In some societies selected species of fish, molluscs and crustaceans have been stocked intentionally to augment the availability and production of protein from ricefields. In floodplain conditions, trap ponds in ricefields, in which wild fish are concentrated in the dry season, have been used to extend the holding period of fish with modest feeding (e.g. rice bran) in order to avoid a bulk harvest (Guttman, 1999). This is characterised as an intermediate system of managing non-stocked aquatic animals contributing to rural livelihoods (Islam, 2007).

The ricefish system functions through the feeding of fish on organisms (particularly insects and other possible rice pests) and weeds, and the stirring of the sediment through their foraging action which leads to nutrient re-suspension (Lightfoot et al. 1993). In ricefield systems it has also been frequently observed that rice yields increase through the inclusion of fish (dela Cruz et al. 1992; Cai et al. 1995). As the price of rice has fallen considerably in recent decades, the value of the produced fish can be higher than that of the crop and, thereby, of great importance for additional cash generation by farmers (Prein, 2002). The benefits of ricefish culture as a low-investment entry-level technology for resource-poor farmers has been demonstrated in Bangladesh (Gupta et al. 1996), Indonesia (IIRR/ICLARM, 1992; Purba, 1998), the Philippines (IIRR/ICLARM, 1992; Horstkotte-Wesseler, 1999) and Vietnam (Rothuis, 1998). Research initiatives over the years indicate a range of variability in the productivity of ricefields for fish (Table 1.1).

Table 1.1: Ricefield productivity for aquatic animals in wild and cultured condition in different countries

Means of production	Countries	Production	Sources
Wild captured	Thailand	208kg/ha	(Middendorp, 1992)
	Malaysia	175kg/ha	(Ali, 1990)
	Bangladesh	37kg/ha	(Anonymous, 1985)
Culture intensification	China	2.5t/ha	(Li, 1992)
	India	2t/ha	(Ghosh, 1992)
	Indonesia	805kg/ha	(Koesoemadinata and Costa-Pierce, 1992)
	Vietnam	2.2t/ha	(Quyen et al. 1992)
	Thailand	900kg/ha	(Fedoruk and Leelapatra, 1992)
	Bangladesh	980kg/ha	(Ali et al. 1993)
	Bangladesh	271kg/ha	(Haroon and Pittman, 1997)
	Bangladesh	742Kg/ha	(Frei et al. 2007)

Although ricefields have shown potential for fish production, several studies suggest that the lack of availability of fish seed when required is one of the major constraining factors to promote ricefish cultivation (Waibel, 1992; Gupta et al. 1996; Halwart, 1998; Edwards, 1999b). Over the last decade however, irrigated ricefields have evolved as a potential system of fish fingerling production in the Northwest region of Bangladesh (Barman and Little, 2006).

1.3.2 Present context of irrigated ricefields

Rice is cultivated in approximately 147 million ha worldwide, which roughly corresponds to the combined land area of Portugal, Spain, France and Germany (Frei and Becker, 2005). Almost 90% of this areas lies in Asian countries, most of which are under considerable population pressure (Figure 1.4). Currently, the highest yields per ha obtained are in the sub-tropical regions, e.g., Egypt, southern United States, Australia, Southern Europe and Japan, where rice production is highly mechanized and fully irrigated (Frei and Becker, 2005).

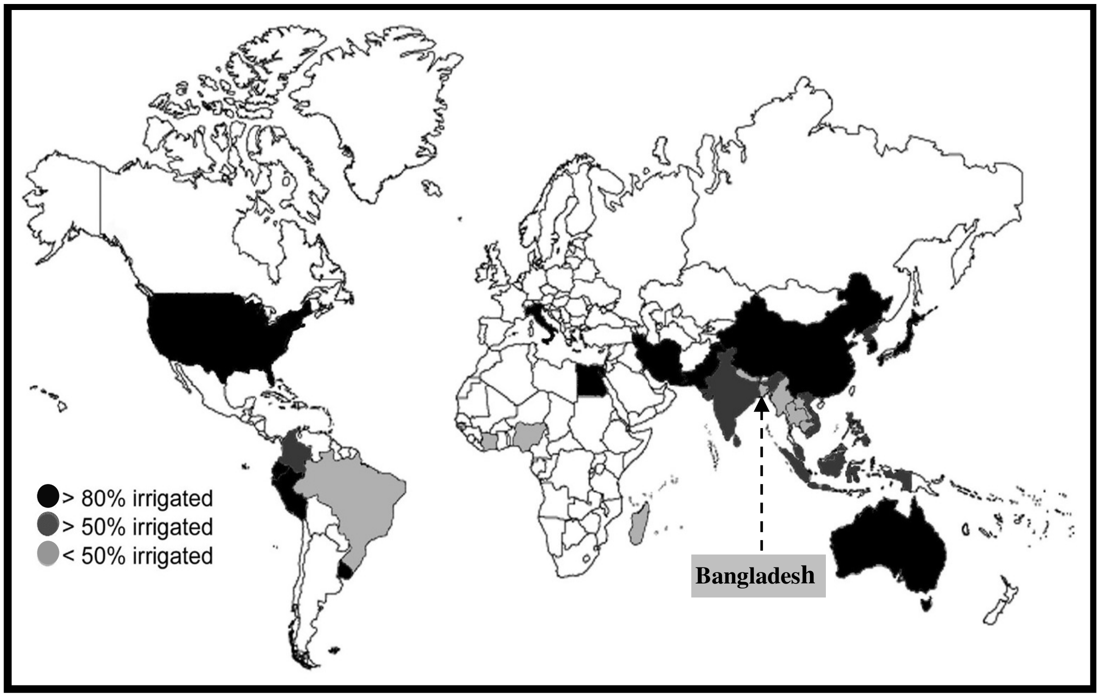


Figure 1.4: The most important rice producing countries as characterized by their irrigation development, adapted from MacLean et al. (2002).

Production pressure on land was reportedly increasing rapidly in developing countries in Asia that rely heavily on rice production, such as Bangladesh. Population density is projected to rise by more than 80% in Bangladesh by 2050 (United Nations, 2002). To meet the projected increase in food demand, agriculture productivity will have to increase (Frei and Becker, 2005) and the use of agricultural land will be further intensified (Jenkins, 2003).

Traditionally, Bangladeshi farmers grew their main annual rice crop in autumn (*amon*, in lowland fields), and summer (*aus*, in upland areas), along with secondary winter crops of pulses, wheat, oilseeds, and other minor grains. *Boro* (irrigated spring rice) rice did not constitute a major proportion of the overall rice harvest. However, over the past few decades improved varieties of *boro* rice have become the dominant winter crop in Bangladesh (Oakley and Momsen, 2005).

The main factor making *boro* rice the dominant crop is increased and easy access of farmers to irrigation throughout the country (Hossain et al. 2006). The rapid expansion of irrigation began in the early 1980s with the promotion, under the private sector, of small capacity shallow tube-wells for ground water irrigation. Beginning in 1986, the government removed the ban on private sector imports of agriculture equipment and easy availability of spare parts, and reduced import duties on agricultural machinery. Those led to a substantial reduction in the cost of tubewells and development of a market for irrigation services which contributed to the large expansion of irrigation in the 1990's (Mandal, 1980; Hossain et al. 2002). Ground water irrigation now accounts for nearly three-fourths of the total irrigated area in Bangladesh (GOB, 2002). In particular, 65% of the area planted to *boro* rice is operated through the expansion of minor irrigation through shallow tube-wells and power pumps (Hossain et al. 2006).

1.3.3 Decentralised fish seed production in irrigated ricefields: an overview

The production of fish fingerlings in irrigated ricefields by farmers rather than in specialised geographically clustered hatchery and nursery enterprises can be termed as a form of decentralised fish seed production. Indeed, stocking eggs of common carp, broodstock of tilapia and hatchery produced fry in ricefields is the approach used in the decentralised fish fingerling production system (Little *pers. com.*, 2004). Fish seed/fingerling production in irrigated ricefield based systems has taken a new direction over the last 1990s in Bangladesh.

Initially through the initiative of Northwest Fisheries Extension Project (NFEP) in 1991, forty farmers from four tubewell schemes in Northwest Bangladesh were willing to attempt rice-field culture in their ricefields during the *boro* rice crop. Encouraging results from these farmers led to an expansion of activities in 1992, when Cooperative American Relief for Everywhere (CARE) promoted fingerling production of common carp in irrigated ricefields at the farmer level (Gregory and Kamp, 1999b). CARE initiated the use of locally produced common carp eggs in irrigated ricefields to produce fingerlings through its Integrated Rice Fish (Interfish) project with the funding support from the Department for International Development (DFID), UK. Although this approach was used initially as a tool for integrated pest management (IPM) techniques, it later showed its potential for fish seed production. Emphasising the potential of ricefields for fish seed production technology, such promotion was further extended from 2000 to 2005 by CARE with continuous support from DFID through its Greater Opportunities for Integrated Rice Fish (Go-Interfish) project (Barman et al. 2004). The CARE's Go-Interfish project together with its 45 partner NGOs, disseminated this technology along with broader livelihood improvement programmes for poorer households in the Northwest region of Bangladesh in Dinajpur, Thakurgaon, Panchagar, Rangpur, Nilphamari, Kurigram, Lalmonirhat, Gaibandha, and Joypurhat districts (CARE, 2006). Initially, the practice of fish seed production in the ricefield based systems was developed at the rural household level using common carp eggs collected using water hyacinth from their own or neighbouring household ponds in winter (December to February) and stocked in irrigated ricefields to produce fingerlings. Thereafter, seed production of an improved tilapia strain (GIFT) in ricefields, supported by a DFID-NFEP research project, was piloted in two communities within CARE-Interfish project areas of Rangpur district in 1999. The use of tilapia in which a small number of broodfish were stocked in ricefields was evaluated as a potentially complementary seed production strategy to the ongoing production of common carp seed (Barman, 2000). CARE later disseminated both common carp and tilapia seed production in its new Go-Interfish areas in Northwest Bangladesh. In addition, some farmers who had the ability to purchase riverine carp fry stocked them along with common carp and tilapia in the same ricefields to produce fingerlings (Barman et al. 2004).

The impacts of ricefield based seed production on households' livelihoods could occur in several ways. Lack of availability of cash input is an obstacle for many poor farmers and their livelihoods (DFID, 2004). The bulk of their income typically comes only after rice harvest and many farmers do not have sufficient access to credit, savings or remittances to finance the costs of inputs such as seed and fertilizer (DFID, 2005). In order to minimize input costs of fish culture, fingerlings produced in decentralised systems could be stocked in household's own ponds (Barman and Little, 2006; Little et al. 1999).

Sustainable agriculture technology seeks to minimize the dependency on external inputs. The high dependency on external inputs increases farmer's vulnerability to reduced profits, as they have no control over supply and price of inputs (Ikerd, 1993; Pretty, 1995; Altieri, 2000). Thus, sustainable agriculture tends to be about low-input farming which can contribute to growth and poverty reduction (DFID, 2005). An efficient aquaculture system requiring fewer inputs and producing wider benefits and fewer wastes could be expected to be more sustainable (Muir, 2005). Decentralised common carp and tilapia fingerling production in ricefields is less likely to be 'competitive' with centralised hatchery based seed production as centralised hatchery/nursery based seed production is dominated by riverine carps and catfish (Barman et al. 2004). As the fingerlings produced are large in size, it might be expected that they some could also contribute directly to enhanced food security through direct consumption (Barman and Little, 2006). In decentralised systems, tilapia fingerlings could be produced as well as foodfish over a longer period of time, potentially alleviating seasonal malnutrition through filling the seasonal hungry gap of farming households (Gill, 1991).

Fingerling production in irrigated ricefields is relatively extensive and low input, thus pressures to intensify with the consequent negative impacts on quality are low.

Therefore, the fingerlings tend to be healthy and more predator resistant and they are easy to identify and less likely to have suffered physical damage as a result of transport over long distances (Little et al. 1999). Through decentralised fish seed production systems, employment and income generation would be localised and the monopolistic tendencies that lower returns and increase risk for poorer workers in the existing fish seed networks be reduced (Little et al. 1999). Fingerlings could be readily marketed in the localities though direct involvement of fry traders and food fish producers (Barman and Little, 2006) which in turn could overcome the major quality issues for rural foodfish producers. Moreover, marketing of locally produced fish seed can stimulate and support local people to incorporate fish culture within their livelihood systems (Little et al. 2002b). As the movement of women is culturally restricted in Bangladesh, it is quite difficult for them to travel to distant areas to purchase necessary inputs like fertilizers, fingerlings and feed that are required for fish culture (Shelly and Costa, 2001). Household level fish seed production could potentially encourage women to be involved in aquaculture (Barman et al. 2004).

A previous study showed that better-off farmers tended to adopt ricefish technology (Gupta et al. 2002). However, during the development of ricefield based fish seed production (RBFSP), the strategy of the promoters was to emphasise the involvement of poorer households into their intervention from the onset (Banu and Bode, 2002; Barman and Little, 2006). In irrigated ricefields seed production tends to be carried out with the minimum expenditure as it does not require many external inputs. Such a poverty focused approach along with the low cost nature of this technology appears to stimulate adoption the technology by poorer households (Barman and Little, 2006). However these earlier studies showed few insights into the reasons for adoption of this technology. Reasons responsible for non-adoption identified were water scarcity, time competition with off-farm activities and other agricultural activities (Barman et al.

2004). Adoption of RBFSP has also been reported to minimize and eliminate the use of pesticides in ricefields (Gregory and Kamp, 1999b; CARE, 2001a; Barman and Little, 2006). In terms of water uses for human food production in terrestrial and aquatic environment, aquatic food production requires a much higher volume of water compared to terrestrial food production (Verdegem et al. 2006). Adoption of fingerling production in irrigated ricefields could maximize the utility of irrigated groundwater.

Initially, this technology was promoted by the CARE Interfish project through farmer participatory action learning process with their groups within deep tube-well irrigation schemes. Shortly after that CARE Interfish and Go-Interfish projects adopted a farmer field school approach to disseminate ricefield RBFSP technology. Farmer field schools (FFS) were adopted as a participatory experimental learning process delivering hands-on training to attract and facilitate both illiterate and literate farmers and to keep them interested in a range of innovative ricefield management practices. In FFS curricula, ricefield based fish seed production was only one of several low-input approaches promoted (CARE, 2001a).

In ricefield based decentralised seed production system, an initial institutional support to farmers for providing training and supply of quality strain of broodfish of common carp and tilapia is important (Barman et al. 2004). This is because the quality of tilapia could deteriorate after several generations through negative selection and genetic introgression through contamination with local tilapia (Macaranas et al. 1986). Quality deterioration of tilapia in terms of growth has been perceived by some community farmers in Northwest Bangladesh (Barman et al. 2004). This indicates a potential need for external institutional support to provide farmers with initial training on this technology and quality germplasm in new areas as well as to replace the germplasm in areas where the species are already established.

The literature reviewed regarding local level fish seed production has shown few insights into its impacts on farming households or especially its impacts on the wider community, its adoption process and need for institutional support. In order to better understand these broader impacts of decentralised fish seed production, a project based investigation was carried out.

1.4 Justification of the study

Achieving benefits from agriculture across MDG targeted countries, ensuring the supply of basic inputs such as seed and fertilizer have been heavily emphasised by the member states of the United Nations (Rosegrant et al. 2006). As aquaculture is an important and fast growing part of agriculture, the agenda of ensuring and strengthening seed supply to aquaculture at the farmer level deserves similar attention.

Initially riverine hatchlings were the main source of seed in Northwest Bangladesh as in other parts of the country. In the 1980s, hatchlings were produced and supplied from hatcheries in Jessore in Southwest Bangladesh over 100 miles away from the Northwest region. In recent times, a small number of government and private hatcheries have started to supply fish seed to the region and a large amount of seed is supplied from Adamdighi in Bogra district located in the southern part of the Northwest region. Most hatcheries are small or medium in size, compared to hatcheries located in districts further north that all are small. The number of nurseries in the region has increased as demand for fingerlings has increased. Between 70-100 million fingerlings however, were imported from outside the region in 2002 (Barman et al. 2002) which indicates the increasing demand for fish fingerlings that exists. In this context, decentralised fish seed production has developed rapidly in ricefield based systems. This relatively new model for seed supply in aquaculture certainly deserves holistic investigation.

The poverty related questions remain important for any future targeted aquaculture development strategy in Bangladesh (Lewis, 1997). Conventional approaches to the development and dissemination of aquaculture technologies have failed to have major impacts on the poor (Edwards, 1999b). This study was designed to understand the impacts of this technology on the poorer sections of the communities in rural areas by identifying households according to their well-being status to understand to what extent this technology fitted with the need and resources of poorer households. As a major proportion of people live in rural areas, a significant section of them remain vulnerable to food security (Hossain et al. 2005). This study also explored potential seasonal impacts of this technology on the livelihood systems of the farming households.

Aquaculture has often been narrowly viewed as intensive farming, adopted mainly by relatively wealthy farmers to provide high value products for export (Philips et al. 1993). The narrow view of aquaculture development hides the potential of fish farming, particularly in the context of rural livelihood development (ADB, 2005). There is a need to view aquaculture within the wider context of roles and relationships within which it takes place. A poverty focused approach to aquaculture will need to consider other participants, or ‘actors’ in the network of aquaculture activities. Such categories include the fish seed traders who traditionally supply village ponds, and the fishermen who are traditionally hired by pond owners to harvest their pond on a share cropping basis (Lewis, 1997). In particular, fish seed traders are the last and most critical actors in the complex network linking sources of seed producers and foodfish producers – the ultimate users of seed (ADB, 2005). Addressing such linkages and coalitions is becoming increasingly important in natural resource based research and development (Biggs and Matsaert, 2004). This study comprehensively attempts to investigate how this technology impacts on the broader network of actors towards livelihoods improvement beyond the seed producing farmers.

Questions of agricultural technology adoption lie at the heart of economists' longstanding concerns over economic growth and poverty reduction (Moser and Barrett, 2006). Adoption of agricultural technology is directly linked to livelihoods of the poor around the world. Thousands of studies have been carried out across the globe seeking answers to why and how people come to adopt, or not, new agricultural technologies and practices (Leeuwis and van den Ban, 2004). Most of the studies however, used instrumental variables (e.g. econometric model) looking at a few household characteristics but were unable to unpack the adoption process of technology as a whole (Leeuwis and van den Ban, 2004). In this context, there was a need for a comprehensive understanding of the adoption process of RBFSP technology. A non-instrumental participatory approach was applied to understand the causal reasons behind the adoption and rejection process of this technology in farming households.

This technology has been developed and promoted in a participatory way through the involvement of farmers and promoting organizations provided with improved quality tilapia germplasm. Introduction and maintenance of the genetic quality of fish within decentralised systems requires some continued linkages to the networks of promoters (Little et al. 2007). Institutional mechanisms for promotion of this technology require grass roots level capacity (Little et al. 2007). Therefore, the process of technological dissemination needs to be addressed in terms of cost and effectiveness of different promoting mechanisms and their sustainability. Considering the above circumstances of decentralised fish seed production technology, this research was designed based on the following hypotheses and objectives.

1.4.1 Research hypotheses and objectives

The working hypotheses and objectives of the research are presented in the following Table 1.2.

Table 1.2: Research hypotheses and objectives

Working hypotheses	Objectives
The asset profiles of RBFSP adopters are the same as non-adopter households of different levels of well-being	To assess the livelihood impacts of rice-field based fish seed production strategies on the adopting farming households compared to non-adopting households in the Northwest Bangladesh.
Seasonal changes may cause variation in livelihood outcomes of farming households by well-being and farmer type and these are affected by adoption of RBFSP	To assess the affect of seasonality combined with other household characteristics on the livelihoods strategies such as household level activities, food consumption, income, expenditure, health etc. in both adopting and non-adopting households.
RBFSP benefits other actors such as fry traders, pondfish producers and other beneficiaries within seed production and marketing network	To assess impacts of rice-field based fish seed production on a broader-scale and among a range of actors from seed producers, fingerlings traders, food fish producers, consumers etc.
Adoption of RBFSP can be sustained by farming households	To analyze the process of adoption, adaptation and rejection of rice-field fish seed production strategies among farming households.
FFS promoting RBFSP delivery is the most cost-effective approach to achieving positive impacts through aquaculture	To determine the cost effectiveness of different approaches to extension of RBFSP in farming households.

1.4.2 Outline of the thesis

This dissertation is organised into eight chapters including this introduction –**Chapter 1**. This chapter inaugurates the present context of aquaculture ranging from a national to global level in relation to fish seed production based on development concept towards livelihoods impacts of the poor. This chapter discusses the inadequacies of fish seed production and supply in Bangladesh and other Asian countries impeding widespread involvement of the poor in fish culture. A review of the relationship between ricefields and fish culture then strategies for RBFSP is provided with the recent evidence of its livelihoods impacts on poorer farming households.

Chapter 2 discusses the process of the whole study including an introduction to the different types of methodologies used. Based on the sustainable livelihood approach relating to participatory research, the methodologies consisted of both quantitative and qualitative investigation and analysis of data/information. Investigation and analysis were carried out at different levels ranging from micro to macro level e.g. household, community, institutions etc. Details not relevant to an overview of methods used were included within specific chapters.

Chapter 3 provides a snap-shot of the current livelihood condition of 118 households in 20 communities in 4 districts of the Northwest Bangladesh. This information was collected through well-being analyses of farming households at the community level based on participatory methods and then through in-depth questionnaire surveys. This chapter attempts to understand impacts of RBFSP on adopting households as compared to non-adopting households in view of the household's well-being status.

Chapter 4 explores the seasonal dimensions of livelihoods of the farming households investigated in Chapter 3 based on a longitudinal survey. This Chapter describes the affects of seasonality on livelihood strategies including various household level activities, food consumption, income, expenditure and health condition. This chapter explains how RBFSP impacts on fish consumption and income in different seasons among poorer farming households.

Chapter 5 explores the potential benefits to a range of actors through quantitative and qualitative investigations including focus group discussion, survey, case studies etc.

Livelihoods benefits were investigated among different types of actors such as producing households, fry traders, fishers, neighbours, relatives, markets, NGOs etc.

Chapter 6 describes the process of adoption, adaptation and rejection of RBFSP among farming households. The study did not use a conventional instrumental procedure for adoption studies, but rather used a qualitative approach based on a semi-structured and mostly open-ended survey tool with respondents aggregated by type of households and gender in seed producing communities. The types of households investigated in this study were primary adopting households, secondary adopting households, households who had never adopted, households who adopted initially and then rejected, households who had adopted for several years after withdrawal of CARE support and then rejected. The perceptions of women regarding RBFSP were assessed in a specific exercise with women in adopting households and women in non-adopting households. The investigation with different types of household allowed the assessment of complex socio-cultural processes responsible for adoption, adaptation and rejection of RBFSP in farming households in the Northwest Bangladesh.

Chapter 7 attempts to determine the cost-effectiveness of dissemination strategies of RBFSP technology at the farmer level. In this chapter, extension strategies of CARE and its different approaches to development were examined comparing centralised hatchery based seed production based on primary and secondary data. The sustainability of a partner NGO's extension strategy based on the approach of farmer field schools has also been examined.

Chapter 8 discusses the results from each chapter in an overall livelihood context of farming households. Special emphasis was given to explore the asset-bases of households, seasonal impacts of RBFSP on households, broader scale impacts on other actors, the adoption and rejection process of this technology and cost-effectiveness of RBFSP delivery mechanisms at the farmer level. Potential implications of the findings for future interventions are discussed and, where appropriate, recommendations made.

Chapter 2: General methodology

2.1 Introduction

A research methodology is a system of explicit process on which research is based against which claims for knowledge are evaluated (Nachmias-Frankfort and Nachmias, 1996). The methodological processes of the research are continuously being improved; scientists look for new means of observation, analysis, logical inference and generalisation (Nachmias-Frankfort and Nachmias, 1996). A major function of any methodological process used in research is to facilitate communication between researchers and other audiences who either have shared or want to share a common experience.

This chapter describes the methodological process followed to achieve the objectives of the study. Firstly, it describes the conceptual framework of methodological process, mode of investigation and general background of the study area. Secondly, it presents an overview of steps followed in individual chapters with their study design, sampling procedure and tools and procedures of data collection. Finally, this chapter presents techniques of data management, data analysis and triangulation and validation of the key findings.

2.1.1 Conceptual framerowrk of methodological process

The sustainable livelihood approach (SLA) was used as the main foundation in this research investigation. The SLA recognises diverse livelihood strategies, it can be multilevel, household, community, regional or national as well as dynamic (Singh and Gilman, 1999). It provides a framework for policy makers, which focuses on poverty within the contexts of the people who are poor, and on the processes that underlie poverty. For consultants who operate in the field of development, the SLA represents a framework for the formulation of development projects that focus on the people being affected by the project and the variety of ways in which they might be affected. For social scientists, the SLA provides a framework for a holistic interpretation of the dynamics of development and the different rhythms of change. For natural scientists the sustainable livelihood framework serves the purpose of linking their specific work and capacities with what people are capable of doing, what they are looking for, and how they perceive their needs. The sustainable livelihood framework thus provides a continuum for research and development (Hebinck and Bourdillon, 2002).

Assessing the impacts of agricultural research and development is difficult as agricultural technologies impact peoples' livelihoods in diverse ways. Earlier, many studies simplified the assessment focusing on few factors missing many important aspects of life and livelihoods of the rural poor (Adato and Meinzen-Dick, 2002), which seems to be similar to the prevailing situation of aquaculture. In order to understand the impacts of aquaculture research and development interventions, this approach is increasingly being used in Bangladesh. Recently, the use of SLA in aquaculture research has built an intrinsic information base of farming households and the impacts of aquaculture through several studies in the fields of integrated aquaculture, aquaculture and marketing and non-stocked fish management (Little et al. 2007) . In order to present a holistic view of SLA, the use of participatory research, a growing family of approaches and methods to enable rural people to share, analyse their knowledge of life and condition, and to plan, act, monitor and evaluate has been an essential (Chambers, 1997).

2.1.1.1 Participatory research

At its simplest, participatory research ensures involvement with farmers in the process of agricultural research (Okali et al. 1994). The on-farm research literature has always placed a strong emphasis on farmer participation and collaboration, and on talking to farmers about their needs, problems and reactions to technology. The idea of farmers participating in research is not new (Biggs, 1989). Participatory research is not a method, but a methodological approach to its application (Cornwall and Jewkes, 1995). Participatory research is a source of considerable contention and it covers a wide range of approaches and applications (Chambers, 1994) and in principle this orientation can be applied to any group of farmers, resource-rich or –poor (Biggs, 1989).

While the need to work with resource-poor farmers has been recognised, there is a wide difference of opinion over central issues such as how farmers should participate, for what purpose, and at what stage in the research process. A lack of clarity has led to the failure of other scientists and farmers to understand what on-farm researchers were trying to do, often resulting in implementation problems (Biggs, 1989). To facilitate analysis of these issues, four models of farmer participation in research have been defined (Table 2.1).

Table 2.1: Types of farmer participation in participatory research (Biggs, 1989)

Mode of farmer participation	**Objective of farmer participation**
Contractual	Scientist contract with farmers to provide land and services
Consultative	Scientist consult farmers about their problems and then develop solution
Collaborative	Scientist and farmers collaborate as a partners in research process
Collegial	Scientists work to strengthen farmers' informal research and development systems in rural areas

Participatory approaches have proved effective in generating and adapting new technologies for a range of natural resource based adaptive and applied research programmes at the farmer level (Sutherland, 1998). Indirectly, participation familiarizes farmers with research, although they usually are not trained in formal scientific methods, and experiment systematically as part of their everyday production activities. Farmers, through their informal research activities, contribute to the stock of indigenous technical knowledge in rural areas and are important sources of technological innovation (Biggs and Clay, 1981). Such informal research and development systems have considerable potential to contribute to agricultural development (Biggs, 1989).

Approaches which aim towards a more collaborative or collegiate research process include participatory rural appraisal (PRA) (Chambers, 1992), participatory action research (PAR) (Rahman and Fals-Borda, 1991), and participatory research (PR) (KKU, 1987). Although in principle PRA seeks to create an open and collegiate approach to research, in practice applications are often consultative or collegiate (Cornwall and Jewkes, 1995).

PRA developed from rapid rural appraisal (RRA) influenced by action research (Rahman, 1994), applied anthropology (Brokensha et al. 1980) and agro-ecosystem analysis (KKU, 1987). The focus of PRA shifted from rapid, extractive data collection to facilitating local people to produce and analyse their own information, according to their own practice (Chambers, 1992). However, PRA shares some of its principles with RRA such as direct learning from local people, offsetting biases, optimizing tradeoffs, triangulating, and seeking diversity. To these it adds its own principles which concern the behaviour of outsiders such as facilitating analysis by local people, practicing critical self awareness and responsibility and sharing (Chambers, 1994). Mode of investigation in PRA, sharing and analysis are open-ended, and often visualised by groups of people, and through comparisons. Among many applications, PRA has been used in natural resource management (fisheries, soil and water conservation, forestry, wildlife, community planning, etc.), programmes for women and the poor, agriculture, health and food security. Moreover, participatory methods have been used increasingly to identify target groups, particularly to identify the poor through well-being ranking exercises (Chambers, 1994).

PRA involves collecting different kinds of data, which focuses attention on people, their livelihoods and their inter-relationships with socio-economic and ecological factors. When compared to conventional structured surveys, PRA is neither looking for averages nor for set patterns. The strength of PRA lies in the flexibility of generating both quantitative and qualitative data through a range of methods appropriate for revealing rural peoples' perceptions. PRA methods can generate data both at a single point in time, through seasons or over extended timelines (Mukherjee, 1997). It has been argued that a lack of standardization in the concepts and categories emerging from PRA can make comparability difficult across areas and over time (Mukherjee, 1997). Furthermore, PRA methods can give undue attention to dramatic events, in outliers rather than the central tendency. In this context however, there is a great scope for combination of both PRA and survey methods to complement each other in building up a rich information base (Mukherjee, 1997). As pointed out in the literature, participatory methods complement questionnaire surveys, using various protocols and schedules for recording and standardization (Chambers, 1994). A combination of qualitative and quantitative tools such as PRA, sample surveys, institutional appraisals etc. can make research investigation effective (Kleih et al. 2003).

Within the growing PRA family, actor network analysis (ANA) derived from actor network theory (ANT) (Law, 1992) is an increasingly important tool being used to understand the linkages, and relationships behind the linkages, developed among various types of actors involved directly and indirectly in natural resources base management (Biggs and Matsaert, 2004).

2.1.1.2 Analytical framework

Using SLA as a foundation, the analytical framework was designed to demonstrate linkages between different aspects of livelihoods of the households both in horizontal and vertical terms. Horizontal refers to the various domains of household well-being (e.g. poor, intermediate, better-off etc.) and 'vertical' refers to the various domains of household administration (e.g. household, community, institutions etc.). The zoom-in or zero-in approach in the methodological process follows a similar logic in organizing the modalities of data collection, ensuring that those sets of linkages are fully explored (Pittaluga et al. 2004).

The growing body of participatory research approaches on the compilation of livelihood profiles at micro level (e.g. in a household or community) has come to the fore. Various techniques particularly the wealth ranking approach are commonly utilised to classify individuals or households into poverty, vulnerability, or food security classes (SCF-UK, 2000). Identifying and characterising the poor and vulnerable is crucial for designing and implementing actions to improve their livelihood conditions. This is because policies and programmes do not commonly target single individuals, it is necessary to identify meaningful groups for policy and programme action. By employing the livelihood framework, it is possible to cluster individuals at the micro level with similar characteristics into groups that are subject to similar factors and processes affecting their poverty and vulnerability (e.g. seasonality). Within a livelihood system, the analysis could be focused at the household or individual level depending on the scope and nature of actions envisaged (Pittaluga et al. 2004).

Analysis of livelihood systems at the micro level attempts to go beyond an investigation on common views of poverty and vulnerability, attempting to evidence how these co-vary with respect to gender (Pittaluga et. al. 2004). Gender analysis is a process to better understand the realities of the women and men, girls and boys whose livers are impacted by the development interventions. Principally it aims to unpack the dynamics of gender differences across variety of issues (DFID, 2000). These include gender issues with respect to i) social relationships - how male and female are defined in the given context, their normative roles, duties and responsibilities; ii) activities - productive and reproductive activities at the household and community level); iii) access and control - over resources, services, institutions of decision-making and networks of power and authority; iv) and needs - distinct needs of men and women (e.g. needs which, if met, would change their position in society). In gender analysis daily activity schedule is an important task in terms of identifying daily patterns of activity by gender division of labour and understand how busy women and men are in a day, how long they work and when they have spare time for development activities (DFID, 2000).

Inter relationships between people at various levels (individuals, households, institutions etc.) are complex and by interviewing a number of people at each level, the network could be explained. Understanding networks of various actors (such as people, institutions etc.) is viewed as increasingly important in natural resource research and development (Biggs and Matsaert, 2004). By interviewing a number of people expected to be knowledgeable about realities at each level, networks making up livelihoods systems begin to unfold. For example, analysing poverty simply from a micro-perspective may implicitly obscure the policy and institutional elements that could contribute to reproducing poverty. On other hand, a conclusion simply from interviews at the individual level may obscure the distinctive features of poverty and vulnerability of individuals at household level, their dynamic nature, and the local body of knowledge about those dynamics (Wilson, 2001). The zero-in approach lays out a framework for ensuring that many stakeholder voices are able to express their understanding of reality, and in doing so, it provides a mode of organizing information about multidimensional issues related to poverty.

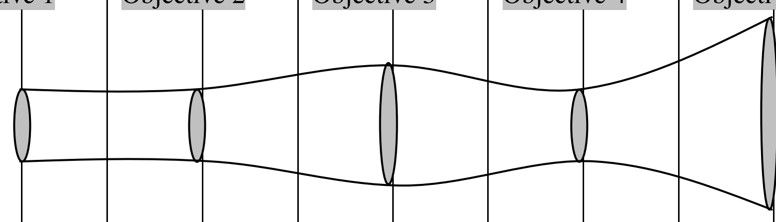
Poverty, food security, and vulnerability and impacts of development intervention on poor are diverse and context-specific. In order to understand them it is necessary to include the realities perceived by stakeholders (e.g. development organizations). The overall picture then emerges gradually from the combination and analysis of different viewpoints of stakeholders (Sapsford and Jupp, 1996). Involving different stakeholders and informants at various levels is based on more than a simple need to foster bottom-up approaches of participation at all levels. From a data collection as well as from an analytical point of view, this approach of participation is justified by different and distinct understandings of reality by different stakeholders (Campbell, 2003).

The nature of the different levels micro, meso and macro varies, and depends on the specific situation. Therefore, interpretation of each level can be very flexible (Pittaluga et al. 2004). For example, in the Ivory Coast, a livelihood system profile was carried out in communities living on a lake. The lake was large and no formal institutions operating throughout the overall water body existed. Researchers therefore decided to look at the dynamics of poverty in all the prefectures adjacent to the lake (macro), then in a selected sample of villages (meso) and finally complementing those observations with a household (micro) survey (Pittaluga et al. 2004).

In the present study, the macro scale denotes the institutions such as CARE-Bangladesh and its partner NGOs that promoted RBFSP; the meso scale includes communities, villages and markets; and the micro scale includes households and individuals. The analytical framework of this thesis draws on the notion of 'zero-in' approach developed by Pittaluga (2004) to describe livelihoods of farming households. Most research carried out over multiple scales usually takes a linear or conical approach, either starting with a general and then 'zooming in', or starting with particular and 'zooming out'. However, the analytical framework in this thesis is a hybrid between the two traditional scale sensitive frameworks by adopting an 'hourglass approach' (Bush, 2004) (Figure 2.1).

The central theme of this thesis was to address the livelihood impacts of ricefield field based fish seed production ranging from adopting households to community and market level, and the institutional role of disseminating this technology. Analyses therefore started at micro scale at household level and progressively zoomed-out to meso scale at the community level and again zoomed-in at micro scale research at household level and finally zoomed-out at macro scale at the institutional level at which the dissemination strategy was formulated.

Conceptual scale	Micro-scale	Micro scale	Meso-scale	Micro-scale	Macro-scale
Administrative scale	Household	Household	Household, community, Village, market	Household	Community and institutions
Chapter	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7
Research objectives	Objective 1	Objective 2	Objective 3	Objective 4	Objective 5



Mode of investigation	Well-being analysis and one-off questionnaire survey	Well-being analysis and longitudinal questionnaire survey	Focus group discussion, actor network analysis, questionnaire survey and case studies	Focus group discussion, semi-structure and open-ended questionnaire survey	Key informant interview, exploring secondary data/information, case studies and questionnaire survey

Figure 2.1: Schema illustrating analytical framework of the research (adapted from Bush, 2004).

2.1.1.3 Mode of investigation

In this research approach, both quantitative and qualitative methods of investigation have been employed. Over the years there has been a large amount of complex discussion and argument surrounding the topic of research methodology and the theory of how inquiry should proceed. Much of this debate has centred on the issue of qualitative versus quantitative inquiry which might be the best and/or more scientific. Different methodologies become popular at different social, political, historical, and cultural times of development and all methodologies have their specific strengths and weaknesses (Dawson, 2002).

Quantitative methods refer to random sampling for survey research, structured individual interviews for data collection and the statistical analyses generated. These methods maximize representativity and generalizability to a larger study population (Krishna and Shrader, 1999). In quantitative methods, the uses of histograms, pie charts, and line graphs add dynamic visual applications to the presentation of findings.

On the other hand, qualitative methods refer to a wide range of data collection and analysis techniques allowing for in-depth analysis of social phenomena (Krishna and Shrader, 1999). Qualitative methods including observation, participant observation, life histories, in-depth interviews, and focus group discussion, have long been used to elucidate values, perceptions, attitudes, and opinions of both individuals and groups of people, providing in-depth examination of relationships and behaviours. Qualitative methods are used in a variety of disciplines, including organizational management studies, evaluation research, and sociology, to assess the organizational dynamics of both formal and informal institutions, key structure of social capital (Krishna and Shrader, 1999). In qualitative methods, visual analysis by researchers, respondents or both provide dramatic documentation of causality links, patterns of behaviour, mapping of community assets and so on. These often illustrate, on a single page complex interrelationships which are difficult to capture in pages of text (Miles and Huberman, 1994). Over the years, a range of participatory qualitative methods have developed with the added benefit of being produced by respondents with little or no intermediation of external researchers (Chambers, 1997).

Quantitative and qualitative methods may be combined in a variety of ways to improve the trustworthiness of survey and experimental findings. During the second half of the 1990s, attempts were made to highlight the complementarity of the two approaches. Also the pros and cons of each type of approach, and the value(s) of surveys in a general development context, were examined. In the field of renewable natural resources research it was realised that although some research practitioners were combining methods, experiences were often not documented and moreover, several avenues of potential remain untapped (Marsland et al. 2001). However increasingly, socio-economic research has employed both quantitative and qualitative methods in the quest for research designs best suited for assessing complex issues and concepts. Integration of complementary methodologies is a successful strategy for several reasons: it enhances confirmation or corroboration of varying methodologies via triangulation; elaborates or develops analysis providing richer detail; and initiates new lines of thinking through attention to surprises or paradoxes (Rossman and Wilson, 1984).

2.2 General background of the study area

Bangladesh is criss-crossed by innumerable rivers, of which the Jamuna, the fifth longest river in the in the world, flows from north towards south and virtually divides the country into east and west zones. The river, Padma (the major trans-boundary river and distributary of Ganges) again dissects the west zone into southern and northern part. The Jamuna had not only created a serious physical barrier to uninterrupted road and rail communications but also results in uneven development between east and west zones of the country. The recent construction of a bridge (known as Jamuna bridge - south Asia's longest bridge) has dramatically improved connections between country's east central part including capital city of Dhaka (Alam et al. 2003). Although communications between the north, and the eastern and the central regions have improved, the Northwest region is still distant from the main and central part of the country (Figure 2.2).

The Northwest region of Bangladesh is generally considered to be one of the poorest parts of the country (WFP, 2002). Overall in the western region-Rajshahi including the Northeast, 61% of the total households are poor compared to 45% in central region-Dhaka (Sen, 2003). People in the Northwest are mostly dependent on agricultural activities and overall improvements of their livelihoods greatly depend on a broarder agricultural development. This type of agricultural development cannot be possible without emphasising the development of fisheries resources being an important part (25%) of agricultural economy in Bangladesh (DoF, 2005).

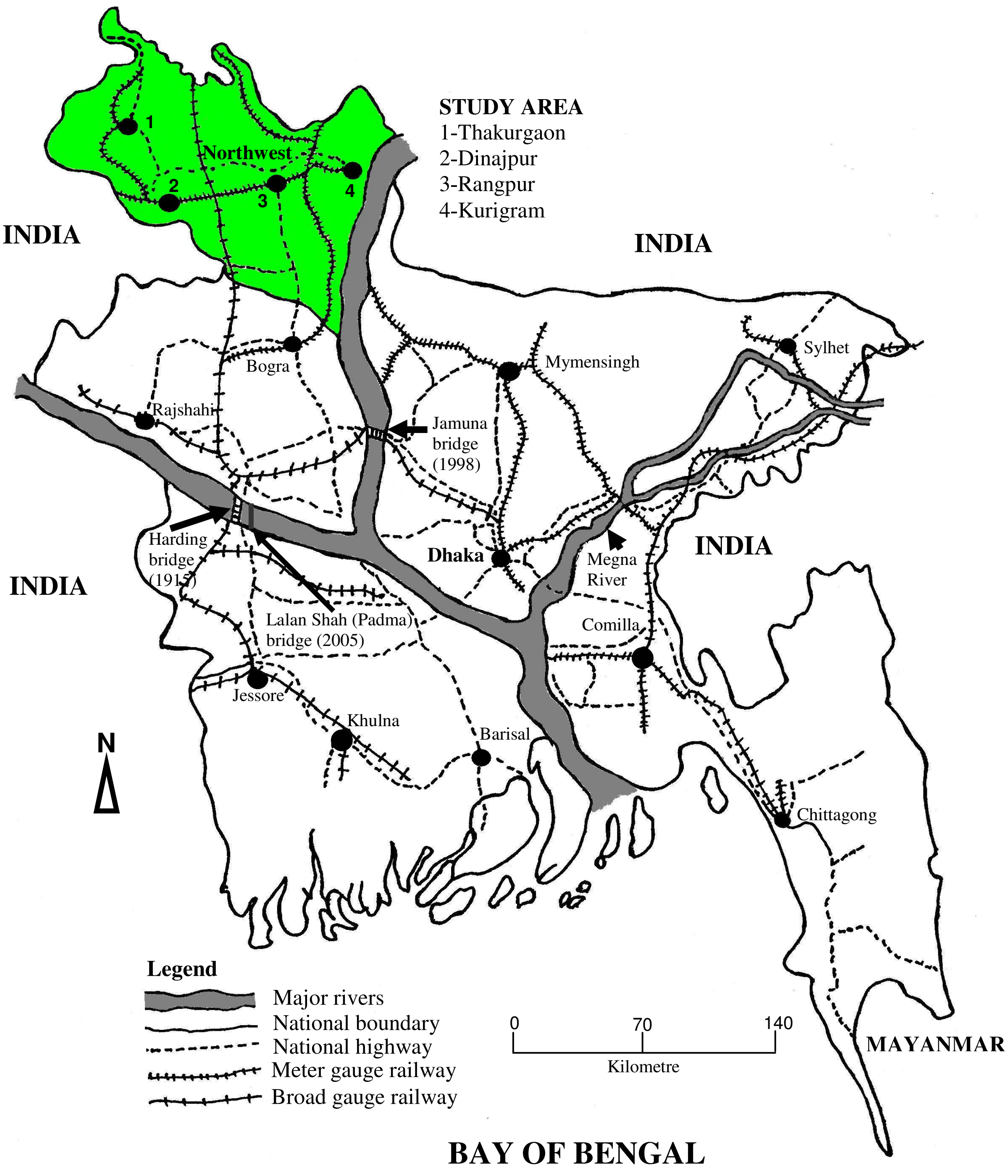


Figure 2.2: Map of Bangladesh showing study area in four districts (Thakurgaon, Dinajpur, Rangpur and Kurigram) highlighted in Northwest Bangladesh.

In terms of fisheries resources, the Northwest region is characterized by limited openwater resources (rivers, floodplains, lakes etc.), a relatively low level of natural fish production and low rainfall suggesting more attention is needed for the development of aquaculture. The small landholdings, homestead size, seasonal ponds and ricefields of the large numbers of poor and marginal farmers show great potential for the development of small-scale aquaculture in the area. There are few private fish hatcheries and nurseries in the region due to unfavourable soil and water quality and the presence of a large informal fish seed market in Parbatipur (Barman et al. 2002). In Parbatipur railway junction, traders transport fish seed by rail from Jessore – a southern district of Bangladesh about 100 Km away from the Northwest region (Figure 2.2). In Jessore, the large-scale development of hatcheries and nurseries occurred due to favourable soil and water quality, proximity to rail communication, high demand for seed from pond fish producers, and access to essential materials (e.g. pituitary glands, insecticides, net, etc) from West Bengal (Milwain et al. 2002).

As a result, the farmers in Northwest are largely dependent on the supply of fish seed from outside of the region, namely Jessore and Bogra. Development of aquaculture technologies focusing on small-scale farmers' resources in the Northwest, with appreciation of their social, cultural and economic aspects, is important in this regard (Barman, 2000). As part of the development process of aquaculture technology, a decentralised fish seed production strategy in the ricefield based systems has been developed through two subsequent project phases of CARE in the Northwest. The developmental process of decentralised seed production has been discussed in detail in Chapter 1. Focusing the development decentralised ricefield based fish seed production, research investigation based on a project has been carried out according to the following chronological Steps (Figure 2.3).

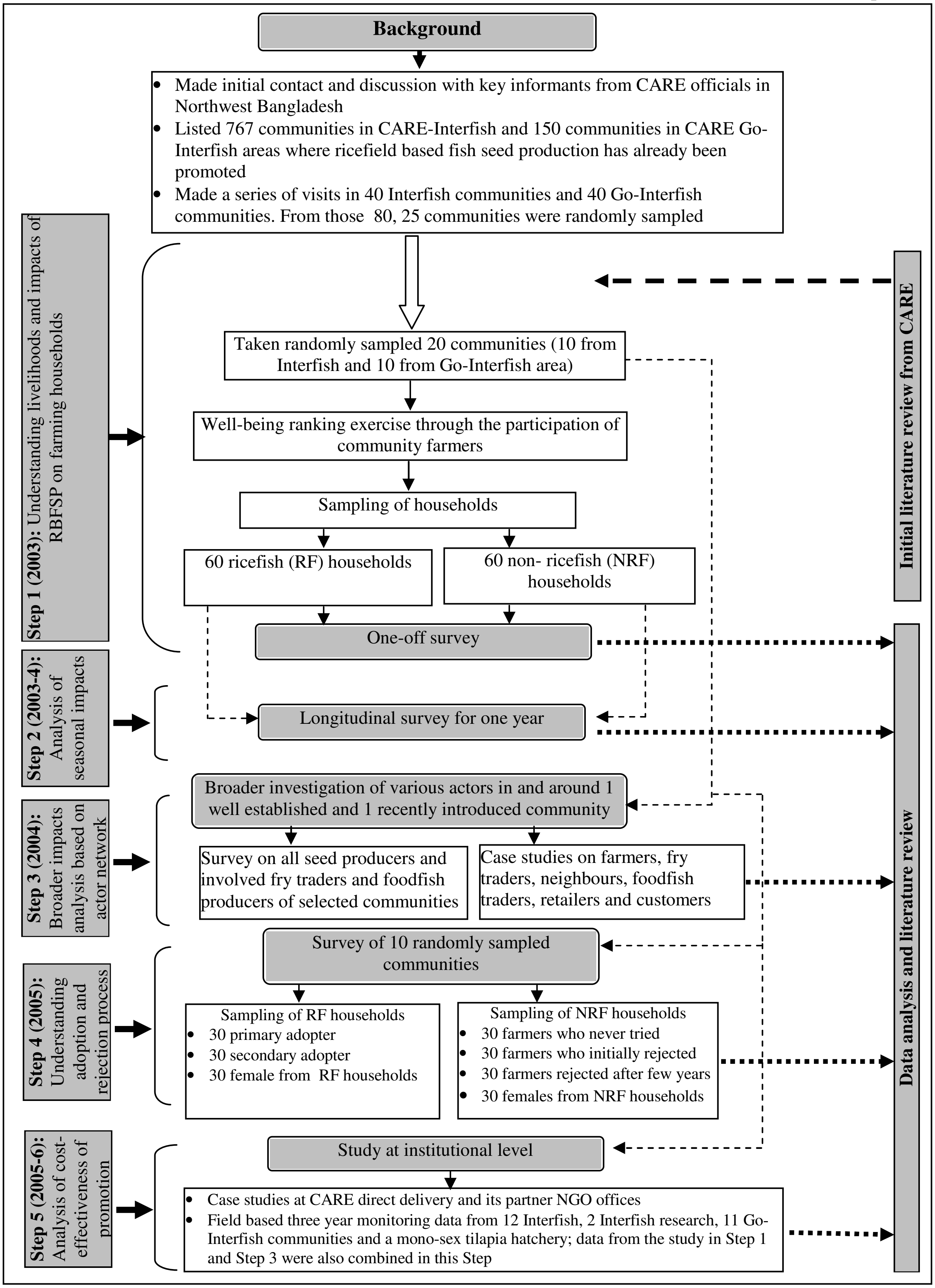


Figure 2.3: Flowchart illustrating methodological processes used in whole study.

2.3 Step 1

Project set up

The ‘decentralised seed project’ was a five-year collaborative project funded by Aquaculture and Fish Genetics Research Programme (AFGRP) – DFID programme. This project carried out its research activities in Asia in collaboration with the Institute of Aquaculture, University of Stirling (UoS), UK; WorldFish Centre, Bangladesh; School of African and Asian Studies, University of Sussex, UK; Asian Institute of Technology, Thailand; Research Institute for Aquaculture, Dinh Bang, Vietnam; CARE International, Bangladesh; and Bangladesh Agricultural University (BAU), Mymensingh. The purpose of the project was to develop the “sustained availability of quality seed in rural areas”. Based on this, the following activities were undertaken over a 5 year period between 2001 and 2006.

- Assess existing seed supply practices
- Action research to assess causes of performance deterioration and appropriate approaches to production initiated
- Monitoring and evaluation of seed production approaches; potential for strain improvement using different methods assessed; and institutional changes in partner organizations monitored.
- Assess impacts of strategy including importantly productivity and livelihood benefits of producers and supply network; broader community level changes analysis; partner institutional changes analysis; and develop strategy with key regional donors to link pro-poor aquaculture development with appropriate seed supply mechanisms.

Involvement of researcher in the project

The decentralised seed project was a multi-disciplinary team based research project which was implemented through the WorldFish Center in Bangladesh and based in temporary field office in Dinajpur district in the Northwest region. Local staff were recruited for field work during a previous phase of support to Dr. Benoy Barman as a research fellow of University of Stirling, UK seconded to WorldFish Center. In this project, I was contracted as a doctoral student but with some responsibilities for project management. The activities related to assessing the livelihood impacts of RBFSP were the focus for the doctoral study presented in this thesis. The major activities were as follows:-

- Orientation to RBFSP research in Dhaka and Northwest based field offices of WorldFish Center and making visits to CARE field offices and communities where RBFSP had been promoted through FFS.
- Collection of relevant literature and development of research protocols.
- Giving training to field staff on the use of PRA tools, questionnaire pre-testing, data collection and data entry to computer. At the same time receiving IT based training on large-scale database preparation, data management and analysis.
- Personal involvement in data collection in the field. I personally conducted approximately 15% and 65% of field work for quantitative and qualitative data collection respectively.
- Monitoring and overseeing of field work, particularly with regard to quality control of data collection. Checking, analysis and interpretation of all collected data.

- Maintaining the progress of the work in accordance with the stages agreed with supervisors, including preparation of fortnightly written reports to allow for comments and discussions before proceeding to the next stage.

- Discuss impediments to maintaining the agreed time table with the supervisors at regular intervals.

- Presenting findings in different local and international fora to inform a wide range of audiences.

Selection of study sites

During Step 1, attempts were made to understand livelihoods of farming households and the impacts of RBFSP on farming households. This study was built on a previous study (Figure 2.3) conducted to improve the general understanding of practices of RBFSP in Northwest Bangladesh. At the onset of that study, initial contacts with personnel working in the CARE Go-Interfish project were made to collect information about on-going and previous activities of CARE Interfish project related to RBFSP. A list of 767 communities from the Interfish and 150 communities from the Go-Interfish project area was drawn-up to make visit where RBFSP has already been promoted.

Then with the help of CARE field staff, a series of visits to 80 communities (40 from Interfish and 40 from Go-Interfish) were carried out to understand the methods CARE used when working with farmers, especially the concept of the farmer field school (FFS) approach and general background of fish seed production practices at the household level (Barman et al. 2004). Based on this background information, a total of 10 communities in the Go-Interfish areas of Thakurgaon and Dinajpur districts and 10 communities in the Interfish areas of Rangpur and Kurigram districts were randomly sampled. The study area is located within 4 districts of Northwest Bangladesh (Figure 2.2), consisting of 9 upazilas (sub-districts) and 12 unions (local government units).

A large number of communities were sampled randomly from a broader geographical area to generate a representative view of RBFSP. According to Rob (1995), a community is defined as a local informal management unit, comprising i) a number of households bounded by a shared culture, consisting of e.g. language, religion, social organization or values; and ii) the surrounding environment which provides the basis of their livelihoods and the focus of their subsistence activities. Physically, a community consisting of the inhabited area as well as the surrounding environment, may or may not be clearly delineated from the point of view of the outside (Kuper and Kuper, 1989).

In the present study, important criteria of communities sampled were: a) development of decentralised fish seed production technology in ricefield based system within the community; b) a sizable promotion of adopters (regardless if they were primary or secondary adopters) within the community; and c) access to community households with respect to farmer's cooperation to collect data/information. Moreover, in the study sites access to available information at the level of on-going organizations (CARE and its partner NGOs) was also considered.

Well-being analysis

Wealth is defined in terms of access to or control over important economic resources (Grandin, 1998). Determining the wealth (or poverty) status at the individual, household, family or community level is a highly complex task. It is usually carried out by development programmes through structured questionnaires or means tests designed to elicit information on income, savings, landholdings etc. Designing and implementing such investigatory exercises is complicated and time consuming. People are often reluctant to disclose details of savings or landholdings and sample surveys risk missing out the poorest who usually live a low profile existence with little involvement in community affairs. The technique of poverty ranking has been developed to correct these biases, or at least minimise them (Grandin, 1988). Well-being ranking provides field workers with a simple participatory technique that enables them to identify the poorest people in a target community, using the value judgements of community members (Grandin, 1998).

The well-being ranking exercises were carried out through the collaborative efforts of the researcher, facilitators/enumerators and key informants in the sampled communities. In order to carryout range of research activities, a team of facilitator/enumerator/field staff comprised of 3 males and 1 female was formed and based in a local field office in Dinajpur. All staff were the inhabitants of the Northwest and each individual had at least a graduate level of education and a good understanding of local terms/language and socio-cultural factors. The key informants were selected during initial visits in the communities with the help of CARE Go-Interfish project staff and discussion with community people. Individuals who stayed most of the time in the communities and knew more about the well-being of the households were chosen as key informants (Mukherjee, 1997).

A complete list of all household heads was developed through interviewing a key informant from each community with the assistance of the facilitators. Then the household list was checked by other key informants to ensure that all households were included. The name of each household head was written in a separate small piece of white paper (card). The facilitator explained the method of well-being ranking and the key informants carried out the exercise on an individual basis independently. No other person was allowed to join the key informants during the exercise in order to avoid possible noise and bias. Key informants were asked to group the households into categories from richest to the poorest (putting the piles of the cards sequentially from left to right). The numbers of piles or groups were not fixed but they ranged from 5-6. They checked and re-checked the households in each pile in order to get homogenous grouping. The facilitator scored the cards as each key informant completed the ranking exercise. In the case of ranking, a score was put on the back side of the card based on the serial number of piles from left to right (richest to poorest). If the informant created 4 piles then the households were given a score of 25 (1/4x100) and the households furthest to the right were given a score of 100 (4/4x100). At the end of the piling, the facilitator recorded the criteria used by the key informant for grouping each of the piles. The exercise was repeated with two further key informants without revealing the outcomes from previous exercises. Finally, each household received 3 scores and from that the average score was calculated.

Based on average scores the households in the selected communities were grouped into three wealth categories using natural breaks of score (Grandin, 1994). This process of well-being exercise has been well established on extension work in Northwest Bangladesh (Gregory and O'Riordan, 1999) and has proved very useful in poverty focused extension, particularly when identifying poor extension clients (Lewis, 1997). All community key informants and other associates identified the well-being of households as poor, intermediate and better-off mainly based on criteria including land ownership, food security, house and its boundary, livestock, agriculture equipment, off-farm activities, credits, toilet facilities etc. at the household level (Table 2.2).

Table 2.2: The major criteria perceived by key informants to group households in different well-being categories

Criteria	Poor	Intermediate	Better-off
Homestead and land area	Small homestead area; some cultivable land around homestead or not; tended to share/lease land in for rice cultivation	Small/medium homestead area; own and some share/leased in land for rice and other crop cultivation	Big homestead area; large amount of land for rice and other crop cultivation; tended to share out land
Food security	Rice production from their own, shared/leased in land provided their food. Sold rice during harvest and had to purchase rice during lean period	Rice production from their own and share/leased in land could meet their year round food demand. Sold rice during harvest and some of them had to purchase rice during lean months	Rice production from own land could meet their year round food demand. Sold rice over meeting their demand for different purposes
House and its boundary	They had mostly straw and sometime tin made living house. House boundary was made of straw or bamboo flecks	Straw and mostly tin made living house. House boundary was made of earthen wall	Tin and concrete made living house. House boundary was made of earthen and brick wall
Livestock	Had small number of poultry, goat and some cow	Livestock consisted of poultry, goat and cow	Livestock consisted of poultry, pigeon, goat, cow, buffalo etc.
Agriculture equipment	They had traditional plough for tilling land and some other accessories such as hoe, axe, etc.	Traditional plough for tilling and sometimes power tiller for tilling land and other accessories. Some of them had own irrigation pump	Traditional plough, power tiller and own irrigation pump. Some of them sold irrigation waters to the poor and intermediate households.
Off farm activities	They sold labour; pulled van/rickshaw; and did petty business and service	They had small shops/business in the locality. And some of them had small jobs such as office peon, salesman in town shop etc.	Some of household members involved in services like teaching in rural school madrasa etc. Sometimes they had big shop in the nearby upazilla market
Credit	They received credit from NGOs and *mohajan* (moneylenders)	They received credit from bank and NGOs. They sold and/or lease/mortgaged out land during crises.	They received credit from government bank and some of them from NGOs
Toilet facilities	They developed non-concrete and semi-concrete closed toilet facilities	They developed semi-concrete closed toilet facilities	They developed concrete closed toiled facilities

Sample size determination

Determining the sample size of farming households is important for several factors such as - the type of research, research hypothesis, financial constraints, the importance of the results, the number of variable included, the method of data collection, and the degree of accuracy needed (Sufian, 2003). In this study, the sample size of respondents used in the Chapter 3 & 4 was determined through a systematic procedure.

From the previous study conduced by Barman et al. (2004) and from CARE reports, it was possible to estimate the proportion of adopting households at the community level. Therefore there was an easy way to apply a proportional estimate, which minimises the expected variances and indicates a sample size that is sure to be representative. The assumed proportion used for determining sample size was 0.05 with the expected precision level of 5% (NAO, 1992).

In order to calculate the required sample size a standard statistical formula was used (Hays and Winkler, 1990) which is as follows:-

$$n = \frac{z^2 pq}{d^2} \text{ --------------- } (i)$$

$$n_f = \frac{n}{1 + \frac{n}{N}} \text{ -------------- } (ii)$$

Where,

n = Desired sample size (when population is more than 10,000)

n_f = Desired sample size (when population is less than 10,000)

N = Population size (approximately 2,000)

z = Standard normal distribution value (Z is given in the probabilities table of the standard normal distribution, 1.96)

p = Proportion in the target population estimated (that is 0.05).

$$q = 1.0 - p \text{ ------------- } (iii)$$

d = Degree of accuracy (desired set at 0.05)

Therefore calculated sample size is

$$n = \frac{(1.96)^2 \times 0.05 \times 0.95}{(0.05)^2} = 72$$

But the population size in the study is less than 10,000 (i.e. approximately 2,000)

Therefore, the calculated sample size is

$$n_f = \frac{72}{1 + \frac{72}{2000}} = 69$$

Sampling procedure

A random sampling technique was employed to avoid sample bias. In order to achieve a representative sample size and considering the capacity of field research, 3 ricefish households were randomly chosen from each of 20 communities from 4 districts, i.e. 60 (=20 x 3). Corroborating this calculated sample size, literature suggested a rule of thumb that if the total population is 20,000, the recommended sample size is 392 (Arens and Loebbecke, 1981). Along with ricefish farmers (RF), the same numbers of non-ricefish farmers (NRF-treated as control) were sampled randomly from each community. Normally in experimental design, control is accomplished by randomly assigning research participants to experimental and control groups. The logic of controlled experimentation assures that all extraneous variables have been controlled for and that the two groups differ only with regard to their exposure to the independent variables (Nachmias-Frankfort and Nachmias, 1996).

The total sample size therefore, eventually consisted of 120 households. Out of 120 households, 60 households (50% RF and 50% NRF) from 10 communities of Rangpur and Kurigram districts and 60 households (50% RF and 50% NRF) from 10 communities of Thakurgaon and Dinajpur districts were included in the study. The categorisation of RF and NRF households were made based on the criteria of having knowledge of ricefish farming, adoption, fish culture in pond, and current practice of fish seed production in ricefields (Table 2.3).

Table 2.3: Basic characteristics of sampled farming households by type

Criteria	Ricefish (RF)*	Non-Ricefish (NRF)**
Idea of seed producing farmer	They acquired technical knowledge of RBFSP as direct participants of the CARE Interfish and Go-Interfish projects; some of them were secondary adopters acquired technical knowledge from primary adopters (participants of CARE projects)	They might or might not be the participants of CARE projects; they had knowledge of RBFSP as some of them received CARE training and live in the same community
Adoption	They adopted ricefield based fish seed production	They had not adopted ricefield based fish seed production
Fish culture in pond	Not all RF farmers had a pond. Those who had pond for growing fish tended to use fish fingerlings from their own source	Not all NRF farmers had a pond. Those who had pond for growing fish tended to collect fish seed from other sources
Status during selection	They were selected in 2002 according to their on-going fish seed production practices	They were selected as farmers not currently practising fish seed production, however they might be the previous adopters but rejected later

**A household producing seed in ricefield will be denoted as a RF household.

**A farmer not producing seed in ricefield denoted NRF households throughout the thesis.

In this study, farmer type as defined in the Table 2.2 was considered as the main factor to investigate the impacts of RBFSP on the farming households. The well-being status (poor, intermediate and better-off) of households was also used as the second factor to explore the impacts of RBFSP on farmer type within different strata of well-being.

Data collection through questionnaire survey

A one-off structured questionnaire survey was employed to collect data/ regarding livelihood asset-base, livelihood strategies, livelihood outcomes and vulnerability context of farming households. As 4 facilitators/enumerators were involved in data collection, variation in consistency, interpretation, unit of measures and methods of presentation of data was possible. Hence, adequate measures were taken to minimize data collection errors such as (a) initial training of staff in data collection at the field level; (b) pre-testing of and checking the questionnaire to identify any shortcomings; (c) modifying the questionnaire where the questions remained unanswered; and (d) finally data collection was carried out from the field level.

2.4 Step 2

The second step was a year long longitudinal household monitoring survey using a structured questionnaire (Figure 2.3). This was conducted with the same households sampled for the survey in Step 1. The purpose of this survey carried out with farming households was to investigate the seasonal patterns of livelihood systems focusing on the impacts of RBFSP. The 60 RF households sampled in Step 1 were interviewed every month throughout the year of investigation. The remaining 58 NRF farmers were interviewed every three months (i.e. the respondents were interviewed four times over the year of investigation). The NRF farmers were only interviewed four times in a year as opposed to 12 times due to their reduced interest in the project. After each monthly interview, the questionnaire data was checked thoroughly to highlight any confusing or missing data/information. Microsoft Access was used to store data for subsequent analysis. The data entered in the database was cross-checked with the hardcopy of the questionnaire to identify important errors.

2.5 Step 3

At this stage, based on an actor-oriented approach, an investigation was carried out to look into the broader-scale impacts of RBFSP on actors at different levels (Figure 2.3). This study was conducted in two communities including a well established community and a recently introduced community of RBFSP using PRA tools of key informant interview (KII), focus group discussion (FGD) and case study with structured and semi-structured questionnaire surveys. Key informant interviews examined various resources at the community level while focus group discussions identified the actors within the community and outside the community involved in RBFSP activities directly or indirectly. The roles and motivations of key actors including seed producers (RF farmers), fry traders and food fish produces were studied using structured and semi-structured questionnaire surveys. All seed producers in both communities, all fry traders and 30 foodfish producers linked with well established community were surveyed based on the concept of "census sampling" (Walonick, 2004). Other actors including fry traders, foodfish producers (of recently introduced community) fishers/food fish traders, *aratdar* (owner of auction market), retailers, and consumer were interviewed using case a study approach. As in Steps 1 and 2, the data from the questionnaire surveys were entered in a database.

2.6 Step 4

This step looked at the adoption, adaptation and rejection processes of RBFSP activities in farming households (Figure 2.3). This study was conducted in 10 communities sampling various categories of respondents including primary and secondary adopters of this technology, households who had never adopted the technology, initial rejecters of the technology, late rejecters of the technology, women in the adopting households and women in the non-adopting households. In each group, 30 respondents were interviewed using a semi-structure questionnaire. A sample of 30 respondents is generally taken as an adequate sample size however, sample size smaller than this fall into the category of case studies, where statistical inferences to the population cannot be made (NAO, 1992). After survey, data and information was entered into a database and responses were coded in numerical frequency for subsequent analysis.

2.7 Step 5

In this Step the cost-effectiveness of disseminating decentralised fish seed production through different approaches to CARE delivery was analysed making a comparison with a centralised mono-sex tilapia hatchery (Figure 2.3). In addition the sustainability of such types of programmes of CARE partner NGO level was also examined. The costs of training for dissemination of RBFSP were determined by conservative methods (Quizon et al. 2001) using secondary sources of data collected from CARE and its partner NGOs. The effectiveness of the approaches to delivery mechanisms was determined with respect to project based investment and development effectiveness. For these, three years monitoring data of income of fingerling production from 12 Interfish, 2 Interfish research and 11 Go-Interfish communities along with the data from a mono-sex tilapia hatchery were used. Alongside these, data from Step 3 and Step 5 were used to determine multiplier effectiveness i.e. development effectiveness (Richardson and Moore, 2002) involving fry traders and foodfish producers. The sustainability of such types of programmes at NGO level was assessed using open-ended questionnaire interviews comparing nine partner NGOs during their on-going partnership with CARE and following the withdrawal of CARE support.

2.8 Observation

Observation and analysis are ‘interwoven processes’ in field research (Babbie, 1979). In conjunction with data collection for the sake of specific objectives, observations should be undertaken during field work and important outcomes of these observations should also be noted (Sufian, 2003). In this research, complementary observations were made during field surveys of the physical, social, economic and environmental conditions of the study area as well as the overall livelihood conditions of the people and community (Appendix 10).

2.9 Data management

After collecting the data using structured or semi-structured questionnaires, databases were designed using Microsoft Access where validation rules and text were built for minimizing errors during data entry. The database interface was structured to appear as a similar to the form of the questionnaire to make data entry easy for the field staff (e.g. Figure 2.4). Data were entered by field staff in the field office and checked thoroughly comparing with the original hardcopy of the questionnaire to identify missing information or errors. Using the Query Option in Microsoft Access, data was arranged in various ways to conduct statistical analyses according to the research objectives.

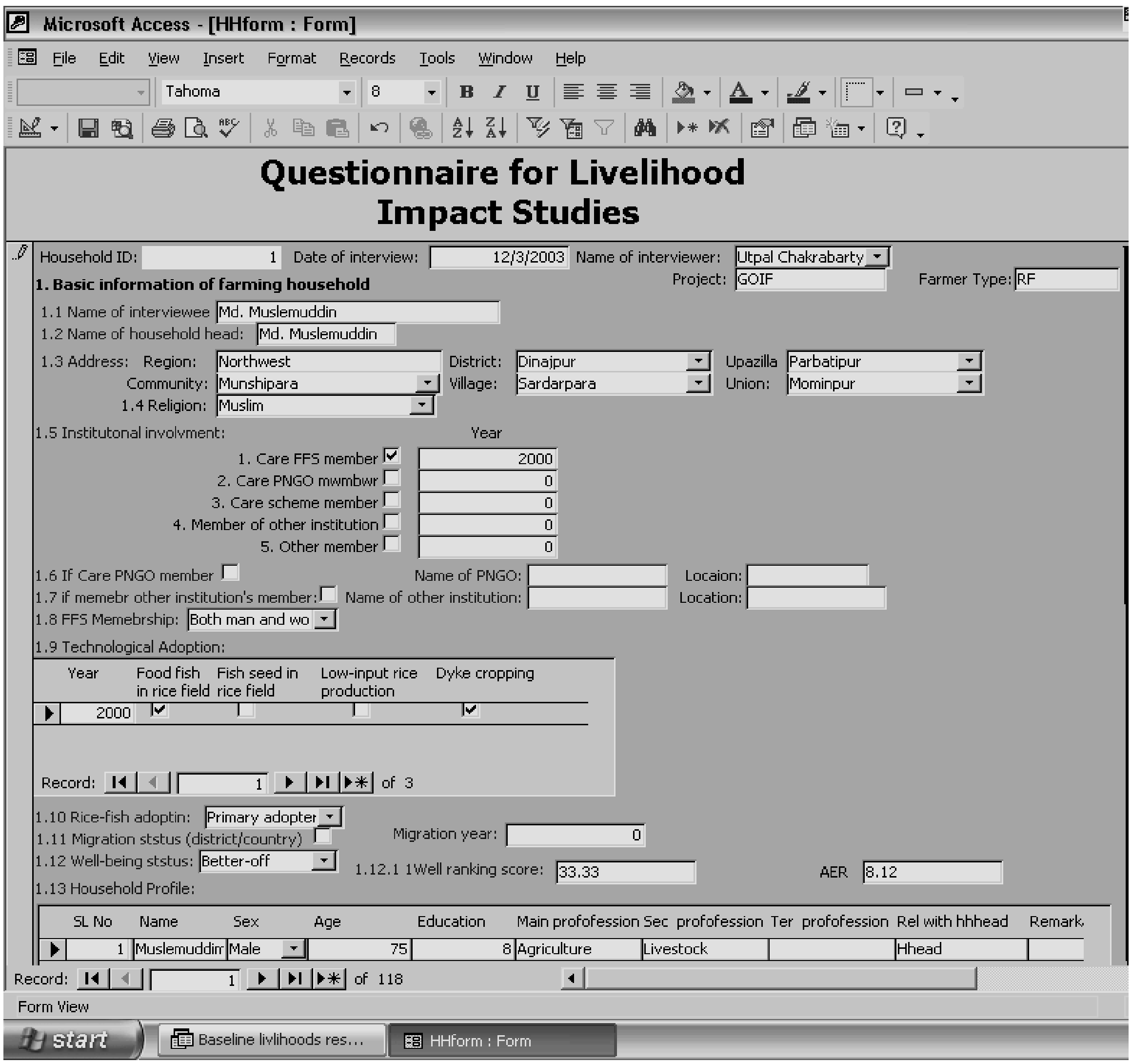


Figure 2.4: Interface of database in Microsoft Access.

All statistical analyses were carried out using SPSS version 11.5 (statistical software), and Microsoft Excel was used for tabulation and graphical representations of the findings. Comparisons of proportions and means across the farmer types (ricefish and control farmers) by well-being categories (poor, intermediate and better-off) were carried out using appropriate statistical tests. The general features of the major statistical tests used in this study are given below:-

2.10 Statistical analysis

Both parametric and non-parametric statistical tests were used to analyse the parametric and non-parametric data respectively. Brief discussions of these statistical tests are given below.

2.10.1 Parametric test

Analysis of variance (ANOVA)

In SPSS version 11.5, univariate analysis of variance was performed through the General Linear Model (GLM) procedure. The General Linear Model (GLM) procedure provides analysis of variance (ANOVA) for one dependent variable by one or more factors and/or variables. The factor variables divide the population into different groups. Using this GLM procedure, it is easily possible to test hypotheses about the effects of other variables on the means of various groupings of a single dependent variable. It also allows investigating interactions between factors as well as the effects of individual factors. Normality of data was tested before analysis based on the distribution of data on normal probability plot - a procedure for testing normality in SPSS.

Correlation and regression analysis

Correlation studies, as the phrase implies, look at co-relations between variables. A correlation analysis frequently used is the Pearson product-moment correlation or the

Pearson r. (Field, 2005). Although Pearson r is predicted on the assumption that the two variables involved are approximately normally distributed, the formula often performs well even when assumptions of normality are violated or when one of the variable is discrete (Field, 2005). The correlation coefficient (r) ranges from -1 to + 1 indicating two variables are negatively or positively correlated respectively.

Regression analysis is a statistical technique designed to predict values of dependent (or criterion) variables from knowledge of the values of one or more independent (or predictor) variable (s). If the relationship between two variables is known, then it can be used as regression analysis to predict one variable from knowledge of the other.

The general form regression equation is written as

$$Y = \alpha + \beta X + e ------------- (iv)$$

Y is the value of the dependent variable or the variable being predicted or explained

α or alpha is a constant; it equals the value of Y when the value of X=0

β or beta is the coefficient of X; the slope of the regression line; how much Y changes for each one-unit change in X.

X is the value of the Independent variable, what is predicting or explaining the value of Y

e is the error term; the error in predicting the value of Y, given the value of X (it is not displayed in most regression equations).

2.10.2 Non-parametric tests

Chi-square test

The Chi-square test is a non-parametric test that makes comparisons (usually cross-tabulated data) between two or more samples of the observed frequency of values with the expected frequency of values. The Chi Square test requires that the data should be expressed as frequencies, i.e. numbers in each category; this is a nominal level of measurement. The general equation of Chi-square test is as follows:-

$$\chi^2 = \sum_{i=1}^{6} \frac{(O_i - E_i)^2}{E_i} \text{---------------} (v)$$

Where,

Oi = an observed frequency

Ei = an expected (theoretical) frequency

To be reliable the Chi-square statistic requires that the expected frequencies in each category should not fall below 5 - this can cause problems when sample size is relatively small. Finally, the different categories of data used must be independent of each other.

Friedman test

The Friedman test is the non-parametric test similar to the parametric repeated measures ANOVA. It tests whether three or more groups differ significantly from each other, based on average rank of groups rather than comparison of means from normally distributed data.

Wilcoxon's signed-rank test

The Willcoxon singed-rank test is a non-parametric alternative to the paired Student's t-test for the case of two related samples or repeated measurements on a single sample. Likewise the t-test, the Wilcoxon test involves comparisons of differences between measurements.

2.10.3 Statistics used for presenting results

The field of statistics involves methods for i) describing and analysing data and ii) for making decisions or inferences about phenomena represented by the data. Methods in the first category are referred to as descriptive statistics; and methods in the second category are called inferential statistics (Nachmias-Frankfort and Nachmias, 1996). Descriptive statistics is a group of methods used to organize, summarize, and present data in an informative way. The techniques are commonly classified as graphical description in which graphs are used to summarize data and tabular description in which tables are used to summarize data. On the other hand, inferential statistics consists of generalizing from samples to populations, performing hypothesis testing, determining relationships among variables, and making predictions. Inferential statistics try to reach conclusions that extend beyond the immediate data alone. Both descriptive and inferential statistics help researchers to develop explanations for complex socio-economic characteristics of households that deal with relationships between variables (Nachmias-Frankfort and Nachmias, 1996). In the present study both descriptive and inferential statistics have been used.

2.11 Triangulation and validation of key findings

Triangulation of findings derived from data analysis was both formal and informal. At Stage 1, after analysis of one-off survey data, key findings were shared at the individual and community level to understand findings and interpret results. At the stage 2, community meetings were convened at the termination of data analysis (Figure 2.5). The research findings were presented by researchers through drawings of graphs and charts on paper and setting on a stage in farmer's household premises in the community. Finally sessions were held based on open invitation with groups to discuss any modification of the results based on ideas arising from RBFSP activities. Invitations were given to communities with the help of both RF and NRF farmers who participated in the initial one-off and longitudinal surveys. Participants in the discussion meeting were from the wider community without consideration of class or category. Discussion sessions were facilitated by field staff and all comments, suggestions, and interpretations were noted.

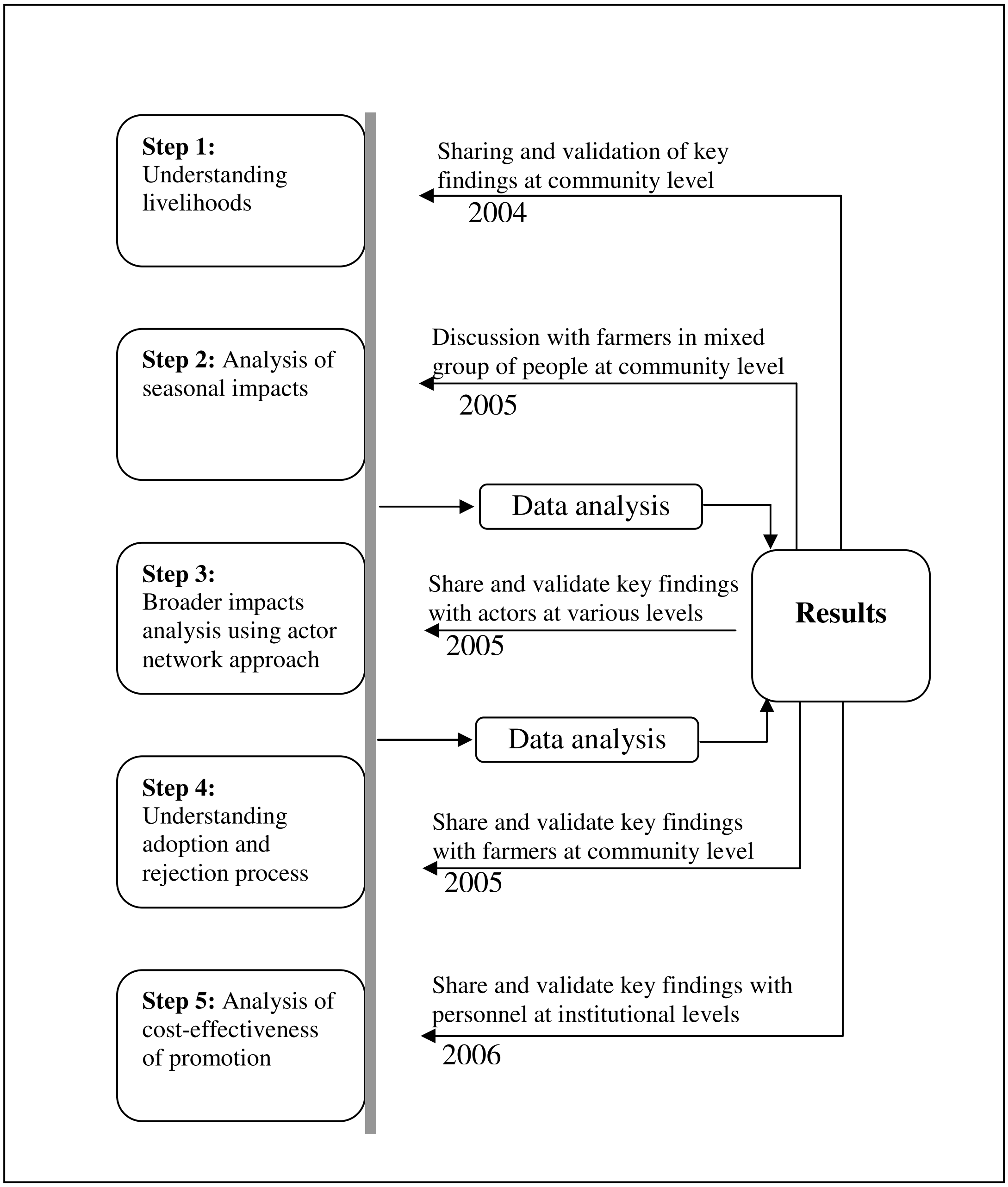


Figure 2.5: Sharing and validation of findings at different levels of respondents.

At Stage 3, key findings were shared individually at actor level particularly at farmer and fry trader levels for validation and better understanding. At the Stage 4, some key findings regarding the adoption and rejection process of RBFSP, were shared with farmers at community level to get better understanding. At Stage 5, the results of the study at the institutional level were validated with respective personnel of CARE and its partner NGOs. In the CARE Go-Interfish project office, Project Manager and Project Officers were asked to validate the findings. At the partner NGO level, sharing and validation of findings were carried out through discussion of key findings with the Executive Director and Account Officer.

2.12 Assumptions of the study

The following assumptions were made while undertaking this study:-

- The respondents selected for this study were knowledgeable enough about their socio-economic context to answer the questions made during the survey.
- The views and opinions provided by the farmers included in the sample were the representative views and opinions of all the farmers of the study area.
- The researcher and the associated team members who acted as an interviewer were well acquainted with the social environment of the study area.
- As a series of research activities were carried out over the period of several years, understanding of various social phenomena of farming households was clear.
- The sampling procedure followed for this study, data collection, the analysis of data and interpretations etc. were systematically carried out reflecting the validity and reliability of information.
- The findings of the study were expected to be useful for planning and implementation of the future extension programmes to make available quality

fish seed in the rural areas for increasing aquaculture production and welfare of household livelihoods.

Chapter 3: Contextualisation of RF households and their livelihoods

3.1 Introduction

This chapter presents the livelihood contexts of ricefish (RF) and non-ricefish (NRF) households by their well-being status based on a one-off structured questionnaire survey. The livelihood aspects include livelihood assets, strategies and outcomes of sampled households. Within the livelihood context, impacts of RBFSP on farming households (RF) compared to NRF households are demonstrated within their different well-being status.

The Northwest region of Bangladesh is comprised of eight districts (Panchagrh, Thakurgaon, Dinajpur, Lalmonirhat, Nilfamari, Rangpur, Kurigram and Gaibandha) with an area of 16,318 Km^2 and encompassing 12% of the total area of Bangladesh (BBS, 2003). This region has traditionally been recognised as marginalised from the rest of the country. The remoteness of the region from the political and economic centres was due to poor infrastructural facilities, lack of industrial development, and the prevalence of remnants of feudalism in agriculture and landholding systems. This has contributed to the positioning of the region as one of the poorest in the country (DFID, 2002). There has also been less industrial development in the Northwest region than in the country as a whole, although the opening of Jamuna multi-purpose bridge in 1998 and the resultant improvement in transport links with other parts of Bangladesh is expected to accelerate industrialisation (WARPO, 2001).

The total population and number of households in the region were 20.58 and 3.05 million respectively in 2001 with an average household size of 6.74 (BBS, 2003a). The population density in this region is much higher (1260.93/Km^2) than the national average (839.27/Km^2) (BBS, 2003). The literacy level at 7 years or older in 2001 was 39.50% in the area which is lower than the national average of 45.32% (BBS, 2003a). The low level of educational achievement is a serious impediment to economic growth in the Northwest. The key characteristics of the Northwest economy are low wages, high interest rates, extreme levels of poverty, and very slow rate of urbanization which shapes the economic behaviour the region. With cultivated land more or less constant, pressure on the rural area is acute and growing and needs a more rapid pace of economic development (DFID, 2002).

Geologically, almost all Bangladesh including the Northwest consists of mainly low and flat land except some hilly parts. Bangladesh is a part of the Bengal basin, one of the largest geosynclinals in the world (Rahman et al. 1994). The formation and growth of the Bengal basin is directly related to the origin and morphology of the Indo-Gangetic trough, which itself is overlaid and filled by sediments, thousands of meters thick (DFID, 2002). The floor of Bengal basin consists of quaternary sediments deposited by the Ganges, the Brahmaputra, and the Meghna rivers known together as GBM river system. The sediments are washed down from highland on three sites of the basin, particularly from the Himalayas. Over 90% of the annual run-off generated in the GBM catchments area flows through Bangladesh. The sediments of GBM provides ideal moisture, water and silt for cultivation of rice in the Northwest as well as other parts of Bangladesh (Rahman et al. 1994).

Hydrologically out of eight regions of Bangladesh, the Northwest (all 16 districts of Rajshahi Administrative Division) is the largest and has groundwater almost free from the threat of arsenic contamination (WARPO, 2001). Hydraulically, there are three aquifers across the country: an upper aquifer or composite aquifer, main aquifer and deep aquifer. The main aquifer occurring in most of the parts of the country ranges from less than 5 meters in the Northwest region to more than 75 meters in south (WPA, 2005; BANCID, 2007). The relatively shallow water table has facilitated the use of shallow tube-well pumps for agricultural irrigation. Such easy access to underground water and cheap installation of shallow pumps has led to a rapid increase and wide coverage of irrigated agriculture in Northwest Bangladesh. Out of total cultivable land, 63.03% is irrigated in this region which is greater than the national average of 48.31% (BBS, 2003a). The development of irrigated agriculture in this region along with other parts of country has been attributed to a series of policy reforms that started in the late 1970s. Particularly, after the devastating floods in 1987 and 1988, government policy to import agricultural machinery caused an influx of cheap engines from Republic of Korea and China, contributing to the accelerated diffusion of shallow tube-wells. The exploitation of groundwater through the use of tube-wells converted the fallow land of the dry season into fertile ricefields well suited to seed-fertilizer technology (Fujita and Hossain, 1995). The lack of off-farm opportunities coupled with the development of irrigated agriculture has increased dependency of farming households on agriculture based livelihoods. In recent years, the availability of irrigation has stimulated diversification through potato and maize cultivation (ADB, 2000).

In terms of fisheries resources, the total estimated area of waterbodies in the Northwest region is 31,954.78 ha including 20,970 ha of household ponds. Every year the area covered by constructed ponds is increasing in Northwest Bangladesh (BBS, 2003a). In parallel, the scope for people to benefit from wild fish supplies is diminishing due to over exploitation and crop intensification (NFEP, 2001) suggesting the growing importance of fish culture in this region.

In this context of higher levels of poverty, strictly agriculture-based farming, low level of literacy and limited scope for off-farm employment indicate the livelihoods of people in Northwest Bangladesh are particularly vulnerable. On the other hand, improved access to irrigation facilities and increased pond based aquaculture identified the development of RBFSP as a strategy with the potential to improve livelihoods. In this milieu, this chapter attempts to contextualise RF households (ricefield based fish seed producers) and their livelihoods in a broader view.

3.1.1 Objectives of this study

Today, aquaculture technology comprises much more than the rearing of fish in ponds or ricefields. With the aim of improving rural livelihoods in developing countries, development organizations have focused on aquaculture with one or a combination of objectives including i) to increase household food supply and improve nutrition; ii) to increase household resilience through diversification of income and food sources; iii) to strengthen marginal economies by increasing employment and reducing food prices; iv) to improve water resources and nutrient management for maximizing household based benefits as well as broader community based benefits; and v) to preserve aquatic bio-diversity through restocking and to reduce pressure in fishery resources (FAO, 2000b). In order to engage the people in small-scale aquaculture with a view to obtaining benefits, different combinations and components of the five types of livelihood asset (human, physical, natural, financial and social) are required. The presence or absence of various types of capital assets can facilitate or hinder, respectively, the likelihood of success. Individual farmers and households employ their capital assets in different ways, and use various means to overcome access barriers through combinations of asset components (ADB, 2005). Considering livelihood assets and impacts, the objective of the research is to differentiate between farmers successfully practising the technology of decentralised fish seed production in ricefields, and the households who were not practising.

3.1.2 Hypothesis

The asset profiles RBFSP adopters are the same as non-adopter households of different levels of well-being.

Research questions

The following research questions were set out to gain a comprehensive understanding of the hypothesis stated above:

- What are the livelihood characteristics of seed producing households compared to non-producers at different strata of well-being? How do the livelihood characteristics fit into the new practice of RBFSP technology?
- Does this technology require higher inputs compared to existing rice farming? How does this technology affect overall on-farm productivity and benefits?
- How does fish seed production impact on poorer farming households in comparison with non-producer households?
- How can fish seed production facilitate the relationship between asset status and adoption of RBFSP?
- How does fish production impact on food consumption and expenditure at the household level?

3.2 Research process and methodology

Site selection of the study area

The primary study area for this investigation was Northwest Bangladesh where decentralised fish seed production had been initially introduced, developed and promoted by external agencies and also substantially spread among farmers. The whole selection process and background of the study sites in Northwest Bangladesh have been discussed detailed in Chapter 2.

Well-being analysis

The well-being status of a household affects almost every aspect of the type and quality of existence. Wealth affects such parameters as the availability of labour, land, money for purchasing inputs, or savings and investment. The amount of cropping, types of crops grown, and use of crops are likely to vary with wealth status (Grandin, 1994). Rural wealth differences are often ignored or not fully addressed in farming systems research and extension. Wealth ranking allows researchers to understand quickly the nature of wealth differences in a community and to determine the appropriate wealth status of each community household. It solves the problem of identifying truly representative farmers, eliminating the serious difficulties that can arise from distorted sampling (Grandin, 1994).

As the special interest of the present study was to determine the livelihood impacts of RBFSP on farming households of different socio-economic status, a well-being ranking exercise was carried out to segregate the households into three well-being groups. A standard wealth ranking methodology developed by Grandin (1994) was applied to segregate the households into different wealth groups, which was descried elaborately in Chapter 2.

Sampling

Sample size was determined using the appropriate statistical procedure of probability sampling. In sampling of households at the community level, a simple randomized sampling technique was employed without considering primary and secondary adopters. The procedure of sample size determination and sampling were described in Chapter 2. The distribution of sample households in Table 3.1 shows a remarkable proportion of secondary adopters developed alongside primary adopters in seed producing communities.

Table 3.1: Distribution of the sample households (N=118) by farmer type and well-being category

Well-being categories	**Ricefish (RF)**				**Non-Ricefish (NRF)**	**Total community households**
Community households	**Primary RF**	**Secondary RF**	**Total RF**	**% of secondary out of total RF**		
Poor	62	17	79	21.5	877	956
Intermediate	42	26	68	38.2	553	621
Better-off	31	12	43	27.9	100	143
Total	**135**	**55**	**190**	**28.9**	**1530**	**1720**
Sample households						
Poor	20	4	24	16.7	31	55
Intermediate	17	3	20	15.0	15	35
Better-off	13	3	16	18.7	12	28
Total	**50**	**10**	**60**	**16.6**	**58**	**118**

Primary RF= Ricefish farmers who learnt technological know-how directly from CARE training; Secondary RF= Ricefish farmers who did not receive any support from CARE rather they learnt from primary adopters.

Framework of the study

Assessing the impact of agricultural technology on poverty is difficult, as there are so many ways in which agricultural research can have an effect (IFPRI, 2000). For this reason, many studies have tended to simplify the linkages between agricultural research and poverty and measure only one or two aspects of those linkages. However, this sort of approach can miss many important aspects of rural poor people's lives, including the diverse ways in which technology directly or indirectly affects their livelihoods (Adato and Meinzen-Dick, 2002). In order to minimize the missing elements, the sustainable livelihoods framework is used by a growing number of researchers and applied development organizations including Department for International Development (Carney, 1999). It is a conceptual framework for analysing causes of poverty, peoples' access to resources and their diverse livelihoods activities and relationship between relevant factors at micro, intermediate and macro levels (Adato and Meinzen-Dick, 2002). The various components of the sustainable livelihood framework and its merits and drawbacks are discussed in detail in Chapter 1. Based on the SL framework the present study explores livelihood assets, livelihood strategies, livelihood outcomes and many other livelihood aspects of adopters and non-adopters of RBFSP. In Chapter 2, farmer or household type (RF and NRF) was defined which is considered as the main factor to investigate the impacts of RBFSP in farming households. Well-being status (poor, intermediate and better-off) of households was considered as the second factor to explore its affects on the livelihood benefits gained through adoption of RBFSP.

Questionnaire survey for data collection

This chapter focuses on micro-level analyses based on the sustainable livelihoods framework using the collected information from the household survey. Commonly, the household is the basic unit of analysis in many microeconomic and government models. By definition, in the context of a developing country like Bangladesh, households are neither a group of people acting as if they were a single individual nor are they a collection of individuals co-operating in the interests of maximizing economic gains (Kabeer, 2001). More specifically, for the purpose of this study, a "household" has been considered a group of people in a housing unit living together as a family and sharing the same kitchen (Paul, 1998).

The household, as a unit of analysis in micro-level studies provides valuable insights into economic and social relations of rural areas in the developing world (Cain et al. 1979). Household surveys provide a rich source of data on economic behaviour and various livelihood aspects of household members. In recent years, there has been a great deal of interest in social experiments, including the use of household survey data to evaluate the results of social experiments (Deaton, 1997).

Household surveys, as a methodological approach were carried-out for primary data collection using a structured questionnaire to interview RF and NRF households in the study area. Questionnaires used for quantitative research in the social sciences are usually designed using operational definitions of concepts, instruments that reflect strength of attitudes, perceptions, views and options. This involves trying to measure and quantify how intensively people feel about issues, as opposed to what they know or can do (Black, 1999).

For development of the questionnaire, secondary information from published and unpublished documents regarding ricefish practices were collected from the CARE Dinajpur field office, used as supporting evidence where necessary. The whole process of the questionnaire survey has been described in Chapter 2. The questionnaire content was fixed to a structure that allowed data to be gathered on general household background information of livelihood assets, livelihood strategies and livelihood outcomes (Appendix 1). Out of a total of 120 randomly selected respondents, 118 were successfully interviewed with a response rate of 98 per cent. Two respondents were excluded due to incomplete questionnaires. While conducting the questionnaire survey, observation of field and household activities was also carried out through informal discussion with key informants at the farmer and institutional level, particularly with CARE personnel.

Data management and analysis

Data management process was discussed in the Chapter 2. Both non-parametric and parametric statistical tests were carried out to analyse data. Non-parametric data was tested using the Chi-square test (e.g. Appendix 3). In the parametric test of analysis of variance, farmer types and well-being were included as independent fixed variables (e.g. Appendix 4). Many other variables such as fish seed production, food fish production, rice production, vegetable production, poultry production, income, expenditures etc. were included as dependent variables.

All main effects were evaluated as well as two-factor interactions between farmer type and well-being. Tukey's test was used for the post hoc detection of significant pair-wise comparisons. Before carrying out parametric tests, data distribution was checked to confirm normality. Non-normal data were log transformed (Pallant, 2001). Only p values for main effects and significant interactions are presented for interpretation of results.

3.3 Results

The results of this chapter include an analysis of livelihood assets, livelihood strategies and livelihood outcomes of the farming households. According to the livelihood asset pentagon (five types of livelihood assets in the sustainable livelihood framework- Figure 1.1), all types of assets are included, however social capital particularly related to seed production activities is explored explicitly and described in Chapter 5. Moreover, how complex socio-cultural factors act as driving forces are discussed in terms of the adoption process of this technology in Chapter 6.

3.3.1 Institutional mediation

The sampled households had previously received training from various organizations of which CARE, DoF, DAE and DoL led to deliver training to farming households on different subject matters (Figure 3.1).

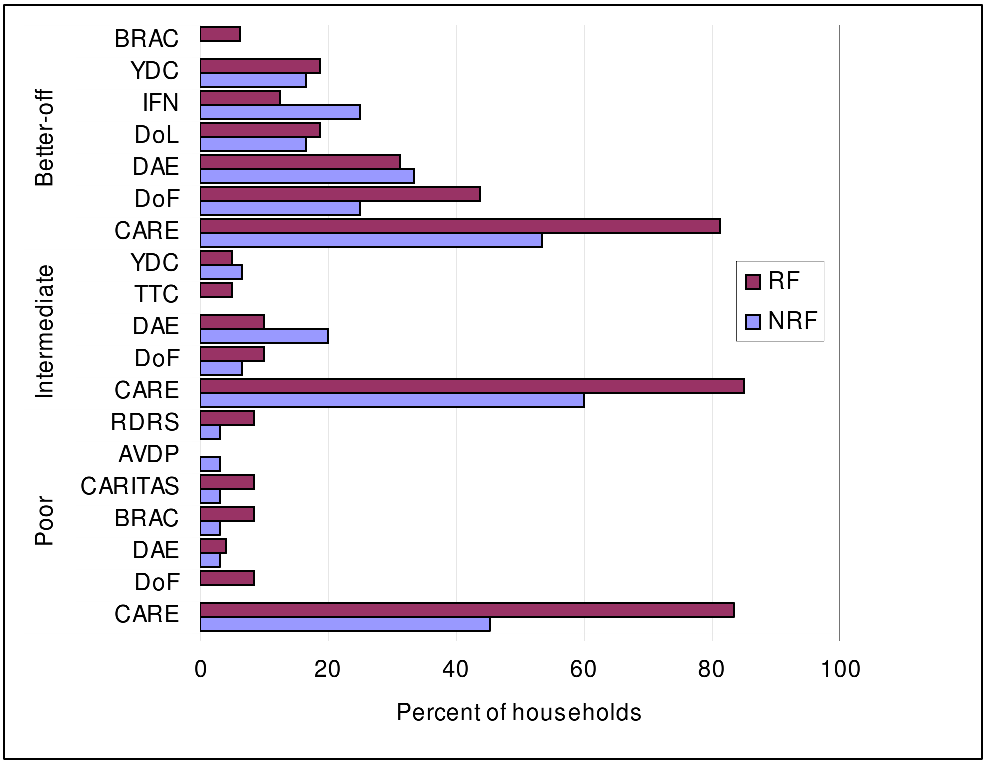


Figure 3.1: Percent of households received training from various organizations by farmer type and well-being (BRAC=Bangladesh Rural Advancement Committee, TTC= Teacher Training Centre), YDC = Youth Development Centre, IFN=Islamic Foundation, DoL=Department of Livestock, DAE=Department of Agriculture Extension, DoF = Department of Fisheries, AVDP = Ansar VDP and RDRS = Rangpur Dinajpur Rural Service).

Except with respect to CARE training, no remarkable difference was found between RF and NRF households in terms of other organizations. CARE had delivered training on RBFSP along with other subject matter (Chapter 7) at the household level. The government organization, DoF and other non-government organizations such as CARITAS and BRAC had trained farmers on pond fish culture. Farmers received agriculture related training particularly from DAE and some other non-government organizations such as BRAC, RDRS and CARITAS. The DoL and YDC - the government organizations had trained farmers on livestock rearing. There was no variation among the different well-being groups of households in terms of receiving training from CARE. However, a higher proportion of better-off households received training from government organizations compared to poor and intermediate households.

3.3.2 Livelihood capital

3.3.2.1 Human capital

Household size

Household size was defined as the number of persons, working or not, belonging to the same household. Average household occupancy (number of members/household) of the total sampled farmers (N=118) was 5.6±2.3 ranging from 2 to 20 members in an individual household. A significant ($P<0.05$) difference was found between RF and NRF farmers in terms of household occupancy with the average RF farmer's household size being 20% larger (6.1±2.8) than the NRF farmers (5.1±1.6). Household occupancy was also found to be affected by well-being level. Better-off seed producing households were found to have more members than intermediate and poor households (Table 3.2).

Table 3.2: Human capital of sampled households by farmer type and well-being

Human capital	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
HH size (no of person/hh)	4.9±1.5(24)	4.8±1.4(31)	5.6±1.4(20)	4.3±1.1(15)	8.8±3.9(16)	5.9±2.4(12)
Age of hhh						
Young age (%)	25(6)	12.9(4)		14.3(5)		8.3(1)
Middle age (%)	75(18)	70.9(22)	90(18)	66.7(10)	62.5(10)	75(9)
Old age (%)		16.1(5)	10(2)		37.5(6)	16.7(2)
Literacy level of hhh						
Illiterate (%)	45.8(11)	41.9(13)	22.7(3)	15.4(5)	25(4)	
Primary (%)	33.3(8)	35.5(11)	31.8(7)	23.1(2)	12.5(2)	16.7(2)
Secondary (%)	16.7(4)	16.1(5)	40.9(9)	30.8(4)	62.5(10)	58.3(7)
Above secondary (%)	4.2(1)	6.5(2)	4.6(1)	30.8(4)		25(3)
Primary occupation of hhh						
Agriculture (%)	70.8(17)	87.1(27)	85(17)	66.7(10)	93.8(15)	83.3(10)
Business (%)	12.5(3)	9.7(3)	5(1)	33.3(5)		8.3(1)
Service (%)		3.2(1)	10(2)		6.3(1)	8.3(1)
Petty business (%)	4.2(1)					
Van puller (%)	12.5(3)					
Secondary occupation of hhh						
Agriculture (%)	35(7)	17.4(4)	17.7(3)	38.46(5)	8.33(1)	20(2)
Livestock rearing (%)	40(8)	21.7(5)	47.1(8)	38.46 (5)	83.3(10)	50(5)
Business (%)	5(1)	13(3)	23.5(4)	15.4(2)		10(1)
Petty business (%)	5(1)	13(3)	5.9(1)		8.3(1)	10(1)
Service (%)		8.7(2)		7.7(1)		10(1)
Day labour (%)	15(3)	26.1(6)				
Fish culture (%)			5.9(1)			

hh= Household; hhh=Household head; figures in the parentheses indicate number (N)

Age

The age of the respondents (N=118), normally the heads of the households, ranged between 20 to 90 years with an average of 45.8 ±13.5 years. From whole sample, 73.7% of the household heads were within the middle age (31-60 years) group (Table 3.2). No significant variation ($P<0.05$) was noted in the age of the respondents between the farmer types. Chi-square test did not show any significant difference ($P>0.05$) in the distribution of age groups between the wealth classes. More than 50% of farmers in the middle age group were found to be involved in fish seed production activities and this was also higher in all well-being groups.

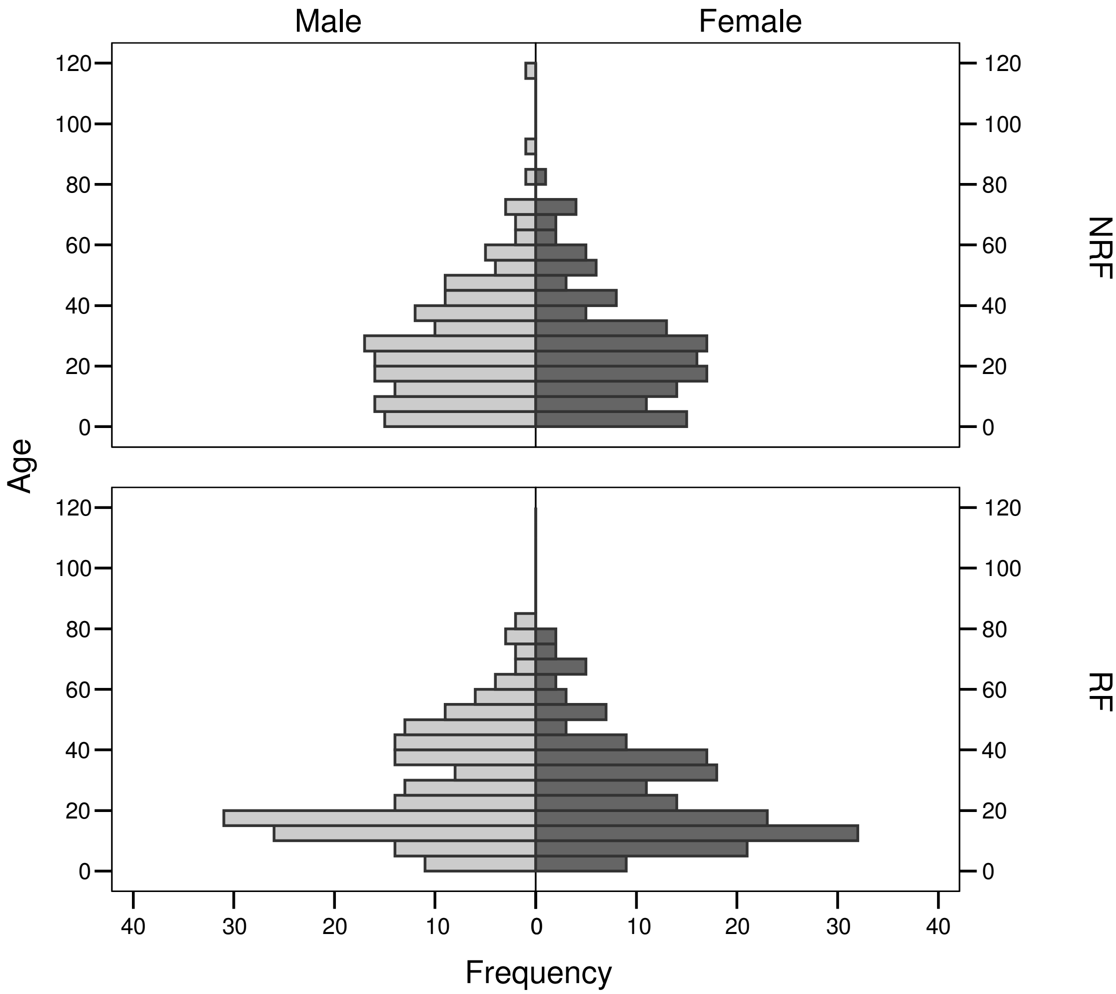


Figure 3.2: Pyramidal distribution of whole population based on age and sex by farmer type in RF and NRF households.

According to age group, the pyramidal distribution of sample shows a bulk of people in RF households lies below the age level of 20 years (Figure 3.2). Lower number of household members at this level in NRF households was possibly be due to the use of family planning method as NRF farmers were more educated than RF farmers. However, this section of household labour in RF households is likely to contribute to the management of RBFSP activities. Age of household members close to zero indicates the presence of lactating mothers in farming households. In addition, the number of household members above 60 years indicates the presence of elderly in households. Almost all (except one) of the sampled household heads were male.

Access to education

The average schooling period of a household head was 5.2±4.4 years. The average number of schooling years for RF farmers (4.8±4.1) was found to be significantly lower than the NRF farmers (5.6±4.7). This was true for all well-being groups (Figure 3.3).

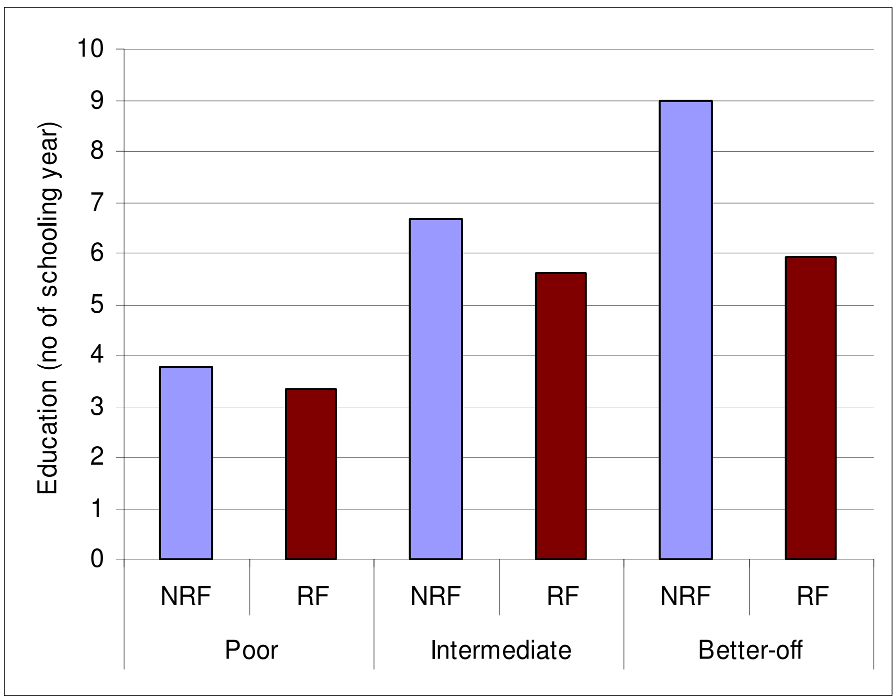


Figure 3.3: Education (number of schooling year) of the sample household head.

A higher percentage of RF farmers had primary (28.3%) and secondary (38.3%) level of education than NRF households (Table 3.2). Above secondary level, a higher percentage of NRF farmers (15.5%) were educated than RF (3.3%) farmers. The number of illiterate RF and NRF farmers was similar. There was a significant difference ($P<0.05$) found in the distribution of educational attainment between the well-being groups. A higher percentage of poor farmers (43.6%) were found to be illiterate followed by intermediate

(22.9%) and better-off (14.3%) groups. However, a considerable portion of poor farmers (34.6%) were found to have attained a primary education followed by the intermediate (25.7%) and better-off (14.3%) groups. On the contrary, the reverse scenario was observed in secondary and higher secondary levels of education, which suggests that poor farmers had adequate access to primary education but inadequate access to secondary and higher secondary levels. In this context, technical and practical knowledge of the poor on RBFSP is more important that for better-off farmers.

Overall the majority of RF farmers were found to be illiterate, nevertheless they learnt and applied technical know-how of fish seed producing technology, which suggests that illiteracy did not exclude households from accessing technology and enjoying livelihood benefits.

Primary occupation

There were no significant differences found between the farmer types and well-being groups in terms of primary occupation. Agriculture was found to be the major occupation amongst both types of farmers, even at a similar level (81%), which suggests that agriculture based activity, was the principal livelihood strategy for the majority of farming households in rural areas. Remarkably in intermediate and better-off category, a higher percentage of RF farmers listed agriculture as their primary occupation compared to NRF farmers (Table 3.2).

Secondary occupation

As with primary occupation, no significant variations were found between different groups of farmers in terms of secondary occupations. However, agriculture, livestock rearing, business, petty business and small service were found as the secondary occupations in both types of households. Only one RF farmer was found within the intermediate well-being group having fish culture as a secondary occupation. Comparatively poor NRF farmers tended to list different non-farm activities as secondary occupations such as business, petty business, service and day labour (Table 3.2). More educated NRF farmers are likely to be involved in more non-farm activities.

3.3.2.2 Physical capital

Dwelling space

The average number of living rooms in the RF household (2.1±1.3) was significantly ($P<0.05$) higher than in NRF households (1.6±0.7). Well-being significantly ($P<0.05$) affected the possession of living rooms in farming households. Poorer RF and NRF farmers had a similar number of living rooms with differences in the intermediate and better-off classes.

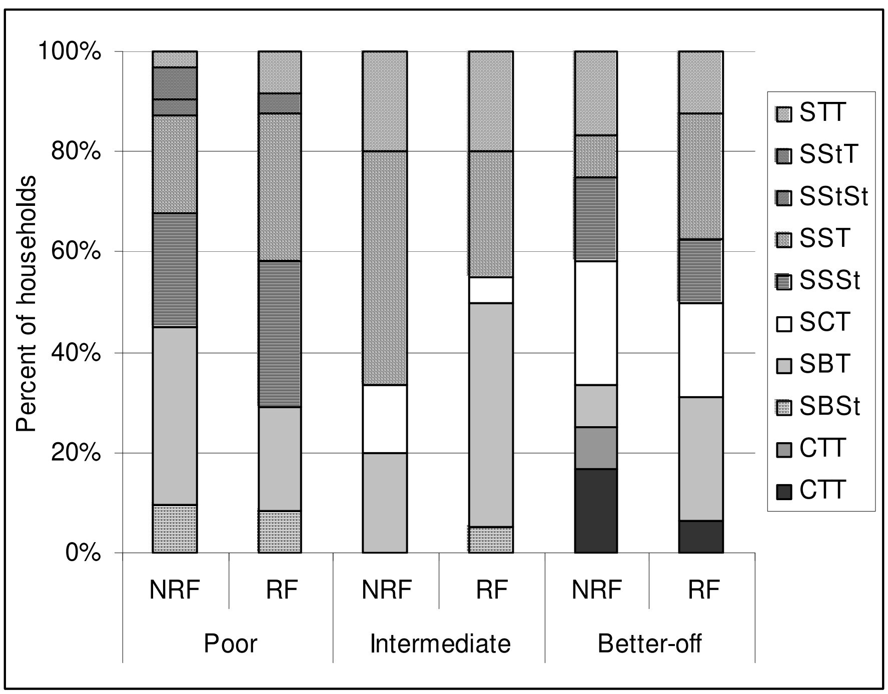


Figure 3.4: Construction materials of living rooms of household members (C=concrete, T=corrugated tin, S= soil, B= bamboo and St= straw; - - - = floor-wall-roof)

Within the whole sample, about 30% of the household's living rooms were made using a combination of soil-floor, soil-wall and corrugated tin-roof. More than 30% household's living rooms were constructed using soil-floor, bamboo-fence and corrugated tin-roof. Better-off farmers tended to construct concrete and tin made living rooms. On the other hand, living rooms of the poorer households tended to be constructed using mostly soil based floor; bamboo, soil and straw made wall; and straw and tin made roof (Figure 3.4). This suggests that poor households made their dwelling rooms using low-cost materials due to lack of sufficient asset base.

Almost every farming household had a kitchen room, which for the most part made of soil-floor, bamboo-fence and straw-roof. The majority of the households had a cattle den which with a soil-floor, bamboo-fence and tin-roof. Some of the better-off households had storerooms which were made of bamboo-floor, bamboo-fence and tin-roof for storage of rice and other agricultural crops.

Table 3.3: Physical capital of sampled households by farmer type and well-being group

Physical capital	Poor		Intermediate		Better off	
	RF	**NRF**	**RF**	**NRF**	**RF**	**NRF**
Housing						
Living room (no/hh)	1.5±0.7(24)	1.5±0.6(31)	2.2±1.1(20)	1.7±0.8(15)	2.9±1.8(16)	1.7±0.7(12)
Kitchen room (no/hh)	1(24)	1(24)	1(20)	1(15)	1(16)	1(12)
Cattle den (no/hh)	1(19)	1(18)	1(16)	1(12)	1(16)	1(10)
Store room (no/hh)	1(3)	1(3)	1(6)	1(3)	1(6)	1(4)
Drinking water source of hh						
Own tube well (%)	91.7(22)	87.1(27)	100(20)	93.3(14)	100(16)	100(12)
Others tube well (%)	8.3(2)	12.9(4)		6.7(1)		
Toilet facilities of hh						
Concrete enclosed (%)			10(2)	13.3(2)	25(4)	8.3(1)
Semi-concrete enclosed (%)	41.6(10)	35.4(11)	50(10)	53.3(8)	75(12)	91.6(11)
Non-concrete enclosed (%)	58.3(14)	64.5(20)	40(8)	33.3(5)		
Pond resources						
Own (no/hh)	1(10)	1.2±0.4(9)	1(15)	1.2±0.5(8)	1.7±0.9(13)	1.8±0.8(9)
Own area (ha/hh)	0.1±0.1(10)	0.04±0.02(9)	0.04±0.03(15)	0.1±0.1(8)	0.2±.1.2(13)	0.1±0.1(9)
Multiowner pond (no)	1(6)	1.3±0.5(4)	1 (4)	1.7±1.2(6)	2.7±1.6(3)	1(3)
Multiowner pond area (ha)	0.1±0.04(6)	0.1±0.1(4)	0.1±0.02(4)	0.3±0.5(6)	0.5±0.6(3)	0.3±0.1(3)
Multiple-ownership ha/hh	0.02±0.01	0.02±0.01	0.02±0.01	0.03±0.04	0.07±0.02	0.03±0.01

hh= household; figures in the parentheses indicate number (N)

Access to drinking water

Regardless of well-being group, around 90% of households were found to have developed their own drinking water facilities through installation of a shallow tube-well within their household premises. No significant difference was found between the farmer types in terms of having a shallow tube-well for drinking water. A small number of poor and intermediate farmers (Table 3.3) were found to be dependent on their neighbour's drinking water sources.

Toilet facilities

Out of the total sample, more than 50% of households had developed semi-concrete enclosed toilet facilities, whereas approximately 40% of households were using non-concrete closed toilet. A non-concrete enclosed toilet consists of an earthen pit surrounded by straw and a bamboo fence. In the intermediate well-being class, most of the farmers used semi-concrete enclosed toilets, and in the better-off category, the same types of toilet facilities were used by most of the farmers (Table 3.3). A semi-concrete enclosed toilet consists of a cemented ring and slab surrounded by a bamboo or corrugated tin made fence. Better-off farmers were found to use concrete enclosed toilets constructed of a cemented pit and wall. Poor farmers however, could not build concrete enclosed toilet facilities. No better-off households used any non-concrete enclosed toilet facilities.

Access to ponds

As the household ponds were constructed by farmers, they were considered as physical capital (Little et al. 2007). Out of the total sample set (RF-60; NRF-58), 93% of RF and 72% of NRF households were found to have access to ponds through different tenures such as their own, multi-owner, share-in and leased in arrangements (Figure 3.5). Sixty three percent of RF and 45% of NRF farmers owned their own pond. The average number of household owned ponds in RF and NRF households was 1.2±0.6 and 1.4±0.6 respectively. RF and NRF households had similar sized (0.08 ha) ponds ranging from 0.01 to 0.40 ha and from 0.01 to 0.49 ha respectively. Although no significant variation was found between the farmer types however, significant ($P<0.05$) variation was found between the well-being groups in terms of the number and size of ponds. Only thirteen farmers of both RF and NRF had multiple-ownership ponds (Figure 3.5) which were larger than single owned ponds.

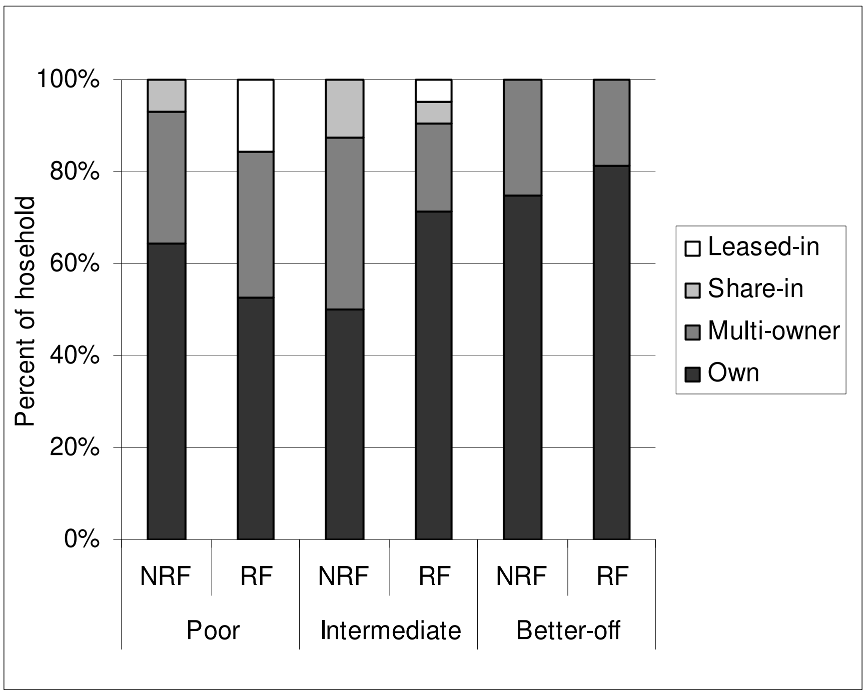


Figure 3.5: Access to different pond ownerships by farmer type and well-being (share in = sharecropping; multi-owner = multiple households ownership; own=single household ownership pond).

Within the intermediate and poor well-being groups, NRF farmers tended to have access to more and larger multiple household owned ponds compared to RF farmers. Very few farmers had shared-in and leased-in ponds which did not show any statistical significance between groups in terms of number and size.

Possession of fishing gear

The tendency to use their own, traditional fishing gear such as *barshi* (hook gear), trap gear, cast net, gill net, harpoon and seine net, was higher in seed producing households. The majority of farmers were found to have their own cast net and trap gear. A significantly ($P<0.05$) higher percentage of RF farmers (60%) owned *barshi* compared to NRF household, which is a very effective method of catching fish from ricefields. In addition, catching fish, particularly tilapia from the ricefields is a recreational event for the children and older members within the household.

Access to rural infrastructure

Farming households had access to different levels of physical infrastructure such as *paka* road (hard bitumen surface), school/college, local shop/market, mosque and temple, *kacha* road (earthen road) etc. RF households tended to have better access to *kacha* roads (earthen road) ($P<0.05$) than NRF households. *Kacha* roads were developed by the local government and have enhanced the suitability of riceplots for fish seed production through facilitating ditch development inside the riceplot and enlargement of at least one dike. For instance, in the community – Bahagili, Rangpur (Chapter 6), the majority of the fish seed producing riceplots are adjacent to the road. Positioning a riceplot adjacent to the road allows the dike to be enlarged ensuring longer term water holding capacity during the irrigated *boro* season.

3.3.2.3 Natural capital

Access to land

On average each household owned 0.08±0.07 ha homestead area with a range of 0.01 to 0.51 ha. There was no significant difference between RF (0.08 ha) and NRF (0.07 ha) households in homestead landholdings. However, there was a significant ($P<0.05$) effect of well-being on farmer type in the possession of homestead area. The better-off households had larger holdings than intermediate and poor households in the case of both RF and NRF households (Table 3.4).

The average farm household studied possessed their own agricultural land with a mean landholding of 0.89±1.04 ha ranging from 0.0 ha (landless) to 6.45 ha. Among farmer types, RF households had larger ($P<0.05$) landholdings (1.15±01.20 ha) compared to NRF (0.63±0.76 ha) households. The level of well-being significantly ($P<0.05$) affected the landholding of farmers. Poor, intermediate and better-off households had average landholdings of 0.34±0.29, 0.83±0.55 and 2.06±1.44 ha respectively (Table 3.4). Apart from the single household owned land, access to land through sharecropping was found to be an important land tenure mechanism among poorer households. In addition, land was accessed by relatively few households through multiple-ownership, leasing-in and mortgaging-in in the poor and intermediate well-being groups.

Table 3.4: Landholdings of sampled households by farmer type and well-being

Household characteristics	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Homestead (ha/hh)	0.06±0.06(24)	0.05±0.04(31)	0.07±0.03(20)	0.09±0.10(15)	0.13±0.12(16)	0.11±0.05(12)
Own land (ha/hh)	0.40±0.29(24)	0.29±0.30(31)	1.02±0.60(20)	0.58±0.37(15)	2.44±1.55(16)	1.41±1.15(12)
Share-in (ha/hh)	0.24±0.16(9)	0.45±0.23(13)		0.26±0.06(5)		
Share-out (ha/hh)				0.45±0.37(2)	0.40±0.42(2)	0.54±0.30(2)
Multi-owner (ha/hh)	0.24±0.04(2)	0.22±0.19(2)	0.06±0.12(2)	0.28(1)		
Leased-in (ha/hh)	0.15±0.14(4)	0.08(1)	0.26±0.12(2)			
Mortgage-in (ha/hh)	0.24±0.20(3)	0.14(1)				
Mortgage-out (ha/hh)			0.33(1)	0.67±0.32(2)		

hh= household; figures in the parentheses indicate number (N)

Ownership of ricefish plot

According to well-being status, 58% of the poor farming households (Figure 3.6) used their own ricefish plots, whereas the remaining 42% of the poor households used other ricefish plots accessed through share-in (17%), lease-in (17%) and mortgage-in (8%) arrangements. In a share-in arrangement, rice production is shared equally between RF farmers and the landowner, but fish fingerling production was owned by only RF farmers.

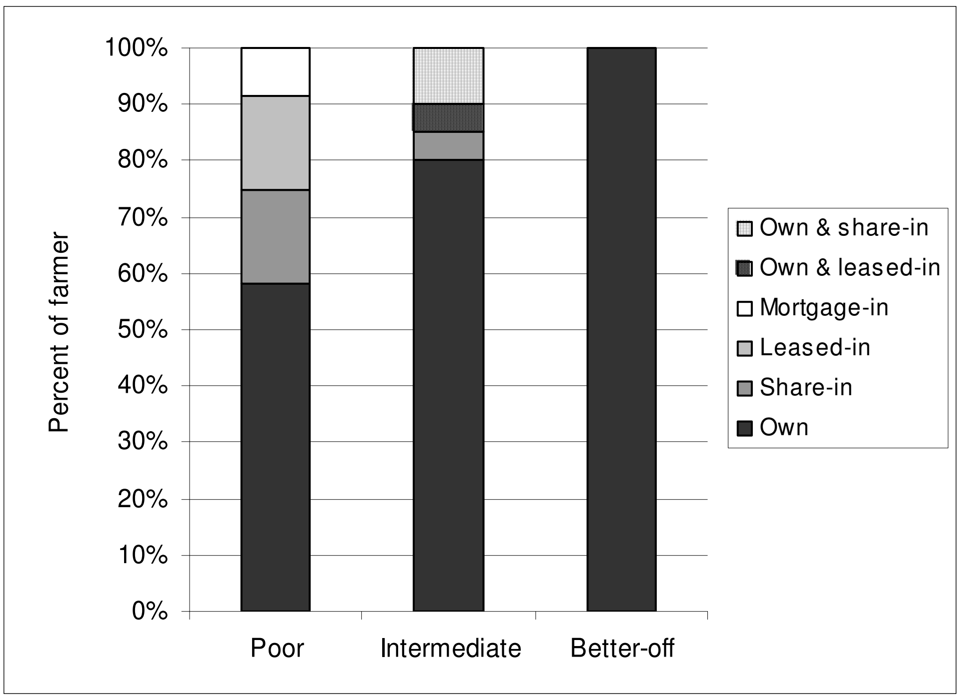


Figure 3.6: Ownership pattern of ricefish plot in different well-being groups of RF households.

In a lease-in arrangement, the RF farmer cultivates the ricefish plot for an agreed period of time paying money to the landowner. In a mortgage system, the RF farmer cultivates ricefish plot paying a loan to the landowner until the loan has been repaid by the landowner. Eighty percent of intermediate farmers had their own ricefish plot and the remaining 15% had other types of access, however all of the better-off households (100%) owned the riceplot used for fish seed production.

Ricefish plot, ditch and dike

The average riceplot area accessed by a farm household was 0.17±0.27 ha ranging from 0.01 to 1.62 ha. A significant difference ($P<0.05$) was found between ricefish plot areas of different well-being groups. The average area of the better-off farmers' riceplots was 0.26±0.4 ha followed by intermediate (0.17±0.22) and poor (0.11±0.09) households (Table 3.5). Poor, intermediate and better-off households used 30, 23 and 16% of the total own land respectively for ricefish plots.

Table 3.5: Various dimensions of ricefish plots accessed by RF households according to their well-being status

	Well-being		
Criteria of ricefish plot, ditch and dike	Poor	Intermediate	Better-off
Plot area (ha/hh)	0.11±0.09(24)	0.17±0.22(20)	0.26±0.43(16)
Plot distance from homestead (m)	164.16±188.61	61.47±199.96	148.41±177.43
Average ditch size (m^2)	2.82±4.56	2.93±3.16	2.22±4.02
Average depth of ditch (m)	0.96±0.66	0.96±0.70	0.89±0.76
Average dike width (m)	0.38±0.33	0.45±0.33	0.57±0.42
Average dike height (m)	0.43±0.27	0.50±0.35	0.51±0.41

hh=household; figure inside the parentheses indicating number (N)

There was no significant difference found between the well-being groups in terms of the distance of riceplots from their households. The average distance from household to riceplot was 125 m. There were no significant differences found between the RF farmers of different well-being groups in terms of ditch size, ditch depth, dike width and dike height of their ricefish plots. Relatively, the ditch area among poor and intermediate households was larger than in better-off households suggesting poor and intermediate households intensified the utility of their riceplots compared to better-off households. In addition it was also observed that the configuration of ditches in most of the farmer's riceplots was rectangular in shape.

Soil type of ricefish plot

According to farmers' perceptions and direct observation at the field level, soil quality was found to be clay-loam in the ricefish plots of the majority of households (63%) followed by loam (17%) and sandy-loam (15%). Clay-loam soil has a higher water retention capacity which facilitated farmers to hold water for a longer period of time in their ricefish plots.

Level of ricefish plot and water holding capacity

According to farmer perceptions of riceplot water holding capacity, the topographic level of ricefish plot has been categorized into low and medium level. Over 70% farmers indicated their riceplot level as medium. The medium level of riceplots implies physical characteristics which include being free from the threat of periodic flooding due to sudden heavy rainfall and periodic drought during the dry season. More than 50% of farmers mentioned that their plots had medium water holding capacity followed by good (25%) and poor (20%).

Sources of water to ricefish plot

Overall, about 60% of farmers developed their own shallow pump facilities and the remaining farmers were dependent on renting access to shallow (30%) and deep tube-wells (10%). Well-being level significantly ($P<0.05$) affected the access of farmers to water supply facilities from irrigation pumps into their ricefish plots. Among the well-being groups, 81% of better-off farmers exploited groundwater using their shallow tube-well to supply their own riceplots followed by 65% intermediate and 37% poorer. Better-off farmers tended to have their own irrigation pumps (machine and borehole) whereas poorer households tended to only have a borehole (Figure 3.7).

Figure 3.7: Whole set of groundwater irrigation pump belongs to a better-off farmer (left) poorer households only had the borehole to which they attached a rented pump-set (right).

Those intermediate and poor farmers who did not own their own irrigation facilities depended on water supply from rented shallow and deep tube-wells. Some poor farmers tended to rent pump-sets to use with their own borehole. From field observation it was estimated that installation of a bore hole cost about US$ 53.3, a pump-set required an additional US$ 161 totalling US$ 200 (Table 3.6).

Table 3.6: Cost for installation of groundwater shallow irrigation pump

Item	No	Unit price (US$)	Cost (US$)
Plastic pipe	3	9.7	29.1
Filter pipe	1	8.1	8.1
Installation			16.1
Cost for a borehole			**53.3**
Pump-set	1	161	146.7
Total pump-set cost			**200**

The dependency of poorer households on rented irrigation systems, particularly on rented shallow pumps, suggests the poor had less capacity to install a full pump-set. Dependency on rental irrigation pumps did not constraint the poor adopting the technology of fish seed production in ricefield based system.

3.3.2.4 Financial capital

Livestock

Livestock are considered as financial capital because of their liquidity, i.e. farmers can sell them easily anytime they need money. In the total number of sampled households, the average number of cows, goats, chickens, ducks and pigeons were 3.9, 3.3, 24.3, 7.3 and 15.8 respectively. There was no significant difference between RF and NRF farmer in terms of livestock holdings. This suggests that fish seed production did not compete with livestock rearing. Livestock inventories were also unaffected by well-being, apart from among the poorer NRF farmers that reared more goats than RF farmers.

Access to credit

Farmers received credit from different organizations, such as government banks and organizations, local NGOs, large national NGOs and money lenders and neighbours (Figure 3.8).

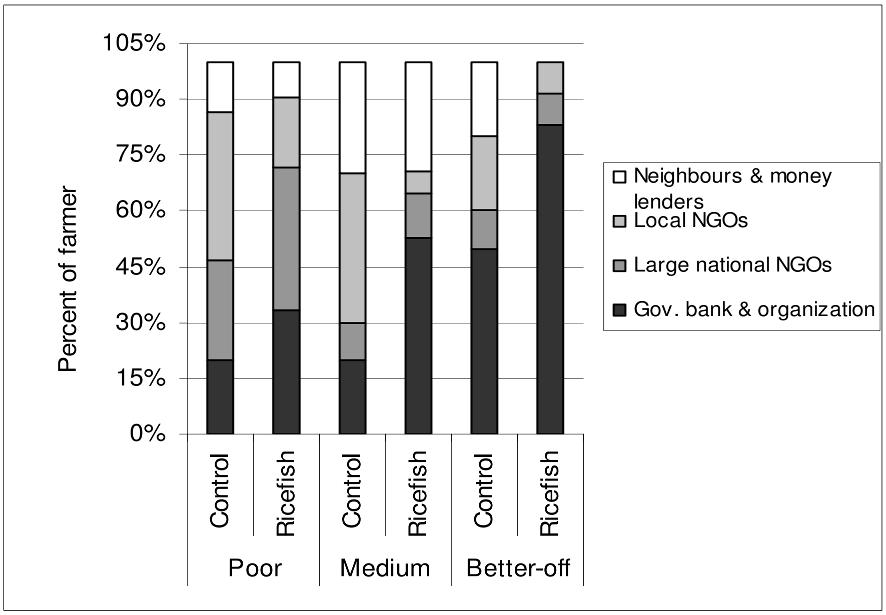


Figure 3.8: Percent of households received credit from different organizations.

A significant difference (P<0.05) was found between the proportion of RF and NRF households receiving credit from different organizations (Figure 3.8). About 59% of RF farmers received credit from major financial organizations which was higher than NRF farmers. This was due to the role CARE played in mediating between farmers and credit providing organizations which possibly improved the access of RF households to larger institutional credit. Relatively poor and intermediate households tended to receive credit from local and large national NGOs as well as from money lenders and neighbours.

Table 3.7: Financial capital of sampled households by farmer types and well-being groups

Financial capital	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Livestock (no/hh)						
Cow	4.9±3.2(22)	3.3±1.6(25)	3.9±2.2(14)	3.5±1.6(13)	4.1±2.5(14)	3.3±1.2(11)
Goat	3.7±2.4(15)	2.3±1.3(14)	2.9±2.1(12)	3.2±2.3(5)	3.8±2.67(12)	4.1±1.6(7)
Chicken	14.0±10.8(21)	14.9±19.0(25)	58.7±140.8(17)	20.1±10.9(15)	15.0±16.8(14)	29.4±19.9(11)
Duck	7.5±6.4(17)	4.9±5.7(18)	11.7±18.5(14)	6.3±5.3(13)	4.2±2.9(13)	11.4±10.1(8)
Pigeon	8.7±3.1(3)		19.0±13.7(4)	6.0 (1)	40.0(1)	10(1)
Access to credit (US$/hh)						
Govt. bank & org.	110.6±67.6(7)	80.7±48.4(3)	206.1±84.5(9)	137.1±34.2(2)	229.4±115.8(10)	261.3±101.6(5)
Local NGOs	112.9±39.5(8)	137.1±95.4(4)	112.9±22.8(2)	32.3 (1)	96.8 (1)	32.3 (1)
Large national NGOs	129.0±86.4(4)	80.7±89.5(6)	80.7(1)	84.7±42.4(4)	80.7 (1)	56.5±34.2(2)
Lenders & neighbours	24.2±11.4(2)	40.3±11.4(2)	109.7±67.9(5)	182.8±260.7(3)		96.8±91.2(2)

hh= household; figures in the parentheses indicate number (N)

There was no significant difference between the amount of current credit received by RF (182.26$) and NRF households (189.33$) from government bank and other organization. However, well-being significantly ($P<0.05$) affected the amount of credit received by RF and NRF farmers. The size of credit and number of receivers were comparatively higher in the better-off households (Table 3.7). Better-off NRF farmer's credit amount was found to be larger than better-off RF farmers. These findings revealed that there was only minimal formal lending from banks, probably because the bank does not target poorer households as they cannot provide sufficient collateral such as a bond landownership and the assurance to repay within the stipulated time.

3.3.2.5 Social capital

Social capital operates at various levels of human life in the rural areas of Bangladesh. In a livelihood framework, it overlaps and interacts with other assets and strategies in different ways. Spreading knowledge of fish fingerling production from primary to secondary farmers through informal relationships is a building block of social capital in this context.

Access to land by means of different tenures such as share, lease, and mortgage systems is an important part of social capital. Among RF farmers (i.e. seed producers), a number of poor farmers were found to gain access to riceplots through different means of tenure. Some poor farmers also gained access to ponds through share-in tenure, depending on social relationships. Access to drinking water and shallow pumps for riceplot irrigation is another building block of social capital. Receiving credit from neighbours and money lenders depends on social relationships. Gifting fish seed and foodfish to neighbours and relatives contributed to social capital in seed producing communities (Figure 3.13).

3.3.3 Livelihood strategies and outcomes

3.3.3.1 Agriculture crop production and income

Farmers cultivated different agriculture crops such as *amon* rice, *boro* rice, *aus* rice, potato, vegetables, wheat, jute, mustard, betel nut and banana. All of the farmers (100%) belonging to RF and NRF households cultivated *amon* and *boro* rice (Table 3.8). Cultivation of *aus* rice between the *boro* and *amon* season was practised by only 2 RF and 2 NRF farmers. The second most important field crop was potato cultivated by 47% households of both types. Potato cultivation is likely to compete for resources with fish seed production in ricefields.

Table 3.8: Cultivation of different crops and income by farmer type

Crops	RF				NRF			
	Percent farmer cultivated	Area (ha/hh)	Expenditure (US$/hh)	Income (US$/hh)	Percent farmer cultivated	Area (ha/hh)	Expenditure (US$/hh)	Income (US$/hh)
Amon	100 (60)	0.9	70.0	243.5	100 (58)	0.7	50.3	167.7
Boro	100(60)	0.7	104.6	201.4	100(58)	0.5	88.4	153.6
Potato	46.7(28)	0.3	59.8	125.3	46.6(27)	0.2	47.7	58.6
Vegetable	36.7(22)	0.2	15.4	55.4	31.3(18)	0.2	13.3	28.4
Wheat	31.7(19)	0.8	28.6	35.3	25.9(15)	0.4	36.7	40.5
Jute	28.3(17)	0.3	18.3	11.9	15.5(9)	0.2	27.3	23.6
Mustard	10(6)	0.3	13.9	30.9	8.6(5)	0.2	4.5	11.8
Battle nut	20(12)	0.1	0.0	44.6	6.9(4)	0.2	0.4	65.7
Banana	8.3(5)	0.2	75.8	179.5	6.9(4)	0.3	48.8	58.9
Aus	3.3(2)	0.3	19.4	83.1	5.1(3)	0.5	21.2	50.3

hh=household; figures inside the parentheses indicate number (N)

Potato farming became popular as a cash crop due to the development of cold storage facilities in northern Bangladesh and improved opportunities for marketing after the construction of the Jamuna Bridge.

Other crops such as wheat, jute, mustard, betel nut and banana were cultivated by a smaller number of farmers in both RF and NRF groups (Table 3.8). The average area cultivated by the RF farming households for *amon* rice, *boro* rice, wheat and potato were found to be higher than by NRF households. The average area cultivated by the RF and NRF farmers for *amon* rice were 0.9 and 0.7 ha respectively and for *boro* rice were 0.7 and 0.5 ha respectively. RF and NRF farmers used 0.82 and 0.39 ha for wheat cultivation and 0.26 and 0.19 ha for potato growing respectively. The area of land used by the RF farmer for growing *aus* rice, banana and betel nut was lower than NRF households. Average per household land use, expenditure and income were found to be higher in *amon* season. This was due to the ability of farmers to cultivate their maximum land area during the rainy season.

Amon rice cultivation by farmer type and well-being

There were significant differences between farmer types in terms of per household land use for *amon* cultivation and related expenditure, production and income (Table 3.9). The area of land use for *amon* was found to be higher than in *boro* irrespective of farmer type and well-being, relating to the dependence of *boro* rice on groundwater irrigation and higher capital investment for fertilizers. These factors limited cultivation to smaller areas than for *amon*.

Table 3.9: Mean (±SD) area cultivated, production, expenditure and income per household from field crops by farmer types and well-being

Crop production	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
A) ***Amon***						
Area (ha/hh)	0.37±0.21 (24)	0.45±0.27 (31)	0.72±0.54(20)	0.46±0.33(15)	1.87±1.17(16)	1.42±0.95(12)
Production (kg/hh)	1102.5±785.4	1320.8±888.9	2274.0±1435.3	1407.5±979.0	5350.6±3073.7	3970.0±2128.9
Production (kg/ha)	2780.3±1496.2	3027.2±970.5	3313.4±938.6	3074.7±784.9	3375.3±2427.9	3102.1±929.9
Expenditure (US$/hh)	27.9±21.5	34.6±30.5	53.3±36.6	33.9±27.3	154.2±107.9	111.1±80.7
Expenditure (US$/ha)	72.5±48.3	77.5±35.0	78.5±31.6	67.8±26.0	80.7±41.7	83.7±47.4
Income (US$/hh)	107.7±93.1	123.0±83.4	205.4±139.2	130.5±79.6	480.5±362.3	329.2±165.7
Income (US$/ha)	261.5±167.9	288.2±112.8	285.3±143.0	288.1±118.2	250.5±135.3	268.8±100.6
B) ***Boro***						
Area (ha/hh)	0.27±0.19 (24)	0.37±0.24 (31)	0.64±0.46 (20)	0.34±0.17(15)	1.47±1.07 (16)	1.25±0.73 (12)
Production (kg/hh)	1369.2±1146.2	1649.9±2600.5	2733.4±1905.9	1488.0±840.3	6226.6±4671.7	5368.3±3375.4
Production (kg/ha)	4894.9±1787.3	4993.1±1125.9	4352.0±1525.7	4335.3±1936.5	4282.5±1757.9	4433.9±1902.4
Expenditure (US$/hh)	44.5±34.5	63.4±41.1	94.0±62.3	56.7±41.6	210.9±191.9	197.8±149.6
Expenditure (US$/ha)	159.2±57.4	175.2±56.9	155.7±69.6	159.8±88.1	141.7±72.3	166.1±79.4
Income (US$/hh)	98.8±96.3	102.8±80.6	199.4±164.2	110.5±73.8	382.5±295.8	347.1±239.1
Income (US$/ha)	349.7±154.2	317.9±274.3	311.6±153.1	314.1±161.2	292.4±142.9	280.6±175.8
C) Potato						
Area (ha/hh)	0.18± 0.17 (8)	0.13± 0.10(11)	0.20± 0.16 (10)	0.13± 0.08 (8)	0.39±0.37 (10)	0.32±0.16 (8)
Production (kg/hh)	2585.0±3927.5	965.5±1048.2	2546.5±2710.9	652.5±455.4	3676.0±4254.4	3673.1±3160.7
Production (kg/ha)	13376.1±6659.8	8106.3±6624.5	11450.2±7154.4	5636.7±3693.9	9729.4±8810.6	11019.3±7044.7
Expenditure (US$/hh)	48.6±79.3	23.0±21.0	62.4±75.2	20.3±16.4	66.2±61.6	103.0±93.2
Expenditure (US$/ha)	240.4±162.5	227.9±206.0	273.6±195.9	202.7±153.3	236.3±257.5	286.4±200.4
Income (US$/hh)	166.3±284.1	33.3±51.6	77.1±114.4	26.2±21.4	139.9±164.5	131.6±94.8
Income (US$/ha)	674.5±536.7	229.2±276.8	335.3±261.2	252.9±243.7	381.6±340.4	437.7±262.6
C) Vegetable						
Area (ha/hh)	0.10± 0.08 (6)	0.08± 0.03 (9)	0.11± 0.05 (9)	0.22± 0.17 (5)	0.30±0.38 (7)	0.36±0.40 (4)
Production (Kg/hh)	308.3±515.2	114.4±113.26	166.7±222.7	367.6±439.2	394.3±381.9	593.0±815.9
Production (Kg/ha)	2348.1±3470.9	1657.7±1693.7	1126.5±1468.2	3669.9±4802.3	4727.1±4955.8	1403.9±1272.4
Expenditure (US$/hh)	19.4±27.6	6.4±8.5	13.8±10.9	13.5±20.8	14.1±16.4	28.5±21.8
Expenditure (US$/ha)	186.3±227.4	86.0±105.2	113.1±70.7	87.9±96.7	152.8±130.4	169.7±158.9
Income (US$/hh)	89.2±121.1	7.5±5.7	44.2±39.4	34.2±30.5	40.8±42.1	68.2±65.6
Income (US$/ha)	810.4±968.6	125.8±124.4	435.1±377.4	460.5±711.7	270.7±208.1	321.9±246.9
D) Wheat						
Area (ha/hh)	0.25± 0.11 (8)	0.20± 0.13 (8)	0.23±0.22 (3)	0.46±0.5 (5)	1.61± 3.5 (8)	0.98± 0.27 (2)
Production (kg/hh)	537.5±245.5	278.8±282.1	386.7±260.3	1040.0±1279.9	481.9±623.9	940.0±254.6
Production (kg/ha)	2280.8±627.1	1549.9±896.8	2151.6±1560.5	2052.9±724.1	1250.9±919.7	1032.9±545.4
Expenditure (US$/hh)	27.8±12.6	16.6±19.9	16.1±13.9	59.4±76.8	33.4±52.9	56.5±11.4
Expenditure (US$/ha)	142.0±109.6	91.4±43.5	75.3±7.7	109.64±37.4	76.6±65.0	58.1±4.5
Income (US$/hh)	36.6±20.7	17.5±17.1	33.7±22.8	72.1±78.0	34.6±36.2	57.3±42.2
Income (US$/ha)	146.3±41.3	99.7±84.7	214.8±228.2	157.8±70.1	84.8±65.5	66.8±61.5

Figures inside the parentheses indicate number (N)

Well-being level significantly ($P<0.05$) affected the area of land used by farmers as well as production, expenditure and income from *amon*. Poor RF farmers cultivated a smaller amount of land compared to poor NRF farmers resulting in lower production and income.

Boro rice cultivation

There was no significant difference between RF and NRF households for land use, production, expenditure and income from *boro* cultivation. Well-being affected the the use of land for the cultivation of *boro* rice. As with *amon*, poor RF farmers tended to use less land for *boro* cultivation compared to poor NRF farmers (Table 3.9). Overall, poor RF farmers had less access to land for rice (*boro* and *amon*) cultivation than poor NRF farmers.

Potato, vegetable and wheat cultivation

Potato, vegetable and wheat are short cycle crops which bring faster returns as cash crops. In the case of potato, vegetable and wheat cultivation, no significant difference was found between the farmer types in land use, production, expenditure or income. Although no significant affect of well-being was found, better-off farmers tended to use more land, attain greater production with resultant higher expenditure and income. No significant difference was presumably due to the requirement of these crops for intensive management and as a result the farmer could not enlarge the cropping area. In terms of cultivation of these crops, poor RF farmers tended to use more land compared to NRF farmers and hence invested more and achieved higher production and income (Table 3.9).

3.3.3.2 Outcomes from livestock

There was no significant difference between farmer type or well-being with respect to income from livestock. CARE assisted farmers to access necessary service facilities from the authorities particularly from Department of Livestock to prevent disease and to promote improved husbandry systems.

Table 3.10: Average annual total income from different types of livestock by farmer type and well-being

Income from livestock	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Total value($/hh) (cow)	378.6±482.2 (22)	213.7±125.1(25)	263.3±155.9(14)	229.1±120.6(13)	283.4±170.7(14)	277.1±101.7(11)
Total income ($/hh) (cow)	108.9±145.7	65.2±61.2	93.7±105.4	76.6±68.8	58.9±47.1	111.9±90.3
Total value($/hh) (goat)	36.8±32.6(15)	26.9±20.6(14)	27.7±18.7(12)	29.1±29.1(5)	53.5±62.6(12)	41.7±13.1(7)
Total income ($/hh) (goat)	27.4±31.9	23.1±29.4	18.4±19.1	22.7±24.8	36.2±25.9	23.5±25.8
Total value($/hh) (chicken)	9.5±8.1(21)	8.8±8.9(25)	20.9±30.5(17)	13.7±11.4(15)	9.7±9.3(14)	18.6±13.8(11)
Total income ($/hh) (chicken)	11.8±9.2	8.8±15.8	25.226.1	14.4±9.8	11.43±10.39	12.6±10.1
Total value($/hh) (duck)	5.8±3.4(17)	4.6±4.8(18)	9.4±12.5(14)	5.6±3.5(13)	5.2±3.6 (13)	11.3±7.7(8)
Total income ($/hh) (duck)	8.1±6.2	3.9±3.4	12.7±19.7	7.4±5.6	6.6±5.4	7.4±6.9
Total value($/hh) (pigeon)	5.2±2.5(3)		9.2±6.6(4)	3.2(1)	32.26(1)	3.2(1)
Total income ($/hh) (pigeon)	8.1±0.00		21.9±28.8	9.7	80.65	16.1
Average total income ($)	44.8±56.1(24)	28.9±26.9(31)	33.5±29.8(20)	29.8±22.7(15)	31.5±22.6(16)	46.2±36.9(12)

hh= household; figure inside the parentheses indicating number (N)

Higher average annual income (US$ 90.7) was earned from cattle by RF farming households compared to NRF ones (Table 3.10). The second most important income earning livestock were goats. Although the average income gained from the chickens was lower the majority of farmers benefited from them. Chickens are easy to manage and bring income faster compared to other livestock.

3.3.3.3 Outcomes from non-farm sources

The involvement of farmers in different non-farm income activities varied with their well-being. The dependence of poor farmers on non-farm activities was higher than other well-being groups and their involvement in non-farm activities was also diversified. Non-farm income earning sources of RF farming households were service (e.g. teaching in rural primary and secondary school, sales man in town shop, job in NGO etc.), business (e.g. stock business- stocking cereal grains, potato etc during production period and selling off season), petty business (small shop in the community, small shop in the local market during market day, *hatbar* once or twice a week), day labour (working for daily wage in crop transplantation, weeding and harvesting, soil digging, house repairing etc. in rural households level) and van pulling. Poor RF farmers as a group were characterised by their income derived from van pulling which was the single most important source income among non-farm activities (Figure 3.9).

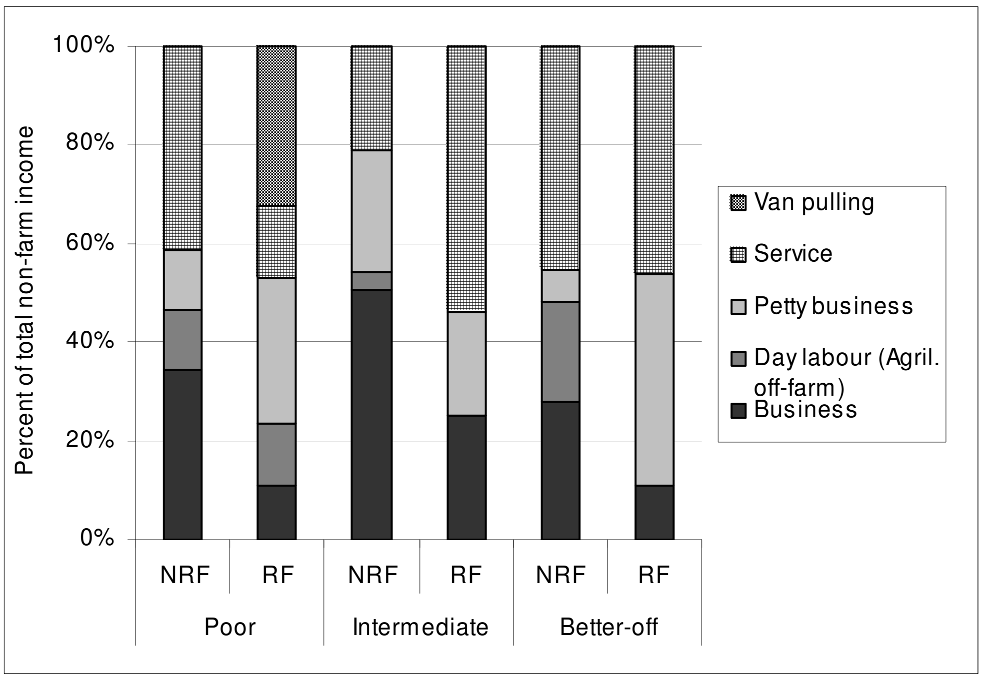


Figure 3.9: Income from different non-farm sources by farmer type and well-being.

Overall, NRF households tended to be involved more in non-farm activities of business and service than RF farmer regardless of their well-being status.

3.3.3.4 Outcomes from fish seed producing riceplot

3.3.3.4.1 Rice production

Use of rice varieties

Various high yielding rice varieties (HYV is the generic name for genetically improved rice varieties) were cultivated in the *boro* compared to the *amon* season by RF farmers in their riceplots (Figure 3.10). During the *boro* season the rice varieties BR-28 (Brridhan 28) and BR-29 (Brridhan 29) were cultivated by more than 80% of households. The same percentage of farmers cultivated BR-11 (Brridhan-11) in *amon* season.

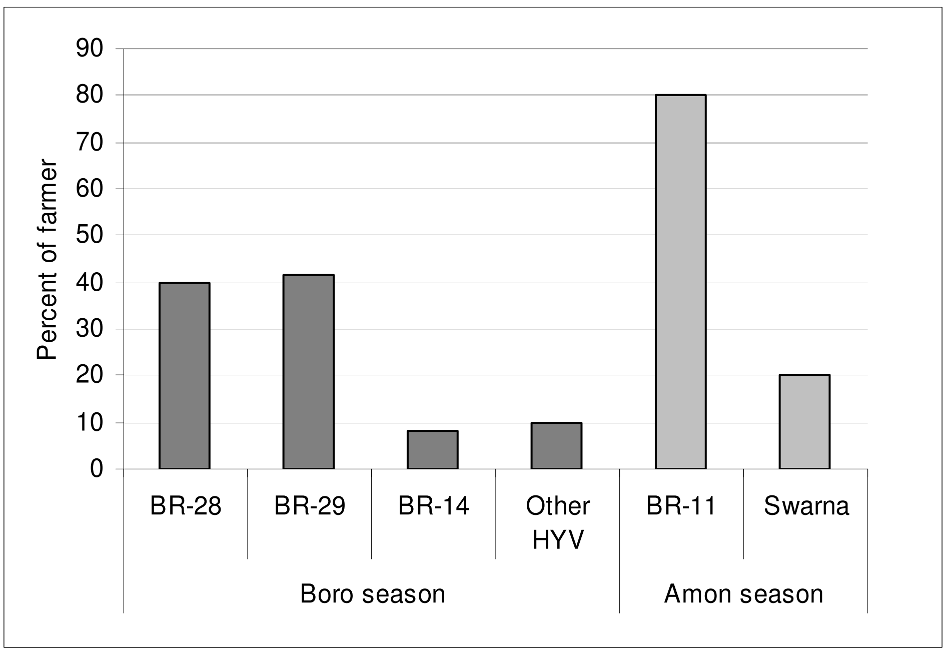


Figure 3.10: Rice varieties cultivated in fish seed producing riceplot (HYV= High yielding varieties).

Rice production in the *boro* season

There was no significant differences in input, production level or income per ha land between well-being groups. Interestingly, poorer households used more organic manure (cowdung) in riceplots which might have been an attempt to minimise their expenditure on inorganic fertilizers.

Rice production in the *amon* season

There was no significant difference found between well-being groups in their input use per ha both in *boro* and *amon* seasons in the ricefish plot (Table 3.11). Similarly, no significant difference was observed in per ha income from rice production between wealth classes.

Table 3.11: Rice production and its management in the ricefish plot in boro and amon season

Rice production in ricefish plot	Well-being		
	Poor	Intermediate	Better-off
Rice production (*boro*)			
Cowdung (kg/ha)	6115.7±4096.2	3119.6±2472.3	4231.1±5483.1
Urea (kg/ha)	214.9±110.4	229.7±151.4	187.7±117.1
TSP (kg/ha)	96.3±71.1	88.9±94.9	74.1±51.2
MP (kg/ha)	61.8±45.9	61.8±62.5	44.5±36.9
Zipsum (kg/ha)	14.8±22.9	39.5±46.2	24.7±34.9
Rice production (kg/ha)	5226.5±2496.9	5016.6±2649.9	5357.4±2504.4
Total expenditure (US$/ha)	143.1±68.8	124.5±91.9	155.1±98.1
Net income (US$/ha)	491.7±234.2	478.1±276.3	466.1±227.7
Rice production (a*mon*)			
Urea (kg/ha)	98.8±68.6	128.4±115.2	61.8±43.3
TSP (kg/ha)	29.6±50.9	39.5±53.6	22.2±28.9
MP (kg/ha)	22.2±32.8	22.2±26.9	14.8±23.2
Rice production (kg/ha)	2702.2±1669.4	2954.1±1442.6	3280.2±725.4
Total expenditure (US$/ha)	43.6±9.3	47.7±17.4	52.9±39.4
Net income (US$/ha)	323.8±30.7	395.2±90.9	373.9±191.9

Figure inside the parentheses indicating number (N)

Overall, the use of inputs was found to be higher in the *boro* season compared to the *amon* in the same riceplot. Moreover during the *boro* season farmers used organic fertilizers and gypsum but not in the *amon* season. In the *boro* season per ha rice production was much higher than the *amon* season for all well-being groups. Likewise, in the *boro* season expenditure per unit area of riceplot was much higher than in the *amon* season. Better-off farmer's rice productivity tended to be higher compared to other groups despite using fewer inputs. Poor farmers' productivity was also lower in the *amon* season as well. Per ha income from *boro* rice cultivation was relatively higher than the income from *amon* rice. Additionally, no farmers were found to use any pesticides in their ricefields either in the *boro* or *amon* season.

Table 3.12: Comparative production, expenditure and income from *boro* and *amon* rice

Doses of inputs	Ricefish plot	RF farmer other riceplot	NRF farmer riceplot
Rice production (*boro*)			
Cowdung (kg/ha)	4488.8±4017.2	7941.3±5715.5	7988.2±5094.8
Urea (kg/ha)	210.8±126.9	254.7±70.1	251.1±79.6
TSP (kg/ha)	86.5±72.4	172.9±34.9	166.7±37.1
MP (kg/ha)	55.9±48.5	156.4±37.7	144.1±28.9
Zipsum (kg/ha)	26.5±34.7	185.3±60.4	183.5±48.6
Production (kg/ha)	5200.1±2550.4	4544.8±1689.3	4702.2±2290.7
Total expenditure (US$/ha)	140.9±86.4	153.1±62.2	169.2±70.1
Net income (US$/ha)	478.6±246.1	311.8±151.6	309.1±227.5
Rice production (*amon*)			
Urea (kg/ha)	96.3±75.7	174.4±40.9	191.5±59.9
TSP (kg/ha)	30.5±44.5	143.5±17.7	145.9±29.7
MP (kg/ha)	19.7±27.6	139.9±14.3	135.9±21.3
Production (kg/ha)	2978.8±1279.1	3116.7±1653.0	3055.8±899.6
Total expenditure (US$/ha)	48.1±22.1	76.7±41.1	76.1±35.6
Net income (US$/ha)	364.3±104.5	279.2±152.4	284.2±110.3

Figure inside the parentheses indicating number (N)

RF farmers used lower amount (kg/ha) of inputs in their fish seed producing plots compared to farmer's other riceplot and NRF farmer's riceplot (Table 3.12). This could have been due to the presence of fish in ricefield which provide organic fertilizers through excreta. However, production of rice in the *boro* season and income in both seasons were much higher in seed producing riceplots compared other riceplots. Ultimately, production of fish seed in ricefields was a win-win enterprise with lower inputs and higher benefits.

3.3.3.4.2 Fish seed production

Fish species used for fingerling production

Poorer households used five different combinations of fish species for fingerling production in the ricefield based system. Of the whole sample set 60% of RF farmers and more than 50% of farmers from all well-being groups used tilapia as a common species along with common carp and other species for fingerling production (Figure 3.11). Overall, poor and intermediate households managed to access tilapia as easily as better-off.

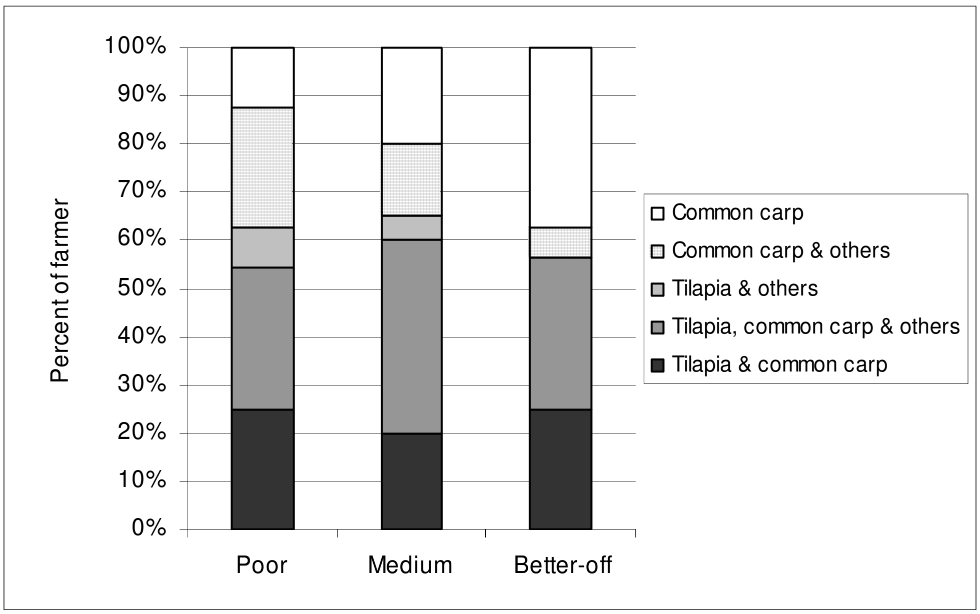


Figure 3.11: Species combination for fish fingerling production by well-being group.

Production of fingerlings

The average production of fingerling in riceplots of the poor, intermediate and better-off households was 34.7, 71.3 and 76.6 kg respectively (Table 3.13).

Table 3.13: Input uses, production of fingerling and associated uses for different purposes of households and income from fingerlings by well-being group

Input used, production and uses of fish fingerling	Well-being		
	Poor	Intermediate	Better-off
Feeding (kg/household)	14.1±23.5	51.0±58.2	21.9±65.8
Total production (kg/household)	34.6±40.4(24)	71.2±81.8(20)	76.6±140.5(16)
Total production (kg/ha)	315.1±448.3	419.1±371.7	294.6±326.7
Consumption (kg/ household)	10.1±13.8	28.5±27.8	13.5±26.4
Restocking (kg/ household)	7.5±10.2	15.8±18.8	14.4±28.2
Gifting (kg/ household)	0.1±0.4	0.7±2.9	0.7±2.5
Sale (kg/ household)	17.1±26.9	26.3±47.5	47.9±122.1
Expenditure (US$/ household)	1.6±3.8	3.3±4.7	9.1±28.1
Expenditure (US$/ ha)	14.9±42.0	19.7±21.3	34.7±65.3
Net income (US$/ household)	22.6±25.8	46.1±78.9	55.1±96.8
Net income (US$/ ha)	205.6±286.3	271.1±358.4	211.9±225.2

Although no significant difference was found between the fingerling production of different well-being groups, the post-hoc test showed a significant difference (P<0.05) between better-off and poor and intermediate and poor. In terms of production efficiency, the average per ha seed production of poor, intermediate and better-off farmers was 323.5, 480.7 and 184.0 kg respectively.

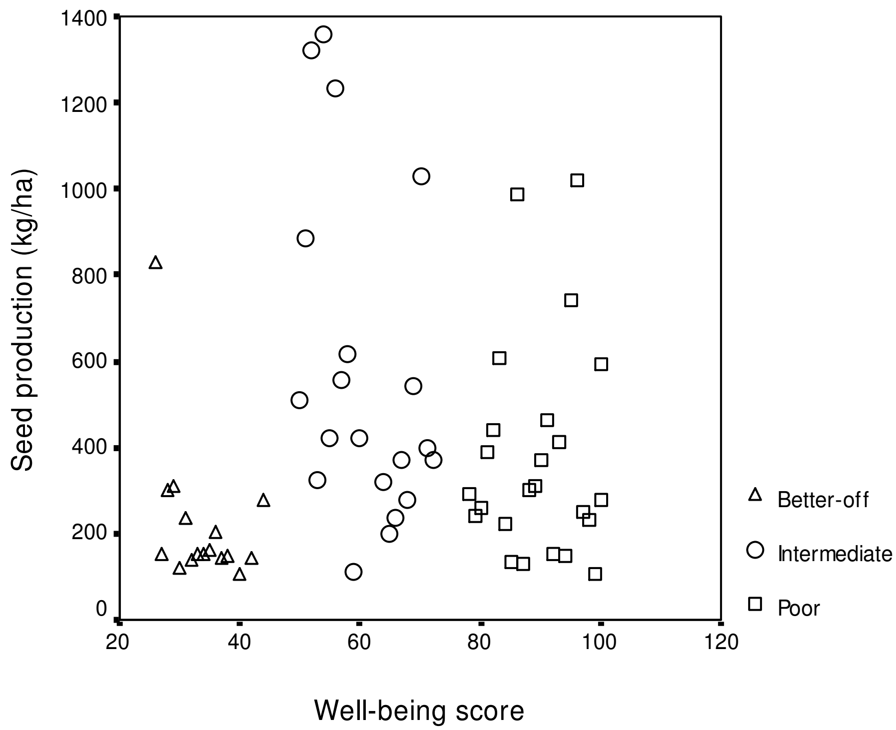


Figure 3.12: Scatter plot of production efficiency of fingerling by well-being status of farming households.

The distribution of production by well-being seen in the scatter plot (Figure 3.12) indicates the higher production efficiency of the poor and intermediate households compared to better-off households. This suggests that poor and intermediate farmers intensified their riceplots to produce more fingerlings in their smaller plots.

Related factors of seed production in riceplots

In the case of feeding, intermediate farmers used a higher amount of feed (50.95 kg) compared to other groups (Table 3.13). The correlation analysis (Table 3.14) suggested seed production (kg/ha) was found to be significantly (P<0.01) correlated with use of the amount of cowdung and supplementary feeds (such as rice bran, wheat bran etc.) used. However, well-being status was found to be negatively correlated with fingerling production (kg/ha).

Table 3.14: Correlation matrix between the seed production in riceplots and other related factors

	Well-being (score)	Riceplot area (ha)	Fertilizer used (kg)	Cowdung (kg/ha)	Feed used (kg/ha)
Riceplot used (ha)	0.407**				
Fertilizer used (kg/ha)	0.206	0.008			
Cowdung (kg/ha)	0.189	0.038	0.598		
Feed used (kg/ha)	0.011	0.063	0.414	0.438	
Seed production (kg/ha)	-0.007	0.034	0.297*	0.356**	0.930**

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Following stepwise regression analysis, the use of feed explains 49% of the variability of seed production (kg/ha) in model 1 (Table 3.15). Model 2 combining feed and fertilizers explains 50.25% variability of seed production (kg/ha). Comparing the two models, it could be noted that use of supplementary feed has a considerable influence on per ha fingerling production. In addition, inorganic fertilizers contributed to fingerling production although it was used for primarily rice production.

Table 3.15: Regression output on seed production from the ricefish plot in farming households

Model	Explanatory variable	B Coefficients	R Square	Adjusted R Square	F value
1	(Constant)	0.243	0.865	0.862	370.551
	Fertilizer used (kg/ha)	0.910**			
2	(Constant)	0.425	0.874	0.870	197.77
	Riceplot used (ha)	0.953**			
	Fertilizer used (kg/ha)	-0.113*			

** Significant at 0.01 confidence level; * Significant at 0.05 confidence level

Dependent variable: Seed production (kg/ha)

Use of fish fingerlings

A significant difference ($P<0.05$) was found between well-being categories in terms of the use of fingerlings for household consumption. During the *boro* season, i.e. very early season of fish production in culture as well as natural environment, seed producing households ate large sized fingerlings, mainly tilapia, from their riceplots. Poor (10.04 kg; about 30% of their total production) and intermediate (28.48 kg; about 40% of their total production) households consumed a relatively higher proportion of their total production compared to better-off (13.48 kg; about 18% of their total production) households. Moreover, intermediate and better-off households restocked more into their household ponds and riceplots compared to poorer households (Figure 3.13).

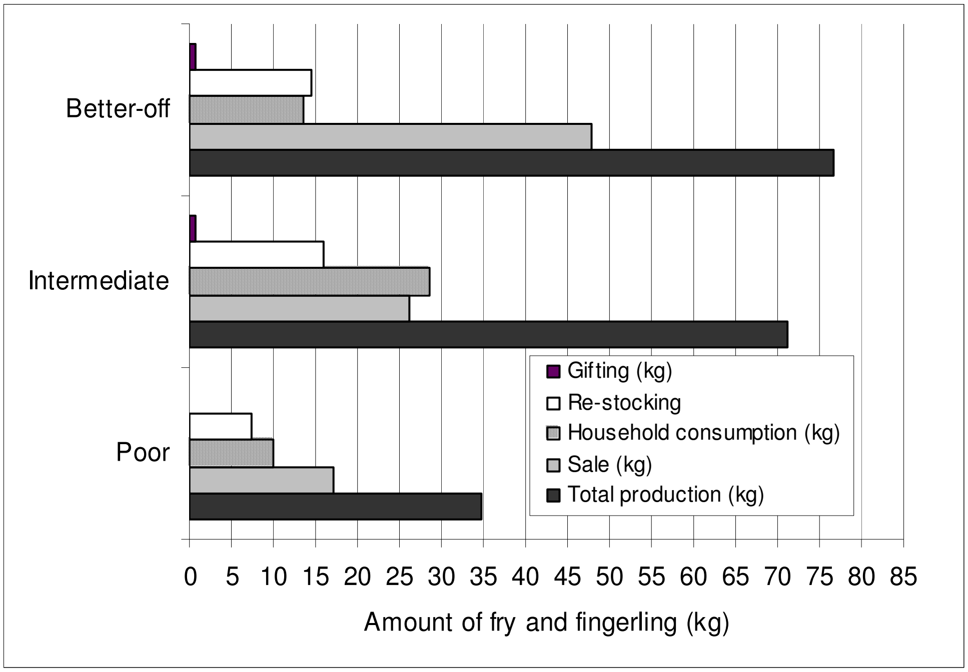


Figure 3.13: Uses of fish seed/fingerling for different purposes.

Poorer households also sold 50% of their total production as fingerlings and foodfish which was higher than the intermediate group (Figure 3.13).

Sale of fish fingerlings

Out of the total number of RF farmers (n = 60) 45% farmers sold seed to fry traders (Figure 3.14), which indicated the importance of this group in the decentralised seed marketing system. About 25% of poor and intermediate producers sold fingerlings directly to farmers/neighbours in their community who then stocked them into their pond for foodfish production. Around 13% of farmers sold large seed as foodfish in the market. Poorer households disposed of their seed in a greater number of ways compared to other categories.

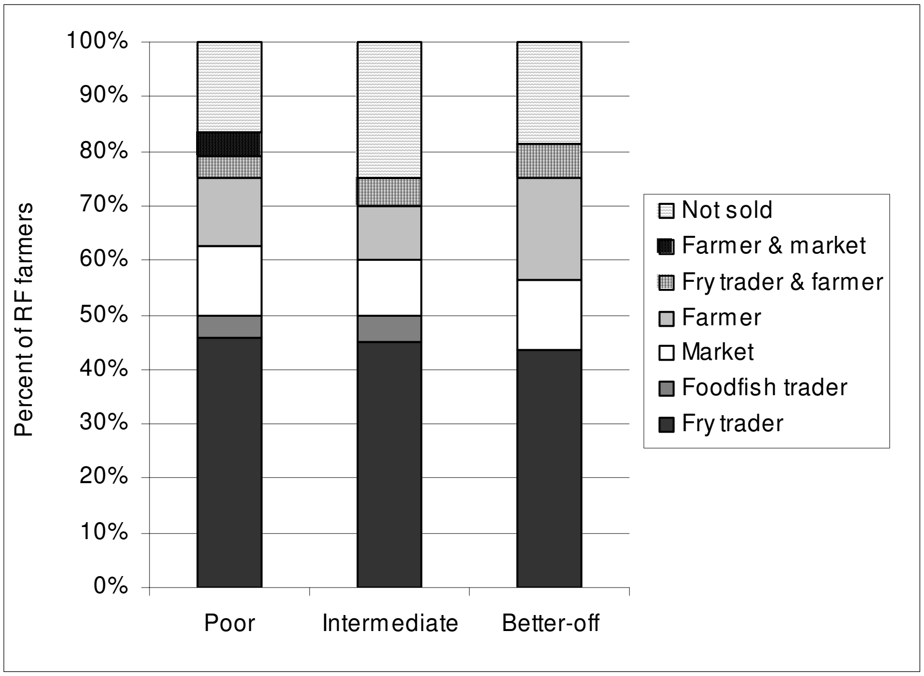


Figure 3.14: Importance of different marketing channels for selling of fish juveniles.

Better-off households spent more compared to others possibly due to their greater use of hired labour for many activities particularly rice transplantation and weeding in larger plots (Table 3.13). On the contrary, the lower expenses associated with management of poor and intermediate households suggest they carried out activities in riceplots themselves due to lack of money. The average income of better-off farmers from seed production was US$ 55.1 compared with intermediate at US$ 46.1 was substantially more than the poor at US$ 22.6 (Figure 3.15). However poor (US$1.3/kg) and intermediate households (US$1.8/kg) sold seed at slightly higher prices than better-off households (US$1.2/kg). Average annual per ha total income from riceplots collectively was (*boro* US$ 476.6 + *amon* US$ 239.4 + fish fingerling US$ 230.0) US$ 945.9.

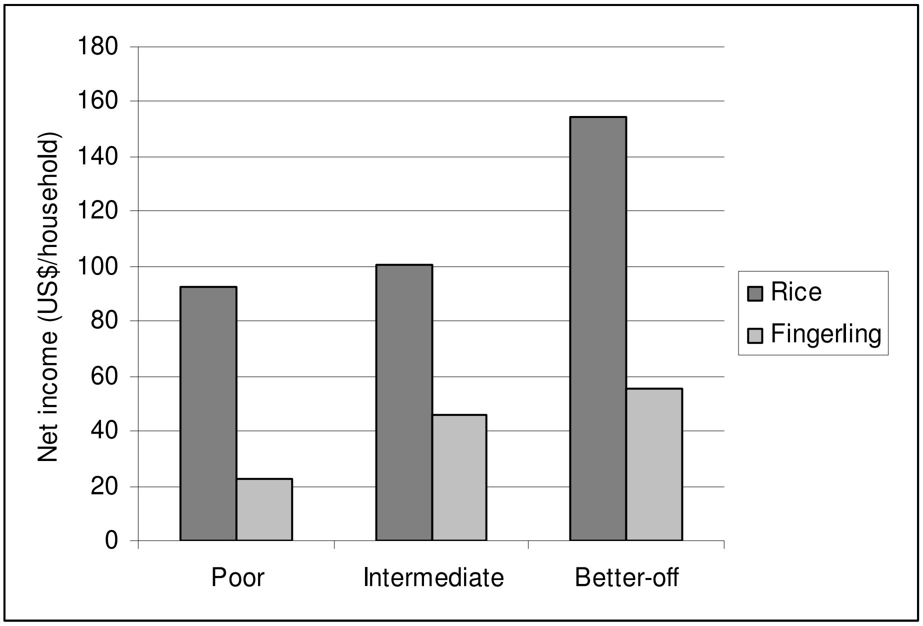


Figure 3.15: Income per household from rice (*boro and amon*) and fish fingerling.

3.3.3.5 Outcomes from fish production in household ponds

3.3.3.5.1 Production and income from own pond

Out of the total sample, 38 (63%) RF and 26 (45%) NRF farmers were found to own their own pond. Production was based on stocked fish seed from different sources including their own riceplot, fry traders, neighbours and hatcheries (Figure 3.16).

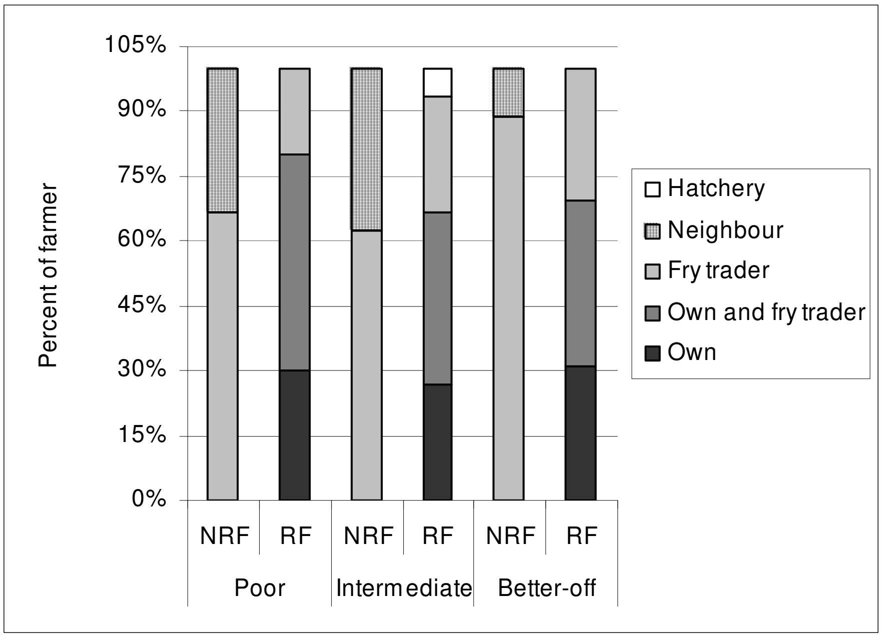


Figure 3.16: Source of fish seed stocked in own pond by farmer type and well-being.

The majority of RF farmers stocked fingerlings produced in their own ricefield based systems. Particularly, in every well-being group, a substantial proportion of RF farmers stocked fingerlings from their own sources and from fry traders. NRF farmers within all well-being groups tended to purchase seed from fry traders, while some collected fingerlings from neighbouring RF farmers, which suggests that they were depending on the local seed sources to some extent. A small percentage of RF farmers bought fry (*dhani*) for stocking into their pond from hatcheries.

There was a significant difference (P<0.05) between farmer types and a significant affect of well-being on the average production and income from fish (Figure 3.17).

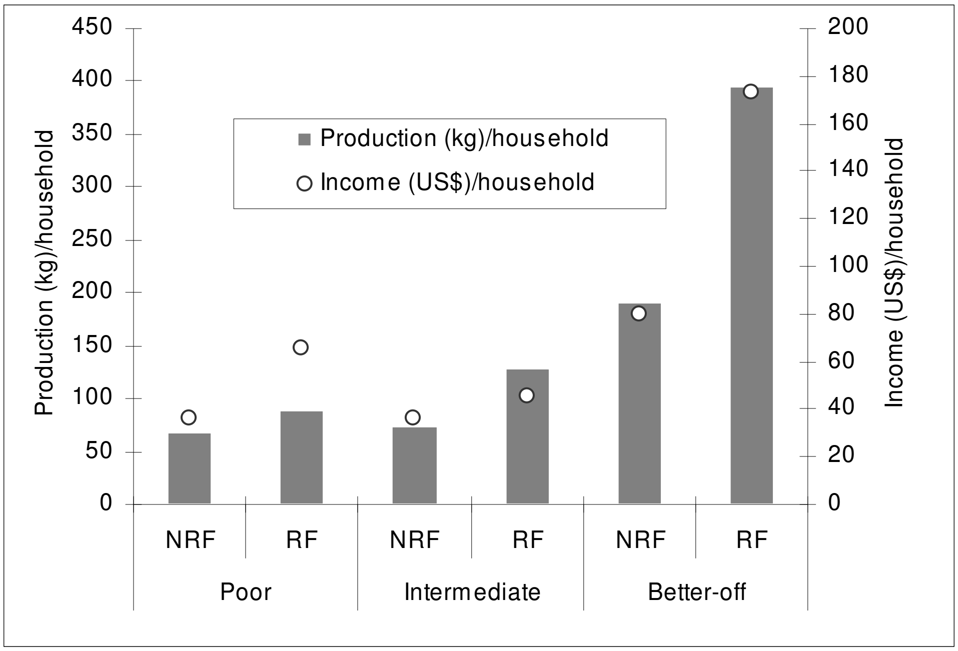


Figure 3.17: Pond production and income by farmer type and well-being.

While no significant difference was found between RF and NRF farmers in terms of their own pond size, the average production from household ponds was 196.7 and 119.2 kg respectively, with average net incomes of 94.5 and US$ 51.2 respectively. In terms of production efficiency (kg/ha) RF households were found to be higher compared to other well-being groups (Table 3.16). Poor and intermediate RF farmers invested less cash in pond culture than NRF farmers as they largely used their own source of fish seed. The better-off RF farmers invested more than the NRF as they tended to produce fish commercially stocking different types of fingerlings from other sources and providing supplementary feed and other inputs.

Table 3.16: Fish production in ponds and income by farmer type and well-being

Pond production	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Single ownership pond						
Production (kg/hh)	88.1±78.5	69.0±53.9	129.5±41.1	74.4±54.4	395.8±397.1	191.6±236.8
Production (kg/ha)	2000.7±1114.9	1538.8±735.8	2882.5±1432.6	1141.1±979.8	2576.2±1148.1	1489.4±647.8
Value (US$/hh)	73.2±47.0	50.5±37.6	40.4±25.5	51.9±32.1	226.9±234.9	91.7±75.9
Expenditure (US$/hh)	7.9±5.6	14.2±16.4	9.7±8.1	16.1±15.7	53.6±59.5	11.9±9.4
Net income ($)	65.3±44.8	36.4±32.9	45.7±45.9	35.9±24.1	173.4±190.6	79.7±73.5
Multiple ownership pond						
Production (kg/pond)	106.75±39.30	105.3±36.9	142.5±20.6	210.7±221.3	435.0±493.9	190.0±103.9
Production (kg/ha)	1525.7±982.7	1276.2±1146.4	1398.9±219.7	1115.5±747.9	958.6±304.3	762.4±231.4
Production/hh	28.5±14.6	20.6±3.1	33.6±4.4	23.7±17.1	66.4±21.3	20.3±6.9
Value ($/hh)	19.31±10.2	11.4±1.8	17.9±6.9	15.0±11.5	49.3±13.0	11.6±2.3
Expenditure ($/hh)	1.1±0.7	2.1±0.6	2.3±0.2	2.0±1.5	3.9±2.3	2.6±0.8
Net income ($/hh)	18.2±9.9	9.4±1.5	15.7±7.0	13.1±10.2	45.4±10.9	9.0±1.9

hh - household

3.3.3.5.2 Production and income from multiple-ownership ponds

A small number of RF (13) and NRF (13) farmers had multiple-ownership ponds. Within this group of farmers, some RF farmers stocked seed from their own sources. Out of 13 RF farmers, 3 poor, 1 intermediate and 1 better-off farmer stocked fingerlings from their own sources along with seed purchased from fry traders (Figure 3.18). In addition, 1 poor NRF and 1 intermediate NRF farmer purchased fingerlings from neighbours (RF farmer) to stock into their multiple-ownership ponds.

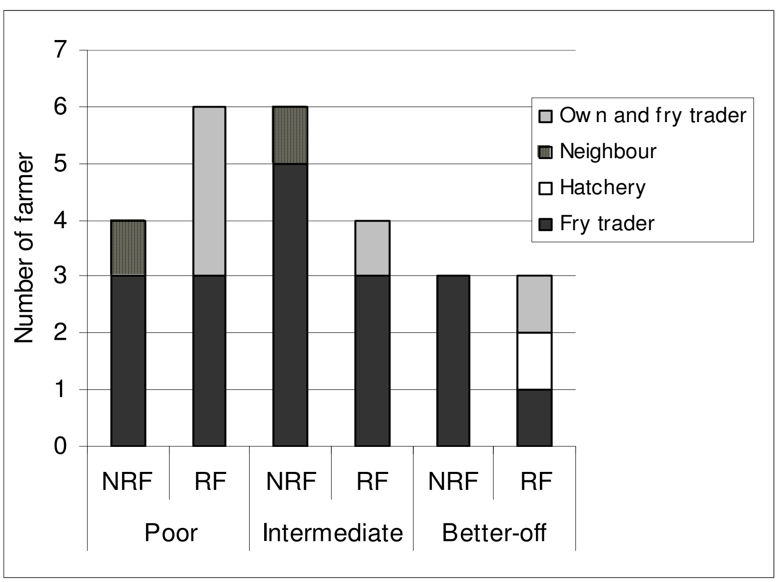


Figure 3.18: Sources of fish seed stocked in multiple-ownership pond by farmer type and well-being.

There was no significant difference found between farmer types and no affect of well-being in terms of production and income from the multiple-ownership pond (Table 3.16). However, in relative terms productivity and net income were higher in RF household ponds than NRF irrespective of well-being groups. Such attitudes of poor and intermediate farmers suggest that small farmers tended to utilise their pond resources efficiently. Alongside RF farmers (i.e. seed producers), farmer level seed production was found to contribute to fish production in multiple-ownership ponds of NRF farmers.

Multiple ownership ponds tended to be managed less intensively. This was due to the inability of farmers to come to a common consensus over the use of inputs such as seed and feed in specific times of the production period. Lower pond production of the better-off farmer suggests their ponds were less intensively managed as they had their own ponds. In contrast the poor farmers' ponds stocking with their on-farm fingerlings appeared to attain higher production is likely to influence positively better pond management practices.

3.3.3.6 Fish consumption

Sources

A significant difference ($P<0.05$) was found between the RF and NRF farmers in the consumption of fish from different sources such as ricefish plot, pond, wild sources and purchased. The seed producing households consumed fish from their riceplots along with other sources (Figure 3.19).

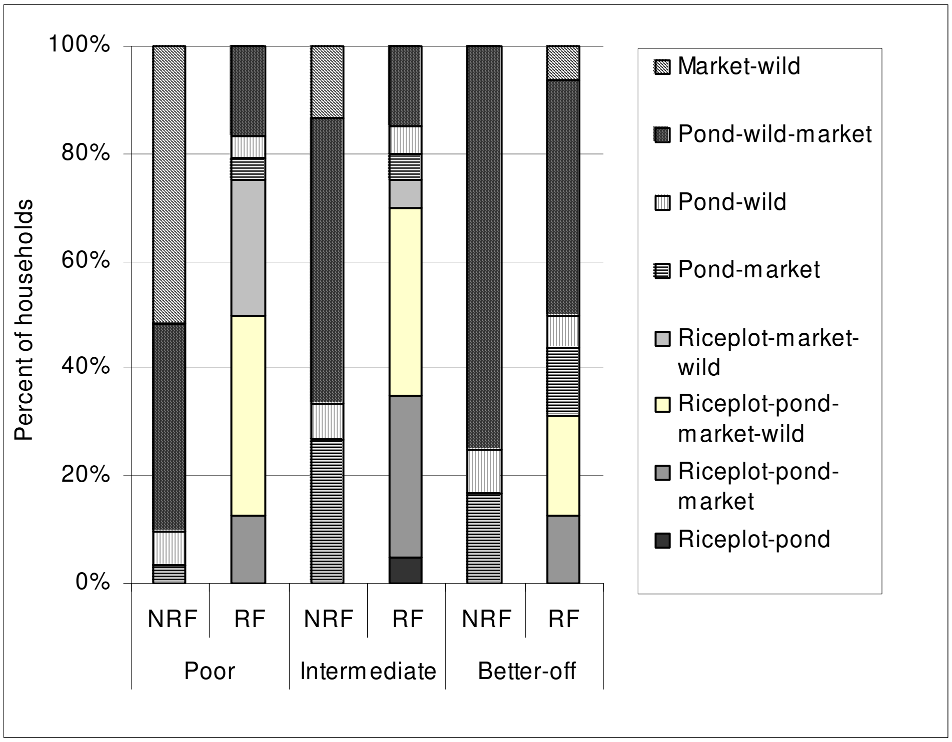


Figure 3.19: Sources of fish consumed by origin.

From ricefish plot

A significant (P<0.05) difference was found between poor (10.04 kg), intermediate (28.48 kg) and better-off (13.48 kg) households in terms of fish consumed from riceplot (Table 3.17). Post-hoc testing showed significant differences (P<0.05) between poor and intermediate and, poor and better-off households in average fish consumption from the ricefish plots. Although the total fingerling production of better-off farmers was higher than others, intermediate households consumed more than double the quantity of fish than better-off households (Figure 3.13). Consequently better-off farmers sold around double the quantity of fish compared to intermediate farmers. Better-off households consumed relatively fewer fish from their riceplots but much more from their ponds. This indicates that better-off farmers consumed fish from ponds stocked with riceplot produced fingerlings showing 'delayed gratification' of fish consumption from their riceplots.

Table 3.17: Amount of fish consumed (kg/household) at household level by farmer type and well-being

Fish consumption	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Ricefish plot	10.1±13.8(24)		28.5±27.8(20)		16.3±26.2(16)	
Pond	52.4±30.2(18)	44.2±39.2(13)	57.5±38.2(19)	48.4±85.3(13)	121.5±87.5(15)	60.9±36.2(12)
Wild sources	9.4±5.6(20)	12.3±6.7(29)	9.5±4.4(14)	8.4±3.5(11)	17.8±10.1(13)	11.5±5.9(10)
By purchase	12.9±13.7(23)	18.9±13.8(28)	16.8±17.6(15)	17.7±16.1(14)	17±16.5(13)	26.8±27.8(11)
Total	99.9±62.2	61.8±32.6	112.3±49.1	74.5±97.5	194.6±117.1	106.0±50.9

Figure inside the parentheses indicating number (N)

From pond

Significant difference (P<0.05) was found between the households of different well-being categories in their consumption of fish from ponds. Average RF household's fish consumption was higher (68.71 kg) than NRF (58.03 kg) (Table 3.17). The stocking of larger sized fingerlings in their ponds, a major factor in increased production, also appeared to impact on fish consumption. There was a significant (P<0.05) affect of well-being on fish consumption from household ponds. On average, RF farming households, irrespective of well-being category consumed 20% more pond fish than NRF households.

Wild Source

No significant difference was found between farming households in terms of fish consumption derived from wild sources. RF households however, consumed slightly more wild fish than NRF households particularly in the case of better-off households (Table 3.17). Better-off farmers had large areas of riceplots from where they could catch fish during the rainy season using trap gear. However, there was no significant affect of well-being on farmer types in case of wild fish consumption. This indicates that wild sources now generally have limited availability.

Purchased fish

Non-seed producing households consumed a significantly ($P<0.05$) higher amount of purchased fish compared to seed producing households (Table 3.17). Own seed production led to multiplier effects on foodfish production in riceplots as well as in ponds resulting in increased household consumption from own source that reduced the need to purchase. On average RF households consumed around 23 kg more fish annually than NRF household (Figure 3.20).

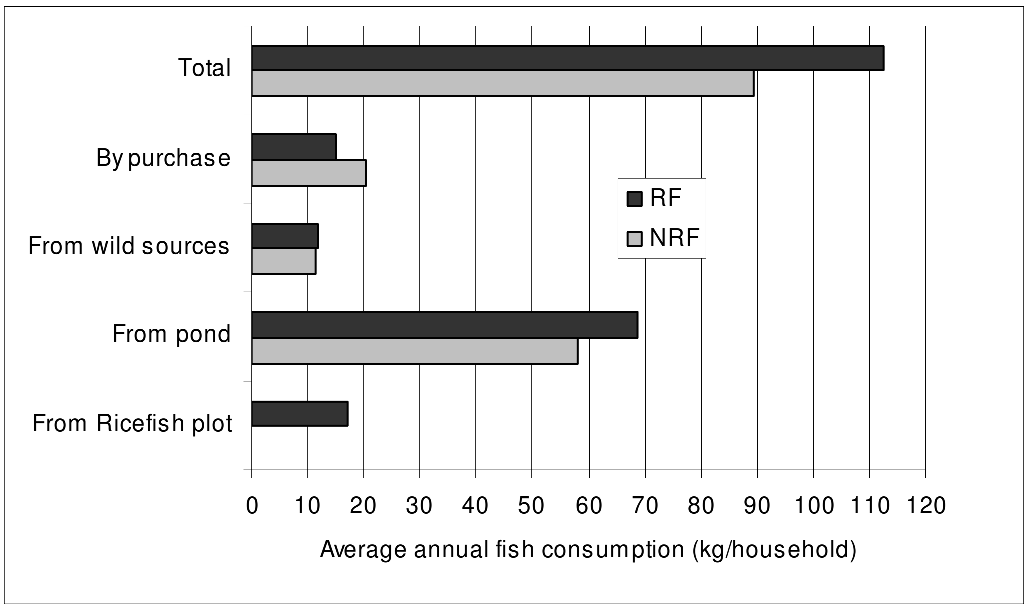


Figure 3.20: Average annual fish consumption by the household from different sources.

3.3.3.7 Comparative income from different sources

In farming households, incomes were derived from agricultural crops, livestock, pond culture and non-farm activities (Table 3.18). Additionally, RBFSP has been added to seed producing households as a new source of income generating activity following CARE FFS training.

Significant differences (P<0.05) were found between farmer types with respect to income derived from agricultural crops. Well-being significantly affected (P<0.05) the income from agricultural crops between the RF and NRF households. This was due to the significant difference in landholdings between the well-being groups.

In the case of income generated from ponds, a significant difference was found between farmer types. Well-being significantly (P<0.05) affected the income generation from pond culture between RF and NRF households with the ricefield households earning more than NRF in every well-being group.

Table 3.18: Household income (US$) from different sources by farmer type and well-being

Comparative income (US$)	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Agriculture	314.4±298.6 (24)	239.8±156.6 (31)	485.2±309.1 (20)	307.5±139.4 (15)	1071.5±770.4 (16)	830.3±378.7 (12)
Livestock	44.8±56.1	28.9±26.9	33.5±29.8	29.8±22.7	31.5±22.6	46.2±36.9
Pond	56.4±77.9	17.8±31.2	70.5±149.9	73.6±90.5	153.3±178.4	93.1±102.3
Fish seed	23.6±25.9		46.1±78.9		55.1±96.9	
Non-farm	159.9±184.7	177.1±197.8	404.2±519.6	241.8±262.6	727.4±1763.2	578.2±683.8

Figure inside the parentheses indicating number (N)

The income from seed production was higher in better-off farming households followed by intermediate and poor with a significant difference between them. This was due to the size difference of ricefish plots and production between the well-being groups. In the case of a household's non-farm income, significant differences were observed between the well-being groups due to the variation in non-farm activities in different well-being groups. Income generated from non-farm sources was lower in the poorer RF households than in NRF households. This explains that the income from fingerling production reinforced the overall income in RF households.

When farm and non-farm income were combined, significant differences (P<0.05) were found between farmer types with well-being also affecting income. Decentralised fish seed production in ricefields contributed an estimated 3% to the total household income. The contribution of pond aquaculture to RF households was 8%, whereas in the NRF household it was 6% (Figure 3.21).

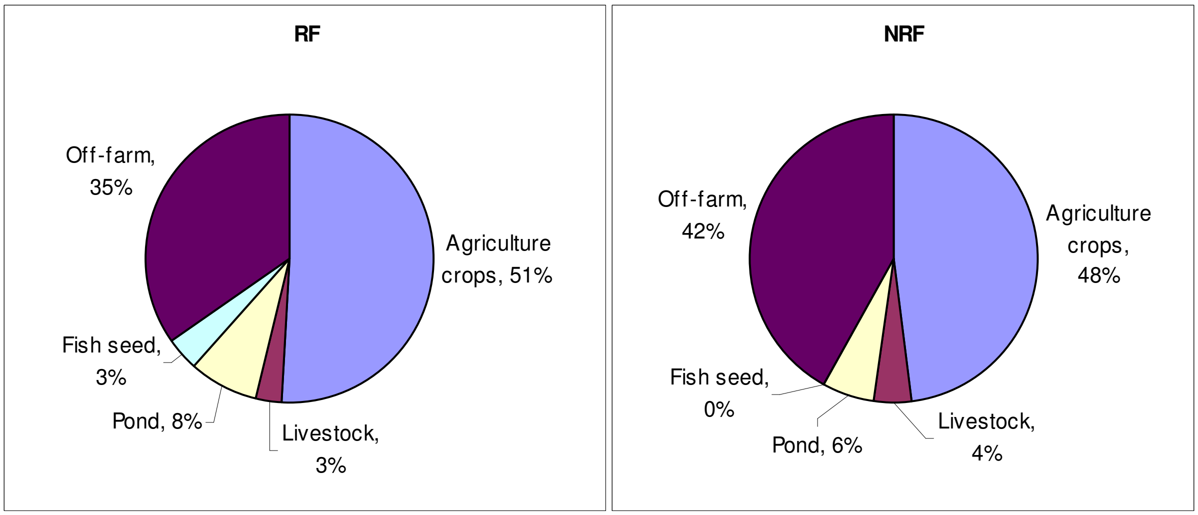


Figure 3.21: Percentage share of income by farmer type and sources.

Fish farming (fish seed and foodfish from riceplot and pond fish) collectively, contributed 11% of the total income of RF households which was nearly double the income from the pond of NRF households. It was also estimated that fish seed production contributed 5% of on-farm income to RF households. This together with pond fish production contributed 17% of on-farm income to RF households whereas only pond fish production contributed 10% of on-farm income to NRF households.

3.3.3.8 Annual expenditure of the households

Figure 3.22 shows that the average annual expenditure on food in RF households (US$ 129.04) was lower than in the NRF group (US$ 154.76). This might be due to RF households consuming more fish from their own sources rather than purchased fish resulting in lower expenditure on food. Irrespective of all well-being categories, expenditure on food was also lower in RF households than in NRF households.

Expenditures on clothing, education, housing, medical treatment and social events were higher in RF than NRF households.

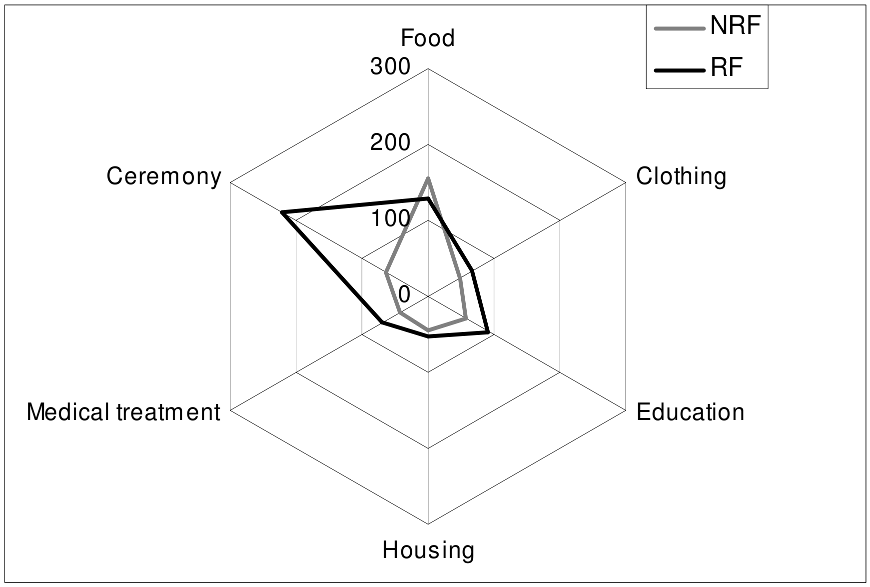


Figure 3.22: Annual household annual expenditure (US$) of RF and NRF farmers.

A significantly (P<0.05) greater expenditure on social occasions was observed in the RF farming households compared with NRF households (Table 3.19). This may due to the larger average size of RF household indicating a probable reason for higher ceremonial expenditures such as buying new clothing during the Eid/Puja festival and additional cost for other social events such as wedding.

Table 3.19: Household level annual expenditure (US$) of RF and NRF farmers by well-being group

Household characteristics	Poor		Intermediate		Better off	
	RF	NRF	RF	NRF	RF	NRF
Food	90.7±46.3(24)	104.8±78.3(31)	99.8±37.9(15)	176.1±124.5(20)	224.1±235.7(16)	312.7±402.5(12)
Clothing	35.4±15.1(24)	35.6±21.4(31)	68.2±35.5(20)	48.9±25.8(15)	105.5±85.5(16)	75.3±37.9(12)
Education	47.9±90.8(20)	39.0±36.0(22)	64.8±54.2(18)	52.2±42.8(12)	177.4±178.7(16)	119.9±94.2(8)
Housing	22.5±13.4(17)	20.4±17.1(25)	89.9±154.2(14)	54.3±87.5(11)	53.6±47.9(13)	83.5±137.9(12)
Treatment	22.6±32.9(22)	37.8±42.5(31)	121.2±361.7(20)	46.7±59.1(15)	60.8±85.1(16)	51.89±58.5(12)
Ceremony/social	191.6±291.9 (24)	59.9±97.8(31)	134.9±234.0 (19)	33.9±31.8(14)	363.4±617.1(16)	109.5±148.4(12)

Figures in the parentheses indicate number (N)

3.3.3.9 Facilitating and constraining factors experienced by RF farmers

RF farmers were asked to unpack the factors that facilitated or constrained seed producing activities.

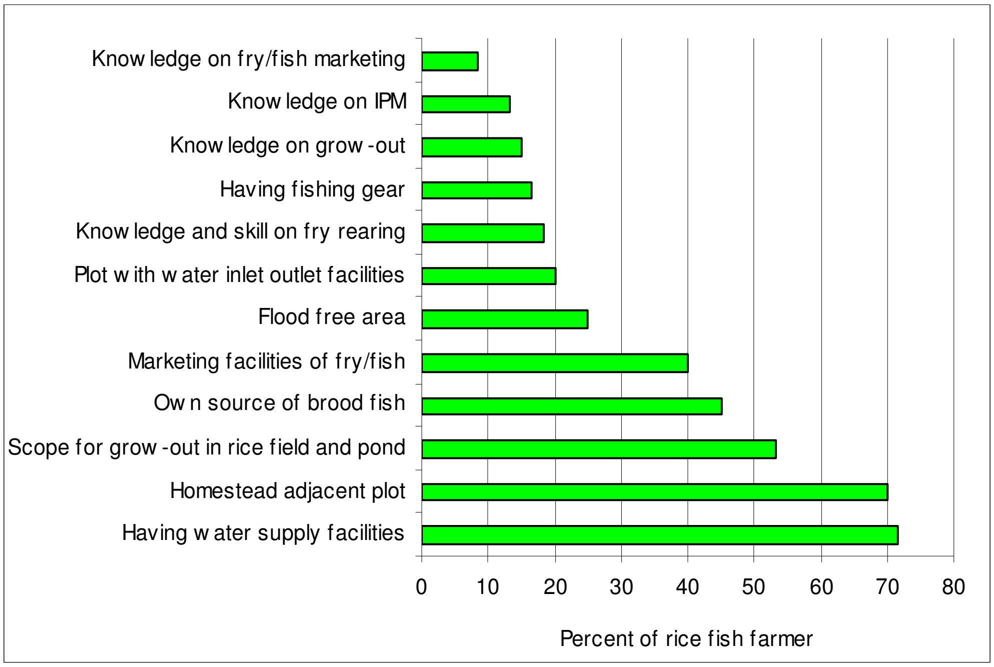


Figure 3.23: Potential factors recognised by RF farmers based on their experience over the year of practices.

Based on their experiences, more than 70% of RF farmers mentioned that good water supply and locating their RF plot adjacent to their household were most critical to support decentralised fish seed production in ricefields (Figure 3.23). The seed production period takes place in the *boro* season which relies on ground water supply provided by pumps installed on the dike of riceplots. Most farmers said that a medium level of water i.e. 3-4 inches deep, was acceptable in the riceplot to allow for the movement of fish and not damaging rice. Pump ownership facilitated farmers to cope with periodic drought during the food fish production period in the *amon* season. In addition, more than 40% of farmers also mentioned that having scope for grow-out in the ricefield and pond, their own source of broodfish and marketing facilities of fry and fish were important factors for practising RBFSP activities. Their own source of tilapia broodfish was a critical factor for many farmers, particularly, poorer households who had no ponds and who were more dependent on other sources of tilapia broodfish such as neighbours' ponds.

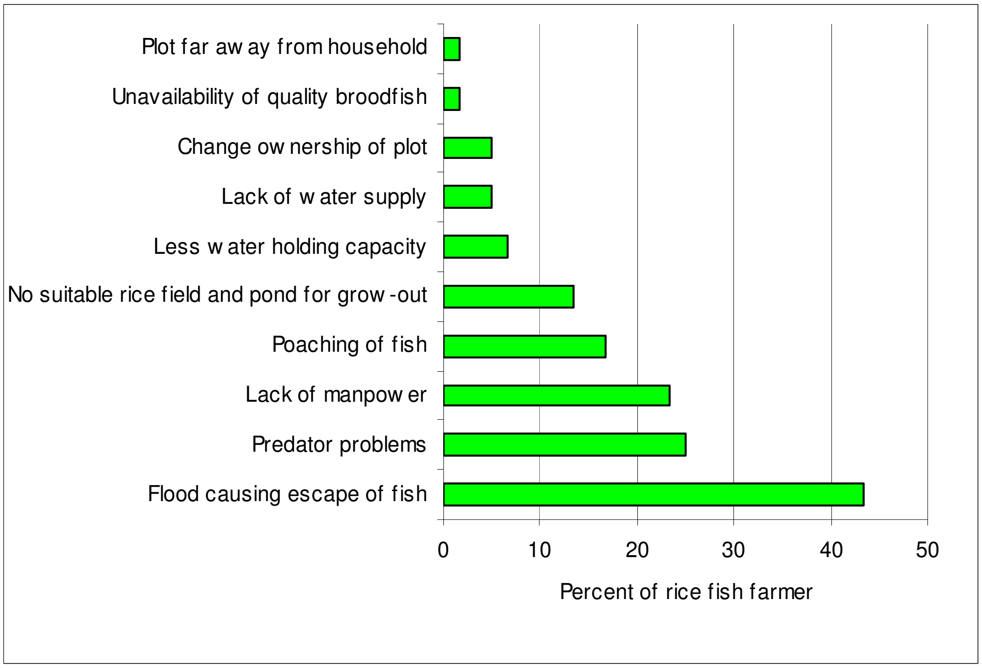


Figure 3.24: Major constraints to producing juveniles in *boro* ricefields faced by the RF farmers.

With respect to the constraining factors in RBFSP practices, more than 40% of farmers faced the problem of fish escape fish from the riceplot as a result of from sudden flash-floods during the monsoon (Figure 3.24). More than 20% of farmers faced predator problems particularly from ducks and some cited a lack of manpower as a problem. The other constraining factors mentioned by a very few farmers were poaching, no suitable ricefield for foodfish grow-out, reduced water holding capacity of plot soil, lack of water supply facilities, changing ownership of the plot, unavailability of quality broodfish and the plot located far from the households.

3.4 Discussion

3.4.1 Institutional mediation

This study reveals the better-off households could access government support more effectively in rural communities. Conventional approaches to agriculture extension have often failed to respond adequately to the needs of poor farming households (Cox et al. 1998). More specifically, in terms of aquaculture extension many pond owners believed that they had to be wealthy to practice proper aquaculture management. Many aquaculture extension agencies (e.g. Department of Fisheries, Asian Development Bank and FAO sponsored programmes) tend to target owners of large ponds who are both wealthy and well-educated (Morrice, 1998). Hence a belief developed that farmers should be better-off to practice aquaculture.

Public aquaculture extension systems in Bangladesh have only had limited impact on the poorest sector of farming households (Scarborough et al. 1997) due to the constraints of (i) inappropriate contact farmer methods, (ii) lack of relevant technological messages (iii) inadequate feedback of farmer needs into research and (iv) small public sector budgets that can supply only a limited number of extensionists in the field (Lewis, 1998). The limited impact was also due to limited number of manpower for extension work for which in each local administrative area or sub-district/upazila/thana which has up to 250,000 people, where there is only one Fisheries Extension Officer with his three official subordinates (Lewis, 1998). This indicates that the government fisheries extension department does not have the capacity to promote such types of farmer field school based programmes involving poor households over wider areas.

CARE however, carried out activities emphasising households of poor and intermediate categories through the farmer field school approach towards improvement of their livelihoods (CARE, 2001a). Initially CARE project activities were concentrated on ricefield management practices. Later alongside ricefish, CARE diversified their activities with a wide range of issues which included other agricultural activities and building linkages between households with many service providing organizations. These were towards engaging poorer people in CARE interventions made its extension approach involving farmer field schools more effective.

3.4.2 Livelihood assets

3.4.2.1 Human capital

The average household size of the whole sample was found to be 5.7±2.3, showing a similar size (5.2) to the national rural average (BBS, 2003b). Better-off households tended to be larger than intermediate and poorer households. This was due to the household head (father) usually retaining ownership of his land with a degree of authority within the household until his death. Such *de facto* authority and day to day control over household and family affairs may have passed from father to sons over a long period, but ultimate authority is most often not relinquished until death (Cain, 1991). This tendency of the better-off household head to have authority over landholdings for a long period of time influences the households to remain united and have a larger occupancy. On the contrary, poorer households are smaller in size compared to the better-off households. In rural Bangladesh, sons of land-poor households leave their parental home earlier than the sons of landed households to form households of their own (Cain, 1977). According to White (1992) it is common among marginal and poor households for married sons to set up a separate household (although they may live in the same family compound) after 2-3 years of marriage. Cain (1977) also stated that land-poor fathers have less influence over the timing of son's departure from the parental households. Such types of behaviour of land-poor households are likely to explain their smaller size of occupancy.

Household occupancy affects the occupation and income of the household members (Islam, 1995) and especially the type of profile of farming activities. In the present study, the size of RF households was found to be larger than NRF ones. A previous study conducted in Mymensingh area has shown that larger households (9.4 members) were more likely to carry out integrated ricefish farming compared to the average national household size of 5.5 (Gupta et al. 2002). Larger households were also reported to have an increased interest in pond farming in the Northwest region (Morrice, 1998) and southern region of Bangladesh (FTEP, 1999). Larger household size i.e. additional labour, also appeared to support diversification into juvenile fish production in the ricefields. Gupta et al. (2002) reported that larger household size was an important factor in supporting ricefish technology adoption. Moreover, larger households need more fish for their daily consumption, which also acted as an indirect but strong stimulating factor towards carrying out this technology. This finding is consistent with the information regarding constraining factors to seed production activities (Chapter 6), where a remarkable number of households reported that the shortage of manpower was one of the constraining factors for non adoption of this technology.

The age distribution of household heads could influence the adoption of new technology in farming households (Miah and Halim, 1998). Comparatively a higher percentage of middle aged farmers were found to be involved in fish seed production activities. According to Miah (2002) middle aged people have more risk taking ability and higher capability to integrate and adjust to change in farming activities. They have a psychological closeness, commonness of understanding with respect to aspects of professional, social, economic, religious and even political issues, which bring them together on many occasions. The variation in belief and attitude between elderly and young people of the rural society is more and wider than the young and middle age and middle age and elderly people. Middle aged people have both experience and wisdom which is likely to act as a balance of interest for both younger and older people. This scenario indicates that middle aged people had more motivation towards technology, who could be the central clients of extension programme and subsequent source of information for younger and elderly farmers in the rural areas.

Generally education encourages the development of the human mind and it increases the power of observation, analysis, integration, understanding, decision making and adjustment to new situations of an individual as well as their family members (Miah, 2002). Making decisions regarding carrying out of agricultural technologies has shown mixed relationships with the education level of farmers. Some studies showed a positive relationship between the decision making behaviour of farmers and their level of education and many did not show any relationship. For instance, the literacy level was positively correlated with the decision making process in the cultivation of *Binasile* rice (improved rice variety) in Bangladesh (Islam et al. 1998) possibly due to the increased complexity in using inputs and other management practices involved. Farmers with higher literacy have a greater likelihood to choose lucrative technologies. In some areas of Bangladesh, mixed and mono-sex tilapia hatchery owners were reported to be relatively highly educated (55% Master degree and 22% Bachelor degree) (WorldFish Center, 2004).

On the contrary, the level of education had no relation with decision making process of women in homestead gardening. This was not unexpected as traditionally women have been responsible for vegetable cultivation where integrating improved knowledge is commonplace. In this study the majority of RF farmers were found to be illiterate and/or with a primary level of education. In Vietnam, a lower level of education did not hamper the farmers who carried out ricefish culture (Rothuis et al. 1998). Similarly in the present study, illiteracy and a low level of education did not impede seed producing farmers gaining benefits from this technology. This was probably a result of knowledge inherent in farmers about fish in ricefields (Prein, 2002). This sort of indigenous knowledge about fish in ricefields possibly simplified the decision making process to carry out this technology.

Agriculture was the primary occupation of the majority of the sample households. Studies done in Northwest Bangladesh show that about 85% of the households derived income from agriculture, either through working their own land/or that of other farmers on a daily paid basis (Morrice, 1998). Similarly a study carried out by CARE has shown that the majority of households in the Northwest depend on one form of agriculture or another ranging from producing crops on their own land to selling labour for agriculture (CARE, 2002). Apart from in the Northwest region, recent studies indicate that agriculture, particularly rice farming, is the main occupation of rural households in Bangladesh (ADB, 2005). Greater involvement in rice farming suggests that there was very limited scope for other non-farm activities. In this regard, a previous study has shown that households that were not involved in non-agricultural activities were more likely to be farming intensively (Ellis et al. 1999). RBFSP technology has diversified such rice-based livelihoods of farming households. For instance, over recent years pond based aquaculture has diversified activities and income in many households in Bangladesh (Ross et al. 2004b). After agriculture, as the primary occupation, poorer farmers tended to diversify more compared to other well-being groups. This can be explained by the relatively greater insecurity of rural poor households stimulating diversification of livelihoods strategies for better survival (Ellis, 2000).

3.4.2.2 Physical capital

The number of living rooms was found to be higher in RF farming households compared to NRF ones. This was due to higher household occupancy of RF farming households.

Out of the whole sample the majority of households tended to have living rooms with soil-floor, bamboo-fencing and tin-roofs. These findings are similar to the national statistics, where it has been reported that that 76% of living room-roofs were made of tin in rural areas and the majority of living room's fences (room walls) were made of bamboo (BBS, 2003b).

Recent studies by CARE-Bangladesh show that during the last two decades, a noticeable improvement has occurred in the area of water and sanitation in Bangladesh (CARE, 2001a). Currently 97% of the population has access to tube-wells or ring wells for drinking water. In the case of some districts in Northwest Bangladesh such as Rangpur and Bogra, the coverage has reached 100% (CARE, 2001a). The findings of the present study were more or less consistent with this, however results show that some poor farmers still use their neighbouring drinking water facilities. As a whole in the present study about 60% of farming households used closed latrines (concrete and semi-concrete) which is more or less similar to the finding of national statistics (72%) reported by (UNICEF, 1999).

About 81% (13 out of 16) of better-off households and 41% (10 out of 24) of poorer households were found to have their own pond. A study conducted in Northwest Bangladesh showed approximately 80% of the wealthiest households had ponds compared to only 20% in the poorest (Barman, 2000). The difference between the previous and present findings in terms of pond ownership by poorer households could reflect the increasing construction of new ponds over the last few years. The average pond size of fish seed producing farmers (0.08 ha) was similar to that reported by a previous study (0.06ha) undertaken in Northwest Bangladesh (Morrice, 1998). This study also showed that 30% of pond owners were marginal and small (<1.0ha landholdings), 50% intermediate (1.0-2.4 ha) and 20% were larger farmers (>2.4 ha) (ICLARM, 1999).

The present study shows that small-scale shallow groundwater pumps at the individual household level brought remarkable change providing access to irrigation to all wealth classes of farmers. Between 1950 and 1987, public tube-wells, regulation of private installations and public monopolies in the supply of pumps, motors and other equipment were a constraint to the development of irrigation in Bangladesh. Since 1972, emphasis has been placed on minor irrigation through low lift pumps mainly using shallow tube-wells and deep tube-wells. From 1979 to 1990, there was a liberalized expansion of minor irrigation with diesel and electric shallow tube-wells (STW) in the private sector (Al-Mamun et al. 2003). Deep tube-wells (DTW) are generally 100 m in depth, require rings for installation and in the past were installed by the government. They have now been privatised and are owned and operated by cooperatives. The STWs, on the other hand, are generally 40-60 m deep, manually installed and privately owned and operated. Both DTWs and STWs, generally pump from the same aquifer, but due to larger investment costs and intricate operation and management, the number of active DTWs has steadily declined following privatization (Mondal and Saleh, 2003). The scenario of irrigation development at the farmer level in the Northwest Bangladesh is similar to the scenario of whole country. Almost all of the better-off farmers installed pumps individually for ensuring irrigation in their field crops. Some intermediate and poor farmers were also found to own irrigation pumps, however those who could not afford to install a full pump (ground water pipe and machine) installed only the tube-well, buying low-cost plastic piping and renting machines locally for pumping water when required. Moreover, poorer households without their own pump tended to access irrigation water from the better-off households at the community level. Hossain (2004) reported that over recent years an increase in the number of shallow tube-wells, pumps, power tillers and rickshaw vans has created jobs as in the operation and repair and maintenance in rural area of Bangladesh.

RF farming households tended to be located adjacent to rural roads. Rural earthen roads developed by local government in the study area were found to contribute to the development of riceplots with broader, more substantial dikes to preserve irrigation water and protect fish from flash floods caused by sudden rainfall. Additionally, improved road communication in rural areas facilitates farmers, fry traders and food-fish traders for marketing fish fingerling and foodfish in different places. More than 90% of the roads in the Northwest Bangladesh are earthen (Bakht, 2000). This was evidence that the development of rural roads contributed to the livelihoods of rural people. This was also indicated by the higher price of roadside land than for land located away from the road. Moreover, the incidence of NGO's membership has been observed to be higher villages serviced by good roads compared to villages remote from good roads (Bakht, 2000). This possibly partly contributed to RF households having more access to credit than NRF households.

3.4.2.3 Natural capital

The average landholdings found by the present study (0.89 ha) were similar to the findings (0.68 ha) of a previous study carried out by Morrice (1998). The average area of land owned by poor RF farmers was found to be 0.40±0.29 compared to intermediate (1.02±0.06ha) and better-off (2.44±1.55ha) farmers. Similar findings regarding land ownership of poor farmers (0.38ha) was reported by CARE (2005b) confirming the limited landholdings of poor households. During formation of farmer field school in the community, the CARE Go-Interfish project considered the landholding criteria of marginal and small farmers to range from 0.19 to 1.01 ha (Banu and Bode, 2002). Due to limited landownership, poor farmers of both RF and NRF households (about 40%)

tended to access land through sharecropping systems. Sharecropping is the most frequent form of land access and the dominant access mechanism for poorer farmers (CARE, 2005b). Under sharecropping arrangements, the farmers divide the harvest of rice with the landowner, and the costs of production are shouldered by the sharecropper. Apart from sharecropping, a few poor farmers were found to gain access to land through leasing and mortgaging tenure systems. These sorts of tenure arrangements require monetary investment which is not affordable for many poorer farmers (CARE, 2005b).

Alongside own landholdings, dependency of poorer households on others' landholdings indicate their insecure livelihoods. Land ownership as an income-generating physical asset has a predictable link with poverty incidence in rural areas. The extremely poor are completely landless, owning neither homestead nor arable land and, if not homeless, they live on borrowed land sometimes in fear of eviction (ADB, 2005). As a result, control over land is a strong indicator of household livelihoods in rural Bangladesh. In Northwest Bangladesh the ownership of land has historically been inequitable and concentrated in the hands of rural elites, who lease or share out their land to land poor farmers (CARE, 2005b). The existing land tenure systems are often found to be defective and as a result, agricultural development has been hampered and rural poverty perpetuated (Griffin et al. 2002). Normally the tenant's rights, including security of tenure, are enshrined in legislation. These are currently almost invariably ignored in practice, and may offer some scope for intervention (CARE, 2003b).

3.4.2.4 Financial capital

In most areas of rural Bangladesh, animals, particularly cattle provide not only draught power, fuel, fertilizer and an important protein source through milk, but also a source of capital that can be readily liquidated in times of need. The majority of sampled households maintained livestock holdings that did not vary significantly between households, perhaps due to difficulty in feeding and management. The most common form of livestock was chicken because of its minimal maintenance costs. Earlier studies in rural Bangladesh showed that family poultry contributed 28% of the total protein supply as eggs and meat in the rural households (Sonaiya et al. 1999). Family poultry plays a significant role in the cultural life of rural people: as gifts to visitors and relatives; as starting capital to youths and newly married women and as sacrificial offering in traditional worship (Sonaiya et al. 1999).

In terms of credit, RF farmers tended to obtain more credit than NRF farmers. This was explained by the institutional mediation undertaken by CARE resulting in linkages between farmers and credit providing organizations. In terms of access to the formal credit, the present study reveals that fewer poorer households received credit compared to intermediate and better-off households. The growing literature on credit and its impacts reports mixed results. According to Sinha (2000) credit in terms of an increased in number of loans has grown, where 80% of the poor are now reached by micro-credit programmes. In contrast, according to Halder and Mosley (2004) poorer households have scant access to the lines of formal credit and tend to face unfavourable lending terms, since lenders have a preference for the less risky clients.

The majority of farmers tended to receive credit from NGOs; it is generally understood that the most common source of credit in the Northwest are the NGOs. Generally NGOs and the Grameen Bank consistently target poorer households when lending money across the region (CARE, 2002). In terms of the use of credit, a study in the Northwest showed that the most frequent uses of credit by borrowers included healthcare (50%), immediate consumption needs (45%) and investing in farming (27%) (CARE, 2002). CARE (2005b) reported some other uses of credit including shelter improvement, social obligations related to marriage, dowry and the settling of previous debts. These studies illustrate the need for and use of credit in farming households where easy access to credit is likely to be an important financial capital towards improving livelihoods.

3.4.2.5 Social capital

The present study showed social capital operating at many levels of farming households in fish seed producing communities. This result is corroborated by previous studies showing similar findings in rural areas in Northwest Bangladesh (Bode and Howes, 2003). Development requires the mobilization of existing social capital as well as the creation of new linkages as success in communities depends on existing social bonds which encourage individuals to pursue a greater diversity of activities (Woolcock and Narayan, 2000). Growth of social capital can result from group activities in a wide range of natural resource management sectors, including watershed management, irrigation, micro-finance, forest management, integrated pest management and farmer experimentation (Pretty, 2003).

Regarding RBFSP, there were different types of relationships and linkages suggesting contributions to existing social capital. Among different bonds of social capital, the relationships between landlord and tenant was found to be an internal vertical social relationship, which is patron-client based relationship in Northwest Bangladesh (Bode and Howes, 2003). This sort of relationship affects the poorer tenants ability to sustain their land tenancies. In contrast accessing drinking water facilities via neighbouring households shows internal horizontal relationships. Production of fish seed/foodfish in ricefields and the subsequent gifting to neighbours and relatives enriched social capital through building internal horizontal linkages. Studies carried out by ITAD/ODI/OPM (2001) reported that RBFSP improved farmers capacity to gift fish to neighbours and relatives which in turn strengthened social capital.

Moreover, social capital developed through the creation of farmer field schools contributed to the community in several ways. According to CARE (2001a), farmers used the social networks that FFSs strengthened to share knowledge and information regarding agricultural technologies and other services provided by government and non-government organizations. Social relationships were also reported to mitigate domestic violence and dowry problems and facilitate the provision services at an institutional level.

3.4.3 Livelihoods strategies and outcomes

3.4.3.1 Agriculture crops

Rice cultivation

In the present study, the basic agricultural crop was rice as it was cultivated by all farmers both in the *amon* and *boro* seasons. Although the area under rice increased only marginally from 9.8 to 10.6 million ha in Bangladesh, rice production increased from 16 million tons before independence to 38 million tons in 2000-2001 (Hossain, 2004). This was brought brought about through higher investment in inputs (e.g. fertilizers, irrigation etc.) used to cultivate irrigated rice (*boro*) than for rainfed rice (*amon*). The increased investment in *boro* results in higher benefits compared to *amon* (Hossain et al. 2006). The source of investment to one crop comes from the preceding crop, as a result farmers have the income from *amon* rice which contributes a substantial amount of investment to *boro* rice. To maximize the benefits from an increased investment in *boro* rice, farmers also produced fish fingerlings in irrigated ricefields. Rice production (kg/ha) of RF households was found to be relatively higher than NRF households. This was possibly due to RF farmers having better access to irrigation which also improved the management of ricefields.

Vegetable cultivation

Vegetables have been categorised into two groups, potato and other vegetables grown as field crops. Average potato production of all sampled households was 9,840 kg/ha where production of RF and NRF households was 11,385.92 and 8,237.70 kg/ha respectively. The average potato production of a RF farmer was similar to the production (12,598 kg/ha) recorded in national statistics (BBS, 2003a). The higher production by RF farmers may have resulted from access to information as well as to good quality and high yielding potato seed given by CARE field trainers. Improved quality potato seeds are supplied by the Bangladesh Agricultural Development Corporation (BADC) and some NGOs in northern Bangladesh. Potato is recognized as a cash crop at the farmer level and land allocation for its cultivation was increased in the 1990s (BBS, 2003a).

The agricultural sector in the Northwest districts has experienced major changes since the opening of the Jamuna Bridge. This was due to the development of a strong marketing infrastructure and diversification into cash crops such as potatoes, vegetables and banana (CARE, 2001a). Poorer RF households tended to produce more vegetables than poor NRF farmers. This suggests that fish seed production is also compatible with intensified vegetable cultivation which is considered a cash crop. In contrast, potato cultivation was reported to be competitive with RBFSP in one community of Rangpur Sadar out of 25 communities investigated in the Northwest (Barman et al. 2004) possibly because of light sandy soil which is relatively better for potatoes cultivation. Apart from potato, the average production of other vegetables was found to be 2405.1/ha where RF farmer's productivity (2,605.3/ha) was relatively higher than NRF farmer (2,160.3 kg/ha). Although the NRF farmers were from the same community as the RF farmers, the lower productivity of NRF farmers was possibly due to less intensive cultivation and their higher education level that enhanced their involvement in non-farm activities.

Vegetable production in Bangladesh increased between 1980 and 2003, with an annual growth rate of 2.8% (Weinberger and Genova, 2005). According to recent statistics the average vegetable yield in Bangladesh is 5,800 kg/ha. However, it is misleading to discuss yields for aggregated vegetables, as the mix of crops may change significantly over time (Weinberger and Genova, 2005). A study carried out in 2005 has shown an average vegetable (potato and other vegetable together) production of 4,155.8 kg/ha in rural areas of Mymensingh district (Karim, 2006). Collectively (potato and other vegetable) per ha vegetable production tended to be much higher in Northwest Bangladesh possibly due to the availability of improved seed.

Other strategies

RF households tended to benefit more from livestock than NRF households. This could be explained by the improved management of livestock by RF households where household members were given training by CARE for timely healthcare of livestock received from different organizations (Banu and Bode, 2002). The behaviour of RF farming households towards improved management of livestock was compatible with other farming activities such as vegetable production and improved management of ricefield for fish fingerling production. This also reflects more intensified farming of RF households whereas NRF households tended to be dependent more on non-farm activities.

Poorer households tended to be more diversified in non-farm activities suggesting farm-based activities were not sufficient for their livelihoods. Diversification into non-farm activities is a very common behaviour of poorer households (Ellis, 2000) and has possibly been replicated on-farm through diversification into ricefield based fish seed production.

3.4.3.2 Production from ricefish plot

Rice varieties and fish species

In the present study farmers cultivated high yielding rice varieties in their ricefish plot during both *boro* (mostly BR-28 and BR-29) and *amon* (mostly BR-11 and *Swarna*) seasons suggesting the compatibility of fish seed production with these varieties. In Bangladesh, rice is grown on over 10 million ha (Joshi et al. 2007). It contributes over 50% of the agricultural gross domestic product (GDP) and accounts for about one third of national GDP (Baffes and Gautam, 2001). The cultivation of high yielding varieties has resulted in a greater contribution to the food supply and national economy.

The high yielding early variety used in the dry season BR-3 was released in 1973. The yield potential of this variety was surpassed only in 1994 with the release of BR-29 that showed an average yield of 7.5t/ha in multi-location trials (Hossain et al. 2006). The highest yielding *amon* season variety for the season is BR-11 released in 1980. Many new varieties have been released for the *amon* season since then but none with the yield potential of BR-11. The most popular varieties during *amon* season are BR-11, (23%), *Swarna* (23%) and *Pijam* (13%) together occupying 79% of the total cultivation area of high yielding varieties. The remaining 22% of varieties might be of less interest to the farmers for their fish seed production plot as well as for riceplot only. During the *boro* season, a large number of varieties were grown; the most popular ones were BR-28 (11%), BR-29(9%), BR-14 (11%), BR1(7%) and BR-8 (6%).

Despite socio-economic factors such as the predominance of small and marginal farmers and tenancy cultivation in the agrarian structure, the adoption of high yielding varieties in Bangladesh has expanded (Hossain et al. 2003). Several studies noted that the rate of adoption was higher among small-scale and tenant farmers in Bangladesh compared to other countries (Lipton and Longhurst, 1989). Generally farmers value traits of high yield, good grain quality and shorter maturity, as shown by rapid diffusion of BR-28 and BR-29 (dry season) in the late 1990s (Hossain et al. 2006). Considering the favourable traits of high yielding rice varieties, farmers discovered a synergy with high yielding improved strain of Nile tilapia (GIFT) for production of fish seed and foodfish in ricefields. These synergies may have also made the ricefields compatible, to a greater extent, to fish seed production. It has been demonstrated that ricefields are compatible for fish fingerling production in Indonesia, China (Halwart et al. 1996) and in Vietnam (Nguyen and Little, 2006).

Riceplot management

The dosages of fertilization vary from region to region as well as from crop to crop in Bangladesh based on different degrees of soil fertility. During the *boro* season average urea, TSP and MP dosages in the present study were 163.6, 87.2 and 59.5 kg per ha respectively. The dosages of urea, TSP and MP for *boro* production across the country were 259.4, 197.0 and 41.5 kg per ha (BBS, 2003a).

During the *amon* season, the dosages of urea, TSP and MP in the present study were 75.2, 28.6 and 17.8 kg per ha respectively. Literature shows the higher corresponding values for *amon* production throughout the country as 111, 111 and 31 kg per ha respectively (BBS, 2003a). The comparatively lower fertilizer doses used in ricefish plots suggest that fish culture in ricefields reduces the need for fertilizer inputs. Earlier there was speculation that ricefish farming might use 50 to 100% more fertilizer than rice farming without fish (Chen, 1954). As with the finding of the present study, an experimental study has shown that ricefish culture could reduce fertilizer use by 30% (Li et al. 1995). This is due to the increase in organic matter through fish excreta and the remains of supplementary feeds (rice bran) (Coche, 1967).

Overall along with a reduction of fertilizer, farmers did not use pesticides in fish fingerling producing riceplots. Earlier on-farm experimentations on tilapia fingerling production in ricefields in this study area of Northwest Bangladesh (Barman and Little, 2006) and in Vietnam (Nguyen and Little, 2006) showed similar results. This could be explained by the changes occurring in natural and human capital in farming households. Naturally, fish eat larvae of many harmful insects in ricefields (Coche, 1967). In terms of human capital, the presence of tilapia in ricefields and its growth were reported to change the farmer's behaviour to avoid the use of pesticides. It was also reported that farmers developed their understanding to an extent where they could still get the same production level of rice without using pesticides (CARE, 2001a). This reflects the effectiveness of CARE's farmer field school approach towards a broader understanding of improved ricefields ecosystems.

Fish seed production in ricefields was less likely to face water constraints as compared to traditional ricefish culture (Coche, 1967) despite seed production activities starting in the dry season. This is due to the hatching of common carp eggs and breeding of tilapia that could take place in smaller ditch water areas in the ricefields. Until the onset of rain, hatchlings could be accommodated in the ditch area (Barman and Little, 2006). Alongside this, those riceplots tended to be located adjacent to earthen irrigation canals allowing uncontrolled leakage of water into the riceplot. This sort of riceplot was reportedly able to maintain a better water level than the riceplots located away from irrigation canals (Gregory and Kamp, 1999b). Immediately after the rains start, hatchlings move into the whole area of the riceplot and use abundant natural food (Barman and Little, 2006). This strategy of fingerling production in irrigated ricefields appears to use irrigation water effectively (Kutty, 1987).

According to the present study however, escape of fish from riceplots due to heavy rainfall is the major constraining factor for fish seed production. This finding is in agreement with an earlier study that reported storms with heavy rainfall to cause flash flooding of the plots and loss of fish (Gregory and Kamp, 1999b). To minimize the degree of this natural threat, farmers tended to locate fish seed production in riceplots adjacent to roads with larger dikes. This protects riceplots from sudden flash floods as well as loss of water during dry months.

Production of rice in ricefish plots was found to be higher than that of the national average suggesting presence of fish in ricefield contributed to an increased yield of rice or farmers have chosen more fertile riceplots for fish seed production. Average production of *boro* and *amon* rice has been recorded as 3,195 and 2,376 kg/ha respectively (BBS, 2003a). Rice productivity was found to be higher in fish seed producing riceplots compared to other riceplots of the RF farmers as well as of NRF farmers. Evidence shows that during the *amon* season, rice production was 4,980 kg /ha (ranging from 3,264 to 6,571) and 4,555 kg/ha (ranging from 3,046-6,000) in integrated and only riceplots respectively. During the *amon* season, rice production was 3,811 kg /ha (ranging from 2,058 to 4,940) and 3,498 kg/ha (ranging from 1,976-6,250) in integrated and controled riceplots respectively (Gupta et al. 2002). In an analysis of 18 ricefish studies an average increase in rice yield of 15% was reported which was due to the presence of fish in ricefields (Lightfoot et al. 1992). Studies in the CARE Interfish area showed that rice production appeared to benefit with a 5% to 10% of yield increase owing to better water management (ITAD/ODI/OPM, 2001). A study conducted on RBFSP in Vietnam reported approximately double the production of rice (>6100 kg/ha) than the present study as a result of using a high yielding hybrid rice variety. However, rice production in fish seed plots was relatively higher than rice only plots (Nguyen and Little, 2006). This study in Vietnam also confirmed that rice production in fish seed plots was higher than rice only plots.

Income from rice

Both investment and net returns were comparatively higher in *boro* rice compared to *amon* suggesting importance of *boro* cultivation in terms of its operating cost being maintained by the farming households. A recent study also showed a higher return from *boro* (US$ 270) compared to *amon* (US$136) cultivation (Gupta et al. 2002). Income from rice grown in ricefish plots was found to be higher than from RF farmer’s other riceplots and NRF farmer's riceplots possibly due to the use of fewer inputs. Literature showed that the cost of producing rice through integrated farming was lower than for rice monoculture in both *boro* (9.4%) and *amon* (10.1%) seasons due to the use of fewer fertilizers and a lower cost of weeding (Gupta et al. 2002). Increased productivity in ricefish plots suggests that seed production in riceplots reduced the level of cash investment for inputs and resulted in higher margins.

In relation to input use and rice production, relatively better-off farmers were found to use fewer inputs and get a higher production of rice compared to poor and intermediate households. The possible underlying reasons could be the use of higher levels of fertilizer inputs by poor and intermediate households that resulted in crop lodging and lower grain production (Biradar et al. 2005). Another possible underlying reason might be that riceplots of better-off households were more productive than those of other groups of farmers.

Feeding of fingerlings

RF farmers tended to use their 'on-farm' produced rice bran as supplementary feed for fish in ricefields. According to Gupta et al. (2002), farmers used mostly 'on-farm' inputs (cattle manure, rice/wheat bran) in the case of ricefish farming. Farmer can therefore use locally derived by-products as feed rather than purchasing high cost industrially produced feed for the production of fingerlings.

Fingerling production

Poorer and intermediate households were found to be more efficient in producing fingerlings compared to the better-off farmers. A previous study showed that smaller farmers were more efficient in their use of land for high yielding rice production through efficient use of irrigation and available labour in their households (Feder et al. 1985).

Poor and intermediate households sold their fingerlings through diversified channels at higher prices than better-off households showing stronger marketing efficiency. Similar attitude of poorer farmers were reported in marketing agricultural products where they participate successfully in marketing chains, either on their own or with the help of co-operatives (Ellis and Biggs, 2001).

Income from fingerling

The present study found the average net benefit from fingerling and foodfish production to be Tk 14,231.1/ha, which was much higher than found in previous studies. A previous study in Mymensingh region, reported the average net income from foodfish produced in ricefield to be Tk. 9,925/ha. The lower net return shown in previous studies was due to the use of purchased fingerlings which accounted for 60% of the production cost (Gupta et al. 2002). However, in the present study farmers purchased fewer fry as they produced fingerlings themselves. Moreover, farmers in the present study sold their fish as fingerlings which tended to be higher value than foodfish. Evidence also shows that income from fingerling production in irrigated ricefields was generally greater than the food fish production from rainfed systems (Kamp and Gregory, 1993). This was due to the high demand for fingerlings peaking at the onset of monsoon period (Barman and Little, 2006). Relatively poor and intermediate farmer's selling efficiency (US$/kg fingerlings) was higher than in better-off households, as small farmers tended to maximize the return through their higher marketing efficiency (Ellis and Biggs, 2001). Moreover in the decentralised fingerling marketing system, producers are likely to have a relatively strong position as they can wait for the next customer without quality deteriorating. If fingerlings are not sold they can still be sold as foodfish, restocked or eaten in households. According to an earlier study, ricefish farming appeared to be suitable only for well-off households (Gupta et al. 2002). However, the present study suggests that decentralised fish production strategy using ricefield system could be a sustainable option that benefits poorer households.

Pond production

In terms of input costs, poor and intermediate RF households reduced their expenditure on pond production compared to NRF households by stocking on-farm produced fingerlings. Better-off households tended to restock more of the ricefield produced fingerlings in their household ponds as they had larger ponds. In rural areas, fish seed can be the most costly input in the pond polyculture of carp and tilapia (Karim, 2006). According to the present study decentralised tilapia and carp seed production in ricefield based system could be a viable option to reduce expenses of pond based aquaculture in many other rural parts of Bangladesh.

Pond fish production significantly increased in RF households compared to NRF households mainly due to stocking of their own large sized fingerlings with higher survival rate. It appears that farmers of the CARE Interfish project used improved knowledge of foodfish production in ricefields in their pond aquaculture (CARE, 2001b). Farmers under the Go-Interfish project received training on pond aquaculture and also used their knowledge in practice. In the present study, average pond production of RF farming households was found to be 2,548 kg/ha. Compared to the present study, a bit (<16%) lower production (2,195 kg/ha) was achieved in trial farmers' ponds in carp polyculture model in Northwest Bangladesh (Morrice, 1998). In that trial, farmers were given training in pond culture techniques and they were provided with fingerlings, fertilizers and rice bran by the NFEP project on the basis of interest-free credit. Average pond production in Northwest Bangladesh was 740 kg/ha in 1992 (Morrice, 1998) which has been increased more than threefold in RF household ponds. The average yields of pond fish increased from 1000kg/ha to 3300 kg/ha after Mymensingh Aquaculture Extension Project (MAEP) interventions (GoB/Danida, 2004).

Multiple-ownership of ponds is a common constraint in all parts of Bangladesh (Gill and Motahar, 1982) which leads to mis-management and lower productivity of ponds. Decentralised fish seed production contributed to the supply of seed and increased production of fish in such less intensively managed multiple-ownership ponds.

The trend towards increased fish production in RF households in this study area shows the potential of fish production in household ponds by stocking on-farm fish fingerlings. Overall, this scenario strongly indicates that far more could be achieved by stocking large size fingerlings in currently managed culture systems than any other single management step.

Fish consumption

The World Bank acknowledges that small-scale fisheries provide most of the fish consumed by people in developing countries. Between 1961 and 1990 the fish food supply per capita declined steadily in Bangladesh and many other developing countries (Kent, 1997). In Bangladesh the overall animal protein supply per capita has been falling together with the fish supply, which means that fish has not been replaced with other forms of animal protein (Kent, 1997).

The present study shows that RF households increased their on-farm fish production substantially and consumed more fish in spite of their larger household size than NRF households. Poor and intermediate households tended to eat larger sized fingerlings produced in their riceplots than better-off households. This suggests that better-off households could delay eating fish from their riceplots as they have ponds in which to stock and add value to them. Evidence from CARE studies show that households participating in CARE interventions have raised their fish consumption (CARE, 2001a). It was also reported that increased fish production at the household level met the consumption demand for children.

Fish consumption from wild sources was found to be limited, with RF households consuming slightly more than NRF. A study carried out by CARE has shown that the estimated annual wild fish catch from inland waters per household for Rangpur, Bogra and Jessore were 8 kg, 15 kg and 22 kg respectively (CARE, 2001a) suggesting variable and lowest wild fish production in CARE project areas. Similarly, a recent study in Bangladesh found that annual per household wild fish consumption was variable ranging from 2.5 to 14.5 kg (Islam, 2007). The amount of wild fish determined in the present and previous study appears to be at a similar level and indicative of their limited contribution to household consumption and a chronic scarcity of wild fish especially for poorer households. The price of small indigenous fish species, that are normally caught from wild sources, has surpassed the price of major carps substantially in recent years (Thompson et al. 2000). Previously small indigenous wild fish was known as poor people’s food, however, due to the supply deterioration and higher prices, this fish has disappeared from the plates of the poor people (Kent, 1997).

Middle and high income people consumed a greater amount of fish compared to low income people (Kent, 1997). A recent study showed that high income households consumed more (90.93 kg/household/year) than low income households (64.88 kg/household/year) in the Mymensingh region of Bangladesh (Karim, 2006). For low income people particularly dependent on fish in their diets this reduction in supply may have serious consequences in terms of both economics and nutrition (Kent, 1997). Adoption of fish culture by any means is therefore very important for low income poor people. The present study shows that poorer households increased their consumption substantially through adoption of fish seed production technology in ricefields. Possibly due to this fact, to sustain domestic fish consumption in Vietnam, fish production from ricefields is expected to increase sustainably (NEDECO, 1993).

Overall household income and expenditure

Considering the whole sample, the present study reveals that, the average annual household income from all sources together was US$ 935.48 where RF and NRF household income was found to be US$ 1138.83 and US$ 732.00 respectively. National household surveys showed the average rural household annual income was US$ 963.2 in 2000 (BBS, 2003) which is relatively higher than the finding of present study. This difference between the national average and the average of the present study suggests that overall households are relatively poorer in Northwest Bangladesh.

Overall the income of RF households was found to be higher than NRF ones. According to literature, the CARE project have produced a number of choices for production systems e.g. fish seed and foodfish production in riceplot, homestead gardening, improved aquaculture, integrated pest management etc. which increased households income by at least 50% (ITAD/ODI/OPM, 2001). According to the present study, considering the whole sample, on average agriculture contributed about 50% of the household income, which is higher than the national average (35%) (BBS, 2003b) presumably due to the greater dominance of agriculture in livelihoods in Northwest Bangladesh.

Irrespective of well-being category, expenditure on food was also lower in RF farming households than in NRF households. A previous study has shown that although the economy appears to be improving in general, statistics suggest that the real living standard of most people has fallen steadily, as there has been a rise in consumer prices disproportionate to income growth (RDRS, 2000). According to the Consumer Association of Bangladesh (CAB), in 1999 the cost of living increased 6.42% with a 2.15% rise in consumer item prices. During 1999, it was reported that the price of fish and meat among other agricultural commodities tended to rise as well as industrial commodities and government-control services (RDRS, 2000). Households' budgets are largely devoted to food and when faced with a large increase in the cost of one of their major foods, they become worse-off economically as well as in nutritive terms (Kent, 1997). Expenditure on clothing, education, housing, medical treatment and social events were higher in RF farming households possibly because of additional income from ricefish farming.

It was also noted that significantly higher ceremonial costs were observed in rice farming households compared to NRF households. This may have been due to the larger size of households compared to the control which gives probable reasons for higher ceremonial expenditures for buying new clothing during Eid/Puja, excessive expenses for wedding event of daughter etc. This also indicates that RF households had more disposable income which they spent in various social activities, possibly leading to the accumulation of social capital. Other studies have shown that households with higher per capita expenditure, more assets, better access to credit and higher savings in the past year have closer relationships and greater social capital (Grootaert, 1999).

Fish farming (fish seed and pond fish) collectively, contributed 11% to the total income and 17% of on-farm income to RF households which was nearly double the income from the pond culture of NRF households. Fishpond operation along with crop production and other on-farm activities contributed between 5 and 10% of the total household income in Bangladesh (Bouis, 2000). Decentralised fish seed contributed a relatively minor proportion of annual household's income however, it enhanced the overall income of the fish sector in farming households.

Spatially in some situations where aquaculture has been targeted to increase on-farm production of resource-poor households in certain agro-ecological regions, the income changes were reportedly more significant (Gupta et al. 1999). For example, following an intervention in a flood-prone area of Bangladesh, income derived from fish culture rose from 4.6% to 21.6% of the total farm income and from 2.8% to 13.5% of the total household income. The higher contribution of income from fish culture to overall household income was as a direct consequence of living in a flood-prone area, where the majority of households tended to be poorer with low household income (Gupta et al. 1999). Northeast Bangladesh is one of the poorest regions, where income from ricefield based fish seed and pond fish production is likely to carry similar importance in households' livelihoods.

3.4.4 Conclusion

The study in this chapter contributed the findings to the hypothesis of 'the asset profiles RBFSP adopters are the same as non-adopter households of different levels of well-being'. At the outset of CARE-project interventions in Northwest Bangladesh, farmers lacked access to livelihoods resources, particularly human capital regarding knowledge of sustainable management of ricefield ecosystems. The dominant livelihood strategy in the study area was rice based agriculture depending on the cultivation of high yielding varieties of rice with few opportunities for non-farm diversification. CARE programmes provided little input in the form of human capital, through participatory FFS training which brought broader changes over the livelihood assets of both primary and secondary seed producing households compared to NRF households.

RF farmers had no knowledge at all of fish seed production in ricefield based systems before participating in farmer field schools either directly as primary farmers or through as secondary adopters. After receiving training on fish seed production they started to utilize their riceplots to produce additional fish seed and foodfish. Incorporating fish seed production in ricefield based systems considerably changed the natural riceplot ecosystems. Farmers did not use pesticides and increased their use of organic manure thus reducing the operational cost of riceplot management. Literature shows that elimination of pesticide uses has been noted in 93% of cases in Northwest Bangladesh though there is no overall trend in other parts of Bangladesh for reducing their use (ITAD/ODI/OPM, 2001).

Restocking fish fingerlings in household ponds increased pond production substantially suggesting improvement pond use which is an important physical capital in farming households. Production of fish in the riceplots and in household ponds increased fish consumption at the household level suggesting improvement of human capital nutritionally. Selling fingerlings and foodfish from ricefish plots and foodfish from ponds diversified financial assets for the farming households. Riceplot tenure mechanisms, gifting fish fingerling to relatives/neighbours and other relationships owing to fish seed production activities contributed substantially to enhance social capital. Overall, ricefield based fish seed producers improved their livelihood asset-base substantially.

Chapter 4: Seasonality of RBFSP and its impacts on livelihoods

4.1 Introduction

The preceding chapter was based on the analysis of one-off survey data and describes the livelihood conditions of farming households in relation to RBFSP. A one-off survey demonstrates household livelihood strategies and impacts of this technology which broadly include fish seed production, foodfish production, consumption, income etc. However, how farm households carry out seed production activities along with their various farming activities throughout the year was not clearly understood. Additionally, how outcomes of RBFSP contribute to or conflict with the seasonal needs of farming households were yet to be fully understood. Therefore, a year long longitudinal household survey was carried-out to understand how the seasonal dynamics of RBFSP affected in farming households.

The world's developing countries lie in the lower latitudes, that is, the tropics and subtropics, being positioned between the Tropic of Cancer and the Tropic of Capricorn. The tropical and subtropical zones have climatic distinctions (e.g. temperature, humidity, rainfall etc.) from temperate zones, which are of vital importance to agriculture and to the influence of seasonality on agriculture (Gill, 1991).

Along with a large number of developing countries, Bangladesh is located in Tropic of Cancer with a considerable distance from the Equator (Figure 4.1). As a result, Bangladesh has a subtropical monsoon climate, where there are six seasons in a year of which three namely winter, summer and monsoon are prominent. This seasonal variation has a close relationship to, and implications for, the livelihoods of rural people in Bangladesh (BBS, 2003a). The importance of seasonality in socioeconomic activities, nutrition, food, and health at the household level has long been a concern of anthropologists (Chambers, 1982).

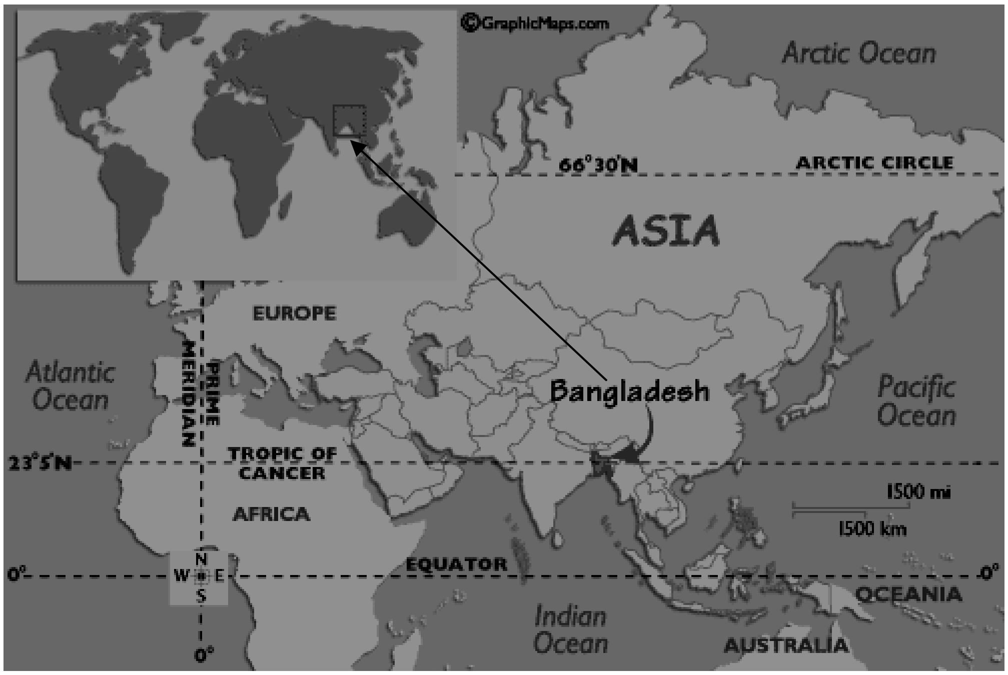


Figure 4.1: Geographical position of Bangladesh (source: http://worldatlas.com).

The annual agricultural cycle results in substantial seasonal variation in the economic activity of both men and women in rural households of Bangladesh (Cain et al. 1979). Consequently, the sources from which income can be generated by household members varies between seasons (Sahn, 1989).

In the mainly agrarian structure of Bangladesh, household level food production strategies are the basis for survival. Seasonal shortages during the planting period, when crops from the previous season have been exhausted and the new crops are not yet ripe cause hunger (Messer, 1989). Therefore, seasonality has been recognized as a key determinant of nutritional status in humans in low-income countries because of its role in food production and food access (Brown et al. 1982; Tetens et al. 2003). Moreover, the role of climatic seasonality in human energetics has been recognised because of its significant role not only in food intake but also in physical activity and thus energy expenditure (Ferro-Luzzi, 1990).

Seasonal differences in the availability and intake of food and the effect of seasonality on the nutritional status of people are well recognized in Bangladesh. However, there is little empirical evidence on how food varies with the seasons and on the availability of food at the household level. The staple food in Bangladesh is traditionally cereal, especially rice, the availability of which is highly seasonal. This is due to the relative abundance of rice occurring cyclically in relation to harvest and storage after sun drying. A shortage of rice then occurs during the pre-harvest period (Abdullah, 1989). Household characteristics with respect to bulk storage of rice after harvest for season long consumption are different to that for other household-produced food items such as vegetables and fish. Fish intake however is also affected by season as well as other factors including location, water level of fish producing waterbodies and household income which is again affected by season (Ross et al. 2004a).

During the past decades, the many ways in which the seasons of the year affect the lives of poor have come to provide a common focal point for scientists and practitioners from a broad range of disciplinary backgrounds. For many people, particularly the poor and marginal farming households, it must have been almost beyond comprehension that such an intrinsic aspect of human existence as the cycle of seasons actually needed to be drawn to the attention of professionals concerned with the problem of food security and poverty (Abdullah, 1989). In this regard, longitudinal studies under various ecological and socio-economic conditions are needed for precise quantification of the effect of seasonality on rural livelihoods to identify appropriate counter-seasonal measures.

Therefore, the study attempts to take an account of the dynamic effects of cyclical changes through assessment household level fish seed production in the irrigated ricefield systems.

The main hypothesis of this chapter is that 'seasonal changes may cause variation in livelihood outcomes of farming households by well-being and farmer type and these are affected by adoption of RBFSP'. The specifics are:-

- Work intensity for different purposes varies seasonally in farming households and RBFSP does not compete for household labour with other more important activities.
- RBFSP increases total household fish production and, improves and expedites consistency of fish consumption year round towards reducing vulnerability.
- Household level income varies seasonally and RBFSP reduces vulnerability to those cycles in adopting households compared to non-adopting households.
- Income from fish seed production is relatively more important to the poor than the better-off.
- Seasonality affects the health condition of household members whilst RBFSP has positive livelihood impacts.

4.2 Methodology

4.2.1 Questionnaire survey

The most common method of longitudinal data collection in developing countries is the personal interview, where an enumerator asks one or more household members to recall information such as expenditure and food consumption over a reference period. Use of recall periods and multiple rounds of surveys increase the reliability of estimates of households which is generally termed longitudinal study (Smith, 2002). There are five approaches to longitudinal investigations namely; repeated cross-section, cohort studies, event history; time series and panel studies (Lambert, 2005). In socio-economic research, a panel study is generally regarded as household monitoring (Diggle et al. 2002). The panel survey designs are a more rigorous solution to the time dilemma of cross-sectional surveys (Nachmias-Frankfort and Nachmias, 1996) allowing insights into the time order of the different socio-economic variables (Bryman, 2001).

In the present study, a month-interval panel survey of a total of 118 households was conducted from May 2003 to April 2004 with the inclusion of the same farmers from the same communities studied in Chapter 3. As the basic information was determined through a one-off survey in Chapter 3, the same farmers were interviewed for this longitudinal survey with a view to understanding the remaining year round dimensions of livelihoods in their farming households. The survey was carried out using a structured questionnaire incorporating information about the aspects of various activities, income from different sources, expenditure for different purposes, food consumption and health condition.

Initially the questionnaire was tested with households that were not included in this final study. After necessary corrections and modification, the questionnaire was used for data collection (Appendix 2). The same four field facilitators, who conducted the cross-sectional survey (Chapter 3), carried out this longitudinal survey which helped them to deal with the farming households easily. The monitoring survey was begun immediately following the cross-sectional survey. During the initiation of this survey, meeting with the cross-sectional survey farmers were organized in each of the 20 communities to share the objectives and process of monitoring survey and subsequently the farmers (3 RF and 3 NRF) were sampled from the same group. During discussion with farmers it was discovered that NRF farmers were less interested in continuing with the monthly questionnaire survey, and therefore a less frequent schedule was agreed with a three-month interval between interviews. The repeated survey was carried-out with the same household heads and available family members at the end of each survey month. The survey dates were fixed for respective farmers in such a way that one month was covered for each of the sampled households. This process of data collection was useful in two ways i) the enumerators were not hurried during the interview to survey 6 households in a day and ii) farmers were aware about their interview date and could mentally prepare himself/herself for the survey.

4.2.2 Data management

After completion of a year-long survey, the collected data were entered by the field enumerators in a database prepared in Microsoft Access. The data were then checked and verified by the enumerators using hardcopies of the questionnaires. This process of database preparation involving the enumerators, minimized the errors in the dataset in two ways firstly, they were confident entering the data they had collected and secondly, they were able to solve any problems regarding incorrect and missing information while rechecking the dataset. Using MS Access, different query options were used to arrange different permutations and combinations as per the respective objectives of the study.

4.2.3 Data analysis

As in Chapter 3, the study population comprised the same 118 households aggregated into three well-being groups selected from 20 communities in Northwest Bangladesh. Out of a total of 118 households, 60 were seed producing (RF) and the remaining 58 were non-seed producing (NRF) households.

Using the procedure of General Linear Model (GLM) in SPSS, univariate analysis of variance was performed for inferential statistics. In the statistical model, time spent for different productive and re-productive activities, income, expenditure and food consumption of farming households were considered as dependent variables. These data were converted to weekly per capita basis before analysis (e.g. Karim 2006; Islam, 2007) for comparison with available literature. Farmer type, well-being and season were included as independent fixed variables. All main effects were evaluated as well as two-factor interactions between farmer type and wellbeing; and three-factor interactions between farmer types, well-being and season.

Tukey's test was used for the post hoc detection of significant pair-wise comparisons. Descriptive statistics such as mean, standard error and percentages as well as inferential statistics of P values for main effects and significant interactions were used to interpret the results. Descriptive statistics were presented through graphs and tables using MS Excel software. Based on the results, a number of meetings were carried out at the community level in February 2005 involving farmers to share the findings for validation and better understanding of results and interpretations (Figure 4.2).

Figure 4.2: Result discussion meeting at the community level.

Before discussion meetings, the results were drawn on a paper with coloured marker pens so that farmers could understand the findings. During discussion with the farmers, any contradictory interpretations were raised and discussed.

4.3 Results

4.3.1 Labour allocation of household members for different activities

Labour allocation between income generating activities in households and other household activities are affected by economic as well as socio-cultural factors. This deserved attention as the participation of women in economic activities outside the home is very low in Bangladesh.

The household level labour allocation has been divided into two categories: i) economic activities (activities which generate income); and ii) domestic activities (activities which generate utility but not cash income). This distinction between the two categories is not clear-cut as domestic activities have a market value (e.g. price of childcare, prepared food etc.) (Hossain et al. 2004). In the present study, household labour requirements have been divided into two categories i) labour necessary for generating income and capital or "productive work"; and ii) labour necessary for maintenance and upkeep the household, which is not directly productive in the sense of generating income-is termed arbitrarily as "re-productive work" (Cain, 1991).

Overall, in a RF household, productive activities with respect to agriculture, fish seed production (ricefish), pond culture and non-farm productive activities collectively required 43% of total time (Figure 4.3). Re-productive activities related to non-farm and homestead level activities collectively made up 55% of household time.

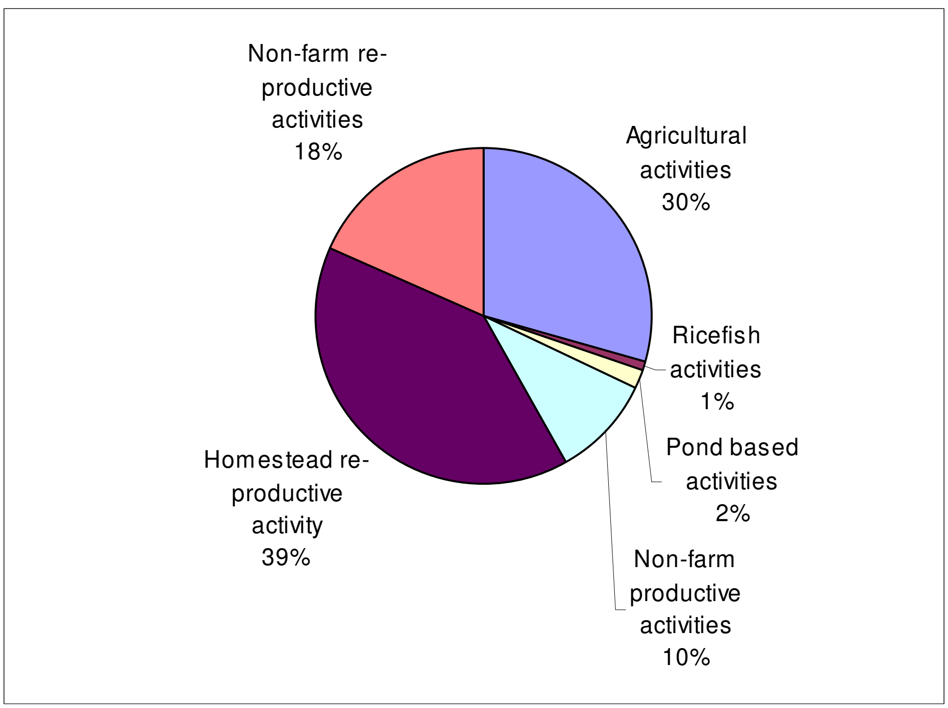


Figure 4.3: Percent time allocation for different activates done in RF household.

Within the overall time (hr/capita/week) spent carrying out different activities, fish seed production activities required only 1% of time, which was proportionality lower than any other household activity (Table 4.1).

Table 4.1 Time spent (hr/capita/week) for different activities in RF households by gender

Activities		Average time spent (hr/capita/week)					
		Household head	Household head wife	Household head son	Household head daughter	Household elderly member	Total household activity
Productive	Agriculture	23.70±0.69	8.32±0.37	10.83±0.62	1.11±0.15	1.47±0.19	45.43±1.04
	Ricefish	0.66±0.03	0.08±0.01	0.53±0.04	0.03±0.01	0.01±0.01	1.3±0.06
	Pond	2.58±0.11	1.26±0.02	1.59±0.08	0.10±0.02	0.12±0.02	5.65±0.15
	Non-farm productive	5.98±0.54	0.26±0.12	8.29±0.78	0.40±0.00	0.95±0.25	15.48±1.06
Re-productive	Homestead re-productive	1.80±0.21	41.28±1.04	1.14±0.15	5.58±0.36	11.23±0.80	61.05±0.93
	Non-farm re-productive	10.68±0.56	3.29±0.40	8.63±0.72	3.92±0.47	1.72±0.31	28.24±1.24

According to the time allocation observed (Figure 4.3), the majority of productive activities were found to be male dominated which were carried-out by household heads and their sons. In terms of ricefish activities, household heads and their sons collectively contributed the major proportion of time required. Homestead level re-productive activities also consumed a major portion of time (Figure 4.3), and were strictly female dominated, where the household wife contributed a major portion of her time.

Agriculture activities

Agriculture activities were categorized into four groups: rice-based agriculture, livestock-based agriculture, vegetable-based agriculture and other agricultural activities (Figure 4.4). Among them, rice-based activities accounted for 50% of the total time followed by livestock, vegetable and other activities.

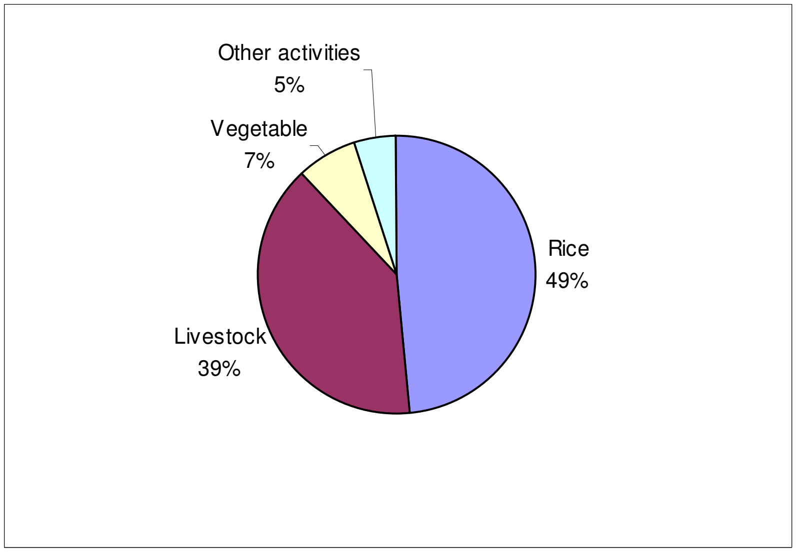


Figure 4.4: Percent time spent (hr/capita/week) carrying out different agriculture activities in RF household.

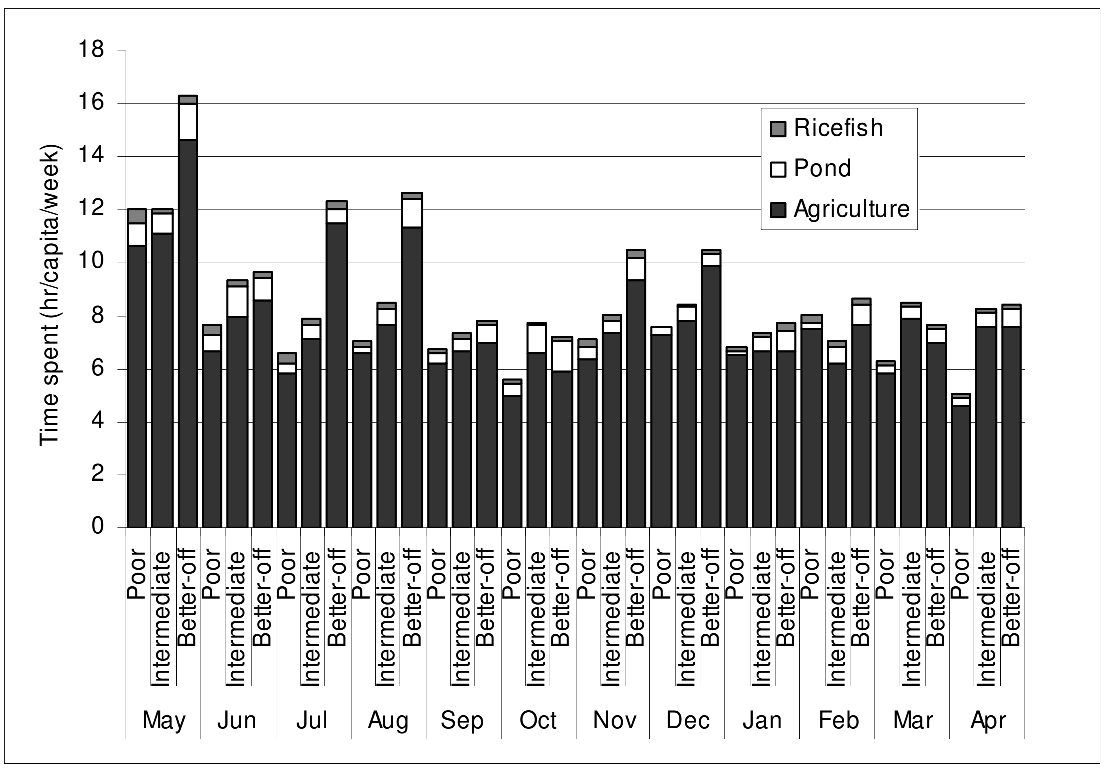


Figure 4.5: Average time spent (hr/capita/week) carrying out agricultural activities in RF household by month and wellbeing.

Time spent (hr/capita/week) carrying out agriculture activities was affected significantly ($P<0.05$) by month. Agricultural activities peaked in the month of May for all well-being groups (Figure 4.5). However, during the months of July and August better-off households spent more time on agricultural activities compared to other groups. This was due to the tendency for better-off households to maximise their land use for *amon* cultivation (Table 4.2).

Table 4.2: Land (ha) cultivated during boro and amon season for rice production

Well-being group	*Boro* season	*Amon* season	Increased land in *amon* season
Poor	0.28	0.37	0.09
Medium	0.64	0.72	0.08
Better-off	1.42	1.87	0.45

There was no significant difference between RF and NRF households in time spent carrying out agricultural activities in the months of May, September, January and April.

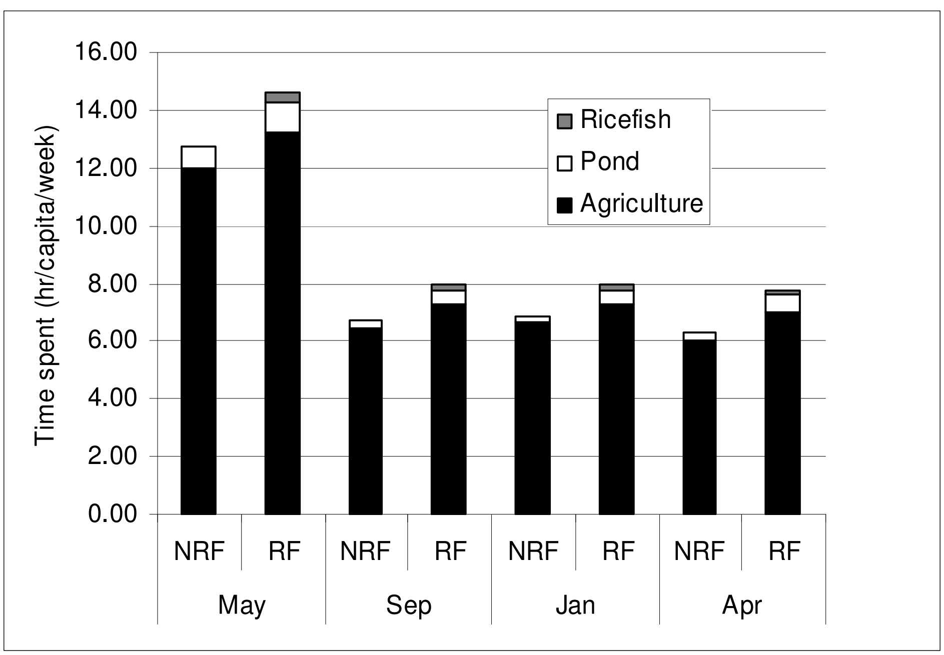


Figure 4.6: Average time spent (hr/capita/week) for ricefish and other agricultural activities by farmer type and month.

The time spent on agriculture together with fish seed production activities did not show any significant difference between RF and NRF farmers in the four survey months (Figure 4.6).

Activities in fish seed producing riceplot

Activities carried out in fish seed producing riceplots have been categorized as follows: plot preparation; plot management (look after plot, fertilization, letting additional water out during rainfall, water supply and weeding); stocking of common carp eggs, tilapia brood and other fish fry; rice harvest; and fingerling harvest. The different activities related to direct fish seed production activities such as stocking of common carp eggs/tilapia brood/other fish fry and fingerling harvest together in a ricefish plot took 17% of total time (Figure 4.7).

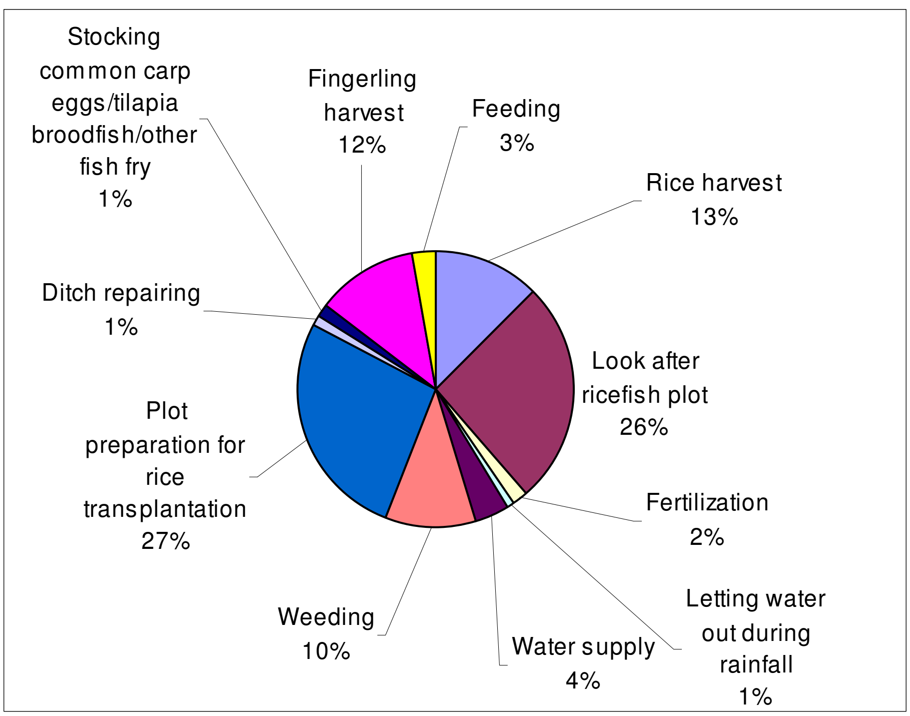


Figure 4.7: Percent time (hr/capita/week) utilization for different activities in fish seed production plots.

The average time (hr/capita/week) spent carrying out fish seed production activities in riceplots was significantly ($P<0.05$) affected by month. The time spent peaked in the months of May, July, November and February, when the poor spent more time compared to intermediate and better-off households (Figure 4.5).

Pond aquaculture

Pond based activities in farm households were: pond preparation, pond management and pond harvest. Activities related to pond management required the highest amount of time (56%) followed by pond harvest and pond preparation (Figure 4.8). Pond harvest consumed a remarkable percentage of overall time possibly related to frequent intermediate harvest of fish by household members typically using a cast net. RF households tended to use cast nets which are easy to operate and effective fishing gear for catching fish from ponds (Chapter 3).

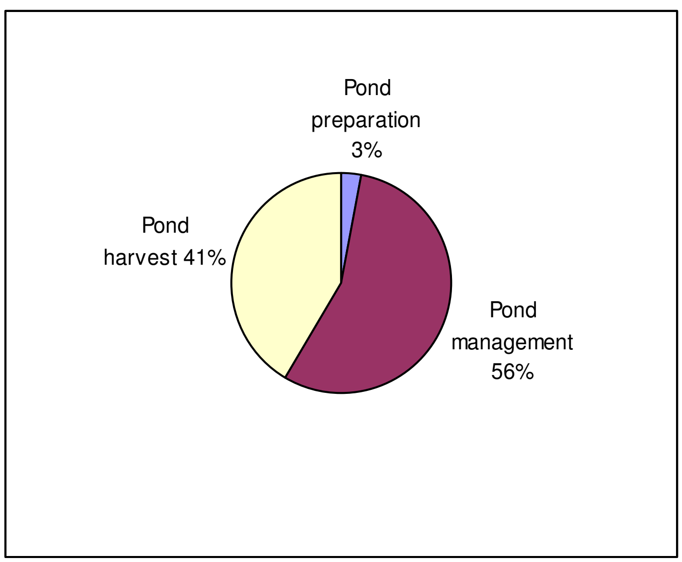


Figure 4.8: Percent utilization of time (hr/capita/week) for different activities of pond culture.

The average time spent (hr/capita/week) carrying out pond culture activities in RF households was found to be affected by month and well-being. The time spent in pond culture activities peaked in the months of May, June and October (Figure 4.5). A significant difference (P<0.05) was found between the RF and NRF farmers in terms of time spent on pond culture activities. The time spent by RF households was found to be 56% higher compared to NRF households (Figure 4.6). This finding suggests that RF farming households were more likely to improve their pond culture compared to NRF farmers. The tendency of RF households to improve pond culture could be explained by their access to fingerlings produced on-farm level, which in turn influenced them to intensify management of their pond culture systems.

Homestead level re-productive activities

There are different types of homestead level re-productive activities carried-out which include cooking and serving food to household members; washing and cleaning; childcare; rice processing (boiling, drying and cleaning of rice); construction and repairs; fuel collection and preparation (e.g. leaf litter collection, cow dung stick making etc.); care of the sick and aged; and making household goods (e.g. handicraft *katha* - blanket making). Among the various activities, cooking food and serving, as well as washing and cleaning consumed the major proportion of the total time (Figure 4.9).

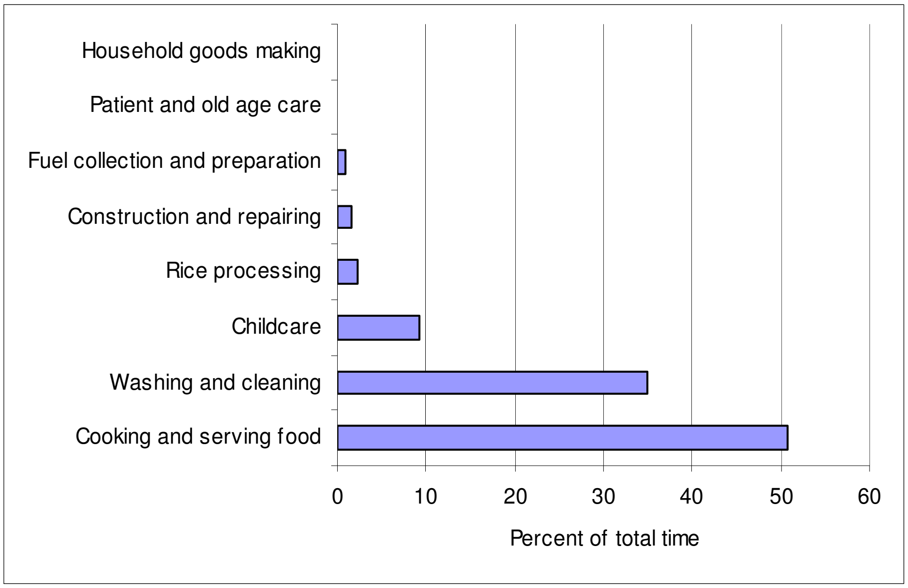


Figure 4.9: Percent of time (hr/capita/week) used for homestead level reproductive activities in RF households.

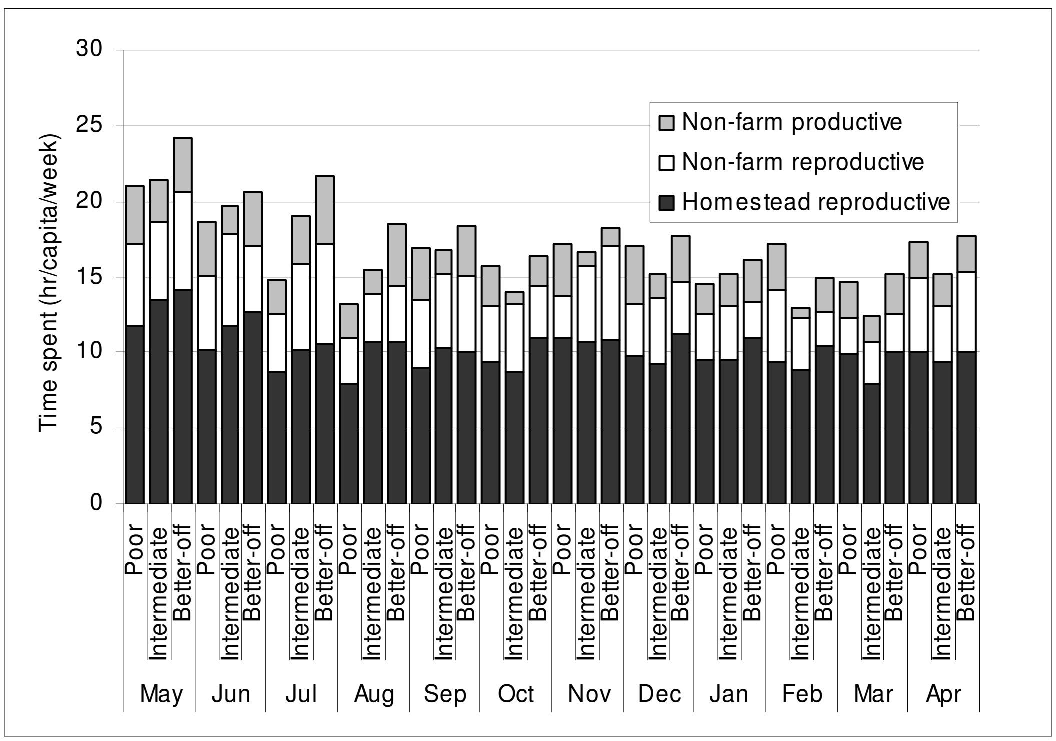


Figure 4.10: Average time spent (hr/capita/week) for homestead re-productive, non-farm reproductive and non-farm productive activities in RF household by month and well-being.

Average time spent (hr/capita/week) carrying out homestead level reproductive activities was affected by month but not by well-being. The average time spent across all well-being groups was found to be greatest in the months of May and November (Figure 4.10).

A significant difference (P<0.05) was found between the RF and NRF households in terms of time spent carrying out homestead level re-productive activities. RF farming households spent relatively more time every month, possibly due to the larger household size compared to NRF households. Time spent peaked in the month of May in both types of farming households (Figure 4.11).

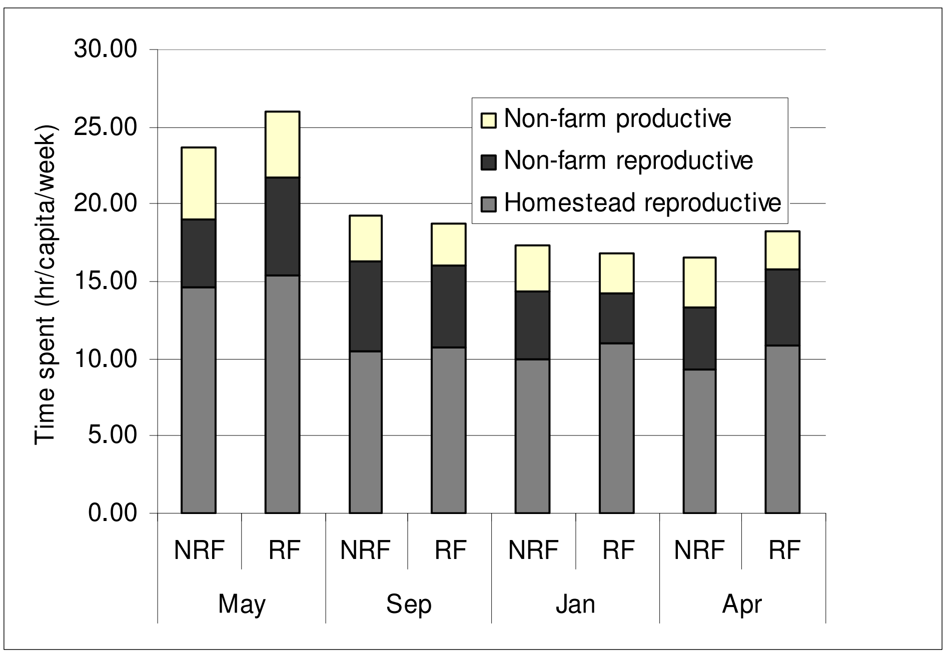


Figure 4.11: Time spent (hr/capita/week) for homestead re-productive, non-farm reproductive and non-farm productive activities by month and farmer type.

Non-farm re-productive and productive activities

Of the total time spent on non-farm activities, the major portion (60%) was used for re-productive activities including, visiting relative/neighbour's house, schooling, shopping, recreation (watching television, listening song to cassette player & radio and gossiping etc.), marketing, official work, treatment as well as other minor activities (Figure 4.12). The remaining 40% of the time was used for productive activities such as service (teaching in primary, secondary, college, and madrasha; engineer, NGO activists etc.), business, labouring and petty service (employee in shop, mill, and office peon).

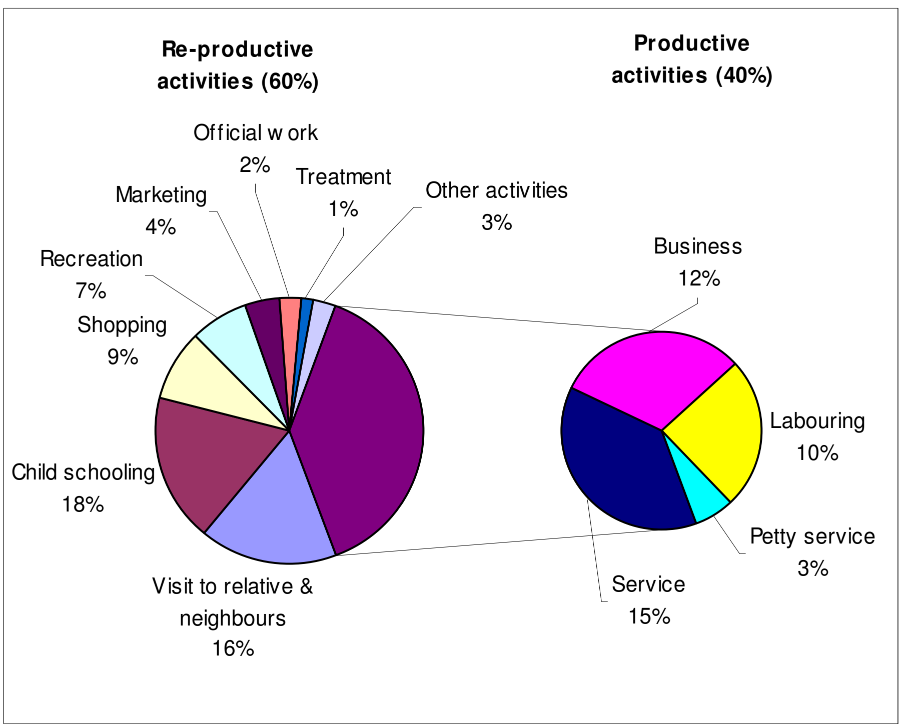


Figure 4.12: Percent of time (hr/capita/week) used in different non-farm re-productive and productive activities.

In terms of non-farm reproductive activities in RF households, the average time spent (hr/capita/week) was affected by month but not by well-being (Figure 4.10). The average time spent on non-farm reproductive activities was also affected by month and farmer type (Figure 4.11). In terms of non-farm productive activities in RF households, time spent (hr/capita/week) was not affected by month but by well-being (Figure 4.10). Time spent on non-farm productive activities was also varied by month and farmer type (Figure 4.11).

4.3.2 Fish seed production in riceplot and its associated usages

Total production of fish seed/fingerling (kg/capita/week) was affected significantly (P<0.05) by month. The production of better-off farmers was relatively higher than the medium and poor farmers. Weekly per capita seed/fingerling sale (kg) was affected significantly (P<0.05) by month but not by well-being. The amount of fingerlings consumed was found to be affected significantly (P<0.05) by month and well-being (Figure 4.13). The amount of fish seed (kg/capita/week) restocked and gifted was also significantly (P<0.05) affected by month but not by well-being.

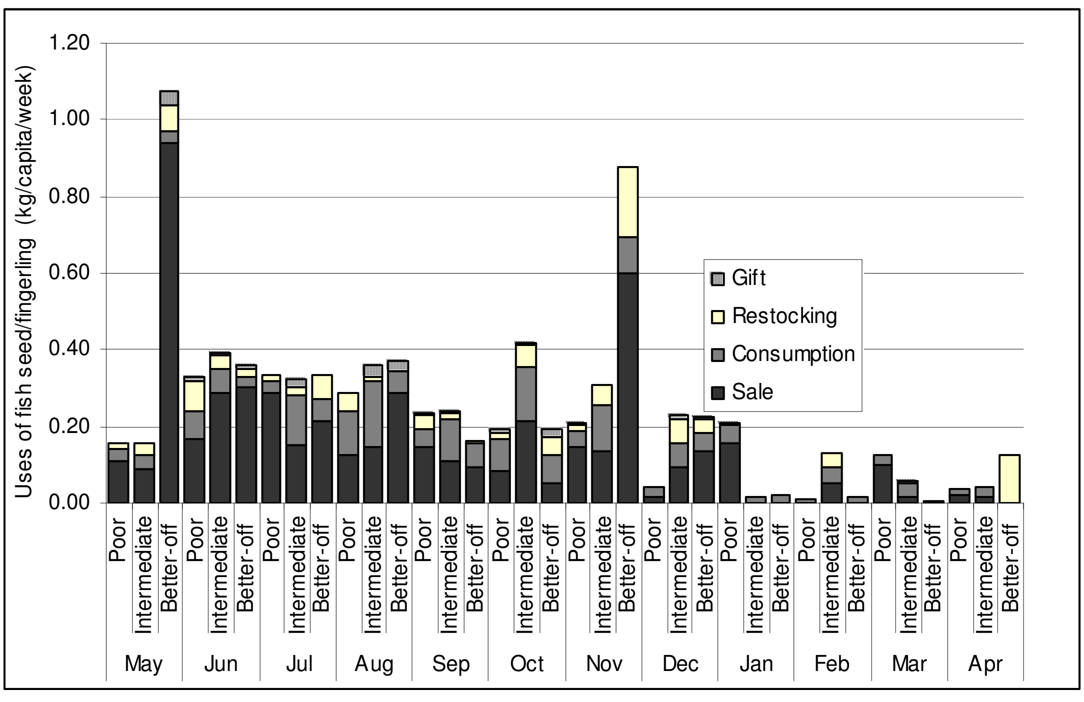


Figure 4.13: Usages of fish seed/fingerling (kg/capita/week) in RF households by month and well-being.

Higher production in better-off households in the months of May and November was due to particularly a large harvest by 2 better-off farmers in these months (Figure 4.14).

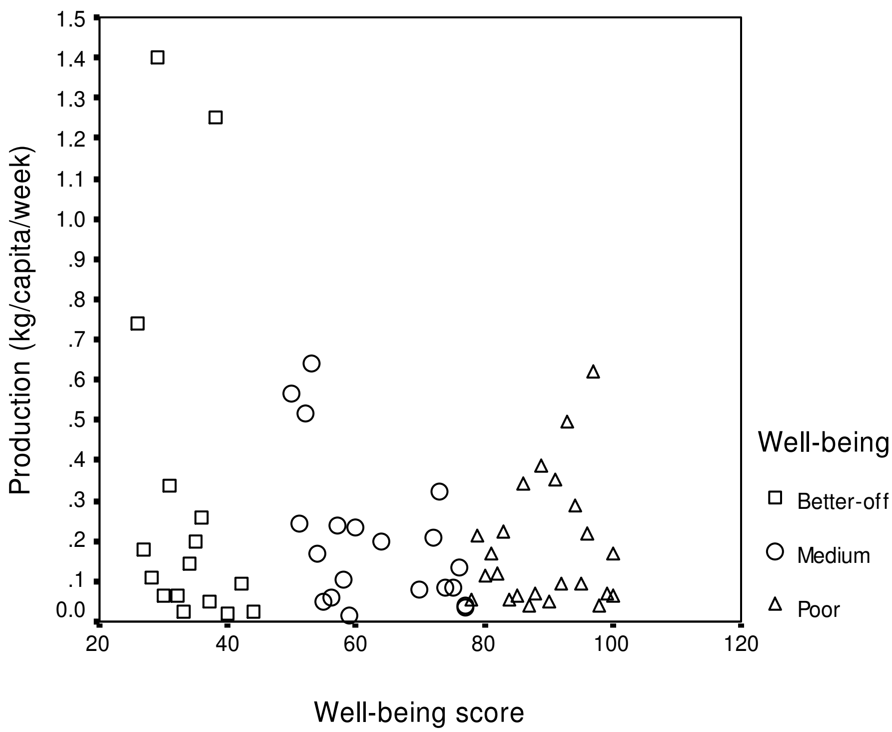


Figure 4.14: Scatter plot showing distribution of fingerling production (kg/capita/week) by well-being.

4.3.3 Income and expenses

Household level income

Rice sales dominated household total incomes (US$/capita/week) in intermediate and better-off RF households earning 40.72 and 44.44% respectively, but were less than 20% in poor households. Poor households had more diversified income sources where RBFSP contributed more (4.64%) to their overall income compared to intermediate and better-off households (Table 4.3).

Table 4.3: Percent contribution of income (US$/capita/week) from different sources by well-being

Income sources	Poor		Intermediate		Better-off	
	Mean	% of total	Mean	% of total	Mean	% of total
Fish seed	0.14±0.49	4.64	0.12±0.49	2.71	0.20±1.30	3.17
Rice sale	0.57±1.89	18.87	2.13±1.64	40.72	2.80±4.02	44.44
Service	0.43±0.18	14.24	1.01±2.17	22.85	0.67±1.74	10.63
Business	0.45±1.04	14.90	0.31±1.07	7.01	0.73±2.54	11.58
Other off-farm sources	0.58±1.41	19.21	0.28±0.95	6.33	0.33±1.63	5.23
Livestock sources	0.40±1.06	13.25	0.41±1.07	9.28	0.65±1.52	10.31
Pond	0.24±0.89	7.95	0.24±0.67	5.43	0.61±1.15	9.68
Vegetable	0.12±0.30	3.97	0.14±0.61	3.17	0.18±0.28	2.85
Other on-farm sources	0.09±0.74	2.98	0.11±0.48	2.49	0.13±0.52	2.06
Total income	3.02±1.85	100	4.42±2.01	100	6.30±2.63	100

Percentage of income is shown by column; service includes both government and non-government services; other ff-farm activities include day labour for agriculture activities, part-time labour in rice mill etc.

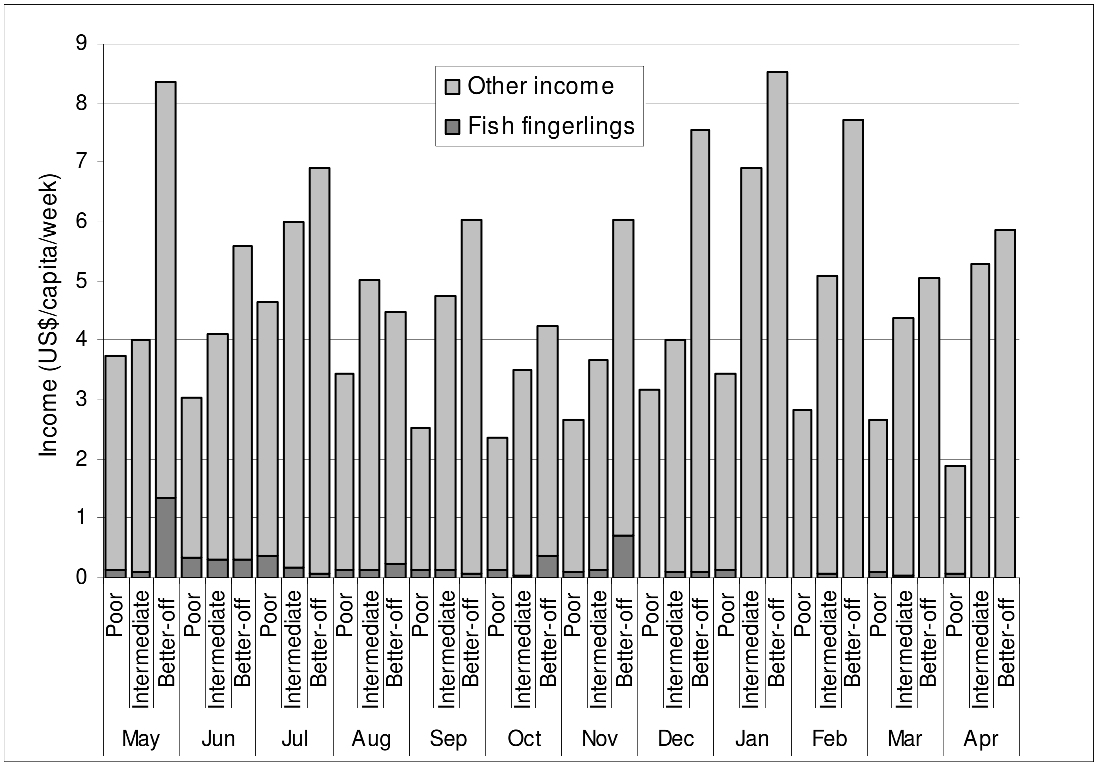


Figure 4.15: Average income (US$/capita/week) of RF households by wellbeing and month.

Average total income (US$/capita/week) in RF households was affected significantly ($P<0.05$) by month and well-being (Figure 4.15). Overall, incomes peaked between the months of December to February and from June to August. Income from fish seed (US$/capita/week) was affected significantly ($P<0.05$) by month as well as month and well-being combined. Contribution of the income from fish seed production to the total income of poorer households was found to be higher in the months of June and October. In terms of farmer type (RF and NRF farmer) and month (four survey months) income (US$/capita/week) did not differ significantly. However per capita income in RF households was relatively higher than NRF household incomes.

Income from rice sales was significantly affected by month and well-being in the RF households. Income from selling fingerlings appeared to protect distress sale *boro* rice in the months of May and June (Figure 4.16).

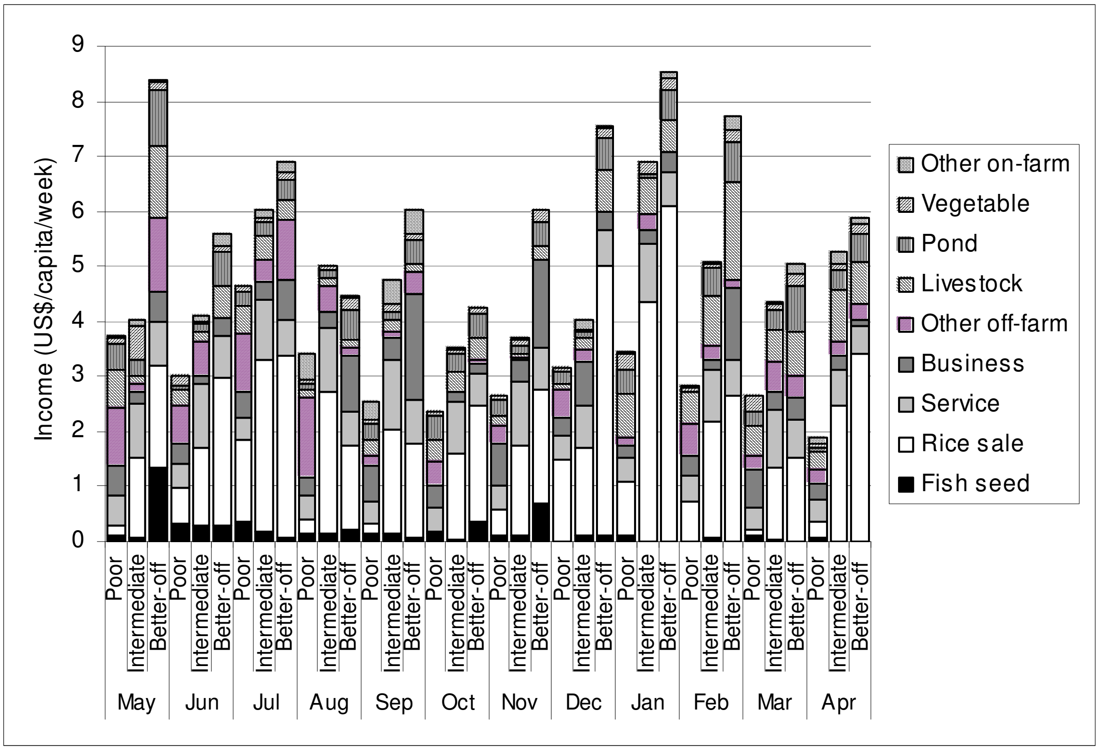


Figure 4.16: Household level income (US$/capita/week) from different sources by month and well-being.

Expenditure

Food consumption incurred the highest expenditure in poorer RF households, whereas purchased agricultural inputs incurred the highest expenditure in medium and better-off households (Table 4.4).

Table 4.4: Average and percentage share of expenditure (US$/capita/week) in fish seed producing (RF) households from different sources by well-being

Income sources	Poor		Intermediate		Better-off	
	Mean	% of total	Mean	% of total	Mean	% of total
Agriculture crops	0.51±1.17	18.81	0.85±1.46	27.41	1.28±1.28	29.83
Food	0.64±0.32	23.61	0.63±0.28	20.23	0.69±0.49	16.08
Clothing	0.17±0.28	6.27	0.18±0.25	5.80	0.27±0.44	6.29
Education	0.11±0.23	3.05	0.13±0.26	4.19	0.24±0.44	5.59
Housing	0.21±1.10	7.74	0.25±1.09	8.06	0.36±2.27	8.39
Kerosene/ electricity	0.05±0.05	1.84	0.05±0.05	1.16	0.07±0.17	1.63
Festival	0.10±0.18	3.69	0.16±0.50	5.16	0.22±1.01	5.12
Health treatment	0.13±0.28	4.79	0.16±0.26	5.16	0.25±0.47	5.82
Livestock	0.07±0.40	2.58	0.09±0.51	2.90	0.11±0.56	2.56
Pond	0.10±0.46	3.69	0.11±0.31	3.54	0.19±0.32	4.42
Credit repay	0.25±0.97	9.22	0.16±0.95	5.16	0.27±1.01	6.29
Other	0.40±1.99	14.76	0.39±1.17	12.58	0.41±1.61	9.56
Fish seed	0.011±0.004	0.38	0.008±0.003	0.24	0.013±0.006	0.30
Total	2.75±0.57	100	3.16±0.54	100	4.37±0.77	100

Percentage of expenditure is shown by column

Expenditure incurred for the production of fingerlings was less than that for kerosene and electricity for all well-being groups. This was comparatively the lowest item of expenditure in farming households.

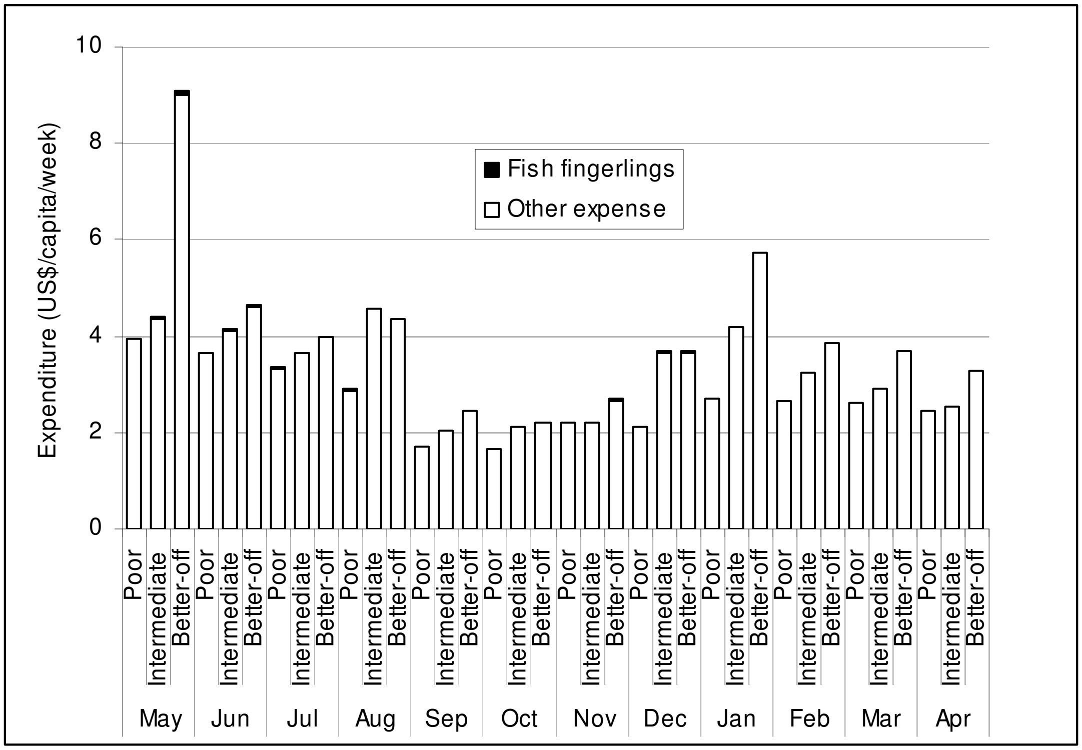


Figure 4.17: Expenditure (US$/capita/week) in seed producing household by month and well-being.

Overall, the total household expenditure (US$/capita/week) was affected significantly ($P<0.05$) by month and well-being (Figure 4.17). Weekly per capita expenditure peaked in the months of May, June, July and January. Expenditure related to fish seed production was found to be very lower compared to overall expenditure in farming households. Overall expenditure (US$/capita/week) in RF household was relatively higher than in NRF households.

The greatest expenditure of a farmer's income was towards agriculture and was significantly affected by month and well-being. Expenditure for health treatment and social/ceremonial purposes was found to be higher in the months of May to August and December to March (Figure 4.18).

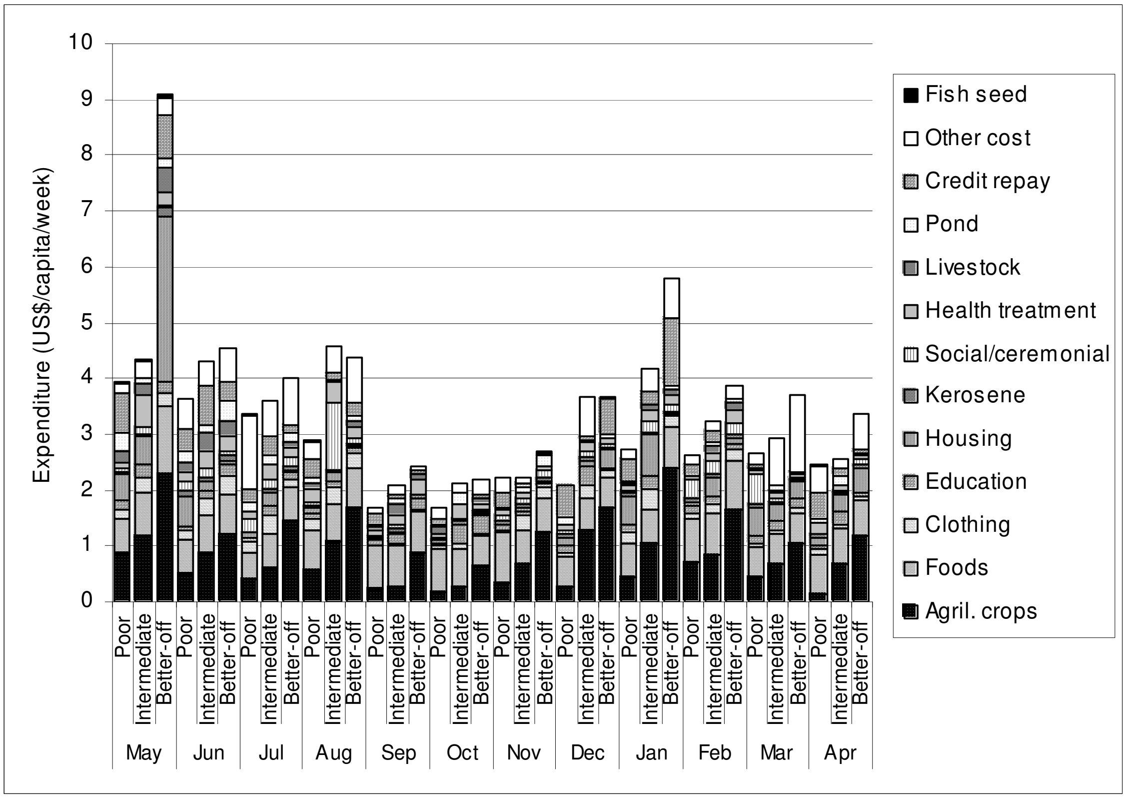


Figure 4.18: Different expenses (US$/capita/week) in RF households by month and well-being.

4.3.4 Consumption of food

4.3.4.1 Fish consumption

Total average fish consumption (g/capita/week) in RF households was found to be 407±12.48 g/capita/week. Average total fish consumption (g/capita/week) was affected significantly ($P<0.05$) by month and well-being. Fish consumption in better-off households was higher than in medium and poorer households. Consumption of fish peaked in August to September but was lowest in March to April.

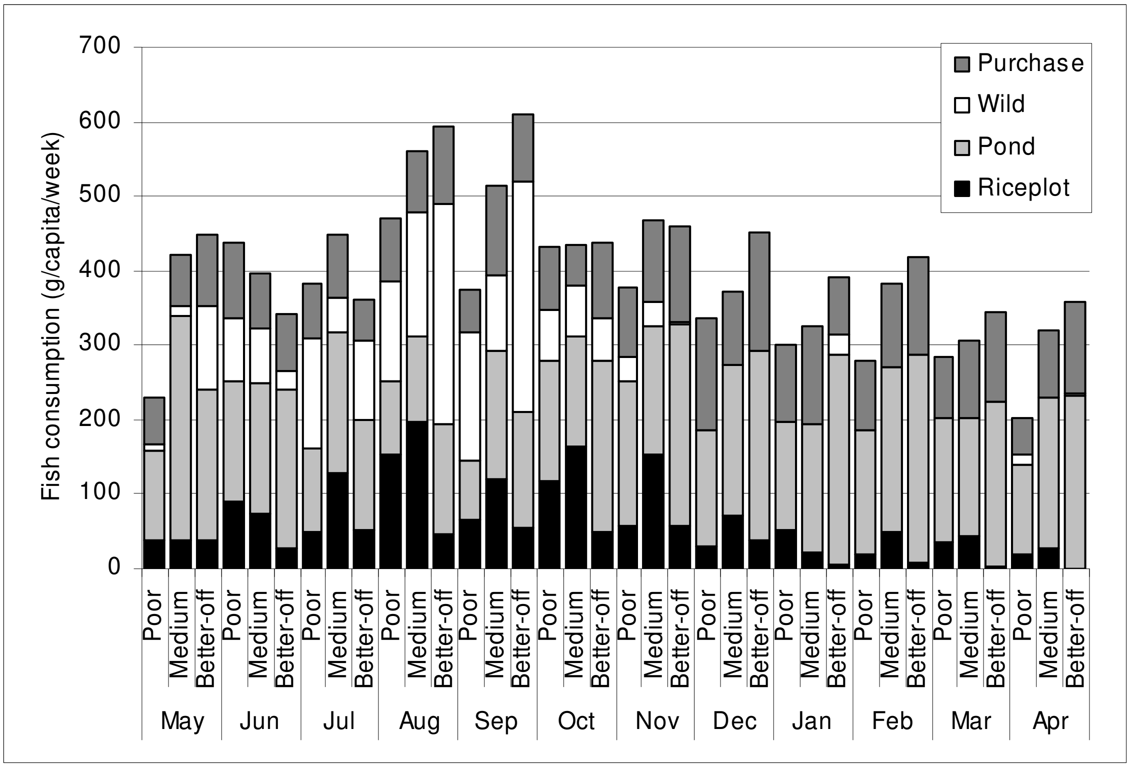


Figure 4.19: Fish consumption (g/capita/week) in RF households from different sources by month and well-being.

Consumption of fish (g/capita/week) caught in the RF plot was affected by month and well-being. Weekly per capita fish consumption of the poor (60.22±7.03g) and intermediate (90.43±11.23g) households was found to be higher than for better-off farmers (31.47±5.09g). Poorer farmers appeared to consume fish from their riceplots in the months of March, April and May while total fish consumption was lower in those months (Figure 4.19). In these months consumption of fish from wild sources was very limited suggesting that the contribution of the riceplot was very important for the poor households compared to other months. Consumption of fish (g/capita/week) from on-farm ponds was affected by well-being and was relatively higher in better-off households than in other well-being groups.

Month and well-being significantly affected (P<0.05) the consumption (g/capita/week) of fish from wild sources. About 56% of total wild fish was consumed in the months of August and September. Better-off farmers consumed more fish from wild sources followed by poor and medium farmers. Consumption of purchased fish was significantly (P<0.05) affected by well-being where the better-off households consumed higher amounts.

Overall fish consumption (g/capita/week) was affected (P<0.05) by farmer type and month. RF farmers consumed significantly more fish than NRF farmers.

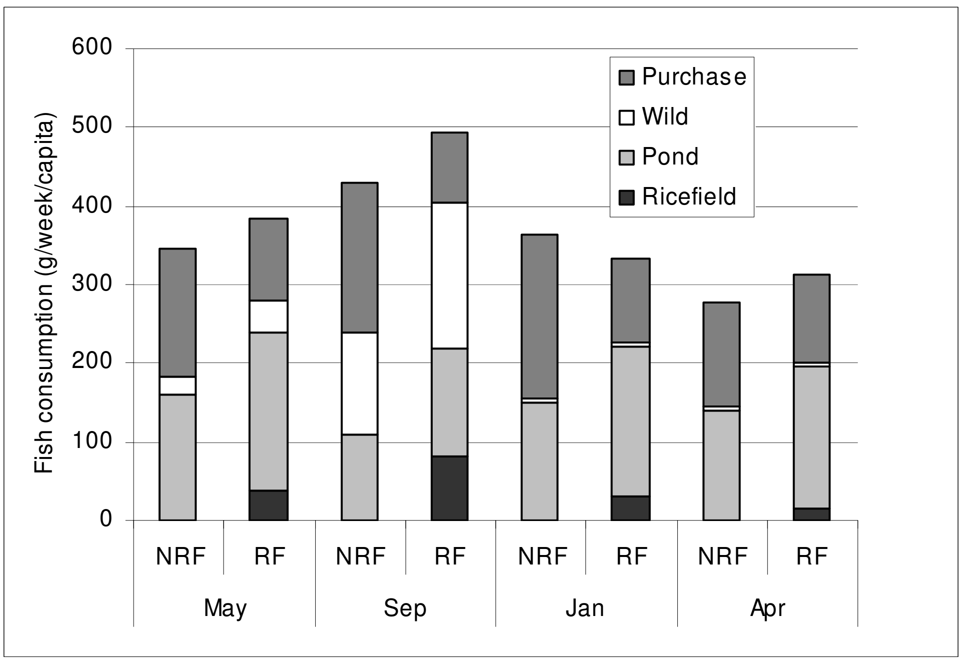


Figure 4.20: Fish consumption (g/capita/week) in farming households from different sources by month and farmer type.

Fish consumption from wild sources was significantly affected by month. Consumption of fish (g/capita/week) differed significantly (P<0.05) between RF and NRF farmers from both ponds and market sources (Figure 4.20). RF farmers consumed a higher amount of fish than NRF farmers from household ponds and vice versa from the market.

The tendency for NRF farmers to consume purchased fish suggests that they used more of their disposable income for this purpose.

4.3.4.2 Rice consumption

As a whole in the RF farming households, 93% of the rice consumed derived from their own farm and the rest was purchased from the market. Better-off households met a relatively higher proportion of their subsistence needs.

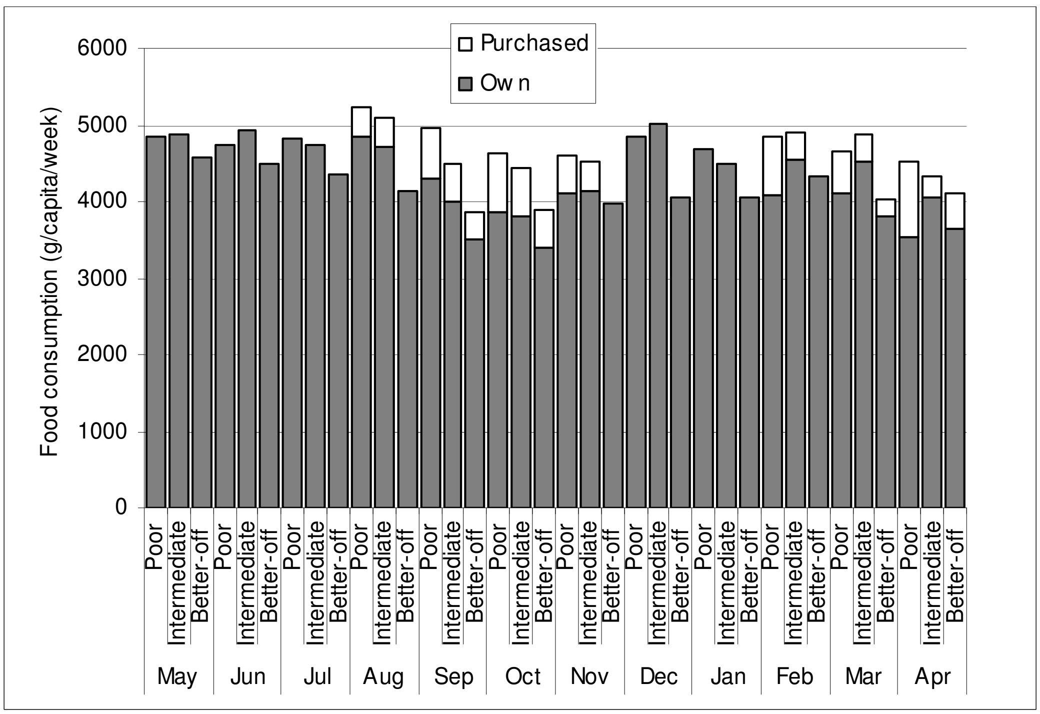


Figure 4.21: Average rice consumption (g/capita/week) in RF households by month and wellbeing.

Although rice consumption (g/capita/week) did not differ significantly between the well-being groups, it tended to be higher in poorer households (4794.57±1946.88) compared to intermediate (4711.84±1689.51) and better-off (4154.69±1013.62) households. Although variation was insignificant in rice consumption (g/capita/week) by month, a little peak was observed during the summer months from May to August irrespective of well-being groups (Figure 4.21). Poor and intermediate households purchased rice from the market in the months of August, September, October, November, February, March and April. There was no significant difference between RF and NRF households in terms of rice consumption (g/capita/week).

4.3.4.3 Vegetable consumption

Regarding sources of vegetables for consumption, 85% of vegetables were sourced from the farmer's own-land and the rest (15%), from market sources. Vegetable consumption (g/capita/week) was significantly affected by month and well-being. Average vegetable consumption (g/capita/week) in RF households was 1780.1±1387.4. Vegetable consumption (g/capita/week) was significantly higher in intermediate (1934.4±1463.8) and poorer (1873.7±1524.8) households than better-off (1449.1±967.8) households.

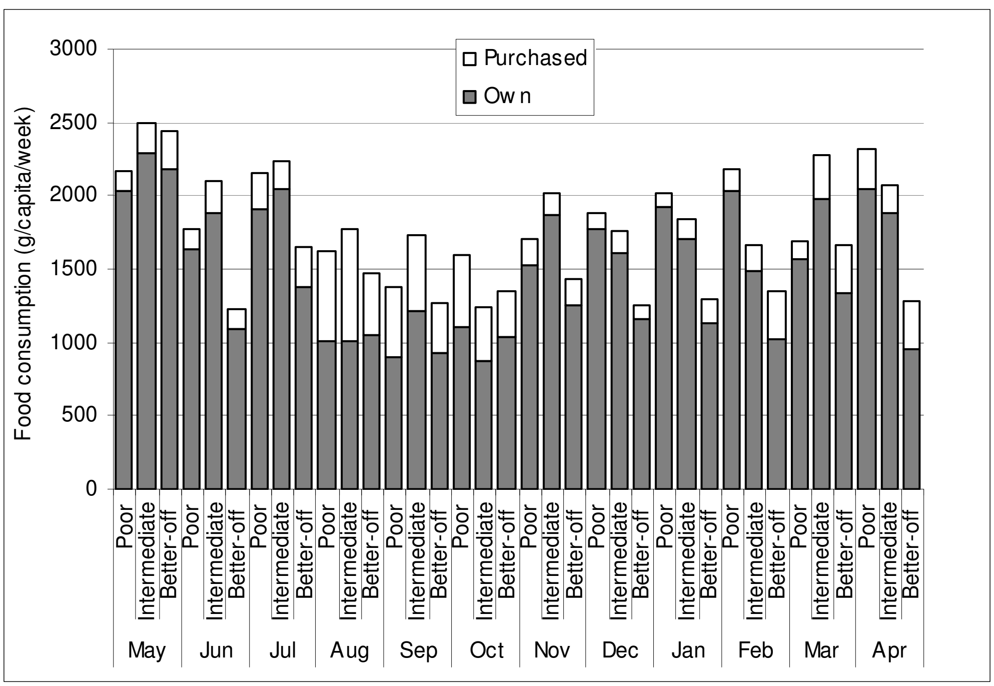


Figure 4.22: Vegetable consumption (g/capita/week) of RF farmer by month and well-being.

An increasing trend in vegetable consumption was apparent from the month of November and continued until May (Figure 4.22). During this period poor and medium households tended to consume more vegetables. Households of all well-being groups purchased more vegetables from July to October. Vegetable consumption (g/capita/week) from on-farm and market sources differed significantly between RF and NRF households. RF households tended to consume more vegetables from their own sources than NRF households. Seasonality significantly (P<0.05) affected total weekly per capita vegetable consumption (Figure 4.23).

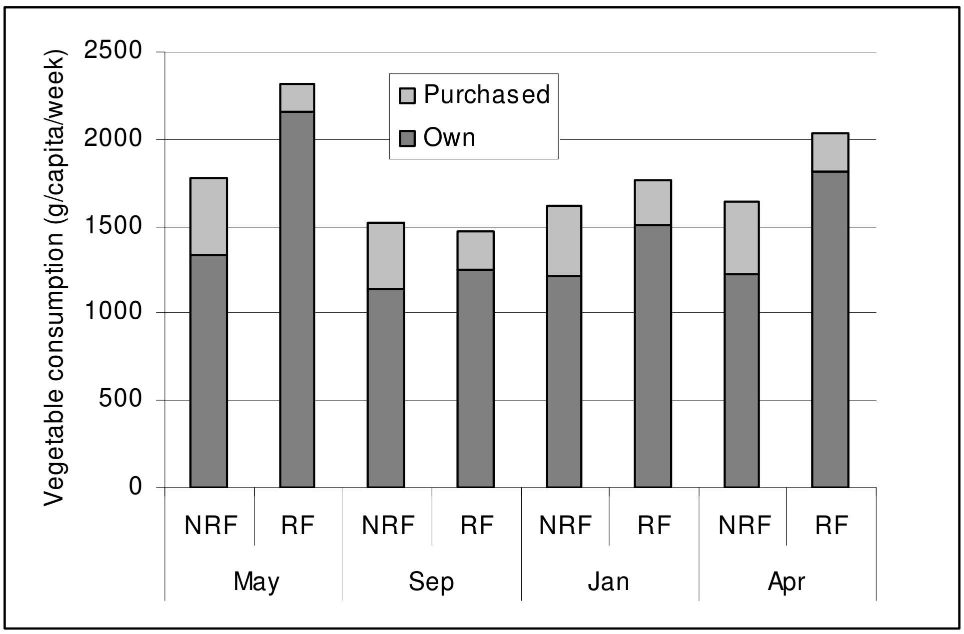


Figure 4.23: Vegetable consumption (g/capita/week) by month and farmer type.

4.3.4.4 Meat and egg consumption

Overall 41% of meat and eggs were derived from on-farm sources and the remaining 59% were purchased from market sources. The average meat and egg consumption in RF households was 115.32±5.60 g/capita/week and was affected significantly (P<0.05) by month and well-being (Figure 4.24). Better-off farmers tended to consume more meat and eggs compared to medium and poor farmers.

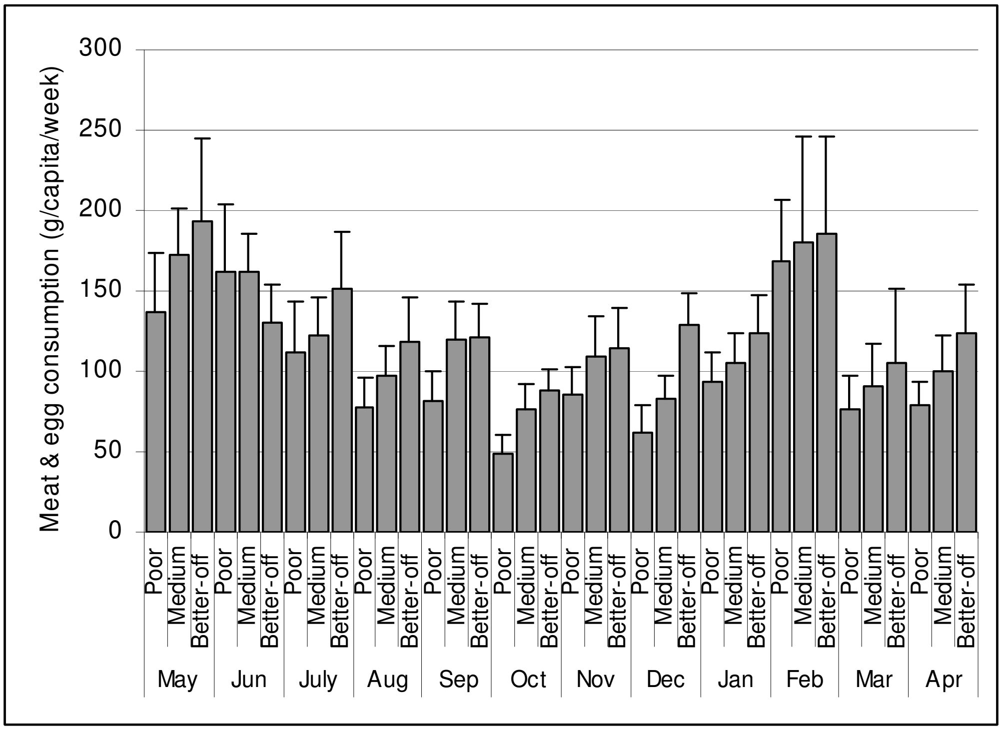


Figure 4.24: Meat & egg consumption (g/capita/week) in RF households by month and well-being.

Average meat & egg consumption for the NRF (130.14±13.38 g/capita/week) households was relatively higher than for RF households (114.71±7.93 g/capita/week) over the survey months (Figure 4.25).

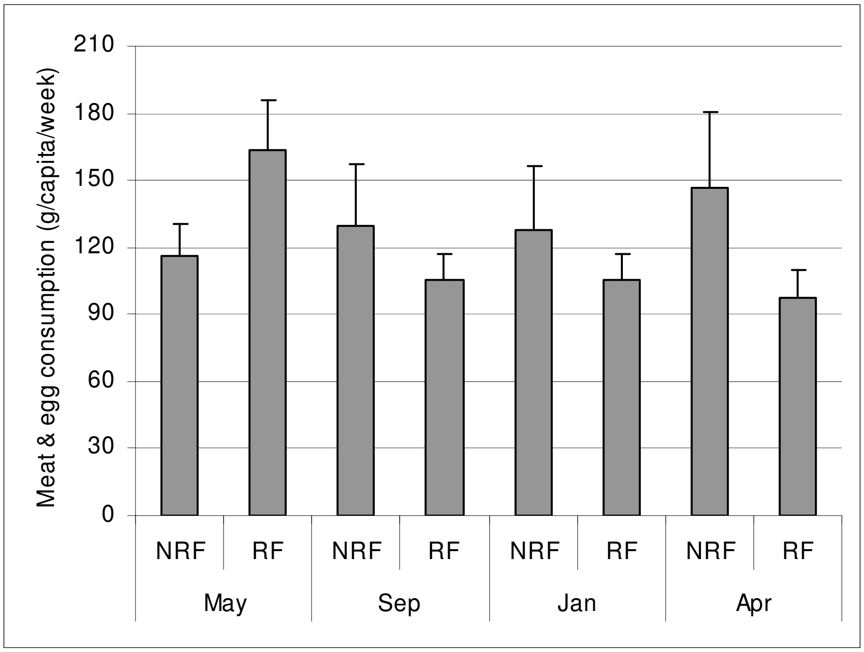


Figure 4.25: Meat & egg consumption (g/capita/week) in farming households by month and farmer type.

4.3.4.5 Pulse consumption

Average pulse consumption (g/capita/week) in RF households was 37.13±2.41. Pulse consumption was affected significantly ($P<0.05$) by well-being with medium and poor farmers consuming more pulses than better-off farmers.

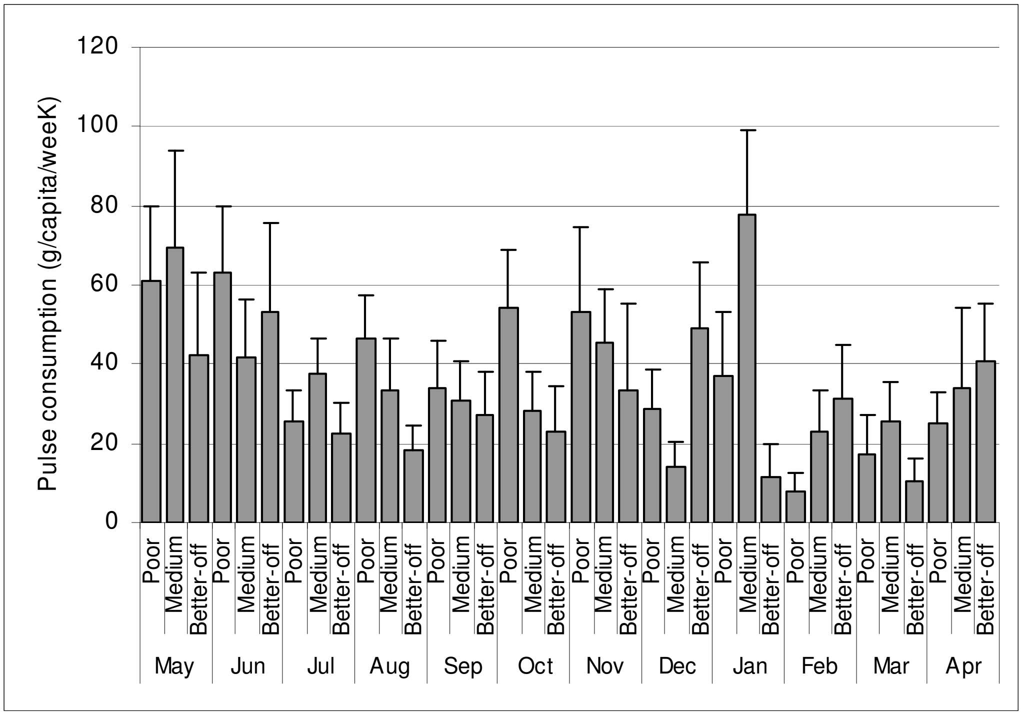


Figure 4.26: Pulse consumption (g/capita/week) in RF households by month and well-being.

Pulse consumption peaked in the months of May and June and declined in the months of February and March (Figure 23), and pulse consumption was affected significantly (P<0.05) by month. Pulse consumption also differed significantly between RF and NRF farmers. Average RF farmer's (43.1±4.5) consumption of pulses (g/capita/week) was (35%) less than for NRF farmers 66.1 ± 5.1 (Figure 4.27).

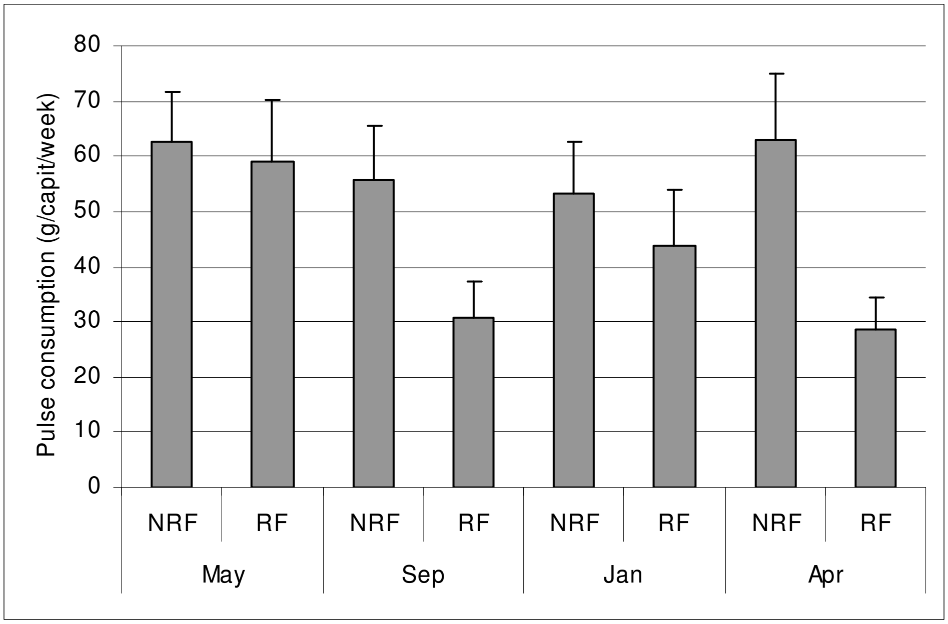


Figure 4.27: Pulse consumption (g/capita/week) in farm households by month and farmer type.

Overall rice and vegetable consumption (g/capita/week) was higher in poor and medium households compared to better-off households. The opposite was found for fish, meat and egg consumption.

4.3.5 Health condition

Sickness (days/capita/week) in RF faming households was affected by month with peaks in June, October and November but not by well-being (Figure 4.28). Sickness was not however affected by farmer type. Poorer and intermediate RF households tended to be affected by respiratory problems including asthmatic disorder, pneumonia, influenza and other diseases at the beginning of winter in November. They were also found to be more affected by dysentery and diarrhoeal diseases than better-off households. Women in poor and intermediate households were more affected by female diseases than in better-off households. Female diseases were not discussed in detail with the respondents. Other diseases/disorders including weakness, gallbladder stones, jaundice, ear problems, eye problems, dental problems etc. also affected household members.

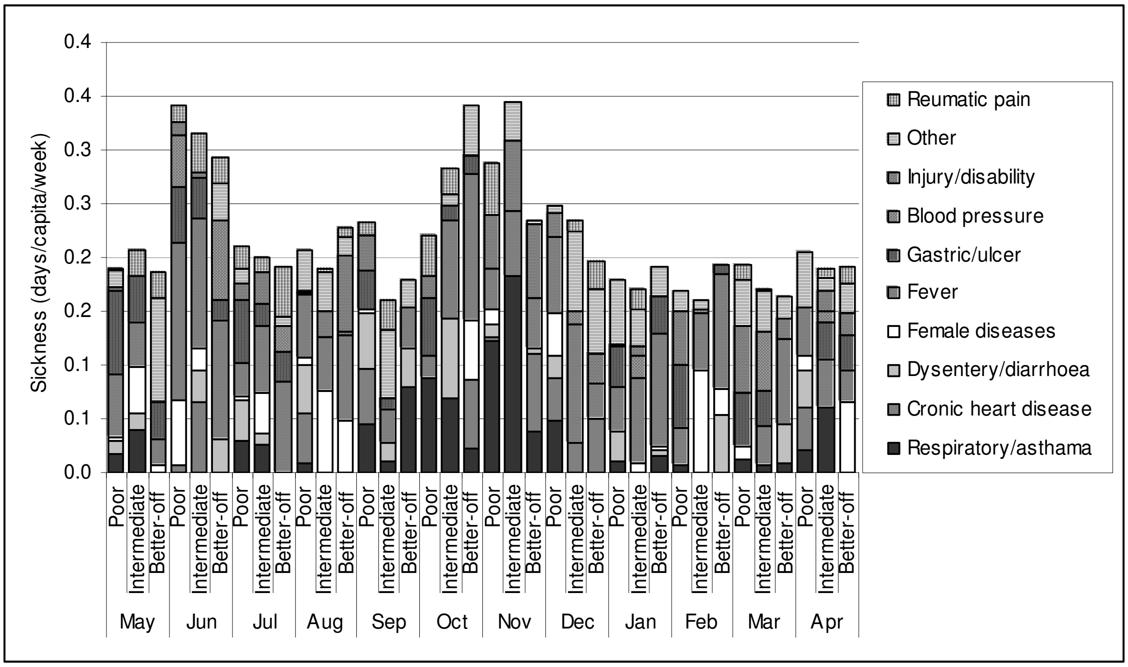


Figure 4.28: Average sickness (days/capita/week) in RF farming households by month and well-being.

4.3.6 Correlation between income and other factors

Correlation analysis between income and activity, expenditure and food consumption related factors showed several positive relationships (Table 4.5). In terms of productive activities, the correlation with income was found to be positive but not significant. Income and expenditure were found to be significantly (P<0.05) correlated. Fish consumption from a household own pond and through purchase were positively correlated with income. Interestingly, the correlation between income and the amount of meat and eggs consumed was positive and highly significant (P<0.05).

Table 4.5: Correlation co-efficient between income and other factors

Factor	Correlation coefficient ('r' value)	Level of significance
Agriculture activity	0.042	
Pond culture activity	0.175	
Ricefish activity	0.022	
Non-farm productive activity	-0.049	
Non-farm reproductive activity	0.980	**
Homestead activity	0.064	
Expenditure	0.183	*
Rice consumption	0.109	
Fish consumption (riceplot)	0.045	
Fish consumption (wild)	0.038	
Fish consumption (pond)	0.025	*
Fish consumption (purchase)	0.033	*
Fish consumption total	0.002	
Meat & egg consumption	0.810	**
Pulse consumption	0.028	
Vegetable consumption	0.040	
Health (sickness days)	0.043	

*Correlation is significant at 0.01 level.

** Correlation is significant at 0.05 level.

4.4 Discussion

In the present study, longitudinal data has been used to understand the behaviour of livelihood characteristics on farm households practicing RBFSP activities and livelihood outcomes. Longitudinal household data can have considerable advantages for social science analysis over more widely available cross-sectional data. Longitudinal data enables researchers to trace the dynamics of behaviours; identify the influence of past behaviours on current behaviours; and controlling for unobserved fixed characteristics in the investigation of the effect of time-varying exogenous variables on endogenous behaviours (Alderman et al. 2001). As a result, advantages of the use of longitudinal data are increasingly appreciated.

4.4.1 Activities

Agricultural activities

The present study shows that household level activities were carried out through team work whereby household members performed different activities or the same activity to different extents. Typically household activities are carried out within an approach of specific institutional arrangements (Kabeer, 1994). In a household economy, a person (typically a husband of wife at the same time a father of children) is the household head ruling to ensure welfare for all household members simplifying the nosiness and messiness of intra-household relationships at the community level (Kabeer, 1994).

Bangladesh remains a highly labour-intensive economy where the majority of people subsist directly as a result of their immediate family’s physical labour. Household labour utilization is for both productive and reproductive activities (Cain, 1991). In terms of productive activities, rice cultivation is the main and most labour intensive activity in agricultural farming (Rasul and Thapa, 2004). In rice cultivation the *amon,* rainfed rice was traditionally the main crop, but *boro* (irrigated rice) rice has become more important over the last decade due to the introduction of high-yielding rice varieties and modern irrigation technology (Tetens et al. 2003). According to the present study, farmers cultivated a smaller land area in *boro* than in the *amon* seasons however, *boro* was more important with respect to its higher production cost, expected yields and use of its income in the following *amon* season (Gill, 1991). During *boro* rice harvest, household members spend time exclusively to prevent the possible loss of production from the ricefield due to seasonal storms (*kal boishakhi*) and heavy rainfall. In this time farmers are very busy drying rice (mainly by women) and straw (mainly by men) as rainfall causes damage to these products. Sun drying of straw is very important as it contributes about 70-90% of cattle feed in rural areas of Bangladesh (Al-Manun et al. 2002). Time spent transplanting and harvesting by better-off farmers tended to be higher compared to other farmers during the months of *amon*. This was due to the cultivation of a larger area of rainfed *amon* compared to irrigated *boro*.

In the present study, the household head spent the majority of his time carrying out productive activities such as agriculture, pond and fish seed production. The head of the household is defined as the person making the major economic, social and household decisions (Paul, 1998). Apart from the household head, productive activities were also performed by other household members where sons played a dominant role. The higher proportion of labour directed towards productive activities done by household heads and sons suggests these activities or direct income generating activities are still male dominated in rural areas. According to Cain (1991), men monopolise the most remunerative forms of employment although they have to depend on other family members for carrying out various supportive re-productive activities.

Women, particularly the household head's wife were found to dominate the performance of reproductive activities within their homestead where preparation of food and serving of other family members was the main labour intensive activity. According to Cain (1991) housekeeping activities are not directly productive and these include activities such as cooking food and serving, cleaning and sweeping the house and compound, washing clothes and shopping, and caring for young children. In contrast, most productive activities generating income directly takes place away from the homestead, a major consequence of this specialization is that in typical households men are primary income producers (Cain, 1991). In rural areas, women do not go away from the homestead (e.g. market) because of the strictures of *purdah* (seclusion) (Cain et al. 1979). Women however, can carry out productive activities that typically take place in and around homesteads (e.g. homestead gardening). Women in the present study were found to participate in RBFSP activities due to the close proximity of fish seed producing plot to their homesteads (Chapter 3).

Apart from household heads and wives, sons and daughters were also found to participate in different household level activities. In the preceding chapter (Chapter 3), a pyramidal population distribution showed the availability of both male and female children under the age of 20 in farming households. Cain (1977) reported that rural children of both sexes begin their economically useful lives at around 6 years of age, performing such activities as caring for livestock, gathering fuel, fetching water, carrying messages and caring for younger children. In general, a household with a greater number of economically active members will be in a better position to diversify and exploit multiple sources of income, particularly when, the peak opportunities of different income coincides (Cain, 1977). Incorporation RBFSP activities in farming households appeared to be compatible with the participation of children.

Seasonality of agriculture activities

The annual agricultural cycle results in substantial seasonal variation in the economic activity of both men and women. Seasonal peaks in activity coincide with the harvest and processing of rice crops (Cain et al. 1979). Time spent carrying out agriculture activities was higher in the *boro* season (May) because of its higher level of harvesting and processing activities. However, seasonally RBFSP did not make any significant difference in terms of time required and its integration with other agricultural activities, suggesting this technology did not compete with other productive activities (e.g. *boro*). In terms of monetary input, this technology required little investment and as such it can be termed a low-external input technology (LEIT). A review study done by Tripp (2006) (Tripp, 2006b) revealed that LEIT is often labour and information-intensive. Tripp argues that such characteristics do not necessarily represent the exceptionally diverse nature of LEIT. The external input requirements of LEIT vary according to technology, farming system and farmer experience. For instance in the Philippines, hillside 'soil conservation' by placing crop residues required a great deal of labour, on the other hand 'compost preparation' for soil fertilization in Tanzania required very little labour (Tripp, 2006b).

In the case of pond fish culture, RF farmers spent more time carrying out pond management activities than NRF farmers in every month of observation. This may have resulted from knowledge provided by CARE-FFS training that led them to intensifying management of their pond, increasing time spent in the RF farming households. According to CARE (2001), the technical knowledge of RF culture has also been applied to their pond fish production. This finding indicates that RF households improved the utilization of their resources including household labour, pond, riceplots etc. in a broader spectrum.

Household level labour division is very distinct in the rural society of Bangladesh for socio-cultural reasons. Women are vulnerable in this setting because cultural prescriptions block their access to most of the remunerative forms of employment (Cain, 1991). Women were found to carry out different homestead level reproductive activities over the year including cooking two meals per day, cleaning the house, fetching drinking water, washing cloths, looking after children, taking care of the elderly, collecting biomass for fuel and shaping and drying cowdung cakes, rearing poultry and livestock etc. (Banu and Bode, 2002). Tasks associated with food preparation, including provision of fuel and water, are the most time-consuming types of household maintenance and do not vary seasonally (Cain, 1991). But at crop harvesting time, when rice and other food crops enter the household in raw forms, women spend more time for processing (Cain, 1991). Rice requires (e.g. *boro*) repeated winnowing and drying and during the rainy season paddy must be brought out and dried at every opportunity (Cain, 1991).

In the present study, along with daily activities, women contributed some time to fish seed production activities. The contribution of women to fish seed production was possible due to the location of RF plot in the vicinity of the farming households. Possibly due to this factor, male farmers (Chapter 3) often consider the ‘proximity of the ricefish plot to the household’ as one of the important factors in adoption of RBFSP. Women also reported (Chapter 6) suitability of the riceplot as a facilitating factor for adoption of RBFSP where perception of suitability included proximity of riceplots to the household.

In terms of non-farm productive activities, poorer and better-off farmers tended to spend more time carrying out these activities than intermediate households. The better-off farmers had higher levels of education and better access to non-farm jobs. In contrast, poorer households had fewer farm resources and therefore tended to spend more time in non-farm activities. This suggests that RBFSP might be particularly appropriate for intermediate households who demonstrated relatively higher productivity (kg fingerlings/ha) of fingerling than better-off and poor households respectively (Chapter 3). Similarly Barman (2000) observed that medium well-being households in the same part of Bangladesh tended to be more successful in *hapa* based tilapia seed production than either poorer or better-off households and related this to their greater labour availability on farm.

RBFSP increased on-farm diversification and had impacts over prolonged periods of the year. Poorer farmers were found to sell a greater proportion of the seed they produced compared to better-off farmers with a corresponding longer period of cash flow. The nature of generating cash flow in farm household indicates the strength of RBFSP in the context of the Northwest as one of the poverty prone areas of Bangladesh (Sen, 2003).

On-farm fish seed production in ricefields impacts social relationships of households through gifting seed and foodfish to relatives and neighbours. Gifting fish seed to neighbours and relatives was not restricted to any particular time of the year but occurred several times. The timing of gifting seemed to be associated with visits from relatives during summer fruit growing months (e.g. mango and jackfruit) and on-farm labour requirements from neighbours. The custom of gifting from small to big items (e.g. chicken, sheep) among extended families and households in African countries (e.g. Burkina Faso, West Africa) is noteworthy and contributes to social security systems allowing integration and mutual moral and material support during times of hardship (Prudencio, 1983). Gifting of fish seed and foodfish to relatives and neighbours is likely to contribute to “social smoothing” (Bogard, 2000) in rural communities.

Social/ceremonial costs appeared to peak in the months following rice harvest. This is a time of increased income when marriage ceremonies generally occur in rural communities where farmers are often invited. According to social custom, invitee farmers normally have to purchase gift items to attend the ceremonies and income derived from fingerling sales could possibly contribute towards these expenses.

4.4.2 Income and expenditure

All rural households confront seasonality as an inherent feature of their livelihoods (Chambers, 1982). The production cycles of crop enterprises are determined by many climatic factors including the timing of onset and duration of the rains, the length of the growing season, temperature variation across the calendar year and so on. Seasonal production variation tends to result in uneven agricultural income in farm households. On-farm diversification can contribute to income smoothing, by utilizing labour and generating alternative sources of income in off-peak periods in the traditional farm cycle (Ellis, 2000).

The major source of income in in the research area farming households irrespective of well-being was the sale of rice which peaks twice during the year after *amon* and *boro* harvests. This is particularly important in the Northwest region as a major rice producing region where it is the principal source of income compared to the South-central region where people were reported to depend more on non-agricultural activities (Islam, 2007). In most households, both rich and poor face continual cash flow problems during the year as inputs and expenditure on irrigation, fertilizers, labour etc. occurs at times when cash reserves are already low as a number of months have passed since the previous crop (*amon*) harvest (Cain, 1977).

In the present study, income generated from RBFSP was significantly affected by month and well-being. Households of all socio-economic groups earned additional income immediately after the *boro* harvest when demand for fingerlings peaked among pond fish producers (Barman and Little, 2006) which in turn reduced the necessity for distress sales of rice by seed producing households. Poorer households generated a relatively important amount of income from fish seed in the months of May, September and October relative to their other income sources. These months are recognised as low income months for households in the Northwest as well as other areas of Bangladesh. Poorer sections in Northwest often face the impact of *monga* - a seasonal famine-like situation occurring before the harvest of *amon* almost every year. Traditional agriculture requires counter-seasonal strategies where reliance on crop diversity as means of extending harvesting seasons and spreading out income is very important for sustainable agriculture (Gill, 1991).

Poorer households tend to spend a higher proportion of income on food purchase (e.g. meat & egg, rice and vegetable), which explains their reasons for adopting RBFSP as measure to improve food security. Monthly variation of expenditure in farm households suggests that farmers had to face expenditure smoothing problems. Irrespective of well-being, low expenditure was observed in the months of September, October, November and April following the trend of income. Most people in rural Bangladesh survive on day to day basis (Paul, 1998), hence the lack of savings to see them through lean periods. There was a strong correlation between income and expenditure found in farm households. Since the major source of income is from the sale of on-farm produced rice, any diversified source of income at other periods of the year has a positive impact.

In developed countries, farmers or agricultural systems with sufficient access to inputs, knowledge and skills can produce large amounts of food. Most farmers in developing countries however are not in such a position, and poorer farmers generally lack financial assets to purchase inputs (Pretty et al. 2003). In the present study, apart from providing food directly and some cash-flow, RBFSP did not make large demands for cash at anytime. Expenditure for fingerling production in ricefields was lower than any other expenditure and close to that of kerosene/electricity. Such low expenditure indicates a 'poor friendly' activity - an important characteristic of a LEIT (Tripp, 2006b). In a broader review, many LEITs including soil and water management, soil fertility management, crop establishment and controlling weeds and pests were criticised as labour-intensive technologies (Tripp, 2006a). However it was argued if LEIT does not require capital investment and its production is high, the margin can outweigh the additional cost of labour (Milner and Bueningen, 1993). For instance, planting velvet bean along with maize in Honduras, which does not require external inputs and by using household labour means that production and economic margin is much higher (Milner and Bueningen, 1993).

In summary, fish seed production was a low cost enterprise that contributed a small amount of income at critical times during the year. The proportion was relatively higher in poorer households compared to intermediate and better-off households. Because costs of production and additional labour requirement were low, households were not negatively affected at the critical time of the year. Considering the low investment, RBFSP contributed proportionately higher income flows than other activities.

4.4.3 Consumption of food and health

The contribution of fish produced in ricefields was modest in terms of overall consumption of households at all socio-economic levels. Poor farmers consumed relatively less fish, but fingerling production in riceplots made an important contribution to fish consumption during certain periods of the year. Weekly average per capita fish consumption in RF farming households was found to be 407.5 g, of which seed producing riceplots contributed 62.62 g. Excluding the riceplot contribution, fish consumption become 344.8 g (= 407.5-62.6), which is close to national rural average (310.4 g) reported by BBS (2003). This consumption figure is about half that in Laos (724.9 g/capita/week) to which abundant stocks of wild fish contribute 60% of the total fish consumed (Bush, 2004). In contrast, wild fish stocks have decreased in Bangladesh and now contribute relatively less to the household diet for several reasons (DoF, 2005). Natural stocks are particularly low in the Northwest compared to South-central region of Bangladesh (Islam, 2007). In this context, the adoption of RF based fish seed production at the household level could increase consumption levels by 20% over the present national level.

The contribution of the riceplot and pond to fish consumption appears to be most important in the months of December to May for the poorer farmers. This is the period when total fish consumption of wild fish is particularly low as stocks are less available at this time of the year. Such coping behaviour of farming households, with seasonal hungry gaps, was reported in a number of recent studies carried out in Asia. In Bangladesh, during periods of low wild fish availability farmers consumed more fish from ponds in the Mymensingh region (Karim, 2006; Little et al. 2007) and from farmer managed aquatic systems (ponds and ricefields) in the Northwest (Islam, 2007). Even in Laos, culture ponds were reported to supplement fish at times of the year when wild fish were low in abundance (Bush, 2004). While NRF farmers purchased more fish from the market RF farmers gained more benefits nutritionally and economically from their seed production activities. This was through supplementation of fish from riceplots and reducing the dependency on purchased fish. Rural diets of low income, fish dependent people are particularly sensitive to reduction in fish supplies from local production sources which may have serious nutritional consequences (Kent, 1997). On-farm fish production was found to alleviate this problem in the current study.

In the food bundle, rice made up nearly two-thirds of the share of the total food consumption (g/capita/week). Recent studies showed similar levels of contribution of rice to the rural diet in Northwest Bangladesh however, which was significantly higher than South-central region of Bangladesh (Islam, 2007). In contrast, people in the South-central region consumed relatively more other foods such as meat, egg, pulse etc. This was due to their higher income from various non-farm sources such as service, business, driving etc which made them better capable to purchase such food items than the people in the Northwest region (Islam, 2007). According to BBS (2003) the contribution of rice to the total calorie intake in rural diets was 73.3% in 2000. Seasonally rice consumption peaked in summer during the *boro* harvest. This is the most obvious example of seasonal variation contributing to nutrient requirements as a high amount of energy is needed during this season of hard physical labour for household member (Abdullah, 1989; Gill, 1991).

Average vegetable consumption (g/capita/week) was found to be at a similar level to recent studies in Northwest Bangladesh (Islam, 2007), however this is higher than the national rural average (BBS, 2003). This is possibly due to the higher consumption of potato in the Northwest, which has also increased in other parts of Bangladesh (Hossain et al. 2005). Interestingly, there has been a change in the diet of the people of the Northwest where, women cook potato in the form of a soup which is used as an alternative to pulses. Possibly due to this, vegetable consumption in poor and medium households was higher than in better-off households. Seasonally, poor households consumed more vegetables during the main vegetable production period of November to December and March to May (Elias and Hussain, 2000), probably related to their own production peaking at that time and purchase from markets as prices were cheaper at this time. Seasonally, vegetable consumption in the RF farming households was higher than NRF households possibly because the production of RF farmers was higher in their backyard fields (Chapter 3). Knowledge regarding improved vegetable production systems may be more widespread in communities targeted by CARE FFS that promoted vegetable production as well as ricefish (CARE, 2001a).

Vegetable consumption irrespective of well-being declined from July to October indicating a critical hungry gap (Abdullah, 1989). The lower level of vegetable consumption can be linked to lower levels of on-farm vegetable production at this time of high rainfall and dependence on market sources (Karim, 2006). In this critical period, on-farm fish production including fish fingerlings produced in ricefields, contributed substantially to households coping strategies.

Average meat and egg consumption (g/capita/week) in the RF farming households was found to be similar to the national rural average (107.8g/capita/week) in 2000 (BBS, 2003). This finding suggests that the consumption of foods from animal origins are at a relatively stagnant level, possibly due to the limited scope for expansion of livestock rearing at the household level. Meat & egg consumption was affected by month and well-being and positively correlated with income suggesting that the majority of these food items were purchased. In the month of October, poorer households consumed significantly ($P>0.05$) less meat and eggs, however at this time they consumed more fish from the riceplot, suggesting that fish seed production in the riceplot supplemented protein during the hungry period. According to the concept of marginal product utility (Gill, 1991), there is a seasonal variation in the marginal utility of consumption and the marginal utility of food is highest during a hungry month. Greater consumption of fish during periods of low meat and egg consumption increased the marginal utility of fish produced from riceplots. The timing of food production can be even more important to a family than its total volume, when households face periods of low food availability (Gill, 1991). Households, irrespective of socio-economic group consumed more meat and eggs during February because of the religious festival of Id-Ul-Azha relating to the sacrifice of mammals (cow and goat generally). At this time households also consumed more fish from their own ponds possibly due to a need for a variety of high quality foods during this festival.

Average pulse consumption was found to be lower than the national rural average estimated in the year 2000 (BBS, 2003) possibly because pulses need to be purchased and potato is used as an alternative. Pulses are not generally produced in the study area (Shahjahan, 2004). In the study area RF farmers consumed fewer pulses than NRF farmers possibly due to their relatively higher consumption of fish and vegetables. Seasonally farmers consumed more pulses in the months following the main pulse harvesting period when prices declined. However, consumption of pulses in the months of the hungry gap in RF households suggests the use of money from sale of fingerlings to purchase pulses.

Per capita rice consumption in poor and medium households was found to be higher than in better-off households. In rural areas, the consumption of rice, the dominant staple food for Bangladeshis, reached higher levels than the minimum requirement, but diets were unbalanced with respect to sources of animal protein (Hossain et al. 2005). Consumption of rice varied less throughout the year than consumption of nutrient-dense diets suggesting nutritional imbalances in the diet, especially in important micro-nutrients which are seasonal in poor societies (Kent, 1997).

Consumption of nutrient-dense items such as fish, meat and egg consumption was higher in better-off households compared to medium and poor households. This reversed scenario suggests that poorer farmers had less access to nutrient dense food hence they consumed more rice. On the other hand better-off households had more access to protein dense food which possibly influenced them to consume less rice. According to Hossain (2005), while the richer sections of the society are able to gradually reduce their rice intake and diversify their diet, the poorer are still spending their incremental income on rice. From a nutritional point of view, this implies that the intake of an unbalanced diet has worsened over the years for the poorer sections of the population. Nutrient dense food items other than rice need to be purchased which is more affordable for better-off farmers. The primary factor affecting the per capita consumption of such nutrient dense food among poor developing country populations is income (Nugent, 2002).

The major source of income for farming households is from the sale of rice. Furthermore, households also strictly depend on rice as it is the staple food in rural areas. Thus rice based agriculture is a linchpin of survival for developing country poor populations, both economically and nutritionally (Nugent, 2002). This dependence on rice is likely to make farmers vulnerable both in turn nutritionally and economically. In this context, RBFSP is likely to contribute the farming households both nutritionally and economically.

Health is an important indicator of development (BBS, 2003b). The present study shows that irrespective of socio-economic groups, household members suffer from similar levels of sickness. However, better-off households tended to spend more than other groups on treatment possibly because they can afford to. Access to healthcare is a basic right and it is an obligatory responsibility of the government to ensure healthcare facilities for all the citizens of Bangladesh. However, statistics from 2001 show that the ratio of persons per government physician/doctor was only 4,043:1 (BBS, 2003a). Government health centres are typically located at the upazila level where private health services are also developing. In terms of receiving treatment in rural areas, as many as 70.32% patients did not take any treatment until their health problems become serious (BBS, 2003b) perhaps due to their lack of knowledge about health and long distance travel to government hospital. Other important causes for delaying treatment include its high cost or negligence on the part of the household head to take the initiative and seek treatment (BBS, 2003b). Poorer and intermediate households tended to suffer more from respiratory diseases in the winter season possibly due to a lack of warm clothing. They also suffered from enteric diseases possibly due to their inadequate hygienic knowledge and poor financial capability to get access to treatment.

Income from fingerlings sale appeared to be used for health treatments of household members during June, July and August. Moreover, at that time the ricefield produced large sized fingerlings which might have been consumed as nourishing food by the patients. In rural society fish are considered to be important nourishing foods especially for those convalescing (Gupta, 1908).

4.5 Conclusion

The study in this chapter contributed the findings to the hypothesis stated in the section 4.1. Overall, seasonality had a significant affect on all aspects of livelihoods in farming households including the use of household labour, income, expenses, food consumption etc. Activities of RBFSP were not gender specific rather were carried out through the participation of men, women and children in farming households. Close proximity of ricefish plots to the households facilitated women contribution to RBFSP activities in a traditionally restricted society in which women are not allowed go far for productive activities. Seasonally RBFSP activities were compatible with other agricultural activities as the activities were within the ricefields in which farmers spent the majority of their working time.

The serious problem for the poor households related to seasonality is the marked fluctuation of food consumption particularly non-cereal protein based food such as meat and eggs indicating vulnerability or food insecurity i.e. 'consumption smoothing problem'. To cope with the seasonal problem of food insecurity, on-farm production technology has been recognised as sustainable strategy for the poor. Production strategies with respect to complementarity between enterprises have been suggested for coping with seasonality (Gill, 1991). Production of fingerlings in ricefields contributed nutrient-dense food in the hungry gap periods of the year. Stocking of fingerlings in ponds increased on-farm fish production which in turn contributed to consumption of fish during hungry gaps.

Fingerling production in ricefields made it possible for households to sell both fish fingerlings and foodfish which provided them long term cash flow. There were marked seasonal fluctuations of income which is recognized as 'income smoothing problem' (Ellis, 2000). The contribution of income from selling fish seed/foodfish during the low income months appeared as a counter seasonal strategy to reduce the 'income smoothing problem'. Seasonal income from fingerling sale facilitated households to purchase other food items, which in turn contributed to the reduction of their 'consumption smoothing problem'. Furthermore, the sale of fingerlings contributed to the health treatment of household members by providing monetary support and nourishing food. Overall this study confirms the importance of RBFSP in terms of several positive seasonal livelihood impacts towards reducing vulnerability in farming households.

Chapter 5: Broader scale impacts of RBFSP: an actor oriented investigation

5.1 Background

The preceding cross-sectional (Chapter 3) and longitudinal studies (Chapter 4) demonstrated livelihood impacts of RBFSP on farming households. These studies ignored the impacts of the approach on other beneficiaries. Therefore, based on an actor oriented investigation, the present chapter attempts to assess the livelihood impacts of RBFSP on other related actors.

The concept of actor networks derived from Actor Network Theory (ANT) is the tenet of heterogeneous networks containing dissimilar elements (Law, 1992). ANT claims that social order is an effect caused by the smooth running of an actor network. This order starts to break down when certain actors are removed from the network (Law, 1992). From 1990s onwards actor networks became an increasingly popular tool for analysis in a range of science and technology studies such as health studies, organizational analysis, informatics, anthropology, sociology etc. Alongside these, actor oriented approach had also been used in the field of natural resource based research and development in developing countries (Biggs and Matsaert, 2004). A network is a simple concept of social science consisting of two things: i) nodes or actors and ii) links between the nodes. The actors in the networks are people, groups and organizations (Davies, 2003). The defining feature of actor network analysis is the focus on the structure of relationships between the actors. This approach is in contrast with other areas of the social science where, the focus has been on attributes of actors, the characteristics of people, groups and organizations, rather than the relationships between them (Scott, 2002). Actor linkages may be developed through social contacts, exchange of information, political influence, money, joint membership in organizations, joint participation in specific events or many other aspects of human relationships (Davies, 2003).

Among different social events, innovation systems are made up of a range of actors involved in a generation and use of new knowledge, technologies, management practices, marketing processes and institutional relationships (Matsaert et al. 2004). Through innovation systems all major social actors affect the revealing, acknowledgement, generation, and diffusion of technical and institutional knowledge over time (Hall et al. 2001a; Hall et al. 2001b; Ekboir, 2002; Clark et al. 2003). Technological intervention develops different impacts points and networks among the different actors (Shah et al. 1991). Within actor networks, the ties and relationships of 'social capital' are embedded by which actors obtain their access to resources and benefits (Nahapiet and Ghoshal, 1998; Burt, 2001). Recently special emphasis has been given for research to take into account how linkages are developed in order to provide benefits to the actors involved in networks (Ratten and Suseno, 2006).

In terms of natural resource development, the need to address actor linkages and coalitions is becoming increasingly important to the development organizations (Byerlee, 1998; Kidd, 2002). Actor network analysis can improve insight into issues of adoption and diffusion of innovation which although less quantitative, can be informative (Engel and Salmon, 1997). Research funders and governments are actively encouraging new, pluralistic models of research, development and extension which bring together actors in the private, public and civil society (Byerlee, 1998; Kidd, 2002).

The hypothesis of the study in this Chapter is that 'RBFSP benefits other actors such as fry traders, pond fish producers and other beneficiaries within seed producing and marketing networks'. The present chapter, focusing on broader scale impacts of decentralised seed, aims to address the network among the actors (e.g. traders, foodfish producers, neighbour, relatives etc.) involved directly or indirectly in RBFSP activities. In addition this chapter attempts to describe how the network among actors creates social capital in decentralised fish seed producing communities in Northwest Bangladesh.

5.2 Research framework and methodology

5.2.1 Community selection

Using a judgement sampling procedure (NAO, 1992), two communities were selected, one of them in which RBFSP was well established (Bahagili-BAH) another in which its introduction was more recent (Guliara - GUL). Bahagili was selected from the Kaunia upazilla of Rangpur where RBFSP began in 1993 through the intervention of CARE's Interfish project. Later in 1999, DFID-NFEP through a research programme introduced tilapia seed production along with common carp seed production in ricefields in BAH (Barman, 2000). In consultation with the staff of the ongoing CARE Go-Interfish project, the recently introduced community-GUL was selected from the Khanshama upazilla of Dinajpur district where the Go-Interfish project had just completed 18 months of farmer field school training in June 2004. In GUL, decentralised RBFSP was started with common carp seed production in ricefields. The purpose of these specific selecting sites, where RBFSP was established or relatively recent, was to explore differences between network development (relations/coalition etc.) among different actors/peoples involved directly or indirectly with fish seed production activities. General background information on the selected communities was collected through key informant interviews. Key informants were selected amongst the more knowledgeable persons in the community who then helped to provide general background information on the community (Mukherjee, 1997). The information given by key informants was cross checked with other knowledgeable people from the same community.

5.2.2 Actor identification

Identification of actors in an actor network analysis approach provides a good basis to gaining a fuller understanding of the wider development intervention. Actor identification can be done by outlining an actor time-line which can be generated through literature review or key informant interviews or focus group discussions (FGD). Usually a combination of these methods provides the fullest information (Matsaert et al. 2004). The main and majority of actors related to RBFSP activities were identified initially during the preceding study (Chapter 3). However for an in-depth understanding, focus group discussions were arranged in the selected communities involving seed producing farmers, local farmers and neighbouring community people. In order to review the historical background related to the development of RBFSP technology, FGD was undertaken to identify all the actors (people, organizations etc.) within or outside the community, those were directly or indirectly connected in RBFSP activities (Figure 5.1). According to Hanneman and Riddle (2005) actor network studies are much more likely to include all of the actors who occur within same (usually naturally occurring) boundary. In addition to focus group discussion, a participatory resource mapping exercises were carried out to understand community resources.

Figure 5.1: FGD for identification of actors/people those are connected directly or indirectly with decentralised RBFSP.

The identified actors from the focus group discussion were as follows:-

Individual actors

- Seed producing farmers: farmers producing fish seed in ricefield based systems in the community.
- Fry traders: people who do not produce fish seed themselves but buy fish seed from ricefield based fish seed producers and sell to other foodfish producers.
- Food fish producers: farmers producing foodfish in their ponds who purchase fish fingerlings from the producers of the selected communities or from traders or both.
- Consumers (neighbours/relatives): people in or outside the producer community consuming fish derived from RBFSP.

Group actor

- Foodfish producer group: a group people who produce fish in a large water body (*beel*).
- Fishermen cum foodfish traders: a group of people from the same or outside the community were involved in harvesting fingerlings and foodfish.
- Local market: in the local fish market there were *arats* (auction fish market) consisting of a small group of people; in fish market there were also other individual actors such as retailers and consumers; in the market foodfish were supplied from seed producers and foodfish producers.
- Non-government organizations (NGO): an NGO was found to purchase tilapia broodfish from seed producing communities to promote their extension programmes in other places.

5.2.3 Development of actor linkage matrices

Actor linkage matrix was developed by summarising the findings of quantitative and qualitative data based on interviews, case studies or monitoring observation of the actors - as suggested by Matsaert et al. (2004). Scientists encouraged such integrated use of quantitative and qualitative approaches to gain a fuller understanding (Leeuwis and van den Ban, 2004). Studies of individual actors were done using quantitative and qualitative methods to observe the relationships between the actors and causal factors behind the relationships.

The collected information from different levels of actors (nodes) was analysed and used to develop an actor matrix. In the matrix the strength of ties among the actors is presented in a binary way. According to Hanneman and Riddle (2005), the strength of ties among actors may be nominal or binary (represent presence or absence of tie); signed (represents a negative, a positive tie, or no tie); ordinal (whether tie is the strongest, next strongest, etc.); or valued (measured on an interval or ratio level).

A quantitative questionnaire survey was carried out including fish seed producers within the communities, and fry traders, and foodfish producers within and outside of the communities. In the case of food fish producers there was scope to sample 30 respondents as the population was bigger in comparison to the other actors. However in the case of community seed producers and fry traders, statistical sampling could not be performed due to relatively fewer numbers of respondents. Hanneman and Riddle (2005) stated that actor network studies often do not sample at all rather they include all the actors connected to a particular event in a population. Fry traders and foodfish producers purchased fingerlings from BAH were taken under the survey as their number were higher and suitable for quantitative analysis than that of GUL (Table 5.1).

Table 5.1: Methods of investigations used at different level of actors

Actors	**Methods of investigation**	
	BAH	GUL
Fish seed producer	Survey	Survey
Fry traders	Survey	Case study
Pond fish producers	Survey	Survey
Fish producers in *beel*	Case study	Not included as no *beel* was found connected with RBFSP
Fisher group	Case study	Case study
Aratdar	Case study	Case study
Retailer	Case study	Observation
Consumer in market	Case study	Observation
Consumer in community	Case study	Case study
NGO	Case study	Not included as no NGO found connected with RBFSP

In some instances, the number of actors was very low, so the case study approach was applied. A case study can be undertaken either for an individual or household or group or community in relation to one or more events or phenomenon or alternatively; it could be a study of some socio-economic or political change in relation to an individual, household, group or community (Mukherjee, 1997). At the market level, observation and discussion were carried out with retailers and consumers.

5.2.4 Development of social capital

As an actor network develops social capital (Lyon, 2000), the major ties between focal actors (e.g. seed producers) as well as other important actors in the matrix are considered to explain social capital based on Putnam's theory of social capital. According to Robert Putnam (1993), social capital is made up three interacting and mutually re-enforcing elements: trust, norms of reciprocity and networks of civic engagement (Table 5.4). Trust is the foundation of moral behaviour on which social capital is built. One of the most fundamental needs of social capital is the development of a sense of trust; the belief that one can rely on and believe in others to do what is expected. Reciprocity, in turn, appears in two forms: balanced, referring to near simultaneous exchange of items or services of equivalent value; and generalised or continuing relationships of exchange which are unrequited at a particular point of time, but carry the mutual expectation that a benefit granted now should be repaid in the future.

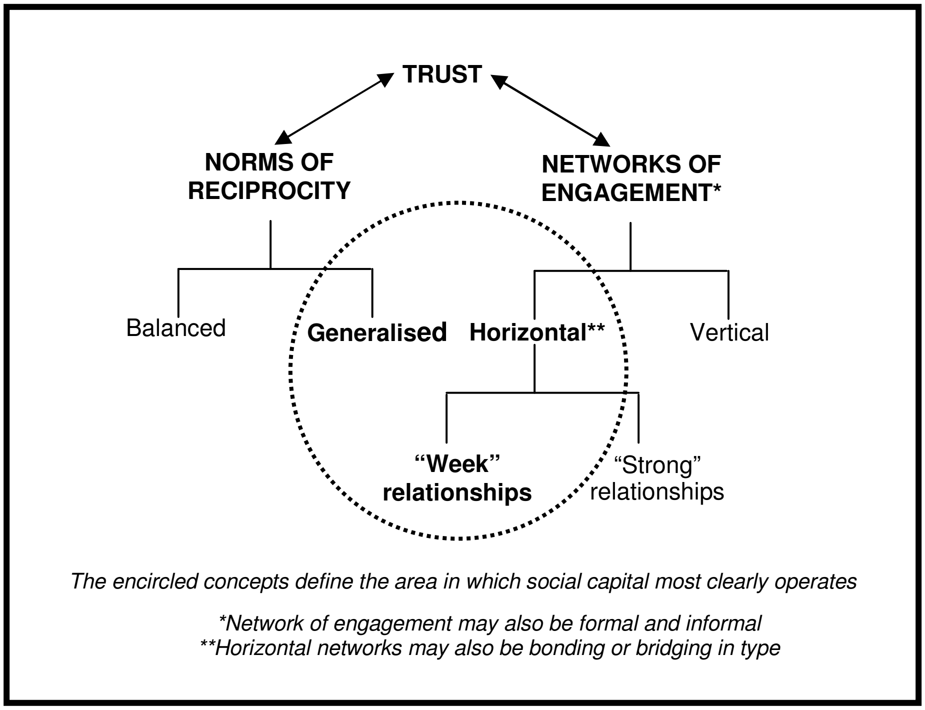


Figure 5.2: Putnam’s conceptual framework of network in social capital -adapted from Bode and Howes (2003).

Networks of engagement are characterized by interpersonal communication and exchange which may be horizontal or vertical. Horizontal networks are web-like connections bringing together agents of equivalent status or power, and these subdivide into weak relationships (e.g. neighbourhood association, clubs etc.) and strong relationships (e.g. kinship). However, in social networks strong interpersonal connection is less important than weak connection with respect to sustainable community cohesion and collective action (Putnam, 1993). The likelihoods of weak ties are higher in linking process of members from different small groups than are strong ones, which tend to be concentrated within a particular group. Another type of network is vertical, linking unequal agents in asymmetric relations of hierarchy and dependence (e.g. relation between the CARE and farmers, or NGO and farmer). In Figure 5.2 the encircled concepts define the area in which social capital most clearly operates.

5.3 Results

5.3.1 General characteristics of community

The well established RBFSP community BAH lies about 5 Km north of Kaunia sub-district and about 15 Km south of Rangpur district headquarter/town. The recently introduced community GUL lies about 23 Km south of Khanshama sub-district and 13 Km west of Dinajpur district headquarter/town. The general features of the two communities are presented in Table 5.2. Both of the communities were more or less similar in terms of common resources. Both covered less than 1 Km^2 but the number of households were substantially different. The proportion of households identified as being of different well-being levels was similar for both communities for BAH (78) and GUL (115).

Table 5.2: General characteristics of the selected communities

Characteristics	Bahagili (BAH)	Guliara (GUL)
Establishment of RBFSP	Well established community- Earlier introduction of seed production in the community where number of seed producing households relatively higher who had linkages with large number of fry traders and food fish producers	Recently introduced community- Recent introduction of seed production in the community where number of seed producing households relatively smaller who had linkages with a small number of fry traders and food fish producers
Total number of household	78 (Poor-51%, intermediate-35% and better-off-14%)	115 (Poor-48%, intermediate-35% and better-off-17%)
Total population	400	650
Literacy level	80%	95%
No. of service holder	9	30
No. of rural doctor	2	1
Number of businessmen	22	15
No. of van puller	4	6
No. of day labour	71	60
Road communication	*Kacha* road	*Kacha* road
No. of household with sanitary latrines	50%	80%
No. of household with safe drinking water access	100%	100%
Primary school	1 government primary school[2] and 1 non-government primary school[3]	1 government and 1 registered non-government primary school[4]
Soil type	Loamy and sandy loam	Silty loam and sandy loam
Total no. of ponds	42	55
Distance of rural market from the community	0.5 Km	1 Km

Kacha roads link both communities to *paka* roads facilitating the communication of the people with upazila and district centres. Households of both communities had safe drinking water facilities either from their own or a neighbour's tube-well. BAH had a government school and a non-government primary school (BRAC school). GUL had both a government and a registered non-government primary school. Over the last decade, the Bangladesh Government has accelerated primary level education through the programme of 'food for education' which has increased the literacy level significantly

[2] Government primary school are government schools under state revenue
[3] Non-government primary schools are run by NGO
[4] Registered non-government primary schools that were started privately by communities or philanthropic individuals that are now registered by the government and therefore receive subventions from the state in the form of teacher salaries and free text books

across the country. BAH has a nearby market (*bazar*) at Mirbag situated 0.5 Km west of the community (Figure 5.4). Similarly a rural market is located at Kachinia situated 1 Km east of GUL (Figure 5.5).

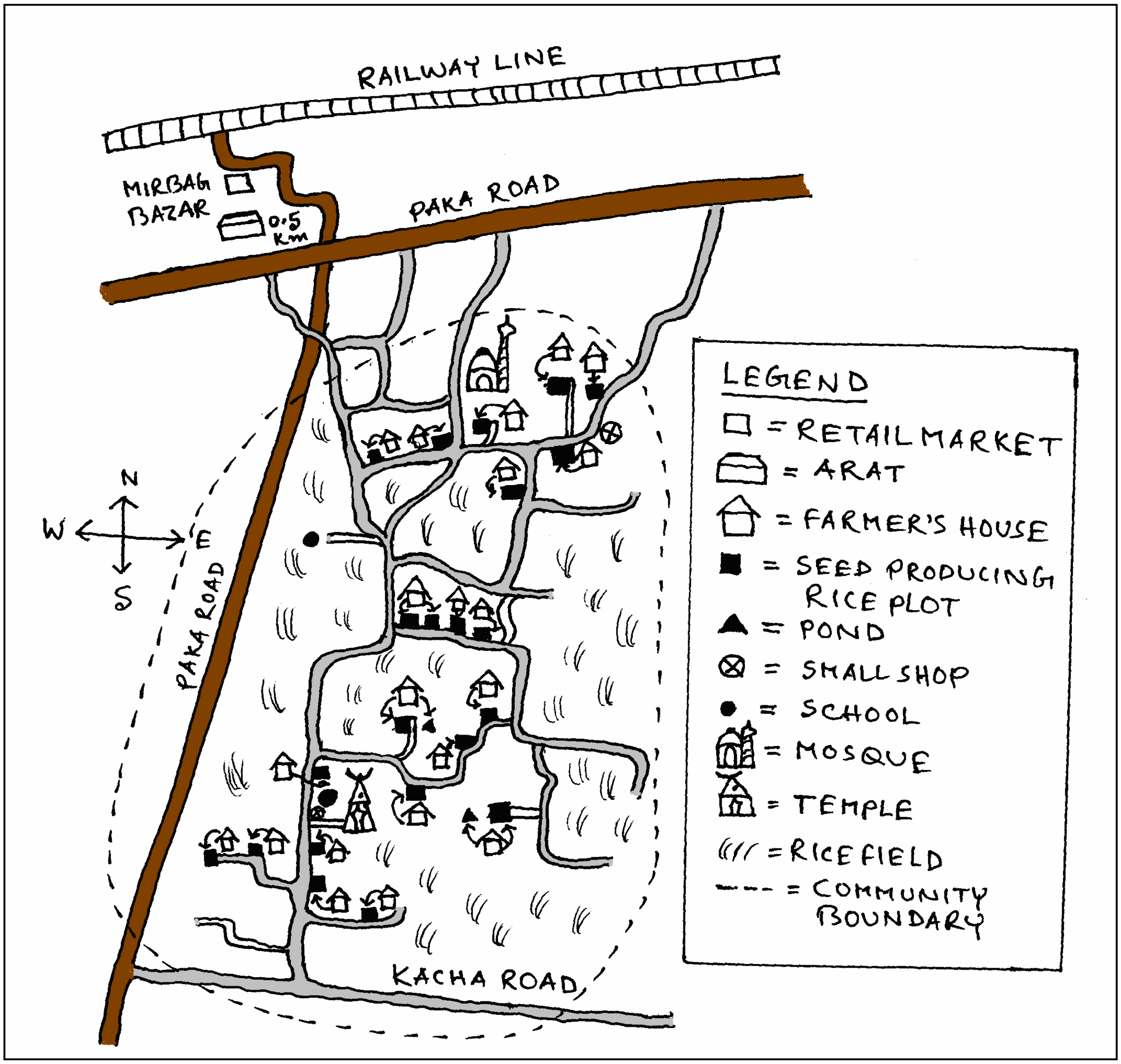


Figure 5.3: Map of well established community (BAH) of decentralised seed production.

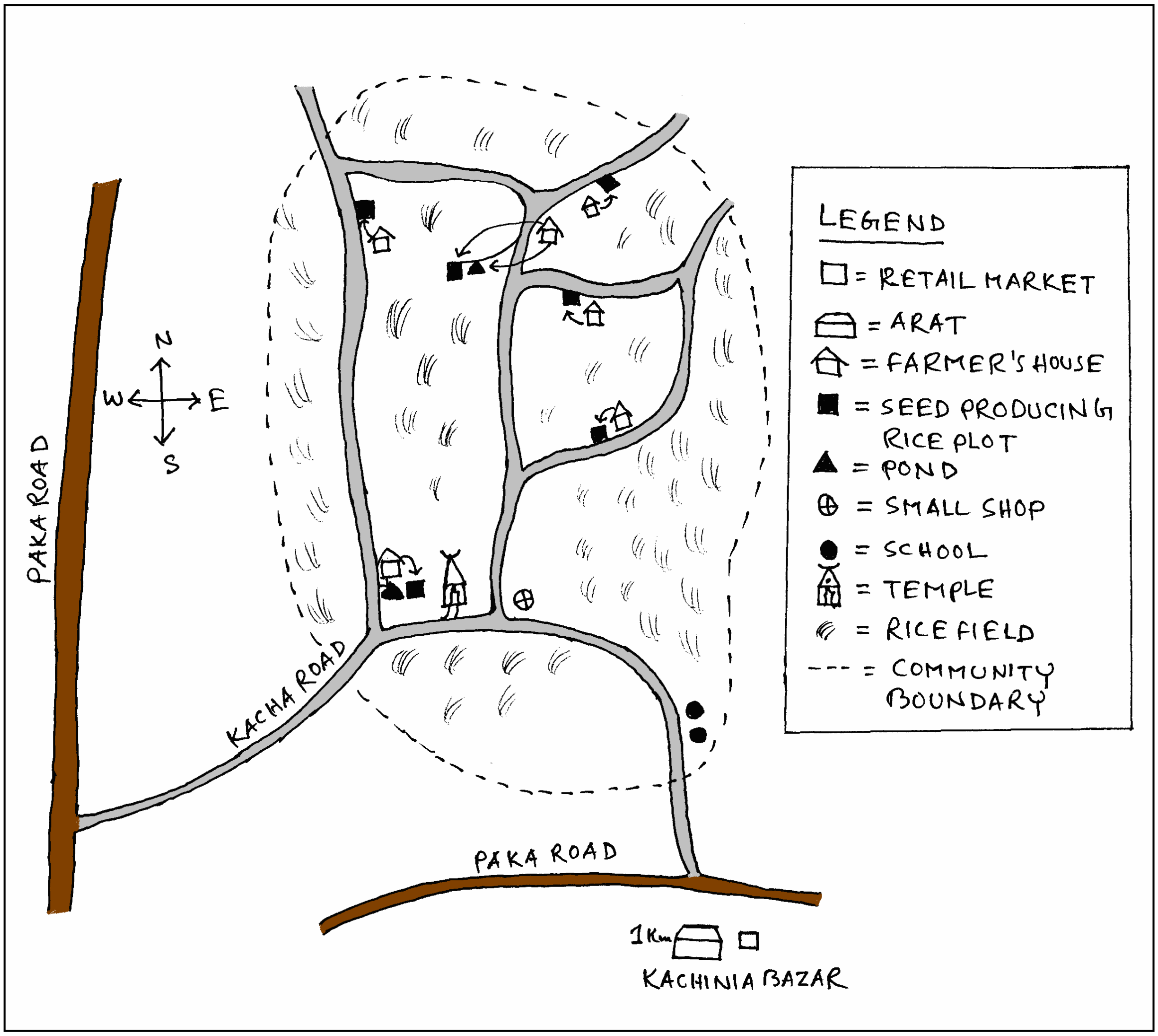


Figure 5.4: Map of recently introduced community (GUL) of decentralised fish seed production.

5.3.2 Seed producers

5.3.2.1 Size of the riceplot

The previous chapters 3 and 4 described seed producer household level impacts of RBFSP based on surveys in 20 communities. However, differences based on the time-scale of the introduction of this technology and farmer's practices in 2 communities, required further study to explore the impacts on seed producing households.

The numbers of the seed producers in BAH and GUL were 21 and 6 respectively. The size (0.2±0.2ha/household) of household riceplots of seed producers in BAH were double the area of plots of households in GUL (0.1±0.1ha/household). The average riceplot ditch size in BAH (0.02±0.01ha) was also found to be larger than in GUL (0.01±0.01ha) and seed production was higher within households of the well established community. Each farmer used 7.7±8.1 and 3.6±3.5 kg fingerlings for their own use in BAH and GUL respectively. Seed producing farmers in both communities experienced various benefits from pond fish production using their own seed produced from ricefield based production systems (Figure 5.5).

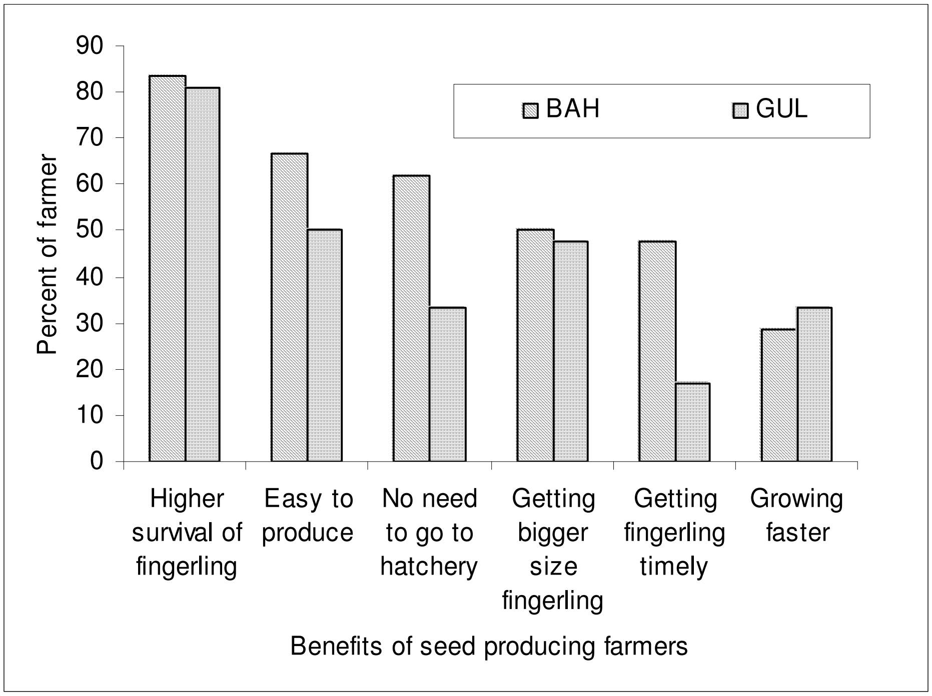


Figure 5.5: Benefits experienced by seed producers using their own fingerling in BAH (N=21) and GUL (N=6).

Among the various benefits associated with the use, by farmers, of fingerlings produced by themselves, some were of equal strength in both communities including higher survival rate of fingerlings, ease of production, larger sized fingerlings and faster growth.

5.3.2.2 Fingerlings sold to fry traders

The total number of fry traders purchasing fingerlings from the well established community was 5 times higher than in the recently introduced community (Table 5.3). The total amount of fingerlings sold to fry traders from BAH was several times higher than GUL.

Table 5.3: Amount of fingerlings produced and sold to fry traders in BAH and GUL

Production and sales of fingerlings by fry traders	Community	
	BAH	GUL
Number of producers sold fingerlings to fry traders (no/community)	12	6
Total amount of fingerlings sold from each community (kg/community)	1134	82
Each producer sold fingerlings (kg/household)	94.5±82.3	13.7±11.3
Total number of fry traders purchased fingerlings (no/community)	15	3
Each fry trader purchased fingerlings (kg/fry trader/community)	75.6±65.8	27.3±22.6

Almost all of the fry traders were from outside of both of the communities. Each fry trader purchased 75.6 and 27.3 kg of fingerlings from BAH and GUL respectively.

5.3.2.3 Seed to the foodfish producers

Out of total seed producers, the number of households that gifted and sold fingerlings to their neighbours and relatives in BAH and GUL were 5 and 4 respectively. Proportionately, a lower percentage of producers gifted and sold fingerlings in BAH (23.8%) than in GUL (66.7%). A total 24 of neighbours and relatives had purchased or received fingerlings as a gift from producing farmers in BAH. The corresponding value in GUL was 16 neighbours and relatives (Table 5.4).

Table 5.4: Gifting and selling fingerlings to relatives and neighbours from the producing households in BAH and GUL

Characteristics	BAH	GUL
Total number of seed producers gifting and selling seed	5	4
Percent of seed producers gifting and selling out of total producers	23.8%	66.7%
Number of neighbours receiving gift	6	
Amount of gift (kg/neighbour)	0.8	
Number of neighbours purchasing	13	10
Amount purchasing (kg/neighbour)	0.9	0.8
Number of relatives receiving gift	4	4
Amount of gift (kg/relative)	1	0.7
Number of relatives purchasing	1	2
Amount purchasing (kg/relative)	1	1
Total number of neighbours/relatives receiving seed through gift and purchase	24	16

The number of beneficiaries receiving fingerlings as gift or through purchase per seed producer was much higher in BAH than in GUL. This might be explained by longer standing production of fingerlings and larger volume of production in BAH leading to stronger and more complex linkages being developed through gifting and selling fingerlings to neighbours and relatives. People receiving seed free of charge reciprocated their services to seed producers during harvesting (operating net, hand picking of fingerlings from net etc.) of fingerlings from ricefields. Beneficiaries also helped host farmers (seed producers) in different ways including assistance to going to hospital, shopping, giving labour during rice transplantation/harvest on priority basis etc.

5.3.2.4 Foodfish to the neighbours/relatives

A proportionately lower percentage of seed producers gifted and sold foodfish to their neighbours and relatives in BAH compared to GUL (Table 5.5). This perhaps shows a relatively commercial attitude of farmers choosing to sell as fingerlings in BAH. Accordingly the total number of receivers of foodfish from BAH was higher than from GUL.

Table 5.5: Gifting and selling foodfish to relatives and neighbours from the producing households in BAH and GUL

Characteristics	**BAH**	**GUL**
Total number of seed producers gifting and selling foodfish	7	4
Percent of seed producers gifting and selling foodfish out of total producers	33.3%	66.7%
Number of relatives and neighbours receiving gift (no/community)	18	5
Amount of gift (kg/relative and neighbour)	1	1
Number of relatives and neighbours purchasing (no/community)	10	8
Amount purchasing (kg/relative and neighbour)	1	1
Total number of neighbours/relatives receiving foodfish through gift and purchase (no/community)	28	13

5.3.2.5 Selling foodfish from the riceplot

From the fish seed producing plots, seed producers sold larger sized fingerlings as foodfish to the local fish market. Comparatively a higher percentage of households sold fingerlings as foodfish in GUL compared to BAH (Table 5.6).

Table 5.6: Selling foodfish in the market with amount and price

Characteristics	**BAH**	**GUL**
Total number of seed producers sold foodfish	10	5
Percent of seed producers sold foodfish out of total producers	47.6%	83.3%
Amount of foodfish sold (kg/household)	45±20.4	27.0±19.9

The major reasons for selling fingerlings as foodfish given by the farmers were variable but included meeting urgent needs for cash, avoidance of flood risk, water supply constraint etc. (Table 5.7).

Table 5.7: Reasons for selling seed as foodfish by % seed producers

Reasons	BAH	GUL
Due to need for money at that time	28.6 (6)	33.3 (2)
To avoid loss of fingerlings due to flush flood after *boro* season	19.1 (4)	16.7 (1)
Due to water supply problem	19.1(4)	33.3 (2)
As too much to eat at house	19.1(4)	-
As market demand was high	14.3(3)	-
As not enough space in own system to stock those	9.5 (2)	16.7 (1)
As no demand to the fry traders	4.8 (1)	-
As no demand to local grow-out farmers	0	-

Figures in the parentheses indicate number of seed producers

5.3.2.6 Selling broodfish

One farmer in BAH sold tilapia broodfish to the other farmers in a distant community. During the *boro* season in 2004, a group of farmers from Farkerhat, about 23 Km away from BAH, purchased 40 tilapia broodfish from BAH to stock in ricefields for the production of fingerlings. They transported the tilapia broodfish by rickshaw and local bus keeping them in a silver pot (*patil*).

5.3.2.6.1 Access to common carp eggs/tilapia broodfish between producing households

Case study: seed producer with his own source of seed (BAH)

Bhagirat Chandra Roy is a 45 year-old man of medium well-being living in BAH. He has 0.75 ha of own land and 7 family members in his extended family. He is connected to the large national political party Bangladesh Awami League, being a leader of the local committee in his ward (a local government administrative section of a Union). He achieved this leadership by means of respect and support from his community as he provides intellectual services (e.g. *shalish* – informal court of the community people) to his community people. In 1995, as a CARE member he received training on RBFSP using common carp eggs collected from his own pond. In 1999 he received GIFT tilapia from a neighbouring farmer and used them for seed production along with common carp in his riceplot. His ricefish plot was 1.01 ha located adjacent to his house. Of the total riceplot area, 50% belonged to his brother with whom it was sharecropped. His household adjacent pond was 0.01 ha in size and held a depth of 2.5 m water year round. His kin and neighbours use his pond water for bathing, household washing and drinking water for their cattle. During CARE-FFS training, a number of farmers started fingerling production in their ricefield based systems by collecting common carp eggs from Bhagirat's pond. From the initial year of adoption, 4-5 adopters used common carp eggs from Bhagirat's pond to produce fingerling in their ricefields. Bhagirat also stocked GIFT tilapia broodfish in his pond. Some poor farmers in his community took tilapia broodfish from his pond free of charge. Mr Bhagirat allows people to collect common carp eggs from his pond every year. He feels that if he would have not allowed the people to collect eggs from his pond the eggs would die naturally anyway. He felt that as the collection of common carp eggs takes place over a short period of time (just one month), it does not hamper his pond in anyway. He believes that allowing his neighbours to collect eggs from his pond has reinforced his pre-existing reputation in the community. He feels that it is a right of the people irrespective of their well-being status to get some help from their neighbours. He believes that supporting the community socially or materially is his social responsibility. He does not ask anything in return directly from the people receiving common carp eggs and tilapia broodfish from him however, he gains benefit through esteem and support which are essential to sustain his leadership in the community. Additionally, he receives benefit from maintaining his neighbour interests in his riceplot probably reducing the risk of theft of fish.

Case study: seed producer without his own source of seed (BAH)

Mr. Uzzal Kumar, a poor 30 year-old farmer lives in the same community as Mr. Bhagirat. He has 4 household members, no educational background and depends totally on agriculture. He was a CARE member and started common carp seed production in his riceplot (0.04 ha) with Mr. Bhagirat. He has no pond hence he has to collect common carp eggs and tilapia broodfish from Bhagirat's pond every year. He did not give anything to Bhagirat in return. He feels that as a community member he can ask for something from his neighbour as it is very common custom in rural Bangladesh.

Case study: seed producer with his own source of seed (GUL)

As with the well established community, in the recently introduced community GUL, Mr. Abinash Chndra Roy, a 55 year-old better-off farmer has a perennial pond of 0.11 ha. He is a leader of a Hindu religious organization named *Sat Shanga* (best companion). Under the umbrella of *Sat Shanga*, community people gather at his homestead every month to listen to religious discussion. He was also a community organizer of the farmer field school in GUL. Common carp eggs were produced in his pond but he had no tilapia broodfish. From his pond, other neighbouring seed producers without their own pond collected fertilised eggs to stock in their riceplots to produce fingerlings. Mr. Abinash feels that allowing other farmers to collect common carp eggs reinforces of integrity of his *Sat Shanga*. In addition he also gets respect and some informal support from egg receivers such as assistance to go to hospital, in shopping from the market and getting labour during rice transplantation/harvest on a priority basis.

RBFSP depends on the availability of common carp eggs and tilapia broodfish in perennial household ponds or in the other ponds of the community. In BAH both common carp and tilapia broodfish were available whereas GUL had only common carp broodfish. Seed producers who had their own source of both common carp eggs and tilapia broodfish in BAH and only common carp in GUL tended to allow access to those producers who had none. This can be termed as a social network developed among the seed producers, which in turn develops social capital.

5.3.3 Fry traders

5.3.3.1 Involvement of fry traders in trading of ricefield produced seed

In terms of trading decentralised seed, 15 fry traders were surveyed to understand the impacts of RBFSP on fry traders connected to the well established community BAH (Figure 5.6).

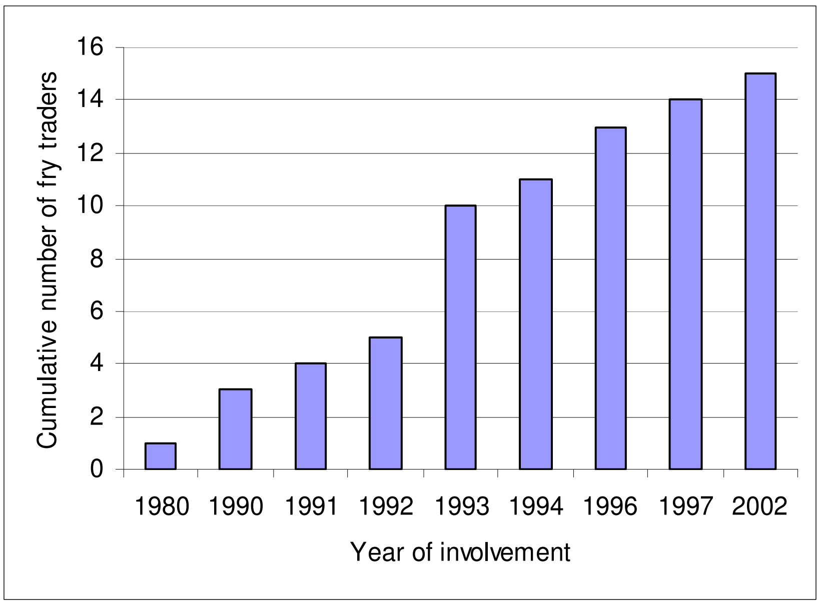


Figure 5.6: Cumulative number of fry traders involved in fish seed trading.

The number of fry traders involved in fish seed trading shows an increasing trend but shows a marked increase from 1993 onwards with a rising trend until 2002. This period coincided with the development of decentralised seed production in the ricefield systems in the Northwest Bangladesh. Additionally, this trend could possibly have been stimulated by the development of NFEP's hatchery based fish seed production system in Northwest Bangladesh suggesting the compatibility of decentralised seed with centralised seed.

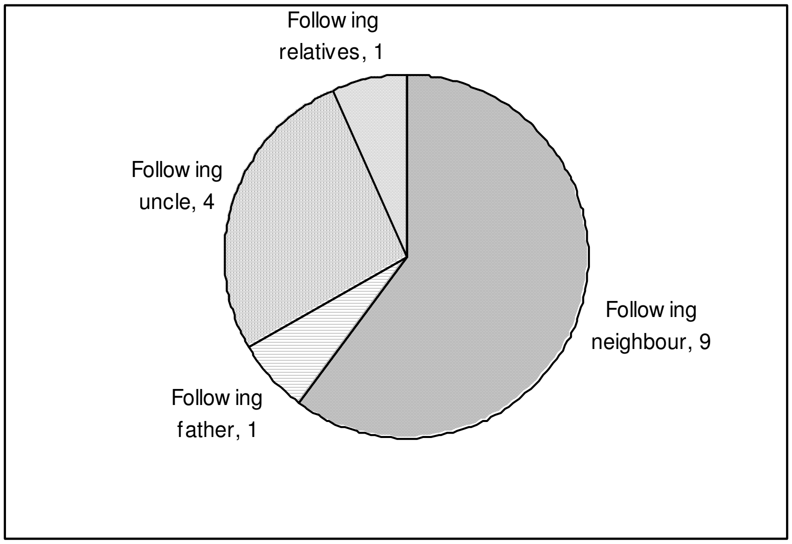


Figure 5.7: Entry points through which fry traders come to this profession.

In addition, out of 15 fry traders, 9 (60%) of them came to the trading systems following their neighbours (Figure 5.7). The remaining 40% became fry traders as a result of this type of profession existing within their kinships (*bongsho)*/relatives.

5.3.3.2 Fry trader's occupation

As well as fry trading, the majority of the fry traders tended to be involved with non-farm activities such as petty business (trading of vegetable seedling, vegetables etc.), fish trading and day labour (Figure 5.8). Their involvement in agriculture however, was very low as they were mostly landless. Almost all fry traders were illiterate and Muslim.

Figure 5.8: Occupations of fry traders.

5.3.3.3 Seed distribution channel of fry traders

Fry traders trading fish fingerlings produced in ricefield based systems live within a 1 Km radius of the seed producing community. Fry traders sold fingerlings in 24 different places with the distance ranging from 1 to 14 Km around the well established seed producing community BAH (Figure 5.9).

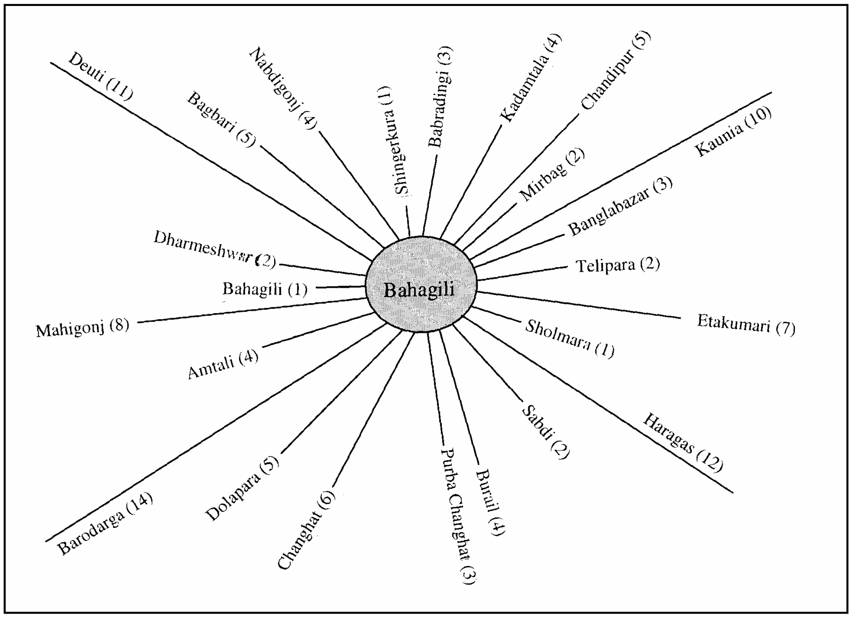


Figure 5.9: Decentralised seed distribution area from BAH (figures in the parentheses indicate distance in Km).

Table 5.8: Characteristics of fingerling distribution through fry traders from seed producing community to the foodfish producers

Characteristics of fry distribution	Units
Distance from the seed producing community to where fry traders live (Km)	1.1±0.7
Distance to fingerling supply outside the seed producing community (Km)	4.9±3.6
Number of places (villages) fry traders distributed seed	6.3±3.4
Time taken by fry traders to carry seed (hr)	3.9±1.9
Number of farmers took fingerling per fry trader	34.5±9.7

On average each fry trader supplied fingerlings to 6 different places, where the average time required for transport was approximately 4 hours (Table 5.8). Each fry trader supplied fingerlings to about 35 foodfish producers over the course of the year.

5.3.3.4 Seasonal income of fry traders through trading of ricefield produced fingerlings

Fry traders began earning income from decentralised seed from the month of April (*boishak*-first month of Bengali calendar). They earned the highest income (approximately US$13) in the month of May followed by the month of April, June, July and August (Figure 5.10). Fry traders started to earn income from hatchery produced seed from June to August.

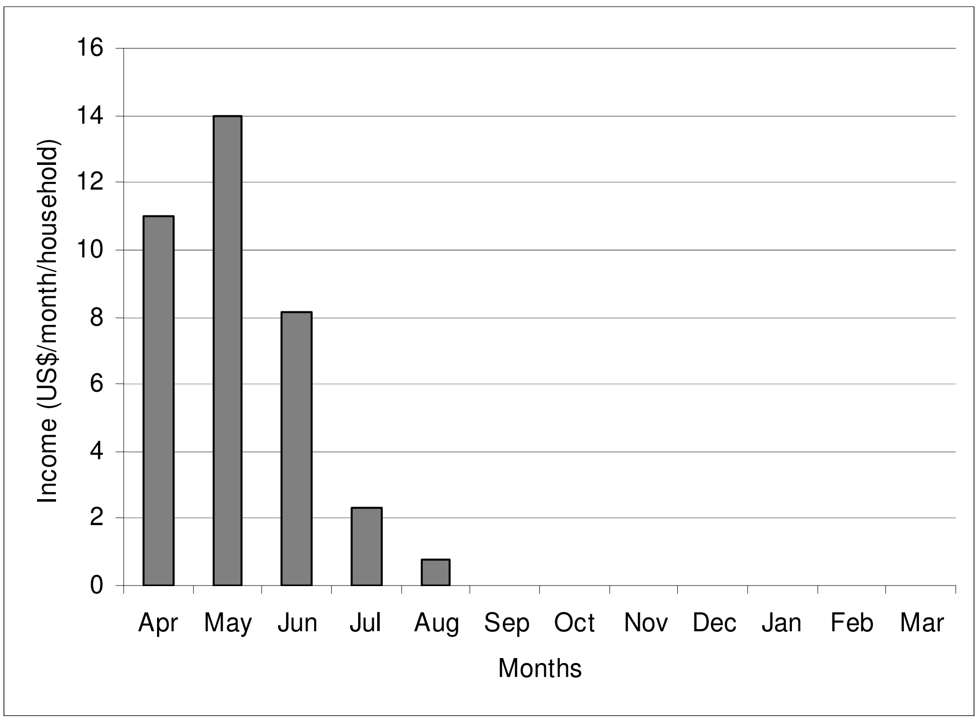


Figure 5.10: Seasonal income of fry traders.

As a proportion of the overall annual income from different sources, fry traders earned an estimated 5% of their income from trading ricefield produced fingerlings. Nevertheless this income was about equal to their income from agriculture and even higher than the income from foodfish trading (Figure 5.11).

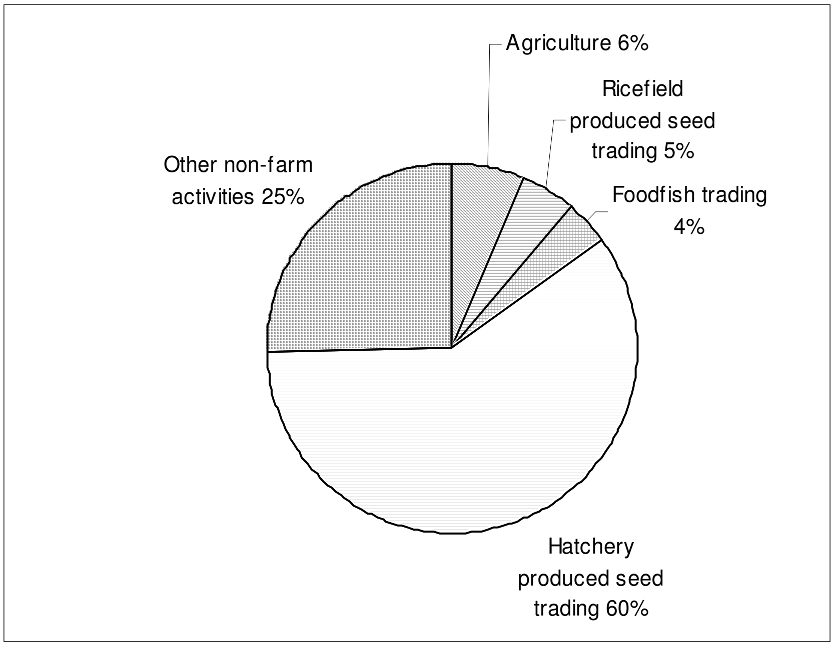


Figure 5.11: Fry trader income proportion from trading of ricefield produced seed in comparison with other income sources.

5.3.3.5 Advantages of trading ricefield produced seed

The major benefit, cited by more than 80% of fry traders, buying locally produced fingerlings was that they could be obtained on credit (Table 5.9). After selling fingerlings they pay cash to the seed producers.

Table 5.9: Advantages for trading of fish seed produced from the ricefield based systems

Advantages	No	Percent
Fry traders can buy fingerling from seed producers on credit	13	86.7
Easy (as very near) to get fry and transport from local area	12	80.0
A low investment with higher income	10	66.7
Easy to sell as large fingerlings have high demand	10	66.7
Direct cash income from the trading	7	46.7

Other advantages included easy access to seed and transport of locally produced fingerlings using a bicycle; low investment business; easy to sell as large fingerlings have a higher demand; and direct cash income from this trading.

Out of 15 fry traders interviewed, one Muslim fry trader named Jafur Mia (46) started decentralised seed trading from a seed producer Mr. Bhagirat Barman in the BAH community. He lives in Paschimbahagili very closed to the well established decentralised seed producing community. Through selling fingerlings, Jafur makes an informal contract with Mr. Bhagirat by which both of them had benefited. In this contract, Jafur informs other fingerling traders about the overall situation of fingerlings in the ricefields of Mr. Bhagirat along with time and date of selling. After selling the fingerlings, Jafur collects credit money (as fingerlings are sold in credit) from fry traders, in return he earns Tk 5.0 per kg of fingerlings from Mr. Bhagirat. As an efficient agent, only Jafur took this opportunity as he lives locally and has good relationships with many fry traders and seed producers. Mr. Jafur worked as an agent for another seed producer in BAH and he would not allow any other fry traders to take this income opportunity. From this informal contract, Mr. Bhagirat benefits by selling fingerlings without having to spend time to find fry traders and collect money. However, from the other seed producers in BAH, fry traders directly purchase fingerlings without any mediation.

Out of 3 fry traders involved in GUL, one of them, Md. Sobhan, a 38 year-old landless fry trader lives at Aftabmembarar Para in Margaon Union – about 1.5 away from GUL community. As a livelihood strategy for his 5 member-household, in addition to fry trading, he is involved with other non-farm activities such as day labour and vegetable seedling business in the fish seed off-season. He has been involved in fry trading since 1995 with hatchery produced seed and in 2004 he started trading ricefield produced fish fingerlings from GUL. In 2004, he purchased 25 kg of common carp fingerlings from GUL and earned Tk 1500 (US$ 21.4) in the month of April (*Jestho*) just before to trade hatchery produced seed.

The number of fry traders involved in BAH was much higher than GUL. Figure 5.10 shows the fry traders linked with well established community trading both common carp and tilapia fingerlings over a number of months. On the other hand fry traders in GUL traded decentralised seed of common carp only for one month.

5.3.4 Pond fish (foodfish) producers using fingerling from BAH

Foodfish producers have been purchasing seed from BAH directly and through fry trader channels for several years therefore, linkages have been established. Therefore 30 foodfish producers were identified with the help of seed producers and fry traders to interview to elicit their views on locally produced seed.

Table 5.10: Advantages and benefits of foodfish producers due to use of fish fingerling produced in ricefield based systems

Benefits for using fingerling produced in ricefields	Percentage (%)
Getting required amount of fingerling in time	90.0 (27)
Getting large size fingerling from fry traders	90.0(27)
Can stock fingerling in pond and harvest earlier for consumption	86.7(26)
Can harvest earlier for foodfish selling	80.0 (24)
Get higher price from foodfish selling at that time	56.7(17)
Can stock again in pond after earlier harvest	66.7(20)
Fingerlings show higher survival	86.7 (26)
Fingerlings increase production	80.0 (24)
Fingerlings bring cash quickly	86.7 (26)

Figures in the parentheses indicate number of foodfish producer

Among the foodfish producers, the local supply of fingerlings produced in ricefields brought various encouraging benefits (Table 5.10) including timely availability of seed at larger size which ensured higher survival rates. This in turn also led to other impacts including earlier harvests and the opportunity for multiple stocking approaches, faster growth, higher production and quicker economic returns.

One of the pond fish producers used ricefield produced fingerlings from GUL, 35 year old Sri Sudir Chandra Adhikari lives in GUL where he owns 1 ha of cultivable land and 0.05 ha of pond. Agriculture is his main occupation but he has no suitable riceplot to produce fish fingerlings. In 2004 the year prior to this study, he purchased 2 kg of common carp fingerlings on credit from Mr. Abinach Chandra paying 200 Tk (Tk. 100/kg). If he had purchased this amount of common carp fingerlings from other sources he could have paid up to Tk. 300.

5.3.5 Fish producers in large waterbodies (*beel*)

RBFSP has extended its impact on fish production to open water-bodies. Interviews with fry traders revealed that fish fingerlings produced in ricefield based systems in BAH were also purchased for stocking in *beels*. Fry traders identified four *beels* to which they supplied common carp and tilapia fingerling from BAH.

Out of the 4 *beels*, one was used as a case study through interview with the manager Md. Abdur Rahim. The area of the *beel* was 2.4 ha and was leased by a group of five landless share-holders. The *beel* belonged to well-off people and was used for rice production during the *boro* season. After the *boro* season from May to November it was underutilized until 2000 when the five people approached and secured a lease for the *beel* from the owners (who grow rice themselves) for the period of May to November to produce foodfish. The lease was agreed on an annual basis for the period of May to November every year. In 2005 they stocked 120 kg of fingerlings at an average size of 3-4 inches consisting of 20 kg of Ruhu, 10 kg of Catla, 30 kg of Mrigal, 25 kg of common carp, 8 kg of grass carp, 17 kg of bighead and silver carp and 20 kg of tilapia. They collected tilapia and common carp fingerlings from Mr. Bhagirat – a ricefield based fingerling producer in BAH. In the *beel* fertilizers and supplementary feed were supplied for the stocked fish. Finally at the end of the season, they produced around

2,000 kg of fish from the *beel* of which 12% was (250 kg) was tilapia. Fish were sold at a rate of Tk.55/kg and each member made approximately Tk 9,000 (US$ 150) profit.

As of 5 years ago, the *beel* had not been utilized for fish culture, however the availability of fish fingerlings facilitated the local people to produce fish in the *beel* for profit. As tilapia fingerlings were not produced in local hatcheries in Northwest Bangladesh at that time (Chapter 7), it was an advantage to collect from decentralised system without facing any problems of long distance transportation. Locally produced seed in the ricefields enhanced stocking into the large waterbodies hence developed the opportunity of additional income and employment of local poor people.

No evidence of fingerlings stocking activity in *beels* was found among any farmers in and around recently introduced community GUL.

5.3.6 Fishers

Fishermen are one of the active actors in the network developed through the adoption of ricefield based fish seed production in BAH. A Muslim fisher group emerged in Dakhinbahagili, a neighbouring community of BAH during 1990s consisting of 6-7 active members. They have a large seine net (*berjal*) for harvesting fish from ponds and fish seed from ricefields in different community households to earn income. The leader, Md. Abdul Awal, having no cultivable land, no educational background and 6 family members, has been involved in fish harvesting and trading activities. All other fishers involved in the team were of similar socio-economic status as Mr. Awal. Through this practice each member of the team earned around Tk.100-150 (US$ 1.5 to 2.5) every day. He said that local fish production was increasing day by day and the income from fish harvesting and trading was increasing as well.

In the BAH community some fish seed producers rented Mr. Awal's net to harvest seed from their riceplot. By netting riceplots he earned around Tk 100 (US$ 1.5) a day. During the seed production season, he earned a good amount of money through harvesting fish fingerlings from the riceplots in the BAH community. One of the bigger fish seed producers in the Bahagili community named Mr. Bhagirat produced around 8 mounds (320 kg) of fish fingerlings last year. The majority of them were harvested by the fisher team of Mr. Awal. Ricefield based fish fingerling production has linked the fishers into a network and reinforced their professional activities through opportunities for employment and income.

There is a Hindu fisher group consisting of 6 members in the village Amnagar, Khanshama - 2 Km away from recently introduced community - GUL. All of the members of the fisher group were uneducated and landless. The group owned equal shares of a seine net that they used to harvest fish from rivers and ponds as their main livelihood strategy. Along with several of the village ponds in Khanshama, they also harvested fish from ponds in GUL, but they never harvested fingerlings from ricefields in GUL.

5.3.7 Aratdar

In the local market Mirbag Bazaar 0.5 Km away from BAH there was no *arat* (auction market of fish) prior to 2005 (Figure 5.4). Earlier retailers in Mirbag bazaar had to purchase foodfish from the district market Rangpur - 15 Km away. Since then two *arats* have been established and Mr. Nasiat owned one of them. Before establishing this *arat* he was a *paiker* (retailer) at the retail fish market in Mirbag. In this *arat* another two persons were employed; one to call prices and the other to calculate the price of fish. In Nasiat's *arat* throughout the year an average 4-5 mounds (160-200 kg) of fish were sold daily worth about Tk.8000-10000 (US$ 100-150). In this *arat* fish came from several places ranging between 1 -16 Km away. Mr Nasiat commented that the amount fish coming to the *arat* was gradually increasing every year.

Mr. Nsaiat was 50 years old with no educational background with 10 family members and 0.33 ha cultivable land. His landholdings were not sufficient to maintain his large family which prompted him to develop the *arat* in 2005. He gets 5% from the farmers after selling fish to the *paikers* through the mediation of his *arat* and earned around Tk. 30,000-40,000 (US$ 500-666) in 2005. He mentioned that a large amount of tilapia (about 15% of the total fish marketed) was sold along with other fishes in this *arat*. This shows the linkage between actors in fish marketing and fish seed producers and foodfish farmers. The development of an *arat* in the local market close to fish seed producing community indicates the development of fish marketing infrastructure in the rural area. In this infrastructure some people were employed and other associated stakeholders also benefited. Ultimately the seed production in the ricefield based systems is contributing to the local foodfish market.

At the village market in Kachinia, 1 Km away from GUL there is an *arat* where fish are brought by fishers and farmers to sell to the retailers (*paikers*). *Arat* owner Mr. Kartik Das mentioned that selling fish produced in ponds, particularly large carps (ruhu, mrigal etc) and Thai Sharpunti were the main species of fish. He also mentioned that a small proportion of tilapias of the local variety were sold along with a large volume of carps in his *arat* during dry months (e.g. November and December) when pond farmers dry their ponds.

5.3.8 Retailer

Mr. Shah Alam (45) is a fish retailer in Mirbag Bazar (Figure 5.4) has 0.3 ha of cultivable land with no educational background and with 5 family members. From his cultivable land he produces about 1 ton of rice every year which is not sufficient to maintain his family. As a result he started as a fish retailer in 1997 and earns about Tk. 80 -100 (US$ 1.5) per day. During 2005 he sold different types of fishes in the market including carps, catfish, tilapia and other small fishes. Last year, about 10% of the fish he sold was tilapia produced by the local foodfish producers (Figure 5.12).

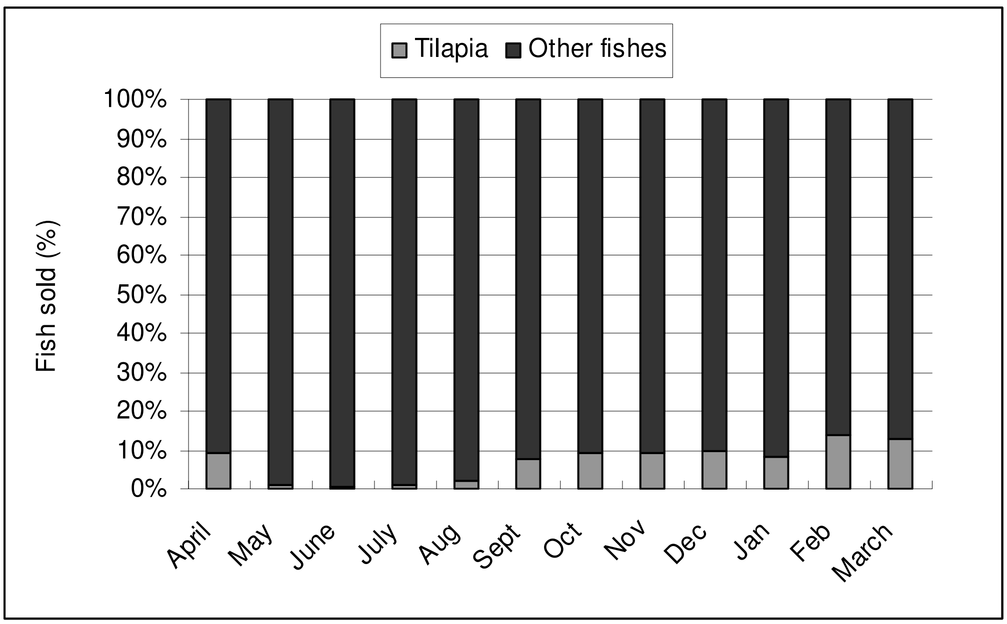


Figure 5.12: Proportion of tilapia in comparison with other fishes sold by a retailer in a nearby market of BAH.

He said that tilapia has been available in this local market over the last 6-7 years and was popular with customers. The size of tilapia ranged from 50 g to 200 g with the smaller ones being of lower price and so were purchased by poorer people. He also added that trading tilapia was more comfortable and less risky as its remains fresh for a longer time compared to other fishes. This finding suggests that local fish seed production has enhanced fish availability and quality in the market and improved affordability to the consumers.

Likewise *aratdars* retailers had also benefited from selling locally produced fresh fish to customers. Availability of tilapia in the local market over the last few years as reported by the retailer indicates that the RBFSP in BAH made a linkage between the retail market and consumers.

In the retail market in Kachinia close to the GUL community, there were no observable impacts of RBFSP at that time of study.

5.3.9 Fish consumer via fish market

Mr. Jamshed Ali was a fish buyer (consumer) living in the village of Sonaton which is 2 Km away from the Mirbag Bazar. He had 0.4 ha of cultivable land and a grocery shop which earned him Tk 50,000 (US$ 830) annually, enough to maintain his 10 family members. He had no pond, so had to buy fish from this market at least 3-4 times per month for his family consumption.

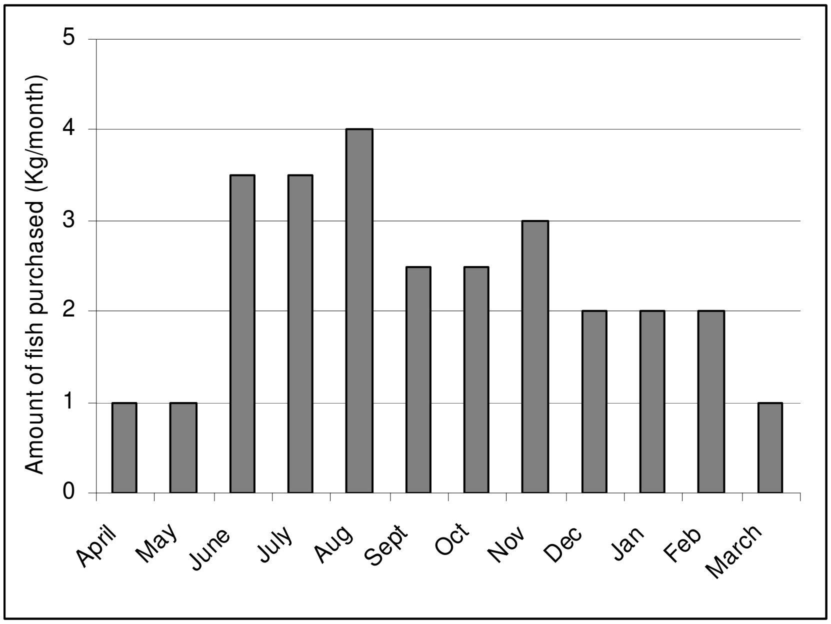


Figure 5.13: Purchasing of fish (kg/month) by a consumer from the local market nearby BAH.

In an average month, Mr. Jmshed buys 2.33 kg fish (Figure 5.13) at a low price ranging between Tk 60-65 (about US$ 1) per kilogram. In order to keep costs low he bought smaller sized fish such as tilapia, smaller sized silver carp, silver barb etc. He also added that in this fish market tilapia has been available over the last 6 years and it was cheaper and tasty to eat. This indicated that local fish seed production in the ricefield based systems enabled the lower income people to consume fish from the local market. The availability of affordable tilapia along with other small fishes in the local market has built a linkage with poor consumers.

In the market close to the recently introduced community – GUL no observable impacts were found on consumers.

5.3.10 Fish consumers directly consumed fish from the community

Poor local farmers in BAH, such as Bankim Barman, have no facilities to produce foodfish or fish seed but were able to benefit through consumption of fish from fish seed producing households. He had no pond or land except his homestead area and the household's livelihood was totally dependent on selling labour year round. He had very little capacity to purchase fish. He however, purchased fish from the ricefield based fish seed producers about 3-4 times during the period from September to October as the price of these fish was about 25% lower than that of the local market. The local level fish seed production, and subsequently foodfish production facilitated the poorer non-producers to consume fish at lower price during a certain period of the year commonly recognised as *monga* – hungry gap.

Poor farmers in the recently introduced community- GUL were found to benefit from RBFSP through consumption of ricefield produced large sized fingerlings as foodfish. One of them, Manoranjan Roy, was a landless farmer living in GUL, self-employed as a van puller. He has no pond to produce fish which is why he has to either catch fish from wild sources (*beel* and river) or buy it from the market. One day last year, he had to purchase foodfish produced in a ricefield in GUL when he could not catch fish in the wild. The fish cost 50% less than those sold in the market.

It appears that poor farmers in the well established community-BAH had a greater chance of purchasing fish at a cheaper price than the farmers in the recently established community GUL.

5.3.11 Non government organization (NGO)

An NGO, Rangpur Dinajpur Samajic Unnayan Sangstha (RDSS) has been working in the Northwest region of Bangladesh at the grass-root level with rural people since 1986. In 2001 it went into partnership with CARE's Go-Interfish project to implement improved low-input ricefield management activities through the farmer field school approach. Among different ricefield management activities, RBFSP was promoted initially through the stocking of fertilised common carp eggs in ricefields collected from perennial ponds. RDSS was also assigned by CARE to disseminate tilapia seed production along with common carp. This activity was restricted to a few NGOs as tilapia brood was not available everywhere. RDSS was able to disseminate tilapia seed production, as broodfish were already available in BAH under its working area of Kaunia Upazila in Rangpur district.

After setting up the FFS, RDSS's field trainers suggested that the farmers collect tilapia broodfish from BAH. Approximately 100 tilapia broodfish were purchased (Tk 8-10/broodfish) by FFS farmers from 2 BAH seed producers in 2002. Although RDSS did not hold tilapia broodstock, it acted as a source of information for new farmers. Accordingly FFS participants, through their own efforts collected tilapia broodfish from BAH to stock in their riceplots along with common carp. The NGO therefore played an important role encouraging communication between established and current seed producing farmers.

In GUL there was no source of tilapia broodfish. If good quality tilapia brood had been available in GUL, NGOs working in the Go-Interfish area (Dinajpur and Thakurgaon) could have disseminated tilapia seed production in their other intervention areas along with common carp.

5.3.12 Actor network matrix

An actor linkage matrix was used to explore and then summarise the relationships between different actors. This process leads to the analysis of more complex systems with many actors, ensuring all possible links between actors are examined and allowing links to be given a value (Matsaert et al. 2004). This investigation resulted in the following actor network matrix and the observed linkages between the actors were visualised (Table 5.11).

Table 5.11: Actor linkage matrix showing links developed for RBFSP between different actors in well established community - BAH (upper diagonal) and recently introduced community - GUL (lower diagonal)

Actors	Seed producer	Fry trader	Foodfish producer	Fisher	*Aratdar*	Retailer	Community level consumer	Market level consumer	NGO
Seed producer	• •	•	•	•	•		•		•
Fry trader	•		•						
Foodfish producer	•			•	•		•		
Fisher					•				
Aratdar						•			
Retailer								•	
Community level consumer	•								
Market level consumer									
NGO									

• Indicates the linkage between the actors

The focal actor (ego) in this matrix is the seed producer connected with other different types of actors (alters). The network between the actors is more diverse in the well established community BAH (upper diagonal) compared with the recently introduced community GUL (lower diagonal), although almost all actors were available in and around GUL. The RBFSP was just emerging at this stage in GUL and the number of seed producers (ego) and their production status of fingerlings was relatively low.

5.3.13 Building social capital

The network of relationships around seed producers leads to the development of social capital. Such interactions have led to a trust relationship between the actors in the wider community. During the production of fish seed in a ricefield based system the collection of common carp eggs by the neighbouring farmer does not hamper the host farmer's pond fish production. Neighbouring farmers who collected common carp seed from the host farmer were not obliged to give anything in return. The host farmer was reciprocated through the esteem and support essential for sustaining leadership in the community. Additionally fry traders and foodfish producers do not need to pay instantly after buying fish and foodfish respectively from seed producers.

In terms of the norms of reciprocity, these sorts of relationships between seed producer and other actors are 'generalised'. Generalised relationships do not need immediate reciprocity, which is flexible in nature rather reciprocation could take place in future. Since common carp egg collectors, fry traders and foodfish traders are not the kin of host seed producers, this relationship can also be expressed as a horizontal and weak network of engagement which is essential for building social capital.

5.4 Discussion

Investigations undertaken for this chapter were both quantitative as well as qualitative to understand reasons behind the linkages between various actors involved in decentralised fish seed production. Many researchers have described the usage and advantages of qualitative methods such as case studies in research. Adelman et al. (1976) described 'case study' as an umbrella term for a family of research methods having in common the decision to focus an enquiry around an instance. Yin (1984) defined the term case study as an empirical inquiry that 'investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident. Bassey (1999) in his critical review of case study research suggested that case studies have the ability to understand the complexity of a particular context. Integrating the quantitative and qualitative, case study methods can unpack the structure of networks in which various actors benefit in different ways.

5.4.1 Seed producers

The production of fish seed in ricefield based systems in farming households linked them with different types of actors who benefited in diverse ways. Seed producers themselves benefit if they have their own grow-out facilities by using their own seed in their own ponds. As seen in Chapter 3 seed producing households obtained 60% extra production from their pond compared to control non-seed producing households. The higher production was due to higher survival, larger size and faster growing characteristics of fingerlings and more taking care (time spent) of their ponds. Stocking larger sized fingerling in ponds results in higher survival and the unavailability of larger sized fingerling has been the major constraint for the wide spread development of rural aquaculture in Bangladesh (AIT, 1997; Alam, 2002; Brown, 2003).

In rural pond based aquaculture, the cost of fingerlings is the largest component of production costs (Alam, 2002; Karim, 2006). So the production of fingerlings in ricefield based system facilitates farmers to stock, quality fingerlings into their ponds and thereby minimizes input costs and dependency on external inputs. A major proportion of seed producers cited that producing their own fingerlings made them self-reliant, which was expressed as ‘no need to go to the hatchery’. Sustainable agriculture should seek to minimise the dependency on external inputs (Ikerd, 1993; Pretty, 1995; Altieri, 2000). The high dependency on external inputs in agriculture increases farmers’ vulnerability to reduced profit, as they have no control over supply and price of inputs (von Braun, 2005).

The benefits of RBFSP were not only felt by the producers themselves but also by other linked actors of which fry traders were most important. Development organizations such as FAO have realized that there is a need to see aquaculture as one aspect of rural development towards improving livelihoods of producers as well as other associated actors rather than as an isolated technology (FAO, 1997). The number of fry traders to whom farmers sold seed was higher in the community where decentralised RBFSP was well established as a trading network was already well developed. This also indicated the magnitude of the local seed production and the involvement of fry traders which then highlighted the demand for decentralised seed from local foodfish producers. Before the introduction of tilapia in BAH, farmers could not sell fingerlings to fry traders due to their limited production of common carp fingerlings (Barman et al. 2004). The production and sales were higher in the well established community, as households used good quality tilapia broodfish along with common carp and their experiences of RBFSP which contributed to building more diverse network of decentralised seed. However, lack of good quality tilapia broodfish is critical (Barman et al. 2004) for the households of GUL with respect to broader impacts in a diverse network like Bahagili - as found in Chapter 7.

Giving seed and foodfish to the neighbour and relatives as gifts is a traditional custom in Bangladeshi society which strengthens the linkage of kinship among the rural people (Nazneen, 2004). As discussed in Chapter 6, gifting and selling seed and foodfish to neighbours and relatives in both communities emerged as a factor of the adoption process of RBFSP. Interestingly, a proportionately lower percentage of seed producers gifted and sold fingerlings to their relatives and neighbours in the well established community. This was possibly due to the development of a more commercial attitude among seed produces in well established community selling more seed to fry traders.

It appeared that a relatively smaller proportion of households in well-established community sold fingerlings as foodfish to the market. In contrast, selling fingerlings as food fish reflects lower demand and poor market development in the locality. Selling fingerlings to the market as foodfish might be a good indicator of ‘market failure’ that is, lack of value of the product as ‘seed’ whereas consumption of fingerlings by the producer household, especially who they have no pond, might be more rational. Also selling to local poor people (e.g. Barman, et al. 2004) or giving fish to neighbours or relatives might be an ‘intermediate’ strategy to cope with market failure.

In Vietnam due to lack of market demand in the first demonstration year of ricefield based tilapia fingerling production by farmers and uncertain perceived quality of seed among potential customers, fingerlings of tilapia produced in ricefields were used as pig feed (Phuong et al. 2006). The major finding of the present study was that local production of quality fish seed was stimulated by tremendous demand among foodfish producers in and around the producing community.

5.4.2 Fry traders

Trading of fish fingerlings is a generic part of fish trading which was once restricted to low caste Hindus. The present study shows this profession has also been adopted by Muslims and that the activity can now be regarded as a 'profession of the poor'. According to de Graaf and Marttin (2000) traditionally professional fishermen in Bangladesh were low caste Hindus where fishing was mainly carried out by the *Rajbangshi*, the *Bapari* and *Halder* communities. The professional Hindu fishermen belonged to the poorest segment of the population. In the socially stratified society of Bangladesh, fishing was considered taboo for Muslims. However over the last decade new Muslim entrants have overcome the social impingement and involved themselves in fishing as their major occupation (FAP 17, 1995; Thompson et al. 1999).

The majority of fry traders connected to the trading of ricefield produced fingerlings were also involved in other non-farm activities particularly small business. Involvement of people in multiple activities is not confined to the rural sectors of developing countries, thus in literature of industrial countries, it is termed as 'pluriactivity' (Shucksmith et al. 1989; Evans and Ilberry, 1993). Their involvement in different income earning activities indicates the livelihood diversification of fry traders. According to Ellis (2000) diverse rural livelihoods are less vulnerable than undiversified ones and local policy should facilitate such types of diversity.

Fry traders linked to the production of fingerlings in ricefields tended to live within a 1 km radius of the well established seed producing community. They sold fingerlings over distances from 1-14 Km which was certainly less than the distance between any fry trader/fish producer and a centralised private and government hatchery which are typically located close to urban areas. The income derived through local fingerling trading was high in the early months of Bengali calendar and this income was collectively nearly equivalent to income flows from agriculture. Although this income was limited, it was seasonally very important for the landless fry traders as hatcheries did not start to produce seed in April. According to Little et al. (1999), local seed production reduces the cost and improves the quality of seed compared to that of seed transported and traded over greater distances. Furthermore, employment and income generation would be localized; and the monopolistic tendencies towards lower returns and increased risk for poorer workers in the existing fish seed network would be reduced.

A major advantage to the fry traders of the availability of ricefield produced fingerlings was that they could be purchased on credit due to the close relationship between fry traders and farmers and lack of working capital of traders. Fry traders are poor, they have little money and they do not have cash to purchase seed from seed producers. It is not easy to purchase fish seed on credit from government centralised hatcheries (Barman et al. 2002) as well as from wholesalers (Lewis et al. 1996). Some fry traders can also purchase seed on credit from centralised hatcheries (Lewis, et al. 1996) but there is the likelihood of seed mortality due to long distance transportation and cost associated with travel by bus or train to repay credit to hatchery.

Informal trading linkages between the decentralised fish seed producers and fingerling traders appear to benefit both partners. Involvement of a large number of fry traders in decentralised seed networks in the well established community generated multiplier livelihood impacts for themselves as well as for foodfish producers. The relative benefits to the network derived from the decentralised fish seed production in seed producing communities, per unit level of initial investment, is compared to investment in mono-sex tilapia hatcheries in Chapter 7.

5.4.3 Foodfish producers (pond and *beel*)

Foodfish producers stocking ponds and any large water bodies (*beel*) are the ultimate users of the fish fingerlings produced in the ricefield based systems. Local seed production by farming households in the well established community and use of seed by local foodfish producers, resulted in multiple benefits encouraged stronger relationships between seed and foodfish producers. These findings presumably suggest that local seed production and the demand for high quality large sized fingerlings was increasing. From the early days of aquaculture production, it was realised that it was desirable to produce and supply large sized fingerlings in the rural areas to enhance stocking into ponds and open waterbodies (FAO, 1992). Ricefield produced fingerlings were found to enhance stocking in the large waterbodies. In the Bangladesh Government's Fifth Five Year Plan (1997-2002), there was an agenda to increase fish production through the massive stocking of carp fingerlings in natural depressions and floodplains (Alam, 2002), however it did not succeed due to a lack of large sized fingerlings.

Decentralised fish seed producing farmers using larger sized fingerlings show 60% higher production in their ponds (Chapter 3) and higher survival as well as quick economic returns. Apart from the impacts on the individual seed producing households, the end users, the foodfish producers received fingerlings were getting a higher level of production in their ponds. The broader benefits to the local area of foodfish producers obtaining a major input (fingerlings) from a local source included the retention and recycling money locally. This in contrast to when farmers purchase inputs from outside, means that most of the money flows either to urban areas or other distance places, and only a small percentage remains in the community as profit received by larger middlemen such as dealers, businessmen etc. (Hefferman, 1986; Ikerd, 1999). Use of local inputs will have positive multiplier effects on both the agricultural and non-agricultural sectors, as a substantial proportion of agricultural income is spent on non-farm goods and services such as chemical fertilizers, irrigation fuel (diesel), labour etc. (Hossain, 1998).

5.4.4 Fish traders and market

In terms of the well established RBFSP community BAH, a network has developed in the marketing chain for selling foodfish from fish seed producing households. Within the marketing chain, fishers, *aratdar*, retailers and consumers were found to be the beneficiaries of the RBFSP in addition to seed producers (Chapter 3 and 4). As a new approach, there could be a question of whether it had an impact on the value chain. Huisman (1990) has suggested that market studies should precede any intervention to enhance the contribution of aquaculture to development. One possible reason why China and Indonesia dominate ricefish farming in Asia is the market for fingerlings cultured in ricefields for stocking in ponds and cages and enhanced fisheries, rather than only contributing to household subsistence (Huisman, 1990).

Commercialization and market integration of the millions of smallholder farms remains a central task in overcoming rural poverty through the diversification in agriculture (von Braun and Kennedy, 1995; Kherallah et al. 2002). The broader externalities of markets, together with public goods and non-market institutions, have important developmental and distributional effects that are not yet well understood for different rural conditions (von Braun, 2005). The appropriate use of the linkages between agriculture and rural industrialisation, as well as rural urban linkages facilitate smallholder productivity growth, which has been proven as essential for pro-poor growth process in for instance, Japan, South Korea and Taiwan (Hayami, 2000). Local fish production and its availability in the local market facilitate local people to consume fish at a cheaper price. The consumption habit of small fish particularly tilapia (<200g) is more important compared to large fish in terms of the food security of poorer households (Barman et al.

2002; Little et al. 2007) who have higher demand in market (Faruque, 2007). According to Edwards (1999b), benefits from rural aquaculture may be either direct to a household farming aquatic products; or indirect from increased availability of low-price fish in local markets.

5.4.5 NGOs

The availability of tilapia broodfish in nearby community facilitated an extension organization (NGO) to promote fish fingerling production along with common carp in ricefields. Within the community some farmers carefully maintained their tilapia broodstock (GIFT) year after year. In the well established RBFSP community, none of the seed producers complained of poor growth of seed or tilapia foodfish (GIFT) over the last 6 years of practice.

In terms of rice as Ahmed (1995) described, the traditional seed markets involve farmers producing seed for their own use as well as for sale to markets in Bangladesh. It is not uncommon for some farmers to become specialised in the production of rice seed. The traditional rice seed markets have been the channel of distribution not only among farmers within the country but also between adjoining farmers within Bangladesh and even across the border to India. The present phenomenon of tilapia brood supply, like rice seed, has occurred through farmers.

Ricefield produced mixed-sex tilapia showed higher yields of 36% over an existing polyculture system in Northwest Bangladesh (Barman, 2000). There should however, be a scientific investigation to determine how long the quality could be sustained. It could equally be argued that farmers might be, or are capable of improving the quality of seed themselves. There is the possibility of deterioration in the quality of improved varieties of tilapia broodfish through mixing with feral tilapias (Lal and Foscarini, 1990). Such deterioration in quality may cause the breakdown of emerging linkages among the farmers in terms of the promotion of tilapia broodfish for wide spread seed production in ricefield based systems. In this context, local organized competent NGOs could take the initiative to produce good quality tilapia broodfish and to supply them to new areas as well as to replace deteriorated stock in established areas. The NGO Rangpur Dinajpur Rural Service (RDRS) working in Northwest Bangladesh is an example of such an NGO with experience in promoting small-scale aquaculture, staff capacity and physical resources (e.g. pond for keeping tilapia broodfish, training centre etc.).

5.4.6 Social capital

Technological adoption contributes to human and social capital at the household and community level (Isham, 2000). Social networks potentially reduce risk and enhance the effectiveness of individual and collective endeavours. Social capital with diverse networks among various actors acts as an incentive to the adoption of sustainable practices, which is of particular significance in the rational management of natural capital (Bode and Howes, 2003).

Social capital is a key element in the Sustainable Livelihood Framework and appeared first as a concept in the development discourse in the 1990s, attracting significant interest from different corners (Stirrat, 2004). Since the mid 1990's, the concept of social capital has become firmly established in the literature of both theoretical and applied social science, including economics (Patrick et al. 2006). Borrowing from others (Bourdieu, 1985; Coleman, 1988; Hirschmann, 1984; Larance, 2001; Portes, 1998; Putnam, 1993; Putnam, 1995; Putnam, 2000), from the viewpoint of the development discourse, recently social capital has been defined as the benefits gained by a group of people from their relationships in extrafamilial networks (Larance and Porter, 2004). In the present study farmer-farmer relationships in terms of movement and use of common carp eggs and tilapia broodfish from one household to another appears to be an important building block of social capital. The farmer receiving eggs and tilapia broodfish reciprocate their political support and informal care for ricefish plots of the donor households. This together contributes to building social capital in a wider community of decentralised fish seed producers.

Fish seed production activities involving different types of actors/stakeholders within the network of relationships may have reinforced the pre-existing social capital with positive development outcomes. A growing body of literature is adding weight to the concept that social capital plays an important role in the rural development process (Patrick et al. 2006). Krishna (2002 & 2003) in socio-economic analysis of Indian farmers, found that economic development performance was associated most strongly with a combination of high intra-village social capital which is expected in the developing countries. According to Bode and Howes (2003) networks of social capital operate at many levels in the village, particularly in rural life and agriculture in Bangladesh. Sharing/leasing land, lending money, lending or exchanging household and food items, renting in irrigation pump, allowing access to drinking water pumps, or pond water are the common avenues for building and creating closer social ties in Bangladeshi society, which have been discussed in Chapter 3.

In the present study it was observed that poorer seed producers were permitted to collect common eggs from intermediate farmers' ponds. Thus social capital increased through the benevolence of one farmer to another. Through this type of access poorer households could produce a significant amount of fish seed and food fish which would have been impossible if the better-off farmers did not allow egg collection. Grootaert (1999) examined how the social capital of rural households, particularly as expressed by their memberships in local associations, affects household welfare and poverty in Indonesia.

For low income households, he found that returns from social capital were higher than returns from human capital. The present study has shown that poorer seed producers benefit depended on their use of social capital as they had little human and physical capital. Within decentralised seed networks, poor fry traders were identified as ‘elite’ having special skills of communication with other fry traders and some seed producers leading to benefits for both elite and seed producer. This sort of elite has been recognised as ‘tertiary elite’ having a landless status but who benefit the community regardless of class, ethnic group, religions or political constraints (CARE, 2005c).

Some decentralised fish seed producers (e.g. Bhagirat Chandra Roy) were linked with diverse actors impacting on a wider scale including community households, a large number of fry traders and NGO supplying tilapia broodfish for further dissemination of decentralised seed. These abilities of farmer indicate that some farmers do not only maintain their seed production practices but also contribute to the broader development of decentralised seed networks. Such type of people benefiting themselves well as and giving better chances of benefits to other people has been termed as a ‘social business entrepreneur’ (Yunus, 2007). Further research could be carried out to develop such entrepreneurs in the decentralised seed networks towards broader social development.

5.5 Conclusion

Agricultural economic research must address a greater diversity of actors for its development and growth (von Braun, 2005). As with other agricultural activities, various beneficiaries (actors) were found to be involved in different activities of aquaculture such as producers, labour, fry traders, fish traders etc. (Edwards, 1999b). Before the last decade, research and development interventions did not address actors including producers and other associated actors properly in terms of their livelihoods and its improvement (Lewis, 1997). Edwards (1999b) argued that the inadequacy of poverty focused assessments was one of the major obstacles to a fuller understanding of aquaculture impacts on poverty.

This study, based on the hypothesis 'RBFSP benefits other actors such as fry traders, pond fish producers and other beneficiaries within seed producing and marketing network' using an actor oriented approach, explored linkages between actors (beneficiaries) benefiting in different ways and to various extents from decentralised fish seed production in irrigated ricefields. It has shown that fish seed production was not an isolated technology at the household level rather it benefits a diverse actors at a broader societal level. For instance, the benefits associated with landless fry traders were important as about one-third of rural people in Bangladesh are functionally landless, unemployed or underemployed, which is one of the major causes of poverty (Rasul and Thapa, 2004). Involvement of fry traders and foodfish traders in the decentralised seed production system indicates the development of an agro-business and rural marketing network. Aquaculture as an agro-business is expected to create opportunities rural, urban, and export markets and using markets as a tool to realise development objectives (DSAP/ATDP-II, 2005). Recent literature also suggests that agricultural systems are increasingly changing from a distinct sector of the economy into a integrated system, in which resource uses and functions are linked to service chains with multiple market and non-market institutions (von Braun, 2005). Fish seed production at the household level was also found to contribute to reinforcing social capital at the community level. Poor seed producers used social relationships to gain access to seed sources in ponds of the better-off farmers showing the relative importance of social capital compared to their other livelihood assets.

Over the years, the development of broader networks among various actors in a well established community indicates the sustainability of decentralised fish seed production.

In the actor network of well established community, seed producers (ego) played major roles with higher number of adopters and their production performances being producers of both common carp and tilapia fingerlings with longer experience on decentralised seed. In order to diversify the actor networks in the recently introduced community, the supply of good quality tilapia broodfish is critical in terms of increasing number of seed producers (ego) and their production performances.

Chapter 6: Adoption, adaptation and rejection process of RBFSP technology

6.1 Introduction

The preceding chapters have described the livelihood impacts of RBFSP on producer and other associated beneficiaries. Having carried out such an impact analysis, the question of adoption and rejection process of this technology at the producer household remained. This chapter therefore, presents some assessment of the adoption and rejection process of this technology among the households.

Lack of fish seed or fingerlings is a major constraint to more widespread involvement of poor in aquaculture in Asia (AIT, 1997; Edwards, 1999a) and both the quality and quantity of fingerlings is the most serious constraint to pond fish producers in Bangladesh (Barman et al. 2002; Alam, 2002; Brown, 2003; Little et al. 2005). Among different aquaculture practices, ricefield based fish fingerling and food fish production in the poorer households, has been found to be a strategy with various livelihood impacts ranging from increased fish consumption to generation of additional income (Haque et al. 2005). As poorer households are generally characterized by having small landholdings and less cash, the capital cost for pond construction may have prevented them from adopting aquaculture, thus fish culture in riceplot has been proven as a potential method for poorer farmers to produce fish (Surintaraseree and Little, 1998). However, the unavailability of fish seed when required is one of the major constraining factors in the promotion of ricefish cultivation to a broader spectrum (Waibel, 1992; Gupta et al. 1996; Halwart, 1998; Edwards, 1999b). Overcoming these constraints and promoting ricefish culture activities, RBFSP has been developed and promoted in Northwest Bangladesh.

In terms of adoption, a previous study by Kamp and Gregory (1993) recognised that the factors responsible for adoption of RBFSP were increased income from fingerling sales compared to food fish, higher income from irrigated rice than rainfed rice although *boro*-monoculture is less profitable than *amon*. This also brought benefits to farming households through rejection of pesticides and environmental and economic advantages. A further study by Barman et al. (2004) recognised that the introduction of tilapia along with existing common carp was the major stimulating factor responsible for the adoption of fish seed production and multiplication by secondary adopters resulting in increased fingerling production, sale and household level consumption. In contrast, that study also revealed some constraining factors responsible for lack of adoption of this technology which included poor availability of water and movement of farmer towards off-farm activities.

The studies discussed above give some insights into the factors responsible for adoption of RBFSP technology in farming households but did not adequately explain non-adoption or later rejection of the technology. In the present study the hypothesis was that 'adoption of RBFSP can be sustained by farming households'. This chapter therefore, attempts to unpack how various factors contribute to the adoption, adaptation and rejection processes of RBFSP technology.

6.2 Analytical framework

Adoption of technological innovations in agriculture has attracted considerable attention among development economists, because the majority of the population of less developed countries (LDCs) derives its livelihoods from agricultural production and because new technology seems to offer an opportunity to increase production and income substantially (Feder et al. 1985). Agriculturally, technology adoption can dramatically improve the well-being of farming households, but many questions about the determinants of adoption remain unanswered (Besley and Anne, 1993). In a review of early empirical and case study evidence on technology adoption, Feder et al. (1985) suggest that some adoption outcomes that can not be explained with traditional models or by standard household data may be the result of differing social, cultural and institutional environments. Furthermore, none of these studies models or tests showed how social structures in the villages affect adoption of innovations or unpack the actual reasons. Rosenberg (1976) in a review of research on adoption of innovations, suggested that the poor explanatory power of models put forward by sociologists was a consequence of poor attention paid to the role of economic variables. Screening numerous adoption studies, Lindner (1987) reported that the results of research in the field have been disappointing and most of the statistical models developed have a low level of explanatory power, despite long lists of explanatory variables already considered in the methodology.

All innovations and their adoption processes have no equivalent units of analysis (Rogers, 1995a). Nevertheless, there is a long-standing instrumental tradition in extension studies that looks primarily at the adoption and diffusion of innovations. Between 1950 and 1970 especially, thousands of studies were conducted across the world which sought to explain why and how people came to adopt, or not, new agricultural technologies and practices (Leeuwis and van den Ban, 2004). Many researchers have investigated the relationship between an individual's adoption index and a variety of social characteristics. Such studies have been conducted in highly diverse areas such as agriculture in industrialised and less industrialised countries, health services and consumer behaviour. Remarkably similar results were found in all of those fields (Leeuwis and van den Ban, 2004). The use of the dummy variable in the traditional regression model does not allow scientists to properly unpack the causal chain or to understand why effects are, or are not, being found. In most studies, adoption variables are categorized simply as "adoption" and or "non-adoption" – the dichotomous adoption variables. Adoption apparently cannot be represented adequately by a dichotomous qualitative variable in many cases (Feder et al. 1985). According to White (2005), several regression models showed an insignificant outcome and even in a few cases a perverse one. He also stressed that developmental analysis needs to be firmly embedded in a theory-based approach which maps the causal chain from inputs to impacts. However, recently in innovation practice and theory, ideas regarding adoption of innovation have changed considerably in association with the shift from instrumental models to interactive models (Leeuwis and van den Ban, 2004). In contrast to the facilitating factors of adoption, how risk and uncertainty factors affect adoption process of technological innovation is also important to understand sustainability (Glantz et al. 1997). This suggests if risk and uncertainty surpasses a modest limit adopters may not continue the technology and eventually reject it. Risk and uncertainty play a number of distinct roles in the process of adopting and rejecting new technologies. These distinct roles have often been blurred or treated incompletely in past research (Marra et al. 2003) in the context of socio-economic and environmental changes (Majumder and Shivakoti, 2004).

Adoption of agricultural innovation is the degree to which a new technology is used in the long-run equilibrium when the farmers has full information about the new technology and its potential (Feder et al. 1985). The adoption of a new practice is closely linked with sustainable development (Dolan et al. 2006) which is concerned about the development of a society where the costs of development are not transferred to future generations, or at least an attempt is made to compensate for such costs (Pearce, 1993). Technology adoption in agriculture is increasingly changing from a distinct sector of economy into a more pervasive integrated system in which resource use and ecosystem functions are linked to the consumer via extended food and service chains with market and non-market institutions shaping the system (von Braun, 2005). von Braun also argued that agricultural development is moving from a linear relationship between different factors towards the systems of interaction between and among the factors in a more complex fashion. Therefore, to understand the adoption process of RBFSP, a pervasive analytical framework encompassing household livelihoods resources and functions of seed production technology into a causal domain encompassing ricefield ecosystem, pond, farming family, seasonality, farming society, market of technological product, technological problems and solution, technological changes carried-out and gender issues in a complex fashion. In addition, this framework is considered to unpack the reasons regarding risks and uncertainties behind process of non-adoption and rejection of technology (Figure 6.1).

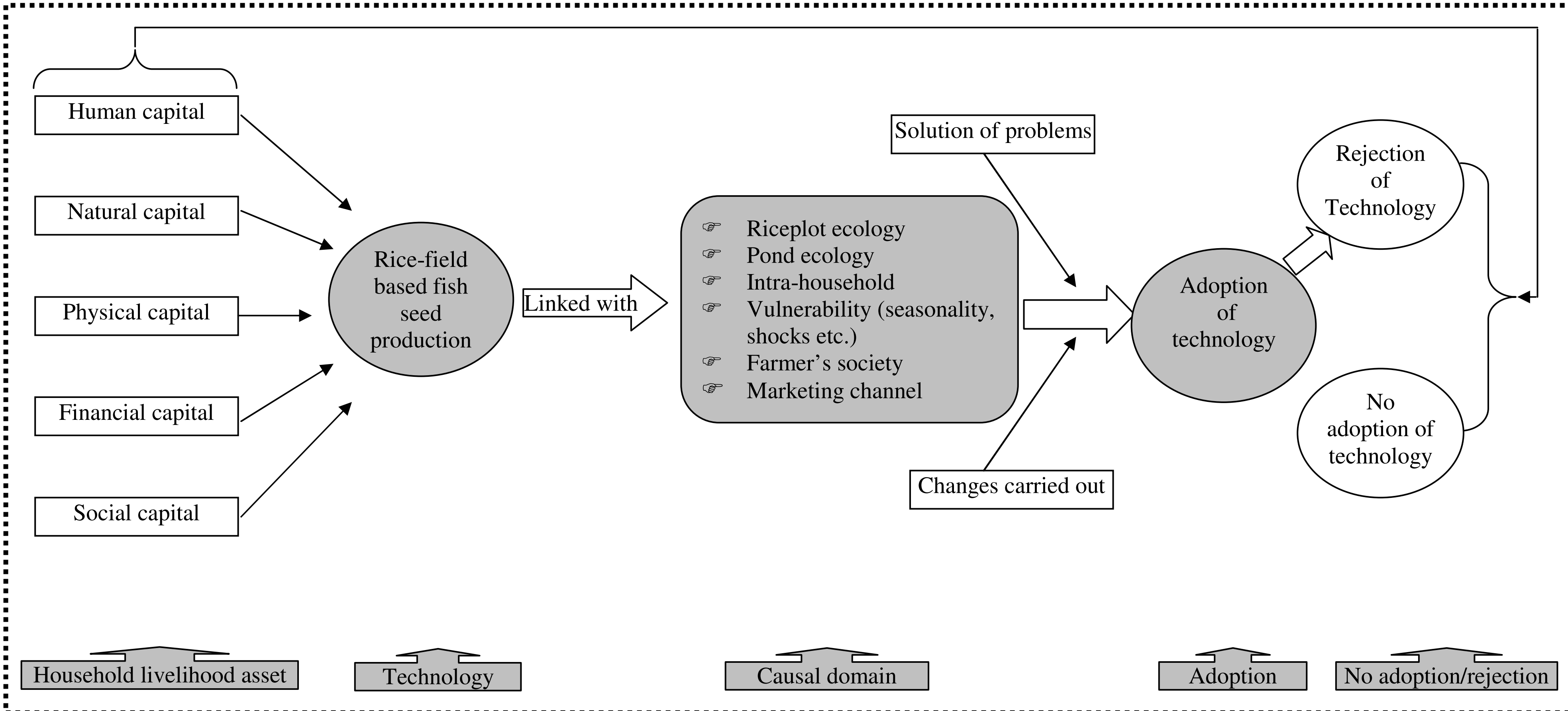


Figure 6.1: Analytical framework of adoption, non-adoption and rejection process of RBFSP in farming households.

6.3 Methodology

Using a PRA tool, the Key Informant Interview, involving a community organizer (leader of the CARE FFS in a community), different types of adopters and non-adopters were identified in communities. For further validation, information given by key informants was crossed-checked with other experienced persons in the same community. Cross-checking of information given by key informant interviews is very important to validate and gain further insights into the issues concerned (Mukherjee, 1997). The adopters were divided into 2 sub-categories, (a) primary and (b) secondary adopters.

The non-adopters were divided into 3 sub-categories (a) farmers who had never tried fish seed production-NT; (b) farmers who had initially adopted during the CARE intervention/support and subsequently rejected it - IR; and (c) farmers who adopted and continued for some years after withdrawal of CARE support but later rejected-LR (Table 6.1). Besides the male groups, two groups of women (household head's spouses) comprising 30 females in each group from both adopting and non-adopting households were sampled to understand their views with respect to fish seed production and to triangulate their views with the male groups.

This study was carried out in 10 communities in 4 districts of Northwest Bangladesh viz. Rangpur and Kurigram (CARE Interfish area) and Thakurgaon and Dinajpur (CARE Go-Interfish area). From each community 3 respondents from each sub-category were sampled randomly to get a representative sample size of N = 30. However, 3 households of IR and secondary adopters were not available in all communities. In order to make sample size N=30 of each of these 2 categories, respondents were sampled from other communities where they were available (Table 6.1). This study was conducted through a questionnaire survey during May to July 2005. In the questionnaire both open-ended and structured questions were included (Appendix 5). According to the literature, this can be termed as a semi-structured questionnaire interview, and is one of the major methods of PRA comprising partly structured and mostly open-ended questions depending on the responses of the person with whom the interview takes place (Mukherjee, 1997).

In the structured part of questionnaire, there was a ranking and scoring exercise method in order to understand the technological preferences of farmers in and around the ricefish plot. It can be noted that CARE basically promoted four types of technologies in and around the riceplots which were low-input rice production, fish seed production, food fish production and vegetable production on the riceplot dike.

In the other structured part of investigation, a checklist comprising farmer's responses was built-up to understand the reasons for adoption of this technology, which was developed based on the preceding two years of field observations. The importance of observation with development research has been stressed by many scientists and practitioners. The value of observation in data collection method has been emphasised by Simpson and Tuson (1995) who stressed that *"there is almost no research strategy to which data collection by observation cannot contribute"*. Bowling (1997) also echoed that systematic observation is a classic method of enquiry in natural science (farmer's experimentation, knowledge and values).

Prior to use in the survey, the questionnaire was tested with four households and changed iteratively in the other communities to ensure appropriateness of the questions with answers and for the complete understanding of field enumerators through discussion between research fellow and assistants at the community level and revision in the field office later on. The final version of the questionnaire that emerged incorporated constructive feedback and suggestions given at different stages of modification by the research supervisor. In this regard Anderson (1998) stated that the success of participatory research depends on the complementary strengths of the research team as a whole.

Surveys were carried-out from the field office in Dinajpur with the assistance of enumerators. As enumerators were native to the Northwest region (Chapter 2), their good understanding of local term/language and socio-cultural factors were complementary to this investigation. Appointing local villagers to work as technicians was found to be a key feature for building strong community based ties in participatory research (Biggs, 1989). It was not possible to appoint an enumerator from every community due to a lack of competent people in each, and the inclusion of a large number of communities over a wider geographical area. However, as the enumerators had worked on the preceding studies for long time, they had built good relationships with community households. According to the respondent groups presented in the Table 6.1, male and female respondents were surveyed separately by male and female enumerators.

Table 6.1: Categories of the households at the community level by adopters and non-adopters and their sample distribution

Basic categories of households		Sub-categories of households	Basic characteristics of sub-categories
MALE	Adopters	Primary Adopters (30 households)	Farmers of CARE FFS who adopted fish seed production in the ricefield based systems and still practise it.
		Secondary Adopters (30 households)	Farmers those learnt know-how from primary adopters and still practising. They were not CARE FFS members.
	Non-adopters	Never tried farmer (NT) (30 households)	Farmer within the same community but never tried to practise this technology. These farmers might be CARE members or not.
		Initial rejecter (IT) (30 households)	Farmers who tried to fish seed production initially during CARE intervention/support period (FFS period-18 months) but rejected within the contact period
		Late rejecter (LR) (30 households)	Farmers who continued fish seed production for few years after CARE intervention/support period over but eventually rejected it.
FEMALE	Adopters	Female of adopting household (30 households)	Females at the primary and secondary household level. They might be FFS members of not
	Non-adopters	Female of non-adopting households (30 households)	Female at the households where fish seed production was not adopted

6.3.1 Data/information management and analysis

The collected information was entered into the Microsoft Access database in a qualitative form according to the questionnaire. After entering, the information was cross-checked with the questionnaire in the field office of Dinajpur with the help of field assistants. In Microsoft Access, using the Query option, the respondent's expressions of the open-ended questions were generalised under different generic strata and then coded for subsequent analyses. Descriptive statistics such as frequencies, percentages and means were used for the data analysis. For pair-wise comparison of parameters between adopters and non-adopters a post-hoc test was done using the GLM procedure. Friedman's test for analysis of variance by ranks (SPPS version 11.5) was used to asses whether significant differences existed between technologies in and around the ricefields with respect to farmers' preferences. The test is a non-parametric equivalent of a single-factor analysis of variance. Significant outcomes were followed up with pair-wise comparisons using Wilcoxon's signed-rank test. Finally the qualitative citations corresponding to each technology were counted and tabulated to describe the reasons for individual mean score and rank derived from statistical analysis. After analysis of data some results were understood clearly from community level discussion with farming households individually and in a group.

6.4 Results

6.4.1 Adopting households: primary and secondary

6.4.1.1 General household characteristics of primary and secondary adopters

The basic data of primary and secondary adopting households shows the general household characteristics, although no significant differences were found with respect to any variable (Table 6.2). Although agriculture is the main occupation in both groups, it was more dominant in primary (86.7%) than secondary (66.7%) households. In terms of non-farm activities, secondary farmers concentrated more on business and service whereas alongside these activities some primary farmers were involved in day labour and van pulling activities. It was noted that more than 30% of secondary adopters mentioned business and service as their main occupation. In the case of household occupancy, secondary households were slightly larger than primary households which might have acted as a facilitating factor to involve household members both in on-farm (agriculture, ricefish etc.) and off-farm (business and service) activities. Secondary household heads were more educated compared to primary households, which shows a close relationship with more secondary adopters being in government (e.g. teachers in primary schools) and non-government service (teaching in *madrasa*- equivalent to secondary school teacher). In the case of land ownership between groups, there were remarkable differences between the primary and secondary adopters. The average area of own land of secondary adopters was greater than primary adopters who were more dependent on leased-in and sharecropped land. The gross annual household income of secondary farming households (US$2505.3±3855.1) was higher than for primary adopter (US$2129.3±2741.0) which might be due to their involvement in off-farm activities such as service and business. Overall the secondary farming households tended to be richer than primary adopters in terms of occupations, education, annual income etc.

Table 6.2: General household characteristics of primary and secondary adopters

Household characteristics	Primary adopter	Secondary adopter
Main occupation		
Agriculture	86.7%(26)	66.7% (20)
Business	3.3% (1)	16.7% (5)
Service	3.3%(1)	16.7% (5)
Day labour	3.3% (1)	
Van puller	3.3% (1)	
Secondary occupation		
Business	6.7% (2)	16.7% (5)
Day labour	6.7% (2)	6.7% (2)
Others (agriculture, petty service, van puller etc.)	30.0% (9)	30.3% (10)
Not any	56.6% (17)	43.3% (13)
Household occupancy		
Household size	5.5±1.8	5.6±2.4
No. of male	3.0±0.8	3.0±1.6
No. of female	2.5±1.4	2.6±1.4
Age distribution of household head		
Young age (=<30)	6.7% (2)	20.0% (6)
Middle age (31-60)	80.0% (24)	80.0% (24)
Old age (above 60)	13.3% (4)	
No. of other member in different age groups		
Age 1-14	1.1±0.8	1.2±1.28
Age 15-30	1.9±1.2	1.9±1.40
Age 31-60	1.5±1.1	1.3±1.30
Above 60	0.1±0.3	0.1±0.38
Education of household head		
Illiterate	33.3 (10)	20.0% (6)
Primary	30.0% (9)	23.3% (7)
Secondary	23.3% (7)	40.0% (12)
Above secondary	13.3% (4)	16.7% (5)
No. of other member in different education attaining groups		
Illiterate	1.1±0.8	1.4±1.5
Primary	1.1±0.9	1.4±1.1
Secondary	1.4±1.2	1.5±1.2
Above secondary	0.8±1.1	0.4±0.6
Land access (ha)		
Own	0.9±0.8	1.1±1.1
Leased in	0.1±0.5	0.03±0.1
Leased out		
Share in	0.02±0.06	0.01±0.1
Share out	0.01±0.04	
Multi-owner	0.06±0.30	
Mortgage in		0.03±0.1
Mortgage out	0.02±0.08	0.02±0.1
Total land access	1.1±0.75	1.24±1.12
Pond ownership (decimal)		
Own pond	13.2±15.8	16.97±22.2
Leased in		
Share in	1.6±8.8	
Multiowner	11.4±32.6	4.23±9.6
Gross annual income (US$)	2129.3±2741.1	2505.3±3855.1

Figures in the parentheses indicate number (n); HH=household head

6.4.1.2 Primary farmers' perceived criteria to be involved in CARE-FFS

All primary adopters (100%) perceived that having a suitable riceplot was the most important criterion for their involvement in fish seed production activities (Figure 6.2). The second most important criterion was having personal interest in this technology (73.3%), followed by access to a water pump (26.7%), higher social position (16.7%) and having a pond (10%). Among the criteria prescribed by CARE when selecting farming households were having a suitable riceplot and personal interest. The other criteria recorded were not formal, however sometimes field trainers had to consider them (e.g. water supply facility, social position etc.) to build up a farmer field school.

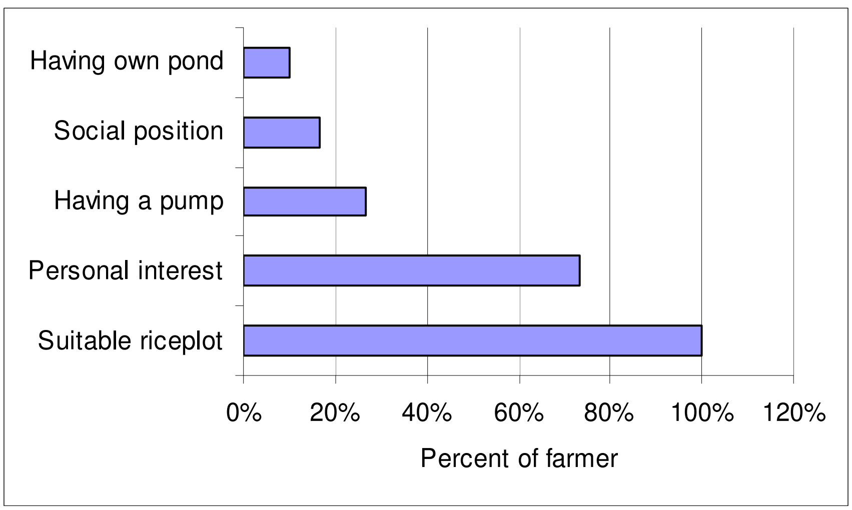


Figure 6.2: Farmer perception of criteria for involvement in RBFSP activities.

6.4.1.3 Acquiring knowledge on fish seed production by primary and secondary adopters

In the primary adopting households the majority of household heads (47%) solely participated in FFS training programmes (Table 6.3). From 34% of households, both husband and wife participated in the FFS training as CARE had a corresponding strategy to form female FFS in the same community. The involvement of other household members in the training programme was not a formal task of field trainers however they could participate in the training programme without any prohibition.

Table 6.3: Household members (%) received knowledge on seed production at primary and secondary farming level

Household member (s)	Training receivers in the primary adopting households (%)	Idea receivers in secondary adopting households on fish seed production (%)
Household head	46.6 (14)	43.3 (13)
Household head and his wife	33.3 (10)	10.0(3)
Household head's son	10.0 (3)	3.3(1)
Household head and his brother	3.3(1)	10.0(3)
Household head and his wife and son	3.3(1)	--
Household head's son and mother	3.3(1)	--
Household head and his son	--	26.7(8)
Household head and his sister	--	3.3(1)
Household wife and her son	--	3.3(1)

Figures in the parentheses indicate number

Among secondary adopters, about 40% of household heads alone acquired knowledge of fish seed production from the primary adopters. They also (40%) received knowledge from the primary adopter together with their son, wife, brother, sister etc. There was an obligation for each of the primary farmers to share learning that takes place at the FFS with at least one neighbouring farmer who was commonly referred to as a “buddy farmer”. However, only 27% of secondary farmers were buddies of primary adopters and the remaining 73% were not formally associated in this way. The majority of secondary adopters (63.3%) learned from their neighbours (33.3% from neighbours’ friends; 30% from neighbour). The remaining 36% of secondary farmers got the idea of fish seed production from close kin.

6.4.1.4 Farmers' perceptions of the technologies in and around the ricefields

Primary farmers acquired knowledge on four types of technologies in and around the riceplots. In terms of farmers' preferences both at primary and secondary level, the Friedman test showed a significant difference (P<0.05) between the technologies in and around the riceplot (Table 6.4).

Table 6.4: Perceptions of approaches to improving rice production incorporating other technologies in and around riceplots

Technologies in and around the riceplot	Mean score		SD		Mean rank		Min		Max		Mode	
	P	S	P	S	P	S	P	S	P	S	P	S
Fish seed production in ricefield	7.3	8.7	2.8	3.9	3.4	3.5	3	4	12	20	7.5	8.0
Food fish production in ricefield	6.1	8.2	3.0	4.9	3.0	3.3	0	0	12	15	6.0	7.5
Vegetable cropping on ricefield dike	3.4	1.5	3.0	2.1	1.9	1.6	0	0	14	8	3.0	0.0
Low-external input rice production in ricefield	3.1	1.7	2.0	2.2	1.7	1.7	1	0	10	10	3.0	0.5

P=Primary adopter and S=Secondary adopter (Higher score indicates higher importance)

According to the sampled primary and secondary adopters, seed production had the highest score (7.3 versus 8.7) followed by food fish production (6.1 versus 8.2), vegetable cropping on plot dike (3.4 versus 1.50) and low-external input rice production in the plot (3.1 versus 1.7 respectively). A higher score indicates a higher "degree of priority" in technological preferences. Fish seed production technology was ranked highest because of its dynamic impacts and lower risk. Among various impacts "no cost" and "additional income" was cited frequently by the majority of primary (80%) and secondary (50%) adopters respectively (Appendix 6 and 7).

Table 6.5: Pair wise difference between the technologies in terms of scoring

Technologies in and around the riceplot	Fish seed production in ricefield		Food fish production in ricefield		Vegetable cropping on ricefield dike	
	P	S	P	S	P	S
Food fish production in ricefield	NS	NS				
Vegetable cropping on ricefield dike	SG	SG	SG	SG		
Low-external input rice production in ricefield	SG	SG	SG	SG	NS	NS

P=Primary adopter, S=Secondary adopter, NS=Non significant and SG=Significant

Similarly as per primary and secondary adopters, Wilcoxon's test has indicated no significant (P>0.05) difference between the fish seed and food fish production technologies in the ricefield systems (Table 6.5). On the other hand both technologies were significantly (P<0.05) more highly ranked compared to vegetable and low-input rice production. Vegetable production on dike and low-input rice production resulted in destructive effects of rats on ricefield dike integration and higher labour requirements respectively.

6.4.1.5 Reasons linked with adoption process

Adoption and adaptation process: linked with riceplot, pond, farming family, farming seasonality and farming society

Almost all of the primary and secondary adopters (96.7 versus 90% respectively) found RBFSP technology an important IPM (integrated pest management) tool to reject pesticide use (Table 6.6). Before CARE intervention, i.e. before adoption of this technology they used pesticides in their riceplot. More than 80% of primary and 40% of secondary adopters reported that RBFSP increased non-stocked fish. The majority (80%) of primary and secondary adopters who experienced this technology reported that it did not hamper their rice production. Similarly, more than 80% of both primary and secondary adopters expressed interest in this practice as it was relatively easier than other agricultural activities in their farming households. About 70% of primary and 83.3% of secondary farmers opined that this technology developed their on-farm fish production.

A big proportion of both adopters (primary 70%; secondary 56%) found that they developed their riceplot as an important household asset over the years through raising dikes, making ditches etc. so they felt that keeping these empty without fish fingerling production resulted in a lost opportunity. The majority of adopters reported that fish seed production encouraged them to use the household adjacent riceplots more effectively as compared to using it for rice alone. Apart from the riceplot, more than 50% of primary and 60% of secondary adopter reported that ricefish technology enhanced the efficiency of groundwater use with shallow tube-well pumps (Figure 6.3).

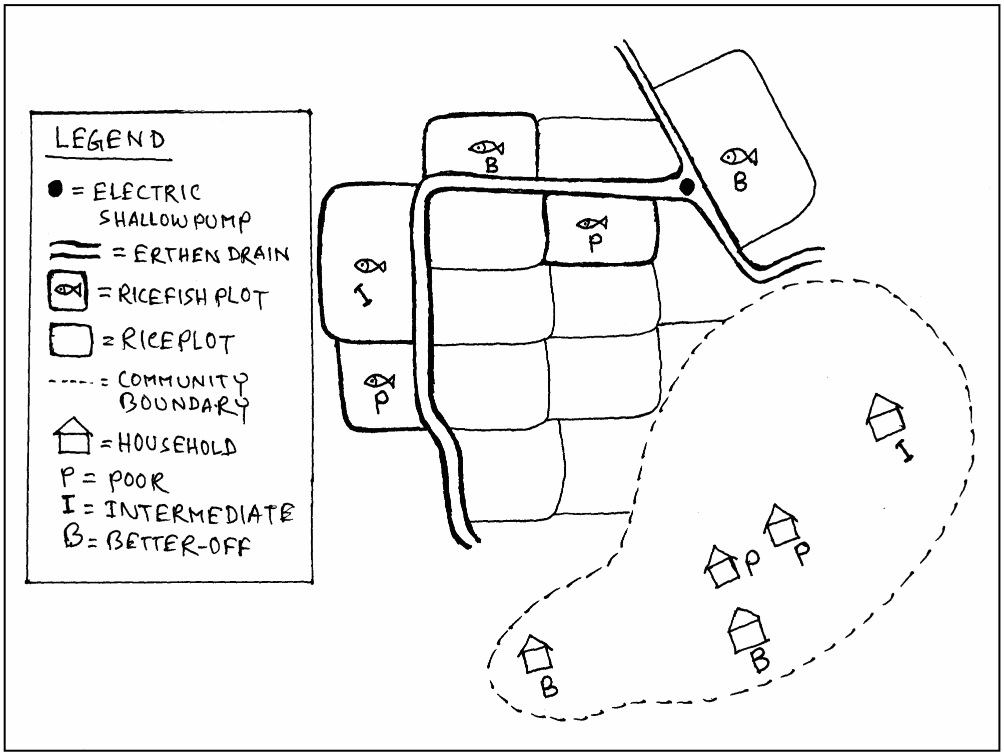


Figure 6.3: Location of irrigation pump and supply of water in ricefish plots.

The majority of adopters mentioned that the introduction of tilapia along with existing common carp increased the total production of the riceplot in terms of seed, fingerling and food fish. Moreover, above 30% of primary and 10% of secondary adopters reported that fish seed plots improved production of *boro* rice seedlings as this could be located in the ricefish plot's ditch. Fingerlings produced from riceplots and subsequently stocked to the household pond increased the pond production substantially; this was experienced by more than 80% of both primary and secondary adopters. Women and other household members were involved in RBFSP in 87% and 57% of primary and secondary adopting households respectively. The majority of farming households reported that fish seed and food fish production in their ricefish plots helped to meet their subsistence demand for fish consumption. A remarkable number of adopters perceived that this technology was particularly useful in regard to meeting consumption needs when entertaining extended family and guests.

Table 6.6: Adoption and adaptation linkage with riceplot, pond, farming family, farming seasonality and farming society

Causal domains	Causal effects	Percent of adopters	
		Primary	Secondary
Riceplot ecology	Rejection of the use of pesticides in seed producing riceplots	96.7	90.0
	Increased abundance of non-stocked fish in ricefields-SRS	83.3	40.3
	Fish seed production does not effect negatively rice production	83.3	83.3
	Farmer's affinity to this technology as it is easier than other agricultural activities	80.0	83.0
	Riceplot has been developed as a threshold of fish production in households	70.0	83.3
	Riceplot becomes developed asset	70.0	56.7
	Effective use of riceplot	70.0	56.7
	Strategic use of water pump	53.3	63.3
	Introduction of tilapia increased total production in the riceplot	70.0	53.3
	Production of *boro* seedling in the riceplot ditch	30.3	10.0
Pond ecology	Restocking to own pond that increased fish production	86.7	83.3
Farming family	Compatible for absorbing available household labour such as men, women and children	86.7	56.7
	Meeting the need of fish consumption of children	86.7	83.3
	Meeting the need of women (household wife) to cook and feed fish herself and her family	83.3	70.0
	Meeting the cumulative consumption demand of joint family having large number of members	40.0	36.7
	Compatible for consumption of extended family where guests used to visit farming households frequently	40.0	16.7
	Meeting consumption demand of old aged person (farmer parents) in farmer's family	26.7	53.7
Farming seasonality (vulnerability)	Fish consumption during the lean season of fish during *boro* harvest while availability is very less both in nature and market	93.3	66.7
	Income from fingerlings and its availability in the ricefields immediately after *boro* harvest reduces needs for distress sales of rice	70.0	57.0
	Consumption and income of fish during low income month	66.7	53.3
	Easy to catch fish during wet season	50.0	43.3
Farming society	Gifting seed and foodfish to relatives	45.0	55.0
	Gift seed and foodfish to neighbours	67.3	53.0

Fish seed production in the ricefield based systems acted as a strategy for overcoming the 'fish scarce period' namely 'hungry gap of fish' immediately after the *boro* harvest as reported by both primary (93.3%) and secondary (66.7%) adopters. More than 50% of adopters of both categories reported that during the *boro* harvesting time they could avoid distress sales of rice to meet household expenditure and to avoid purchasing fish from the market as they consumed fish from the ricefish plot. Fish seed production in the ricefish plot enhanced fish consumption in the low income months for the majority of households. Catching foodfish particularly tilapia by angling for household consumption during the wet season was reported by 50% of primary and 43% secondary of adopters. The majority of both primary and secondary adopters (67% versus 53%) gifted seed/fingerling/foodfish to their relatives. Gifts were confined not only to relatives but also to neighbours (45% primary versus 55% secondary adopters).

Adoption and adaptation process: linked with seed marketing channel

The majority (70%) of primary adopters sold seed to different customers such as pond owners, fry traders and both fry traders and pond owners (Figure 6.4). However 25% of adopters did not sell seed but rather used them for restocking their own pond and riceplot to produce food fish. Overall 40% of the households sold their fingerlings to fry traders.

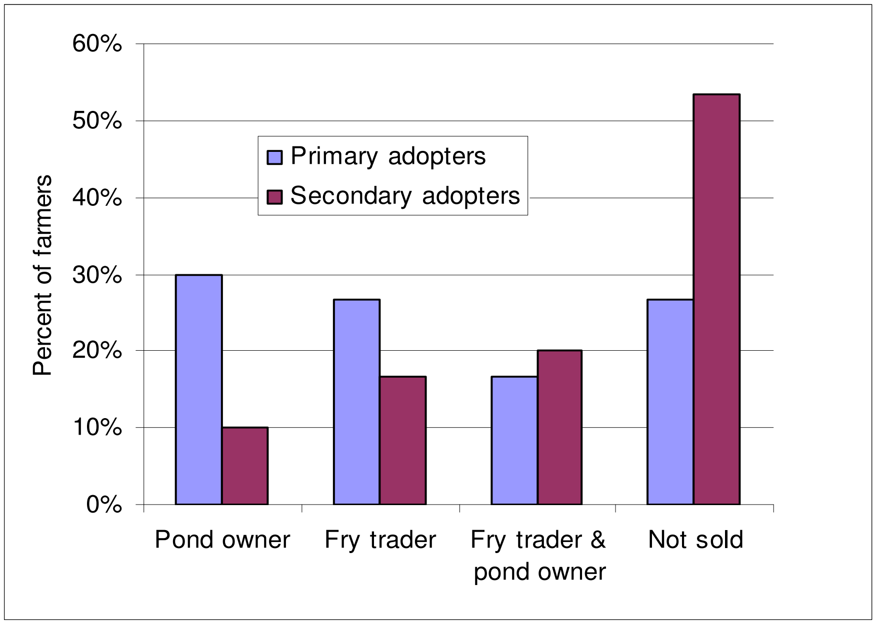


Figure 6.4: Number of adopters (%) sold fish seed through different channel.

About 50% of secondary adopters sold seed and the remaining 50% not at all. Out of them, 20% sold to the fry traders and pond farmers and collectively about 35% of them sold seed through fry traders. Figure 6.5 shows the majority of primary adopters sold seed during the period of *Boishak-Jaistha* (April-May). On the other hand, the majority of the secondary adopters (23%) sold seed in the period of *Jaistha-Bhadra* (May to July). The delaying of fingerling sales by secondary adopters was due to their relative better-off status than primary adopters.

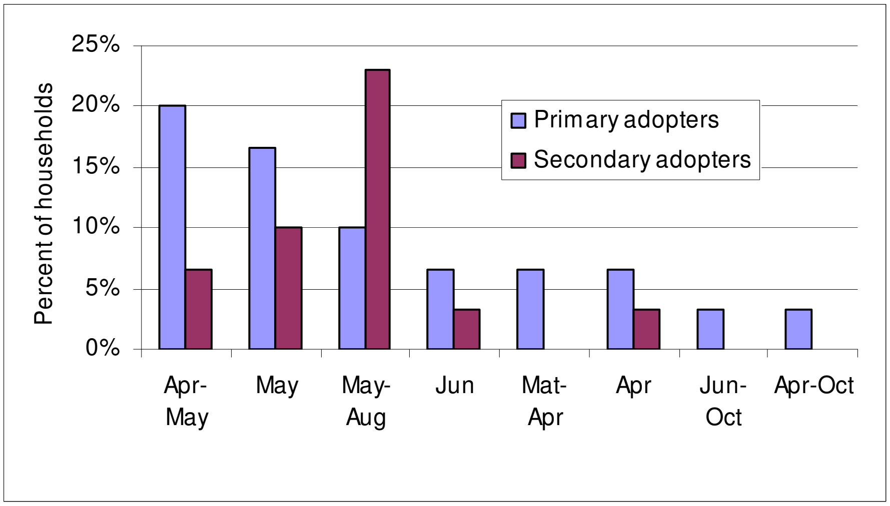


Figure 6.5: Percent of adopters sold seed/fingerling in the different months.

In the primary adopting households, the money earned from selling seed was used mostly for household expenditures such as shopping for food items from the local market (Table 6.7). Twenty percent of adopting households used the money towards their children's education.

Table 6.7: Use of money derived from seed selling by primary and secondary adopters

Uses of money	Adopters (%)	
	Primary (N=30)	Secondary (N=30)
No use as not sold	27	53.3
Used in household expenditure (household shopping, purchasing clothing in ceremony etc.)	20	13
Used for child education expense	13	3.3
Invest in pond & household expenditure	10	
Invest in agriculture	10	3.3
Invest in pond	6.7	3.3
Paying loan, household & agriculture expenses	3.3	
Invest in agriculture & household	3.3	
Invest in grocery shop	3.3	
Saved in bank	3.3	
Used to purchase land		13.3
Invested in riceplot development		3.3
Invested in business, household expenditure & bank saving		3.3
Invested in business and household expenditure		3.3

Around 10% of secondary adopters used the money for household expenditures and 13 % for purchasing land.

Adaptation of RBFSP

Half of the primary adopters made significant changes to their systems over the period of adoption. Thirty percent of adopters extended their plot area to increase production and income from both seed and food fish. Some adopters (10%) increased the ditch area in their plot to raise seed in the fallow period between the *boro* to *amon* seasons and to ensure safety for both fingerlings and brood fish, particularly tilapia from the threat of water crisis and theft. Moreover, changes in fry harvesting strategies were made by 10% of adopters which included harvesting and selling of fry intermittently (3-4 times observed at field level) to reduce the density and enhance the growth rate of fish. This practice accelerated the production of fingerlings, attracted fry traders and resulted in higher economic returns and better cash-flow. More than 60% of secondary adopters did not carry-out any changes in their seed production systems. More than 20% extended their riceplot to produce seed and food fish. In addition, about 3% of adopters shifted fish seed production to other plots due to rat disturbance, 3% raised dikes to further protect fish and 3% stocked additional carp fry.

More than 30% of primary adopters did not face any problems over the period of adoption of fish seed production. However, about 70% of adopters faced different challenges (Appendix 8), of which scarcity of broodfish was most important and experienced by 26% adopters. Similarly, about 40% of secondary adopters (Appendix 9) did not face any problem during seed production. The remaining 60% adopters faced different types of problems, of which failure to collect common carp eggs due to inconsistent spawning in household ponds was most important.

6.4.2 Non-adopting households

6.4.2.1 General household characteristics of non-adopting households

The primary occupation of household heads in non-adopting households (NT, IR and LR) was agriculture, however those household heads who had never tried (NT) fish seed production were found to be more plurimodal. Activities included business (20%), service (10%), day labour (7%) and van puller (3%). In the case of secondary occupations, business, day labour, agriculture, petty service, van puller etc. were found in the all three categories of non-adopting households. Other households' characteristics were more or less similar in all three categories of non-adopting households (Table 6.8).

Table 6.8: Characteristics of households who never tried, initially rejected and rejected after few years the RBFSP technology

Household characteristics	Never tried (NT)	Initial rejecter (IR)	Late rejecter (LR)
Main occupation			
Agriculture	60.0% (18)	83.3% (25)	73.3% (22)
Business	20.0% (6)	3.3% (1)	6.7% (2)
Service	10.0% (3)		16.7% (5)
Day labour	6.7% (2)	3.3% (1)	
Van puller	3.3% (1)	10.0% (3)	3.3% (1)
Secondary occupation			
Business	13.3% (4)	20.0%(6)	13.0% (4)
Day labour	10.0% (3)	10.0% (3)	6.7% (2)
Others (agriculture, petty service, van puller etc.)	26.7% (8)	26.7% (8)	37.0% (11)
Not any	50.0% (15)	43.3% (13)	43.3% (13)
Household occupancy			
Household size	5.6±1.9	5±2.2	5.2±2.4
No. of male	2.9±1.2	2.8±1.8	2.5±0.9
No. of female	2.8±1.4	2.2±1.1	2.7±1.7
Age group distribution of household head			
Young age (=<30)	20.0% (6)	20.0% (6)	13.3% (4)
Middle age (31-60)	80.0% (24)	73.3% (22)	80.0% (24)
Old age (above 60)		6.7% (2)	6.7% (2)
No. of other member in different age groups			
Age 1-14	1.5±1.3	1.4±1.1	1.5±1.6
Age 15-30	2.2±1.4	1.7±1.2	1.5±1.1
Age 31-60	0.8±0.7	0.9±0.8	1.03±0.9
Above 60	0.10±0.3	0.03±0.2	0.1±0.4
Education of household head			
Illiterate	36.7% (11)	26.7% (8)	20.0%)6)
Primary	26.7% (8)	26.7% (8)	16.7% (5)
Secondary	23.3% (7)	43.3% (13)	46.7% (14)
Above secondary	13.3% (4)	3.3% (1)	16.7% (5)
No. of other member in different education attaining groups			
Illiterate	1.8±1.5	1.4±1.2	1.3±1.9
Primary	1.5±1.1	1.3±0.9	1.4±1.2
Secondary	1.2±1.8	0.9±0.9	1±0.8
Above secondary	0.3±0.6	0.4±0.7	0.4±0.7
Land ownership (ha)			
Own	0.5±0.5	0.7±0.9	0.7±0.8
Leased in	0.1±0.2	0.01±0.03	0.02±0.1
Leased out			
Share in	0.01±0.04	0.01±0.04	
Share out			
Multi-owner			0.2±0.9
Mortgage in	0.03±0.10		0.03±0.1
Mortgage out			
Pond ownership			
Own pond (dec)	6.1±9.7	6.5±8.1	7.1±8.2
Leased in			0.6±3.3
Share in			
Multiowner	2.6±9.9	5.9±15.3	20.0±49.2
Gross annual income ($)	1064.5±617.5	1035.0±863.1	1290.5±981.3

Figures in the parentheses indicate number (n); HH=household head

6.4.2.2 Perceptions regarding RBFSP technology

More than 60% of NTs knew about RBFSP from the primary adopters. Thirty percent of respondents got the idea directly from CARE FFS members and 7% had no idea of fish seed production in the rice fields. The majority (75%) knew at least about common carp seed production techniques which they explained as the collection of common carp seed during winter season from the pond using water hyacinth and stocking them into the riceplot to produce fish seed and fish. The majority (73%) of IRs acquired knowledge of fish seed production from CARE as direct participants. However as secondary adopters, the remaining 27% of farmers achieved the idea of fish seed production from primary adopters. Similarly, 83% of LRs acquired knowledge on fish seed production from CARE as direct participants. Only 17% LRs acquired the idea from primary adopters as secondary adopters. Among the LRs, around 75% farmers continued fish seed production activities for 3-5 years, and the other 25% of farmers continued for a longer period (6-14 years) before rejection of the technology.

6.4.2.3 Reasons for not adoption of rice field based fish seed production technology

Respondents (NTs) expressed different reasons responsible for never adopting RBFSP activities. Out of the total respondents (N=30), 47% did not attempt seed production due to lack of time; their perception was that it would conflict with off farm activities (business, service, etc.); followed by having no suitable riceplot - 30%, having no own land-17%, and the remaining due to the physical inability of the farmer (e.g. old aged, disability to work, chronic disease, heart disease etc.); or being busy with agriculture (on-farm) activities (Figure 6.6).

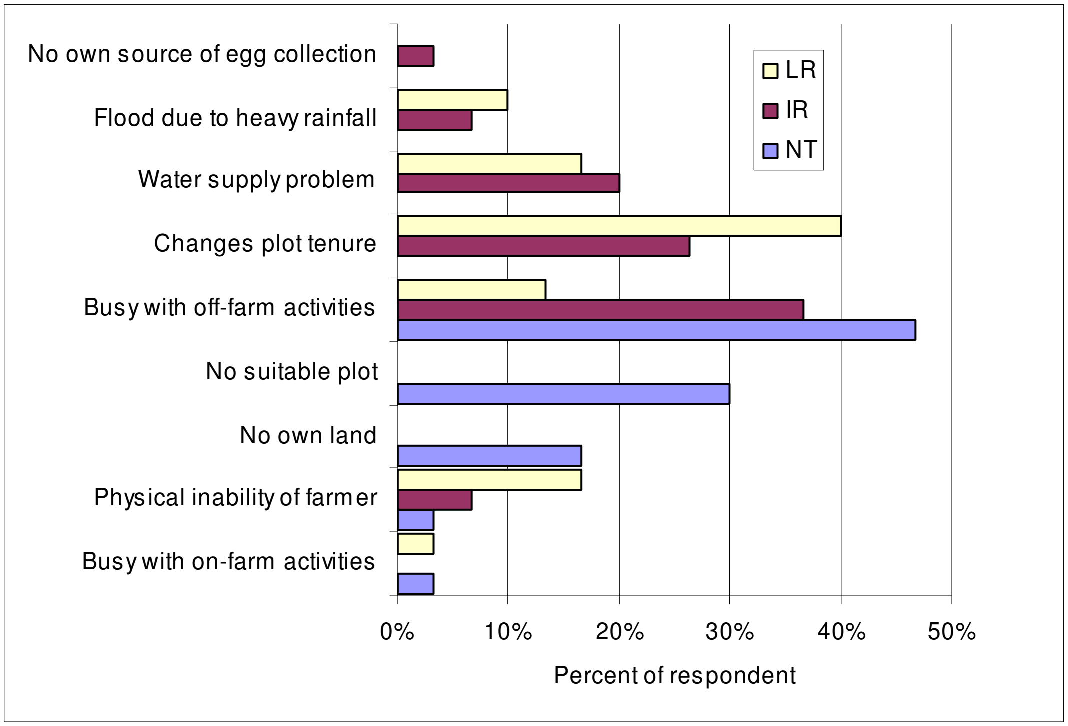


Figure 6.6: Reasons for which respondents (%) did not adopt fish seed production in the rice field based systems.

More than 35% IRs rejected the technology initially citing that they were busy with off farm activities like business, jobs etc. The reason "busy with the off-farm activities" has different dynamisms which are disaggregated (Figure 6.7). About 26% farmers rejected the technology due to changes of plot tenure and 20% rejected the practice because of irregular water supply. Some IRs mentioned problems related to flood and failure in collection of common carp eggs being responsible for rejection of technology.

The foremost important reason for LRs to reject the technology was due to changes in land (riceplot) tenure reported by about 40% of respondents. The detailed causes of land tenure changes in farming households are mentioned in Figure 6.7. The other causes for rejection were water supply problems, followed by physical inability of the farmer and conflicts with off-farm activities.

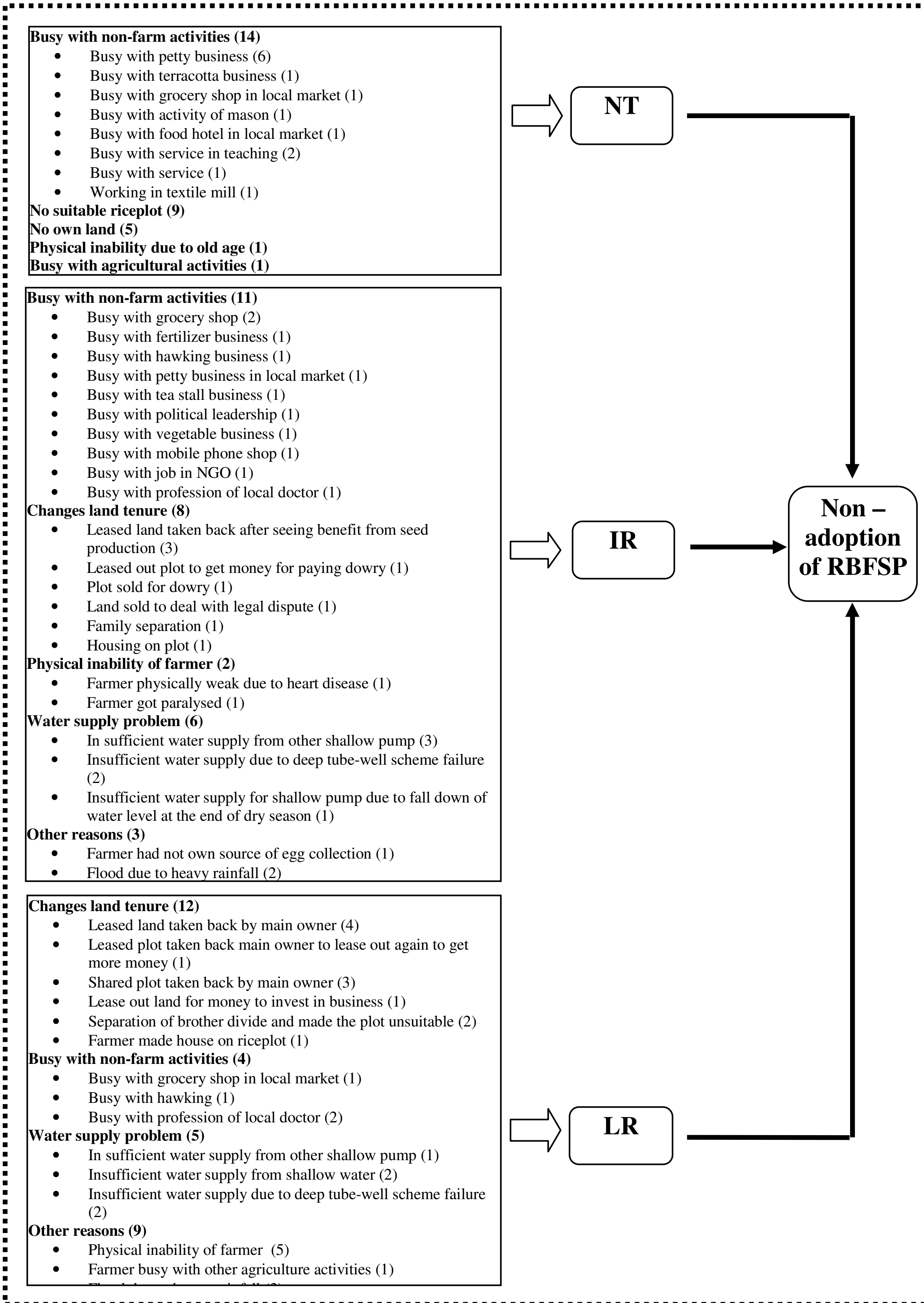


Figure 6.7: Diagram showing detail reasons for non-adoption of RBFSP; figures in parentheses indicate the number of respondent out of 30 in each group.

6.4.3 Pair–wise comparison of major factors between adopters and non-adopters

In terms of major socio-economic characteristics, only NT households differed significantly (P<0.05) with primary and secondary adopters. In terms of own land and annual income, except NT households no significant (P>0.05) differences were found between the other four groups of households (Table 6.9).

Table 6.9: Pair-wise comparison between different groups of respondents

Pair-wise comparison		P value		
		Schooling year	Own land	Annual income
PA	SA	0.266	0.793	0.228
	NT	**0.043**	**0.041**	0.547
	IR	0.054	0.143	0.285
	LR	0.788	0.239	0.467
SA	PA	0.266	0.793	0.228
	NT	0.357	**0.022**	0.042
	IR	0.409	0.085	**0.024**
	LR	0.399	0.151	0.054
NT	PA	**0.043**	**0.041**	0.547
	SA	0.357	**0.022**	**0.042**
	IR	0.923	0.559	0.641
	LR	0.079	0.383	0.900
IR	PA	0.054	0.143	0.285
	SA	0.409	0.085	**0.024**
	NT	0.923	0.559	0.641
	LR	0.096	0.773	0.732
LR	PA	0.788	0.239	0.467
	SA	0.399	0.151	0.054
	NT	0.079	0.383	0.900
	IR	0.096	0.773	0.732

(PA = Primary adopter; SA = Secondary adopter; NT = Never tried; IR = Initial rejecter; and LR = Later rejecter)

6.4.4 Women in adopting households

6.4.4.1 Woman's perception of fish seed production

The majority (70%) of women learned about RBFSP through CARE's FFS training. The remaining 30% were not members of the FFS, however among them 20% acquired the knowledge from their husbands. Some females in adopting households also learned these techniques from their neighbours (7%) and relatives (3%).

Amongst women in adopting households, there were multiple responses in terms of knowledge gained with respect to fish seed production. A considerable proportion of women (42%) knew how to produce common carp and tilapia seed/fingerlings in the rice-fields. About 30% of women were familiar with common carp, tilapia and other fish species. Moreover, about 80% were aware of techniques used to preserve common carp and tilapia broodstock in the household pond for the next year's seed production. They considered this alongside the preservation of crop and vegetable seeds being analogous with common carp and tilapia broodfish with respect to assured production of fingerlings in the following year.

6.4.4.2 Roles of women in fish seed production activities

Women showed multiple responses in terms of their involvement in direct and indirect activities of rice-field based fish seed production. More than 40% of women were involved in direct activities including feeding fish and tending the ricefish plots (Table 6.10). Rice bran and by-products of rice from their households were used for feeding fingerlings rather than purchased feed. Most women (60%) took part in the collection of broodfish and eggs from the pond using water hyacinth for stocking into the riceplots. Regarding indirect activities, more than 50% of women interviewed looked after their riceplots with the help of their children. Indirectly they also maintained plots by informing their husbands of riceplot conditions such as water level, ditch and dike condition, fish condition etc. Over 80% women in adopting households reported that their participation in fish seed production activities did not affect other household activities.

Table 6.10: Women involved in different fish seed production activities

Type	Activity	Percent
Direct activities	Feeding and looking after fish	43.3
	Collection-stocking eggs, feeding and looking after fish	33.3
	Collection-stocking eggs and looking after fish	10.0
	Collection-stocking eggs and feeding fish	6.7
	Collection-stocking eggs	6.7
Indirect activities	Sent her child for looking after the plot	56.7
	Informed husband plot condition to take the necessary measure	36.7
	Send her son to inform fry trader	6.7

6.4.4.3 Women roles in seed selling and use of earnings

The present study demonstrates the active participation of women in rice-field based fish seed production and their share in decision making for fish seed production. More than 50% of women interviewed reported that they actively participated in the selling of seed with their husbands (Figure 6.8).

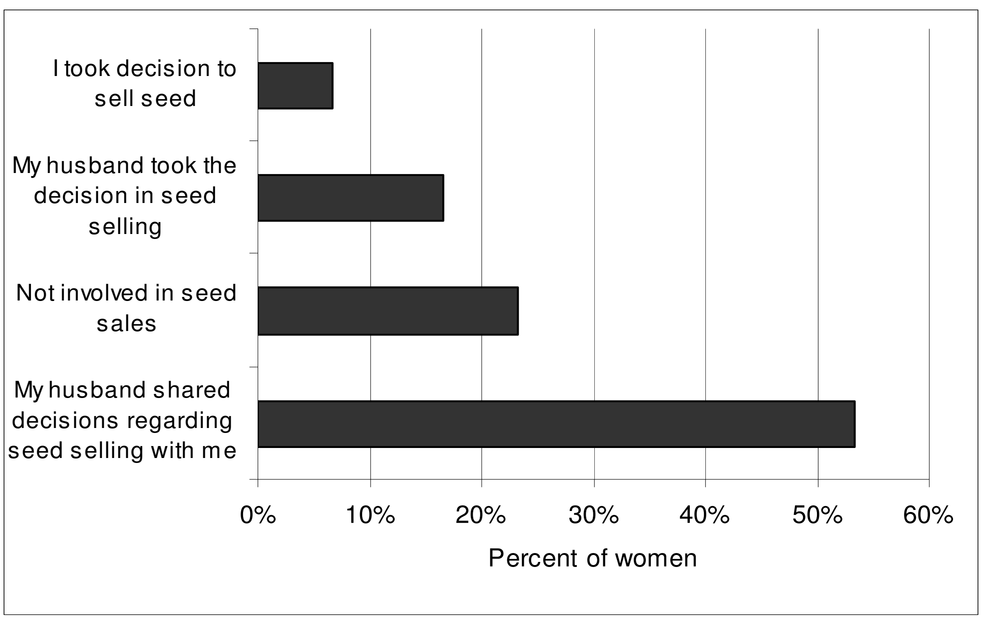


Figure 6.8: Percent of women making decisions regarding seed sales.

In terms of using money gained from seed sales, 30% of women used all of the money for household expenditures which were directly related to their own activities. These included purchasing clothing (*shari*), cooking utensils and others purposes (Table 6.11). In addition, 10 % of women used a proportion of earnings from sales of seed after receiving from their husbands. Women revealed that the access to decision making that was afforded to them through seed sales was positive for them and their children.

Table 6.11: Primary income use from seed selling by household members

Used of money by household member	Percent of women
I used money for household expenses	30.0
My husband used the money	30.0
My husband tended to keep the money from which I used for my expenses	10.0
I keep the money, from which my husband used for his expenses	6.7
Seed were not sold	23.3

6.4.4.4 Gifting fingerlings/food fish to relatives and neighbours

The present study shows that household women played a major role in the gifting of fish seed to their relatives. Figure 6.9 shows that women gifted fingerlings and food fish to different types of relatives almost all of whom were natal family members.

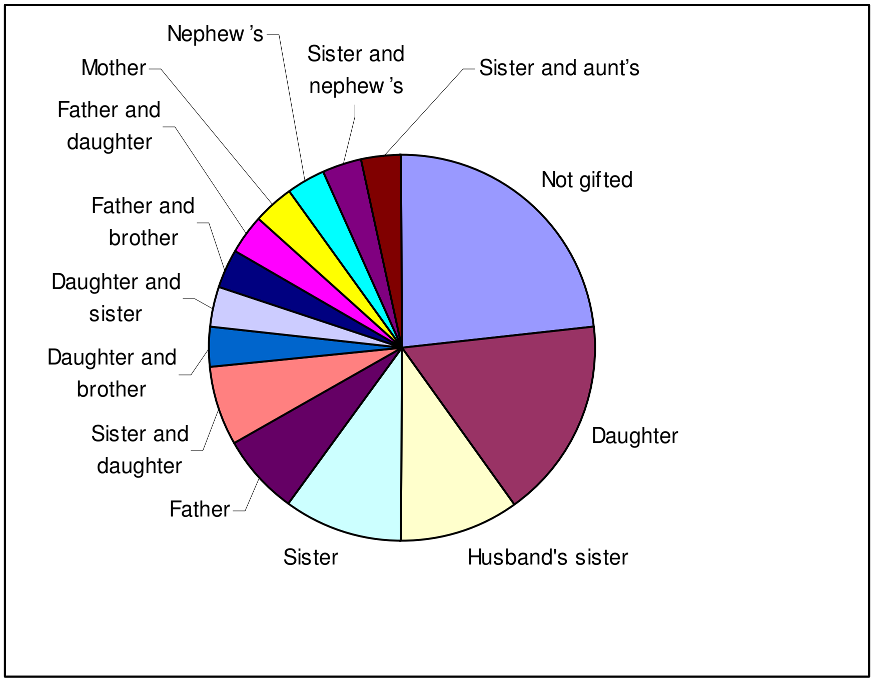


Figure 6.9: Percent of women gifting fingerlings to different relatives and neighbours.

Approximately 64% of women gifted food fish to their neighbours. In return, neighbours often gifted fruits, vegetables etc. or helped to catch fish from the riceplot and protected the area from poachers. Gifting anything like seed/foodfish to neighbours strengthened social relationships.

6.4.5 Women in non adopting households

6.4.5.1 Awareness of ricefish and RBFSP

About 90% women in the non-adopting households had the idea of fish production activities in ricefields. Similarly about 90% of women were aware of fish seed production in the ricefield based systems. Knowledge of these activities was gained in different ways, one of which was through membership of a CARE FFS. While the remainder learned about it from their husbands, neighbours etc.

6.4.5.2 Reasons for non adoption of RBFSP activities

The major reason for non-adoption of the technology i.e. rejection of the technology, was the change in land tenure of the farming households (Table 6.12). In those households where the technology was never tried, no suitable land was the main reason. The causes for non-adoption of this technology reported by the women were similar to male non-adopting farmers suggesting new technologies have fewer boundaries to access for women.

Table 6.12: Causes for current non-adoption of RBFSP by households

Causes	Number of women	Percent of women
Rejected due to leased owner taken back the land	5	16.7
Water supply problems	5	16.7
Rejected as my husband busy with business	2	6.7
Rejected due to heavy rainfall causing escape of fish from the plot	2	6.7
Rejected due to family separation	1	3.3
Reject for my husband physical inability-eye sight problem	1	3.3
Rejected as it is problematic to collect seed from multiunit pond	1	3.3
Rejected as my husband busy with job	1	3.3
Rejected due to leased out the plot for my husband treatment	1	3.3
Rejected as my son busy with agriculture	1	3.3
Never did fish seed production as no suitable riceplot	8	26.6
Never did fish seed production as no time for job	1	3.3
Never did fish seed production as we have no land	1	3.3

6.5 Discussion

6.5.1 Adopting households

Basic characteristics of primary and secondary households

Although agriculture was found to be the main occupation of both primary and secondary adopters it was relatively more important among primary adopting households. Primary adopters were poorer than secondary adopters in terms of some basic socio-economic characteristics such as education attainment, land ownership and annual income. In this context of rice-based livelihoods and relatively poor wellbeing, on-farm diversification (Ellis, 2000) through incorporation of fingerling production in ricefields contributes to the adoption process. Although at a non-significant level, a greater proportion of secondary adopters were involved in non-farm activities such as business and service. While there was a difference of livelihood strategies between primary and secondary households, adoption of RBFSP suggests compatibility of this technology to their existing livelihoods. Sen (2003) argued that poverty escapees overcome structural obstacles by pursuing multiple strategies (such as crop intensification, agricultural diversification, off-farm activity, livelihood migration etc.) which then permits them to accumulate a mix of assets relatively rapidly.

Knowledge on technology

The majority (two thirds) of secondary adopters were not buddies of primary adopters although they were supposed to be by the second season training of FFS. The FFS system encourages wide dissemination of knowledge through farmer to farmer communication and there was a reliance on the trained participants to pass along all that s/he has learnt to the others. In this study, primary farmers perhaps selected nominal buddies as an obligatory task in FFS training sessions who were not appropriate potential adopters of RBFSP. However, some farmers shared their interest and who had suitable riceplots learned this technology as secondary adopters without being buddies with primary adopters. In previous CARE studies evidence showed there was a significant loss and change of quality of the information as it passed from one person to another in the field (Debashish et al. 1999). In agricultural extension, the FFS approach is being implemented in many developing countries in Asia and Africa however, this approach does not result in significant farmer uptake (Quizon et al. 2001). It was anticipated that FFS graduates would retain and disseminate their FFS-acquired knowledge and experiences making FFS a cost-effective and viable approach to agricultural extension on a large scale. Impact analysis has shown very little diffusion of FFS-acquired knowledge from FFS participants to other community members in the Philippines; participants tended to retain their acquired knowledge which made the approach less cost-effective (Rola et al. 2001). Feder et al. (2003) reported that FFS did not have a significant impact on either the participants or their neighbours in terms of rice farming in Indonesia.

Secondary adopters developed systems themselves after receiving knowledge from their neighbours through observation season after season in the ricefish plot of primary adopters. Traditionally in rural areas, it was revealed in previous studies (Hoque, 1972; Latif, 1974) that neighbours and friends were the major sources of information. Such informal networks were revealed in the fingerling trading network in Asia through which pond farmers purchased fingerlings from fry traders (Barman et al. 2002). In another study it was argued that interpersonal communicational media such as friends and neighbours were found to be the main source of new agricultural innovations (Kashem and Halim, 1990). In rural areas having a look at someone's ricefish plot is not a formal matter or restricted which has shown a adoption attribute to 'observability' (Rogers, 1995b). It is quite usual that some technological knowledge can be acquired by osmosis i.e. by observation over time, technological benefits can move horizontally in communities (Basu et al. 2001).

About one third of secondary adopters received knowledge from their kinship group (*Bongsho*) which is a very strong network in rural areas of Bangladesh. Kinship and relatives have long been understood to be the major and most trustworthy source of agriculture innovation information in Bangladeshi society (Hoque, 1972; Latif, 1974; Kashem and Halim, 1990). Another study also suggests that kinship is the chief resource for creating a support and security network among the rural people of Bangladesh (Nazneen, 2004). Beyond kin, many secondary adopters were the neighbours of primary adopters indicating the importance of informal social networks among farming households through which knowledge dissemination occurrs (CARE, 1998).

Among the technologies in and around the ricefish plot, RBFSP was ranked highest by the respondents based on its lack of financial investment by primary adopters and for its role in additional income generation by secondary adopters. This finding supports the assessments that primary adopters are investment averse through poverty but that secondary adopters seek to additional income and are slightly better resourced. Primary adopters saw this as an opportunity to diversify out of need whereas a smaller proportion of secondary adopters saw it as a way to diversify to capitalize. Such attitudes of secondary adopters are likely to indicate that they have sought opportunities for entrepreneurship based on RBFSP. This smaller proportion of entrepreneurs could leverage broader development involving fry traders, pond fish producers and other actors in decentralised seed networks. In this connection, a previous study argued that uniform adoption in agriculture did not occur and in most cases adoption behaviour differs across socio-economic groups over time (Feder et al. 1985) ranging from subsistence to entrepreneurial households. Further research could be undertaken for entrepreneurial development RBFSP among the rural farmers.

In terms of pair-wise comparison of fish seed and food fish production no significant differences were found for either primary or secondary adopters. Similarity in the preference for the two technologies was due to the success of food fish production greatly depending on seed production in ricefields. The season for foodfish production in ricefields is very short and the predation may be very high because of difficulties in excluding all predators (FAO/ICLARM/IIRR, 2001) from extensive areas of ricefields – where availability of large sized fingerlings in relatively small quantities at the critical time is therefore very important. This confirms the widespread assertion that the unavailability of fish seed is a major constraint of ricefish promotion in Asia (Waibel, 1992; Little et al. 1996; Gupta et al. 1996; Halwart, 1998; Edwards, 1999b).

Fish seed production, was ranked by respondents significantly higher than vegetable and low-input rice production technologies probably due to the greater positive impacts of RBFSP technology compared to other risks and disadvantageous factors are considered. Vegetable production on the riceplot dike attracted rats that burrow causing destruction of the dike which then required large scale repair every year. The basic components of low external input rice production were line transplantation of rice seedlings, use of organic fertilizers and application of integrated pest management systems. The lower score of low external input rice production and the significant difference when compared with other technologies was caused by the need for additional labour to these activities and negative attitudes of labourers. Line transplantation was reported to reduce the requirement of seedlings but increase the requirement for labour to carry out weeding (CARE, 1998). At least two additional people are needed for this practice. It becomes difficult in poor and marginal households as they typically transplant rice seedlings without hired labour. A recent study carried out in Madagascar showed that line transplantation of rice is significantly more labour intensive than traditional transplantation of rice (Moser and Barrett, 2006). Additionally, the negative attitude of labourers to line transplantation relates to the need for outward movement within ricefields. In many countries some low external input technologies were not adopted by the farmers due to high labour requirement (Tripp, 2006a). The use of organic fertilizers can reduce rice production costs but farmers lack enough means to use it over the whole cycle of rice production due to its scarcity. Because of these limitations low-input rice production resulted in an incomplete adoption in farming households.

Reasons for adoption related to riceplot, pond, family, seasonality and society

Almost all farmers, whether or not they were primary or secondary adopters had established fish seed production technology as an important IPM tool and given up the use of pesticides. It has been well verified from different empirical studies that presence of fish in the ricefields reduces the need for the use of pesticides (Kamp and Gregory, 1993; Halwart and Gupta, 2004).

Using riceplots for fish seed production stimulated a substantial increase in non-stocked fish. Halwart (2004) reported that since ricefish farming reduces the need to use chemicals for pest control, this assists in preserving rice-field biota where non-stocked fish and other aquatic animals are important. Little et al. (1996) reported that wild fish are important agents in the control of pests in rainfed ricefields in Northeast Thailand. Better water control in seed producing riceplots coupled with increased non-stocked fish eating pests contributed to giving up pesticide use (Biswas, 2007). However, discrimination was observed between the primary and secondary adopters in this regard, i.e. primary adopters perceived the value of increased non-stocked fish more than secondary ones. The causes behind the discrimination were investigated qualitatively at the field level which revealed that primary adopters emphasised the development of riceplots for non-stocked fish also. During the rainy season they set a unidirectional valve across the plot dike to allow the fish to enter. This knowledge developed from the CARE FFS training while farmers were trained about the development of their ricefish plot ecology through increasing non-stocked fish production. During FFS training in the CARE Go-Interfish project, farmers were encouraged to stock broodfish of self recruiting species (SRS). Discussion with a number of secondary adopters revealed that they had not facilitated SRS production in ricefields. Due to their increased access to ponds and knowledge of conventional pond aquaculture they perceived that external fish may result in lower production of fish fingerlings and fish. A recent farmer participatory research revealed that avoidance of negative action on SRS in conventional carp polyculture in pond is important for better management SRS productivity (Islam, 2007). Systematic knowledge on fish management in ricefields is lacking at the farmer level, but it is crucial to understand their role in this ecosystem as well as their potential as bio-control agents of rice-pests (Halwart et al. 1996).

The majority of the adopters reported that adoption of this technology did not hamper their rice production. Long term studies suggest that rice yields from modern monocultures are not practically sustainable (Pingali et al. 1990) and the negative environmental impacts of intensive fertilisation and pesticide uses are now better understood whereas the advantages of encouraging mutualism between rice and fish by which they benefit (e.g fish consume pests and rice plant intake faeces of fish as fertilizer) is clear (Halwart and Gupta, 2004). As a result, introduction of fish in the rice-field can increase rice production (Lightfoot et al. 1992; Kamp and Gregory, 1993; Akteruzzaman et al. 1993; Halwart and Gupta, 2004). This organic farming leads to improved soil quality in more marginal agro-ecosystems (Pretty et al. 2003). There are now growing signs that the rice-centric phase of agricultural/rural development is fast approaching its limit (Sen, 2003). Broad based agricultural growth will continue to play an important role in rural poverty reduction, but its quantitative impact on poverty reduction would be contingent on diversifying to high value added crops and the poultry, livestock and fishery sub-sectors (Sen, 2003).

Many adopting farmers were interested in practicing RBFSP because of its perceived simplicity; the relative multiplicity of benefits possible and its low technical risks. Halwart (1999) termed ricefish as a "lower risk" production technology which can motivate even poorer farming households. Ideally, 'relative advantage' is the degree to which an innovation is perceived as being better than the idea it supersedes (Levine and Fowler, 1995; Rogers, 1995a; Rogers, 1995b; Agarwal, 2000). It is an important factor in adoption of any technology not only in agriculture but also in other fields of innovation (Rogers, 1995a; Davis et al. 1989; Iivari, 1996; Kishore, 1999).

It addition RBFSP has also increased overall on-farm production achieved by the majority of both primary and secondary adopters. A large proportion of adopters mentioned that developing a riceplot through dike raising, digging a ditch etc. was an important investment made by the household over time. Not stocking and no production of fish fingerlings therefore imposed an opportunity cost. Improvement in such physical and human asset as modified ricefields for RBFSP has been identified as important factors influencing the escape from poverty (Sen, 2003).

Fish seed production encouraged adopting farmers to effectively use riceplots adjacent to their households. Typically such plots were less productive due to shadowing by big trees and bamboo bushes. Disturbance by their own and neighbours livestock resulted in reduced rice production, particularly during the *amon* season. Through the introduction of fish seed production activities, adopters often converted the shaded part of their riceplot into a ditch, and the availability of water in the ditch discouraged poultry/cattle birds to enter the plot, household members also paid extra care to the plot; all together these changes made the plot more productive than others.

Ground water irrigation became widely available after the mid 1980's due to a series of changes in irrigation policy in Bangladesh. As a result, although the price of deep tube-wells increased, cheaper shallow tube-wells entered the ground water market dramatically expanding the area under irrigation. Consequently the ground water market has been transformed from a monopolistic situation to an ologopolistic structure after the introduction of shallow tubewells (Al-Mamun et al. 2003). In the present study, some adopters had shallow pumps or boreholes adjacent to their riceplots or household premises, from where water passed to their plots as well as their neighbours, increasing the availability of water through uncontrolled leakage across the earthen drain into ricefish plots and facilitated adopting farmers to manage their plots with little or no irrigation cost. Those farmers, particularly the poorer having no ability to purchase pumping machines tended to have boreholes adjacent to their riceplots. Some adopters with water pumps also rented them to poorer adopters thus benefiting each other. The use of shallow tube-wells in the rural areas has improved the socio-economic condition of rural people substantially (Mondal and Saleh, 2003).

Introducing tilapia along with the existing common carp increased total fingerling production in ricefields (Barman et al. 2004). Relatively higher solar radiation during the *boro* season (March) contributed to increased phytoplankton availability and therefore greater production of fish in ricefields (Halwart et al. 1996). At the early developmental state, tilapia (*Orechromis niloticus*) gradually change from their predominantly omnivorous feeding habit to herbivorous growing faster into large sized fingerlings (Trewavas, 1983). Stocking such on-farm produced large sized fingerlings enhanced pond production significantly (Chapter 3 and 5) (Barman, 2000) contributing to the adoption process, thus the demand of large size fingerling has been a key factor for aquaculture success (Little et al. 2005).

Rice-field based fish seed production absorbed household labour through the involvement of men, women and children. Labour employment is an important indicator of aquaculture's contribution to poverty reduction in developing country agriculture, where labour supply is still abundant (Ahmed and Lorica, 2002). Total labour inputs were higher in the poorer primary adopting households compared to secondary adopters. Culturally, women from the richer households in rural areas were less likely to work outside the household as it is related to prestige of a family (Kabeer, 1997). In the present study, the involvement of family members in seed production activities occurred more in primary adopting households than among the secondary adopters suggesting their relative poverty. Small-scale adopters have been observed to use family labour intensively to the point of self exploitation, because it is seen to have close to zero opportunity cost and in doing so avoids the supervision constraint of managing hired labour (Ellis and Biggs, 2001). Family labour is by far the most important production factor in the agrarian sector of developing countries and maintenance and enhancement of labour productivity is central to securing and increasing income (World Bank, 1986; Zeller and Sharma, 1998).

Fish production in the ricefield played a notable role in meeting the demand for fish of different household members such as children, women and old aged persons. Particularly in terms of intra-household distribution of fish and meat, different members were evaluated differently at the household level as they can catch the small fish of low marketable value on a regular basis. Previous studies recognised that intra-household distribution of food discriminates against women and young children, and that in most developing countries, this discrimination increases at times of shortage (Schofield, 1974; Safilios-Rothschild, 1980). Dowlah (2002) proposed that Bangladeshi people, especially women and children, suffer from some of the highest under-nutrition and malnutrition levels in the world. The literature also suggests that foodfish supply per capita declined steadily in Bangladesh as well as other developing countries in the period between from 1961 to 1990. Similarly, overall annual protein supply per capita has been falling suggesting that fish has not been replaced with other animal protein (Kent, 1997). He also reported that while fish production has increased across the world and overall national per capita consumption level may have gone up there may have been no corresponding increase in consumption by the poor.

The elderly population is increasing day by day and presently they comprise around 6% of the total population in Bangladesh (Kabir, 2003). In rural villages the primary source of support for elderly people is still the family, especially the sons, who are expected to support their elderly parents (Kabir et al. 2002). Good quality food stuffs that includes fish, meat, eggs and milk has been recognized for both promotion of health and prevention of diseases in elderly people (Nilsson et al. 2005). In the present study on-farm fish production contributed to adoption process of RBFSP providing foodfish for elderly people in farming households. Intra-household discrimination at the individual level, lower per capita protein consumption, and special needs of elderly people at the household level appeared to have been positive expectations of RBFSP that triggered the household to adopt this technology.

Fish seed production in ricefield based systems acted as a strategy for overcoming the “hungry gap” of fish which had been identified during the longitudinal observation (Chapter 4). Just before and during the *boro* harvest (mid March to April), fish prices in the market peak due to lower availability and the natural production of fish begins.

Furthermore, at that time adopters are used to having little ready cash as all available money has been invested in the *boro* cultivation hence they cannot afford to purchase fish, and consumption of fish from their own plot attains a particular importance. In addition, the market price of rice can decline rapidly at this time and 'distress sales' of rice soon after the harvest are common (CARE, 1998). The adopting households reported that their need for such distress sales to purchase foodfish from the market for consumption had declined.

During the rainy season the household ponds fill with water and as are typically deep, impeding the harvest of fish. Fingerling production in shallow ricefields were a time efficient way for the adopters to catch food fish 'particularly tilapia' by angling for household consumption. It was observed at the field level that the elderly and children enjoyed angling in the ricefield to catch larger sized tilapia and so the practice was recreational as well. In rural Bangladesh people have a common social custom as well as social obligation to feed guests (*mehman*) with meat and fish (Larance, 1998). In remote villages it becomes difficult for the host to secure meat and fish instantly as their availability depends on specific days (*hatbar*) of the local market (*bazar*). Catching fish from the riceplot reduces reliance on the market and assist adopters in meeting such social expectations.

Some adopters also benefited from using nutrient rich sediments from in the deeper ditches in modified riceplots for production of *boro* rice seedlings and this resulted in production of healthy rice seedlings without the use of external fertilizers. Thus making a ditch inside the riceplot appears complimentary to both production of fish seed and rice an important observable indicator of the adoption process.

Both primary and secondary adopters gifted fish to their relatives as fingerlings, foodfish and brood fish. The major relatives of the adopters include brother, daughter, sister (married in other localities), and father-in-law (*shashur*). This sort of gifting to relatives appears to strengthen kinship links in rural areas. In return, the producing household receives higher esteem and reciprocity of food items such as vegetables and fruits. Adopting farmers also mentioned that gifting fish to their relatives from their own plot made them feel happy and proud. They also gifted to their neighbours and it was found that some adopters gifted tilapia broodfish to their neighbours when they lacked at the time of stocking. Some adopters reported that this type of gifting improved relationship with neighbours. Adopting farmers also stated that as fish were produced in the ricefield in abundance, their neighbours had a social right to a share. Neighbours often helped in harvesting fish from the riceplot which become an enjoyable social event. Gifting something to others is one of the important parts of social custom and obligation in rural areas of Bangladesh (Larance, 1998; Nazneen, 2004). In addition, studies have also revealed that sending gifts to relatives and neighbours strengthens social links (White, 1992; Mallorie, 2003). Household level fish seed production therefore supported these traditional practices being another element in strengthening social position and sustaining better relationship and network with relatives and friends.

Marketing channel of fish seed/fingerling

The sale of fish seed to local pond owners resulted in immediate access to the quality seed network at the community level. Selling seed through the fry trader channels diversified market transactions and impact of seed to other people in the same and other localities. Market transactions influenced distributional outcomes probably to a greater extent than technological innovations in production in comparison with conventional agrarian reform (Lewis et al. 1996). Evidence in the literature suggested that agricultural growth was attributed to few important protagonists where one of them was market transaction (Harriss, 1993). Thus RBFSP encouraged livelihood diversification in a broader context involving not only farming households but also poorer fry traders in the same or different localities (Chapter 5). In this regard, Ellis (2000) echoed that diverse livelihoods are less vulnerable than undiversified ones.

Primary adopters tended to market their fingerlings earlier than secondary adopters. This suggests that primary adopters developed a fingerling marketing strategy by which they earned income at the stage of early fingerling demand. Moreover as they were relatively poor, early cash income from fingerling sale was very important for them. On the contrary, the secondary adopters tended to sell fingerlings later than primary adopters possibly due to their reduced need for money as they were better-off.

In the primary adopting households, money earned from selling seed was mostly used for household level expenditure including purchasing food items and managing expenses for the children's education. Secondary adopters tended to use the money for household expenditure as well as for land purchase. RBFSP therefore contributes to the livelihood strategy of households in different ways – for poorer primary adopters helping with day to day food security and for the better-off secondary adopters supporting asset accumulation.

Adaptation of RBFSP by the adopters

Primary adopters tended to adopt the design and management of their riceplots in different ways after the initial year of adoption. This sort of behaviour might be achieved from FFS training which could be termed as 'trialability' of an innovation (Rogers, 1995b). Trialability is the degree to which an innovation may be experimented with on a limited basis suggesting what primary adopters trialled for RBFSP was within their limited riceplot resources. However, RBFSP holds 'relative advantage' (Rogers, 1995a) in terms of 'trialability' as it does not require large scale installation (e.g. such as poultry farm that requires selective space, fixed shed, feeding accessories, electricity for temperature management etc.) rather moving limited amounts of soil for extending riceplots and ditches. Many primary adopters extended their plot area to increase production and income from both seed and food fish. They also extended the ditch area of their riceplots to improve the safety of seed and broodfish particularly tilapia from the threat of water scarcity and theft. Moreover, changes were also carried out during the fry harvesting time, which included harvest and sale of fry over a prolonged period through a number of harvests. The resultant lower densities were reported to increase individual growth rate. Moreover this practice accelerated production of fingerlings as well as their availability and this probably helped to attract fry traders and resulted in a higher economic return. This learning of primary adopters could be reported as the accumulation of human capital; improving their livelihood strategy to meet the need for cash. Accumulation of such human capital could possibly be explained through the fostering FFS - created relationships among primary adopters (Banu and Bode, 2002) as well their better relationships with fry traders.

The major change among secondary adopters was the extension of riceplots to produce fingerlings and foodfish. Bringing changes to an innovation over time has been termed as 'modifiability' (Glantz et al. 1997). It is the degree to which the innovation can be updated over time. There is growing support in the research literature for the importance of modifiability as an attribute for adopting an innovation (Glantz et al. 1997; Blumenthal, 2001). Ideally, modifiability of an innovation strengthens the adoption process. Overall changes carried out by primary adopters were more diverse than by secondary adopters. This might suggest more innovative behaviour of primary adopters which could be explained by the influence of FFS training and explorative behaviour to enhance their livelihood strategy due to relative poverty. On the contrary, the extension of riceplots by better-off secondary adopters suggests the greater likelihood of them to become entrepreneurs in decentralised seed networks in terms of more commercially oriented production, enhancing the involvement of a wider range of actors/beneficiaries such as fry traders and foodfish traders.

Scarcity of broodfish particularly improved Nile tilapia was the major problem facing households adopting RBFSP. Broodfish escape from the riceplot during heavy rainfall and poaching were problems. The problem of broodfish escape was mitigated by one adopter through rising dikes but that was too costly for most adopters. The collection of broodfish from neighbours and enhancing care of the riceplot at night were used to improve the protection of broodfish in the riceplot ditch.

Failure to collect common carp eggs from household ponds was also identified as a problem for primary adopters and reported as the main problem in the case of secondary adopters. Collection of common carp eggs in the winter season was sometimes irregular as adopters strongly believed that the breeding of common carp is related to the lunar cycle (full moon and new moon) and the availability of broodfish in the pond with suitable breeding condition. In FFSs, adopters were trained to put water hyacinth in ponds during full and new moon when common carps breed (CARE, 2000). While adopters failed to collect eggs from their own ponds they collected them from their neighbours who had placed water hyacinth at the right time. Collection of broodfish and common carp eggs from neighbours during the critical period suggests that the adaptation process of fish seed production is not only related to the adopter himself but also to their neighbouring adopters. This sort of dependency could contribute to building social capital (as discussed in Chapter 5) strengthening the relationships among producers as well as between producers and non-producers at the community level. Generally poor adopters did not have their own pond and tended to collect eggs from the ponds of richer farmers. In this situation, richer farmers felt proud to let poor farmers collect fish eggs in the same way as they allowed them to use pond water for bathing. This dependency of poor on better-off adopters however, can be viewed as strengthening the relationships between the well-being classes of the community. Along with difficulties in egg/broodfish supply other problems were also faced by both primary and secondary adopters which have been mitigated within their own communities without any external support. The ability to solve these sorts of problems makes this technology a simple one without "complexity" which is an important attribute of technology in strengthening the adoption process (Rogers, 1995a).

6.5.2 Non-adopting households

The main occupation of household heads of all three groups of non-adopting households (NT, IR and LR) was agriculture. However, NT household heads were more diversified occupationally. In the case of secondary occupations, business, day labour, agriculture, petty service, van puller etc. were found in the all three categories suggesting similar access of households to these occupations.

Irrespective of the respondents in non-adopting categories, almost all of them gained knowledge of RBFSP activities through formal as well as informal ways. Most of them explained common carp seed production as "collection of common carp seed during the winter season from the pond using water hyacinth and stocking into the riceplot to produce fish seed and fish". The majority of the rejecters (IRs & LRs) received knowledge of fish seed production as CARE direct participants and about a quarter acquired knowledge as secondary receivers/adopters. In terms of the duration of practising this technology, some of the late rejecters continued for relatively long periods.

The major reason of NTs for not adopting the technology was identified as “busy with off farm activities” followed by lack of suitable plot; having no land; physical inability; and busy with on-farm (agriculture) activities. Similarly in case of IRs the reason “busy with off-farm activities” was the main constraining factor casing rejection of the technology. The immediate important reason was “changes in land tenure” followed by water supply problem; physical inability of farmer; affect of flood and failure of common carp egg collection. Finally the foremost important reason for LRs to reject the technology was “changes of land tenure” followed by supply problems; physical inability of farmer; water supply problem; affect of flood; and failure in common carp egg collection.

From results discussed above some common and important reasons for non adoption and rejection of RBFSP technology were identified. Particularly incompatibility with off-farm activities appeared to be a major factor for NTs and IRs. These farmers had diversified access to other livelihood options which hindered their adoption of this technology. There has been remarkable change in the pattern of occupation during the period of 1997/87-2000. The rising human capital content of rural labour and the diversification into non-agricultural activities have been accompanied by a shift of rural labour in favour of non-agricultural occupations (Sen, 2003). Sen reported that the proportion of the labour force employed primarily in agriculture has gone down from 69% to 51%. This has been matched by the proportionate increase in the share of non-agricultural sectors, which included a diverse mix of activities, such as salaried and personal services, non-agricultural labour in transport, construction and agro-processing and commercial activities, such as petty trading, shop keeping and business (Sen, 2003). The scenario has also been reported in other countries (e.g. Laos) of Asia where livelihoods of rural people tended to be de-linked with land (Rigg, 2006).

Changing land tenure was the second most important constraining factor to IRs to reject the technology and the main cause for the LRs rejections. Changes in land tenure occurred in various ways, however the main reason was the loss of leased and shared tenure. Basically the poor tend to access land through leased-in and shared-in tenure systems as they have no land and insufficient cash to purchase. This finding reinforces the concept of decentralisation of fish seed production as an appropriate technology for the poorer section but highlights the issue of substantial access rights to improve rice-fish systems.

Land is very scarce and its ownership is very concentrated (Griffin et al. 2002) particularly in the Northwest (CARE, 2005a). The top 10% households own 47.2% of all the land while the poorest 50% of the rural households owns only 5.7% of the land in Bangladesh (Griffin et al. 2002). Similarly, land tenancy for sharecropping is a crucial issue in Bangladesh and it has reduced from 90% in 1987/88 to 65% in 2000 (Sen, 2003). The benefits or net returns from the adoption of aquaculture technology depend foremost on accessibility to the ownership of the principal production factors which are land, labour and capital. A study by Veerina et al. (1999) on aquaculture development in Andra Pradesh, India revealed that mostly landed people adopted aquaculture, where 85% of the farms owned land. Moreover, where land is not a major source of income, land reforms that provide at least some land ownership even homestead sites-can be important for improving the security, status and bargaining power of asset poor households (Hanstad et al. 2002). However, in Bangladesh as well as other developing countries, many of the rural households are unable to gain sufficient access to land when this access would be their best option for escaping poverty (Bardhan et al. 1998; De Janvry et al. 2001; Binswanger et al. 1995).

This finding obviously suggests that those farmers who have no other livelihoods options tended to grab this technology, having guaranteed tenure/ownership from better-off farmers, as the vital factor for sustained adoption of RBFSP technology.

6.5.3 Women from adopting and non-adopting households

Although the majority of women in adopting households received training from FFS initiatives, some women received knowledge from their relatives and neighbours. It was reported in an earlier study that interpersonal communication with relatives, friends and neighbours was the most reliable and trustworthy method of information transfer regarding agricultural information (Kashem and Halim, 1990). Women were also found to be involved in different activities of RBFSP due to the proximity of riceplots around their households. As mentioned in the literature, women have been involved in small scale aquaculture in different stages of operation and they are active “caretakers” of fish in pond, nurseries, cages and rice-fields especially those located close to the homestead. In some NGO and government programmes, women from landless households cultivate fish individually or jointly in leased ponds, either within or near the homestead (Shelly and Costa, 2001).

Alongside their participation in fish seed production activities, women tended to share in the decision making regarding seed sales with their husbands. Although the participation of women in fish seed production activities is limited, poultry rearing has been a traditional activity performed by women for income generation (Abdullah and Zeidenstein, 1982) because this activity is carried out within their homesteads. Feeding livestock, breeding livestock, cleaning sheds, security measures and healthcare are the activities performed by women. Owing to their crucial role in livestock care, women are generally consulted when the men are buying and selling the livestock (Abdullah and Zeidenstein, 1982).

Decision making regarding income from seed sales appears to be substantially shared by women possibly because of their active contribution to seed production activities. Contribution to income oriented activities (e.g. poultry rearing) increases women's ability to buy personal items and items for their children (Nazneen, 2004). Apart from selling seed, they also gifted seed/foodfish to their neighbours and relatives who were mostly their close relatives. Previous studies have also found that women sent gifts to natal family members in order to strengthen links and assist poor relations. Traditionally natal family members provide material and social support to sustain the woman's marriage (White, 1992; Mallorie, 2003). Women's relationship with their neighbours is a key component of creating a security network and such a network provides emotional support and can mitigate any domestic violence that occurs (White, 1992). The major factor responsible for non-adoption of this technology was land access constraint reported by the majority of women in non-adopting households. The issues regarding access to land have been discussed earlier.

6.6 Conclusion

Rogers (1962) defines the adoption process as "the mental process of an individual from first hearing about an innovation to the final adoption". Feder et al. (1985) however argued that a precise definition of adoption needs rigorous theoretical and empirical analysis. This suggests that the definition of adoption is innovation specific, which is why all innovation adoption studies have no unique unit of analysis (Rogers, 1995a). Many traditional or instrumental studies of the adoption process have been carried out at a large scale and have shown more or less similar and disappointing results focusing on limited number of variables in many disciplines such as agricultural technologies, medical sciences, information technology etc (Leeuwis and van den Ban, 2004).

The present study, based on the hypothesis 'adoption of RBFSP can be sustained by farming households' has been carried out using qualitative approaches beyond the conventional long standing instrumental techniques. This study shows that the adoption process of fish seed production technology does not depend on a few household characteristics but depends on many causal factors embedded within the ecological and socio-cultural complex. In an ecological context, development of the riceplot environment and increased fish production in the riceplot and pond influenced the farming household to adopt. In the context of a farming family, this technology met the basic demand for "food" of different household members such as children, women and the elderly. This study attempts to argue that fish is not confined to the traditional scientific purpose as a "source of protein" but rather has more fundamental familial and social values in Bangladeshi society. This intangible value acted as a power in the adoption process of this technology. The specific technological approach clearly helped as a coping mechanism for the seasonal "hungry gap" of fish consumption and low income. Impacts of this technology were not only confined to the farming households but also extended to poor fry traders to diversifying their livelihoods. Development of a network between adopters and fry traders reinforced the adoption process.

Involvement with off-farm activities was not compatible with adoption by IRs and LRs. This confirms that for those adopters having no other central livelihoods options except agriculture, adoption of RBFSP could be an important livelihood option. However, having sustained tenure/ownership of land was a critical factor for the sustained adoption of RBFSP in the decentralised approach. At the government policy level, there is currently no legal basis for leasing land tenure, and implementing sharecropping tenure rights for the poor is a negligible task in government administrative authority (Awal, 2003). CARE, during its Go-Interfish project phase developed advocacy measures to motivate various levels of actors ranging from farmers to ministry level to bring about changes in existing policy. As CARE programmes have been phased out, local influential NGOs could take the initiative to implement advocacy measures motivating relevant actors and changing policy at the ministry level. Government has already started to distribute state-own land (*khas jami*) to the poorer through the mediation of NGOs.

In terms of ensuring egalitarian access to land, five Asian countries (Japan, Taiwan, South Korea, China and Vietnam) successfully transformed agrarian structure into a system of individual peasant farming after Second World War. Land reform in Japan, Taiwan and South Korea was based on compulsory purchase of land by the government and redistribution to tenants and landless households. China and Vietnam redistributed the land to poorer households after expropriating land from landlords (Griffin et al. 2002). According to Rigg (2006) 'sustainable future rural livelihoods' could be built through amalgamation of landholdings for emergence of large land owners and agrarian entrepreneurs. Land amalgamation and redistribution to poor households or amalgamation to make larger land owners would not be possible in Bangladesh (Griffin et al. 2002) because it could be a very difficult political decisions and the limited financial capacity of government. However in Northwest Bangladesh, there is a potential for the better-off households to be entrepreneurs of decentralised RBFSP, which could leverage broader rural development by producing good quality fish fingerlings, involving landless fry traders, and foodfish producers (Chapter 5).

Chapter 7: Cost-effectiveness of different approaches to extension of RBFSP in terms of its development returns

7.1 Introduction

The preceding chapters illustrate encouraging livelihoods impacts and complex socio-cultural reasons responsible for the adoption process of local level fish seed production technology. In terms of the dissemination process at the farmer level, it is important to know the delivery mechanisms of this technology and to determine its cost-effectiveness.

7.1.1 Development of extension delivery towards FFS in Bangladesh

Agricultural extension delivery mechanisms in Bangladesh have a long history. During the British regime (1757-1947), the agricultural development and extension services were established in the sub-continent as a part of the Department of Revenue to help with the rehabilitation of rural people seriously affected by natural disasters due to terrible famine and destitution over three decades starting from the 1860s, (Kibria, 1987). In agricultural development the then British Government was keen to generate revenue through motivating farmers to cultivate cash crops such as cotton, indigo and jute. However, little attention was given to the improvement of food production and other agricultural crops.

After the end of the British period in 1947, under the government of Pakistan, the Agriculture Department started with a large number of field workers to carry-out several experiments creating different departments and agencies for conducting agricultural and rural development activities. This Department under the project of Village Agricultural and Industrial Development (V-AID) attempted to organize the rural people through their participation in agricultural and rural development activities along with government personnel at the grass root level. Its objectives were to increase the productive output and real income of the villagers through farming modern techniques (such as livestock, fisheries, crop agriculture and initiation of irrigation), sanitation and health, cooperatives, cottage industries and also to develop a spirit of self-help among the men, women and youth of the locality. During this period mass media radio started to broadcast different agricultural programmes. This project was abolished in the mid-1950s and its different activities were merged with the Directorate of Agriculture and passed to other rural development departments.

In the 1960s, the Directorate of Agriculture was divided into two wings, the Extension & Management and Research & Education. It was the beginning of extension through the dissemination of agricultural information to the farmers in a planned and systematic way (Kibria, 1987). During this period, personal and group contacts made by extension workers and the distributors of different inputs (seeds, fertilizer, water, credit etc.) were the main sources of extension information to the farmers along with television which also started to broadcast agricultural information to farmers. The extension approach was mostly top-down and participation of the beneficiaries in the system was almost absent, with extension activities confined to motivation, education, group formation and distribution of inputs to the farmers through traditional extension teaching methods.

After the birth of Bangladesh in 1971, the Directorate of Agriculture fragmented into different mono-crop extension related organizations. The creation of these organizations was based on farmer's needs for extension services, but measures to coordinate activities at the field level were inadequate, the farmers and the extension workers were mostly confused. According to Kibria (1987) the problems of the then extension programmes were: (a) inadequate demarcation of function and areas of responsibility, (b) misuse of resources due to lack of coordination, and (c) farming households and the farming community was not looked at as one unit.

Realising the drawbacks of mono-crop extension in the 1980's, all the mono-crop extension services were unified and the department was renamed as the Department of Agricultural Extension (DAE) and remains so today. At this time the Training and Visit (T&V) programme was taken as an extension mechanism which was first tried in Turkey during 1960's. Moreover, during this period newspapers also started to disseminate agriculture extension information. The focal point of T&V extension approach was the Block, the lowest unit of field extension work, where a Block Supervisor (BS) has to visit and conduct field work. A Block covers 800 to 900 farming households depending upon the intensity of activities in the area. A two-step flow of information (from BS to the contact farmers and then from contact farmers to the non-contact farmers) was the model of message delivery system in T&V approach. At one stage it was observed that the extension activities under T&V system had become ineffective in maintaining adequate flow of information to the farmers (Karim and Halim, 1993).

In 1992, the Agricultural Extension Support Services Project (ASSP) was introduced with the financial support of DFID. ASSP in collaboration with the DAE earmarked institutional reforms aiming to decentralise and to introduce the participatory approach in the delivery of extension services to the farmers. The ASSP set the stage for the government to draw-up and adopt an Agricultural Extension Policy in 1995 and revised it subsequently as the New Agricultural Extension Policy (NAEP) in 1996, in which the role of agricultural extension in the context of national policy has been set up. The components of NAEP are: extension support to all categories of farmers, efficient extension services, decentralisation, demand-led extension, working with groups of all kinds, strengthened extension-research linkages, training of extension personnel, appropriate extension methodology, coordinated extension activities and environmental considerations. Formulation of the NAEP, ensuring participation of beneficiaries (farming community) as development partners and continuous monitoring and evaluation as a built-in-mechanism have also been the main achievement of DAE during this phase. Among different participatory mechanisms, DAE emphasised the farmer field school (FFS) approach to deliver extension services. The goal of DAE is to encourage the various partners and agencies within the national agricultural extension system to provide efficient and effective services which complement and reinforce each other in an effort to increase the efficiency and productivity of agriculture in Bangladesh. By 2016 the DAE hopes to have implemented 69,000 FFS training 1.7 million farmers across the country (MOA, 2004).

Originally, the FFS approach first began in the 1980's in Java, Indonesia, teaching farmers about IPM. In 1990's adopting the FFS approach for disseminating IPM knowledge at farmer level had started in Bangladesh. The principal component of FFS is that it emphasises experimental learning through a participatory approach delivering hands-on training which is important to attract both literate and illiterate farmers and to keep them interested in learning (Rola et al. 2001). This concept does not require that all farmers attend FFS training, rather a selected number of farmers within a village are trained in this informal school, which entail weekly meetings during a season-long training course (Feder et al. 2004b). In order to disseminate new knowledge more rapidly within the community, selected farmers receive additional training to become farmer-trainers and are expected to share their knowledge and experiences with other farmers within their locality. FFSs are run by facilitators rather than instructors in order to create a group learning environment rather than a classroom setting with a teacher giving instructions.

7.1.1.1 Flash-back of FFS

The FFS is currently promoted by many development organizations across the world including the FAO, World Bank and CARE as an effective approach, however there have been mixed results. Empirical studies, including two conducted in Bangladesh by Larsen et al. (2002a) looking at rice and Larsen et al. (2002b) at vegetables, show positive impacts of FFS. Both of these studies compared yields and pesticide use between FFS trained farmers and non-FFS trained farmers and the findings indicated that FFS trained farmers had higher yields and used less pesticide than non trained farmers. Godtland et al. (2004) investigating FFS trained potato farmers in the Peruvian Andes concluded that increased agricultural knowledge leads to higher yields and FFS participants were more likely than non participants to have higher output from their farms. On the contrary, a study conducted by Feder et al. (2004b) using time series data of rice farmers in Indonesia found no significant difference in change in yields or pesticide use when comparing FFS participants with non participants. Another study by Feder et al. (2004a) reported that that FFS trained farmers had a greater knowledge of IPM than non FFS farmers, but that knowledge of IPM was not spreading to farmers who did not attend the training in villages with FFS. An ethnographic study in two Bangladeshi villages showed that farmers trained in IPM practices in FFSs promoted by DAE, used the same amounts of insecticides as untrained farmers and were not doing anything differently from them. FFSs, therefore, did not appear to have influenced farmers to adopt IPM (Hamid and Shepherd, 2005).

In terms of investment, a recent study conducted for the determination of the unit farmer training cost under the IMP-FFS programme implemented by DAE-Bangladesh, where average FFS-farmer cost was found to be US$ 28.53 (Gilbert, 2005). Similarly, Quizon et al. (2001) found that the average cost for training a farmer about IPM through FFS was US $47.50 in Indonesia and US $62.00 in the Philippines. These scales of investment are significant because if FFS graduates do not share their knowledge of IPM with their neighbours, then the lack of secondary spread and the high cost of training farmers through FFS calls into question whether FFS is cost-effective or can be a sustainable method for desseminating IPM at a national level.

7.1.1.2 FFS delivery mechanisms of decentralised fish seed production

Delivery mechanisms in Interfish area

CARE Bangladesh promoted RBFSP technology over 13 years between 1993 and 2005. Initially, CARE promoted the use of locally produced common carp eggs in irrigated ricefields to produce fingerlings through its Interfish-I project (Figure 7.1). The tenure of Interfish-I was until 1997, where promotion through a scheme approach continued from 1993 to 1995. The scheme approach in Interfish-I was to build a farmer's group based around a deep tube-well irrigation scheme. Indeed, CARE intervention with scheme farmers was the pilot-scale developing stage of FFS where the learning process of farmers was based on participatory action learning (PAL) over three seasons. After 1995 Interfish-I and CARE's follow-on project Interfish-II, adopted FFS approach and continued to 2000 in a broader geographical area of Northwest Bangladesh.

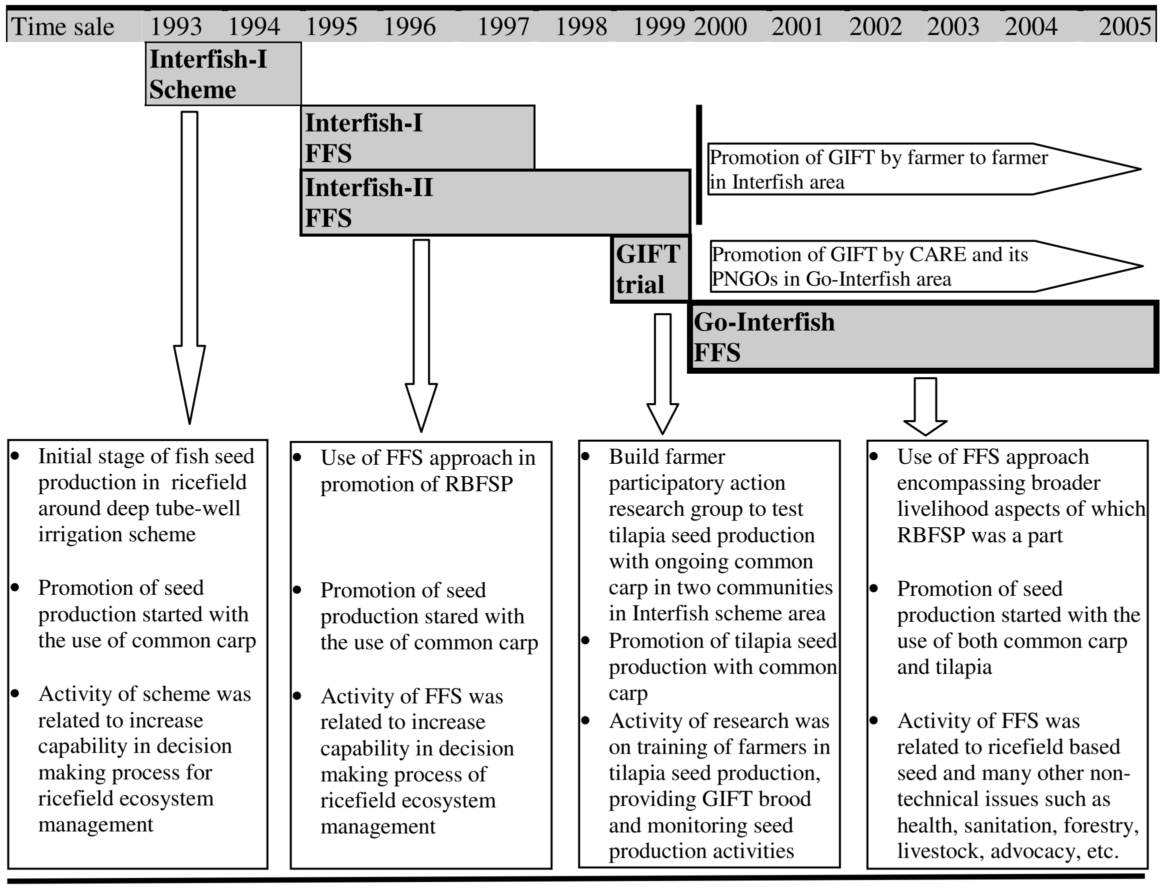


Figure 7.1: Schematic view of promotion of ricefish based fish seed production during the period from 1993 to 2005 (adapted from Gregory and Kamp, 1999b; Barman, 2000; CARE, 2001a).

During the later projects of Interfish-I and Interfish-II, promotion of RBFSP was carried out through FFS using the farmer's riceplot as the learning plot, where FFS participants learnt about ricefield ecology and management practices in a practical way over 3 seasons - *boro-amon-boro* (one and half years). Apart from fish seed production, the curricula of the scheme and FFS consisted of foodfish production, dike cropping, low input rice production and integrated pest management (IPM). During Interfish delivery, 40 participants (30 male and 15 female) were involved in each scheme/FFS.

Delivery mechanism in Interfish research area

Seed production of the improved variety of Nile tilapia was tested in two communities in 1999 through a farmer participatory research trial with household had been engaged in common carp seed production since the inception of the Interfish project. The selected households were given training on tilapia seed production techniques in ricefields as well as a small number of broodfish of an improved strain of Nile tilapia – GIFT (Genetically Improved Farmed Tilapia). Introduction of tilapia to the research area then spread through an organic dissemination (farmer to farmer dissemination process) in other parts of Interfish area (Barman et al. 2004).

Delivery mechanism in Go-Interfish area

During the Go-Interfish project phase, CARE promoted fish seed production in ricefield systems through CARE direct and its partner NGO delivery using a FFS approach over a large geographical area in Northwest Bangladesh. CARE's partnership with local NGOs was due to reach a large number of beneficiaries and to make the NGOs viable, well-governed, transparent, and publicly accountable organisations. In terms of sustainability, CARE also had an expectation of PNGOs that, through their acquired capability from the partnership, they would continue the programmes developed during partnership after withdrawal of CARE support. This partnership evolved from a system that could be characterized as 'subcontracting' to one in which these local NGOs were 'partners' in the development endeavour. In this partnership the PNGOs had no financial input to the implemented programmes and the higher officials (executive directors) of the PNGOs were salaried. The partnership process involving CARE and the NGOs was developed in a systematic way from staff recruitment to FFS implementation (Figure 7.2).

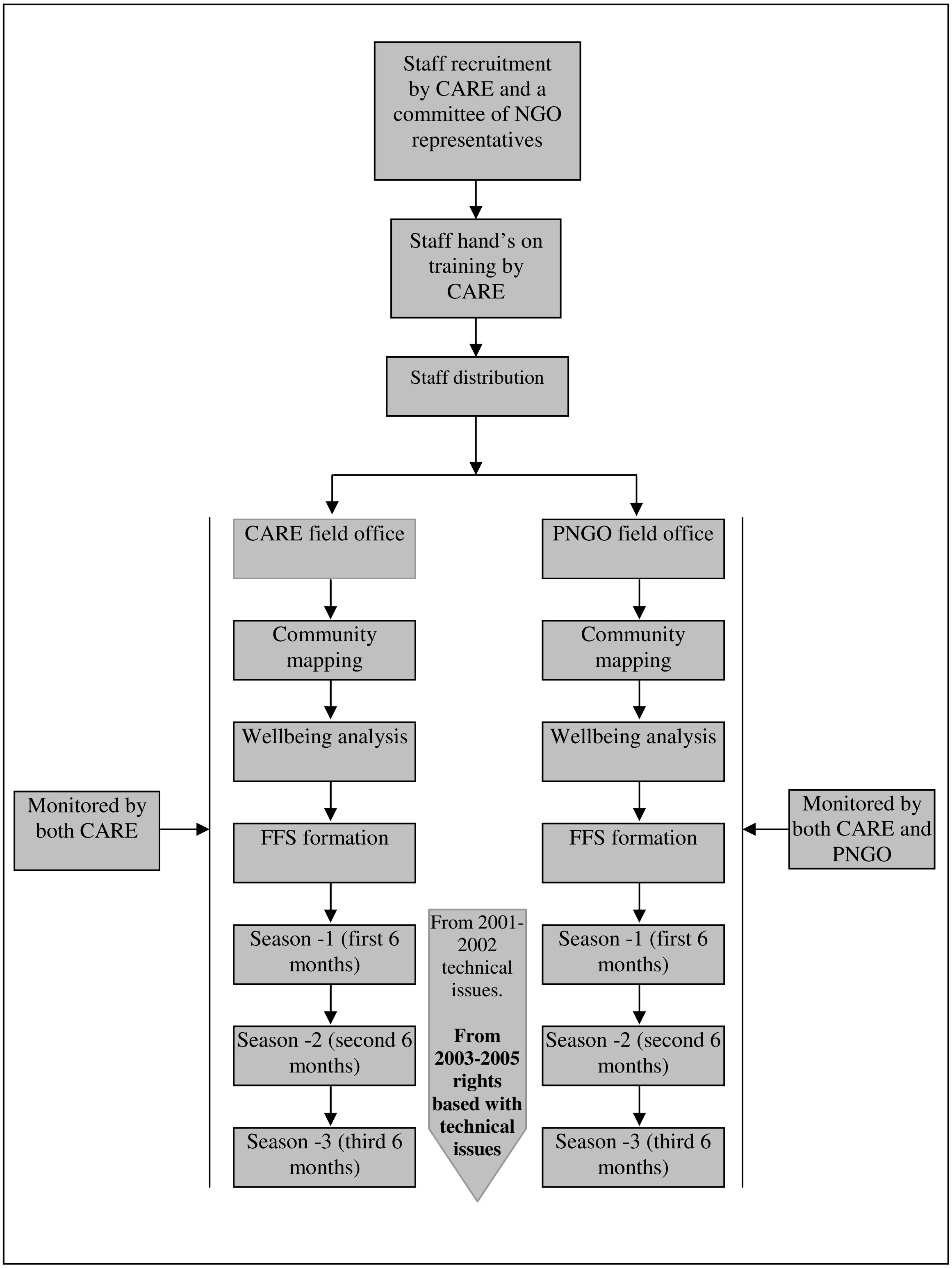


Figure 7.2: FFS implementation by CARE direct and PNGO delivery mechanisms.

Initially, CARE advertised in the newspaper and requesting information from interested local NGOs in the form of a project proposal. The required information included the NGO's registration details, physical facilities, policies, ongoing programmes, previous experience in development work, local people's acceptability etc. After receiving applications from different NGOs, CARE carried out a ground truthing mission to validate the information and finally brought 45 NGOs under the Go-Interfish project partnership. Staff recruitment at the PNGO level was organized by a joint selection committee consisting of CARE and PNGO officials. The recruited PNGO staff were trained together with CARE staff over a three months period (Season Long Training on Sustainable Agriculture).

After completion of the training, the project development wing of CARE distributed extension teams consisting of 7 staff (1 project officers-PO and 6 field trainers-FT) to the PNGOs. Each FT, both in CARE direct and PNGO delivery was assigned to set up 5 FFS within an 18 month period. Training was designed for both illiterate and literate participants and in each 25 farmers were trained. RBFSP was one of the components of the training received at FFS. FFS were formed through a systematic procedure (Figure 7.2), which is described below.

Community mapping

Community mapping was carried out to assess the number of households in each community; poverty, agro-ecology, suitable riceplots; fallow land/waterbody; people's need/interest; communication and locally available resources useful for agriculture such organic manure, indigenous pesticide materials etc.

Well-being analysis

At this stage the community was categorised into 5 well-being groups after which the 2 groups of extremely poor and rich were excluded. Exclusion of the extreme poor and rich farmers was because CARE had predetermined their strategy; the extreme poor were landless (having no riceplot) and extreme rich were not interested in ricefish technology. The middle three groups poor, medium and better-off were prioritised to participate in the FFS.

Formation of FFS

In each community, one male and one female FFS were formed consisting of 25 participants in each. Each FFS was appointed a leader designated as Community Organizer (CO) during the second season the CO was elected by the participants.

Seasonal planning for training

The whole FFS training period (18 months) was carried out over three seasons where each season was planned with twelve sessions (two sessions per month). Each session comprised of a 2-3 hour learning covering both theoretical and practical aspects. In seasonal planning sessions, FFS members were asked to make a plan according to their needs. The activities of the FFS over three seasons were as follows:-

Season 1 (first 6 months) – ricefish activities: Although CARE termed this as ricefish activities, it started produciton of fish seed in ricefields. Each FFS established a common study plot (ricefish plot), in which participants experimented with fish seed production using common carp and tilapia seed production along with other ricefield related activities. At the beginning of the FFS training, field trainers made a plan of activities (learning session) with the direct participation of farmers. In each learning session, FTs imparted their technical expertise on ricefield based technologies where FFS farmers began the adoption process of the improved technologies in their own fields.

Season 2 (second 6 months) – linkage with support services: In this season, the FFS members identified a leader termed as community organizer (CO), who then with the support of the project staff, established networks and linkages with individuals and / or organizations of different support services such as government, NGO, private organizations etc. During this period participants were trained on broader non-technical livelihood issues such as mother and child health, advocacy, marketing, poultry vaccination, road side tree plantation etc. Here each FFS member was also asked to select a 'buddy' (*bando sadasya*) under the secondary adoption approach who could adopt the technologies that FFS members are using.

Season 3 (third 6 months) – CBO (Community based organization) formation: In the third season, the field staff prepared the FFS members as 'facilitators' of the FFS community. Here the farmer leader (CO) and participants took on a greater role strengthening the organizational capacity of the farmers' group, which included the remaining members from the community. The objective of FFS during this season was to form a CBO involving almost all remaining people from the community.

7.1.1.3 Centralised mono-sex tilapia seed production system

Mono-sex tilapia are produced from free swimming mixed-sex tilapia fry (both male and female) fed a diet treated with 17 α methyltestosterone to produce all male (mono-sex) fry (Little and Edwards, 2004). Mono-sex tilapia seed production and all other commercial tilapia hatcheries had been established in central and southern parts of Bangladesh (WorldFish Center, 2004). Most of the hatcheries produced tilapia seed along with carp and other fish species. As earlier tilapia dissemination project worked in some parts of Bangladesh but not in the Northwest region and the availability of tilapia in markets of this region was reported be at subsistence level (Barman, 2000). In the Northwest, there were no hatcheries for tilapia seed production established at the time of the study. In order to get a clear picture of the inputs and outputs, a mono-sex tilapia hatchery was selected for study from the Mymensingh region (North-central Bangladesh). From this hatchery, commercial farmers purchased mono-sex tilapia seed directly without any intermediation of fry traders. In this system, hatchery owner makes contact with foodfish producing farmers directly and fingerlings were transported directly using oxygenated bags.

7.1.1.4 Hypothesis and objectives of the study

Hypothesis

FFS promoting RBFSP delivery is the most cost-effective approach to achieving positive impacts through aquaculture.

Objectives

The objective of this part of study was to determine the cost-effectiveness of the different delivery mechanisms of RBFSP at the farmer level. Cost-effective analysis (CEA) is an important tool in selecting the right delivery system for an extension programme (Marsh and Pannell, 2000). CEA links costs and outcomes to determine the payoff of investing resources in a given course of action. It is an important task in terms of impacting the decision making process, developing awareness and ensuring survival of the extension programme. The CEA approach was first developed in the military before its more general application where it was applied to the healthcare sectors in the mid 1960s (Weinstein and Stason, 1977).

Analysing the cost-effectiveness of the FFS approach is particularly important because in Bangladesh and other developing countries, extension and training programmes receive limited funding, therefore disseminating and implementing cost-effective programmes is vital for sustainability. Unfortunately, until now a comprehensive evaluation procedure that fully captures the potential effects of the participatory extension concept had not existed (Fleischer et al. 2002). Whereas traditional economic evaluation is based on the generated economic surplus, social scientists focus on the process of change in behaviour and attitude of individual farmers and among communities. Neither discipline has yet agreed on common indicators to be used (Waibel et al. 1999).

In the present study however, cost-effectiveness analysis was carried out in terms of project based financial investment (Mindertsma, 2004) and economic development (Richardson and Moore, 2002) of decentralised fish seed production compared with centralised hatchery based tilapia seed production. Within a given discount rate, project based investment appraisal leads to an understanding of whether project benefits exceeded costs over successive years (Mindertsma, 2004) in a particular fish seed producing community being the target of CARE support (Banu and Bode, 2002). On the other hand, cost-effectiveness in terms of economic development means 'multiplier effects', defined here as the number of times that the initial dollar of economic activity causes additional dollars to be generated on a wider scale (Richardson and Moore, 2002).

In this analysis, three extension delivery mechanisms of decentralised fish seed production such as Interfish FFS, Interfish FFS cum research intervention and Go-Interfish FFS in Northwest, and a mono-sex tilapia hatchery in North-central (Mymensingh) Bangladesh were examined. Mono-sex tilapia hatchery was used as a 'control' as there is a widespread assumption that mono-sex enhances value of tilapia-based aquaculture production and income (Little, 2004). Sustainability of the FFS approach towards RBFSP amongst partner NGOs of CARE Go-Interfish project was also examined.

7.2 Methodology

7.2.1 Determination of costs of different decentralised and centralised seed production systems

Valuing programme costs and developing benefits/effects or results of extension intervention, is often difficult as they incur diverse costs and result in different outcomes (Richardson and Moore, 2002). However, with appropriate information, a reasonably accurate job of estimating programme values can be achieved. Conservative methods for the determination of CARE's direct delivery FFS costs were used in the present study. Quizon et al. (2001) used the conservative method in their recent study in th Philippines, where total budget allocated for the programme was divided by the number of FFS participants to determine individual participant cost. This procedure was also used in another recent study conducted by Gilbert (2005) to estimate the investment per farmer on IPM-FFS programme implemented by DAE-Bangladesh. In the present study, data regarding cost and number of beneficiaries was collected from previous CARE Interfish-II and Go-Interfish project reports (Appendix 11). Such conservative estimation of per farmer or FFS cost could not explain several cost components in the implementation of FFS. From CARE direct delivery it was not possible to collect detailed data of all cost components. However, from CARE partner NGOs, the detailed FFS cost components were determined through collection of data from NGO documents (Appendix 12), and interviewing higher NGO officials (executive director).

Broadly FFS costs were classified into training time and materials. Training costs of RBFSP were calculated by estimating the total time allocated for learning sessions of fish seed production along with several components of the FFS curricula. The cost of a FFS was then divided by total time (hours) spent by a field trainer to estimate per hour FFS training cost. Then estimated times (hour) for fish seed production training was multiplied by per hour training cost to determine the RBFSP training cost. After termination of FFS training CARE had not provided any further support. However, materials provided during FFS incurred some costs in the second year which was calculated using the method of depreciation cost (Shang, 1990). The detailed cost components of the mono-sex tilapia hatchery were collected through a case study carried out with the hatchery owner.

7.2.2 Determination of effectiveness

7.2.2.1 Project based financial investment effectiveness

Exploring the effectiveness of the project based financial investment looks at which gives the highest revenues per unit of cost or lower cost per unit of revenue (Mindertsma, 2004). Although seed production was not started in the Interfish and Go-Interfish areas at the same time, the financial cost-effectiveness was carried out for the same period (from 2000) as prior to the introduction of tilapia in Interfish area in 1999 the number of adopters and production was at subsistence level (Barman et al. 2004). The monetary value of fingerlings produced in ricefields was considered revenue during effectiveness determination. In financial investment effectiveness analysis, the estimated net present value (NPV) and the benefit-cost ratio (BCR) of different extension deliveries of decentralised fish seed production were compared with centralised mono-sex tilapia seed production (SEED, 2004).

Net present value (NPV)

The net present value is the present value of net cash flow. The NPV of an investment project can be calculated by subtracting the costs from the benefit on a year to year basis to derive the annual net benefit stream which is then discounted into present value. The sum of the annual net benefits in present value form is the total net present value of the investment project (Shang, 1990; Jolly and Clonts, 1993). The mathematical formula for the NPV calculation is as follows:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} \text{-------------} (i)$$

Where,

B = the gross annual benefit
C = the annual operating cost
t = year
r = discount rate

If ,

NPV>0, the investment would add value to the project, and the project should be accepted;

NPV<0, the investment would subtract value from the project, and the project should be rejected;

NPV = 0, the investment would neither gain nor lose value for the project.

Benefit-cost ratio (BCR)

BCR is defined as the ratio of the total present value of benefits to the costs (Shang, 1990).

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}} \text{--------------} (ii)$$

Where,

B = the gross annual benefit
C = the annual operating cost
t = year
r = discount rate

If,

BCR>1, the total present value of benefits exceeds total present value of costs, investment would be economically feasible;

BCR<1, investment would not be economically feasible;

BCR = 1, it would be a break-even situation.

However, in NPV and BCR estimation, the choice of an appropriate discount rate plays a vital role. The available literature (Gittinger, 1994; Rahman, 1998) suggested that in most developing countries the opportunity cost of capital varies between 8 to 15 percent. The lending rates of nationalized commercial and specialised banks in the agricultural sector of Bangladesh lie between 12 and 14%. As with many agricultural research studies, a discount rate of 14% was chosen for the appraisal (Al-Mamun et al. 2003).

7.2.2.2 Economic development effectiveness

As fish seed availability at the farmer level potentially leverages broader development impacts, assessing impacts only at the seed producer level underestimates overall cost-effectiveness. This leads to other approaches of decentralised seed promotion with a smaller number of 'entrepreneurs' than those with larger developmental effectiveness. The economic development effectiveness provides an alternative which gives the highest benefit per unit cost to the society (Mindertsma, 2004) with multiplier benefits/effects (Richardson and Moore, 2002).

In this regard, following three years of intervention, at per unit cost, the multiplier effectiveness including benefits at the levels of primary farmers, secondary farmers, fry traders and pond fish producers was estimated comparing the different extension deliveries of decentralised fish seed production with a centralised mono-sex tilapia hatchery.

7.2.3 Understanding programme sustainability among CARE's partner NGOs

Beyond CARE's partnership with local NGOs, CARE's expectation was that those organisations would absorb skilled staff and continue such programmes at the community level after the withdrawal of CARE support. It was hypothesised that larger NGOs might be able to continue such type of programmes after the withdrawal of CARE support.

In order to investigate the attitudes of PNGOs, 9 NGOs were selected considering their size based on their existing number of staff. Of 9 PNGOs, 3 were small (staff<20), 3 were medium (staff<100) and 3 were large (staff>100). During the on-going partnership with CARE (January 2005), an open ended survey with 9 NGOs was undertaken to observe the existing programmes and their attitudes towards continuation of partnership programmes. After withdrawal of CARE support at the end of March 2005, another round of observations was undertaken using open-ended questionnaires to understand the prevailing situation of PNGOs.

7.3 Results

7.3.1 Project investment based cost-effectiveness

7.3.1.1 Cost of different decentralised promotions and centralised hatchery

Investment per FFS farmer was calculated taking data from the Interfish project final report prepared by the CARE assessment wing (CARE, 2001a). The report indicates that within the period of the project phase from July 1995 to December 2000 the total allocated budget was GBP 3,929,548 and the number of target FFS participants was 89,680. Therefore, the calculated investment per FFS farmer was approximately GBP 43.8 which was equivalent to US$ 60.2. Using the same conservative approach, investment per participant was calculated from the Go-Interfish project where total allocation for the period of July 2002 to June 2003 was US$ 2,403,573 (CARE, 2003a). The total number of FFS formed by the Go-Interfish direct delivery approach was 900, thus the per participant investment was US$ 106.8. The detailed calculation of data obtained from the NGO showed that investment per farmer was US$ 41.55 (Table 7.1). Out of the total budget, more than 80% of the expenditure was used for staff salary and benefits, vehicle purchasing and maintenance. The cost of farmer level training was minimal.

Table 7.1: Cost for implementing FFS by Go-Interfish partner NGO (1US$=Tk.58.00)

Cost items	Cost (Tk)	Cost (US$)	Cost (%)
Salary and benefits	447900.0	7722.4	37.2
Office rent	14000.0	241.4	1.2
Office maintenance, repairs and cleaning materials	5880.0	101.4	0.5
Communication	495.0	8.6	0.1
Stationary and supplies	7155.0	123.4	0.6
Furniture, fixture and equipment	25900.0	446.6	2.2
Vehicle, fuel, repairs and maintenance	551625.0	9510.8	45.8
Travel and lodging	18300.0	315.5	1.5
Project implementation	122500.0	2112.1	10.2
Others administrative cost/miscellaneous	11140.0	192.1	0.9
Total coat	1204895.0	20774.1	
Per FFS cost	60244.8	1038.7	
Per farmer cost	2409.8	41.6	

Assessing costs for RBFSP training using different approaches

Interfish project area

The total training time of Interfish-FFS was found to be 120 hours. Accordingly per FFS cost was calculated as US$ 2409.6 through multiplying individual participant costs (US$ 60.24) by the number of participants (40 participants in each FFS) in each community of the Interfish project area (Table 7.2).

Table 7.2: Cost for RBFSP training in Interfish-FFS

Session/occasions in FFS	**No**	**No. of hours**
Learning sessions (each session spent 2 hours)	36	72
Field day (each field day spent 4 hours)	3	12
Fare (spent 6 hours for a fair)	1	6
Cross visit (Each cross visit spent 10 hours)	3	30
Total FFS hour		120
Cost for RBFSP training		**Cost (US$)**
Per FFS cost (60.24 X 40 participants)		2409.6
Average per FFS hour cost (2409.6/120)		20.1
Per FFS fish seed production training hour cost*		120.5
Fish seed production training cost in Interfish 12 FFS (12 communities)		1445.8
Each farmer fish seed production training cost at first year (1445.8/480)		**3.01**

* Each FFS held 3 sessions (each of 2 hours) for RBFSP

From the total FFS expenses, costs for RBFSP training were calculated dividing the total FFS cost by the number of hours spent for seed production training. Hence, the per farmer or household level fish seed production cost was calculated at US$ 3.01. In the second year there were no costs related to the CARE project for RBFSP with the exception of some material provided during FFS. The current value of those materials (plastic bowls and jars) was estimated using the declining balance depreciation method (Shang, 1990). In this method, a fixed rate (30%) of depreciation was used every year. The amount of annual depreciation costs for the materials used in 12 FFS were calculated for the second, third and fourth years as 20.2, 14.2 and US$ 9.9 respectively.

Interfish research area

In the 2 Interfish communities, tilapia seed production was trialled along with common carp seed production in ricefield systems. The costs for training on fish seed production provided by the CARE Interfish project and research programme, were calculated (Table 7.3). Here per farmer or household seed production cost was calculated at US$ 12.06. In existing CARE Interfish FFS, research programme also provided farmers with some materials during the trial of tilapia seed production in ricefields. Collectively the depreciation value in the second, third and fourth year were as 44.7, 31.3 and US$ 21.9 respectively.

Table 7.3: Cost for RBFSP training in FFS of IF tilapia research area

Session/occasions in FFS	**No**	**No. of hours**
Learning sessions (each session spent 2 hours)	36	72
Field day (each field day spent 4 hours)	3	12
Fare (spent 6 hours for a fair)	1	6
Cross visit (Each cross visit spent 10 hours)	3	30
Total FFS hour		120
Cost for RBFSP training		**Cost (US$)**
Per FFS cost (60.2 X 40 participants)		2409.6
Average per FFS hour cost (2409.6/120)		20.1
Per FFS fish seed training hour cost*		120.5
a) Fish seed training cost of CARE Interfish in 2 FFS (2 communities)		**240.9**
1 researcher 40 weeks monitoring cost (US$ 8.6 X 40)		344.8
3 research assistants 40 weeks monitoring cost (US$ 2.58 X 3 X 40)		310.3
Cost of tilapia broodfish supplied during training		68.9
b) Research cost in CARE Interfish 2 FFS (2 communities)		**724.1**
Total training cost (a + b) of CARE and research team		**965.0**
Each farmer fish seed production training cost at first year (965.0/80)		**12.06**

*Each FFS held 3 sessions (each of 2 hours) for RBFSP

Go-Interfish project area

The training cost of Go-Interfish only for RBFSP was calculated as US$ 89 per FFS (Table 7.4). In each community of CARE Go-Interfish, two FFSs were formed hence per community cost for fish seed training was US$ 178.0. Accordingly per participant and per household seed production training cost was calculated as 3.6 and US$ 7.2 respectively. Depreciation value of materials provided by CARE in 11 communities in second, third and fourth year were 37.2, 26.0 and US$ 18.2 respectively.

Table 7.4: Training cost for RBFSP in Go-Interfish project

Session/occasions in FFS	**No**	**No. of hours**
Learning sessions (each session spent 2 hours)	36	72
Field day (each field day spent 4 hours)	3	12
Fare (spent 6 hours for a fair)	1	6
Cross visit (Each cross visit spent 10 hours)	3	30
Total FFS hour		120
Cost for RBFSP training		**Cost (US$)**
Per FFS cost (106.82 X 25 participants)		2670.5
Average per FFS hour cost (2670.5/120)		22.3
Per FFS fish seed production training hour cost*		89.0
Per community fish seed production training cost in Go-Interfish (89.0 X 2)		178.0
Fish seed production training cost in 11 communities (178.0 X 11)		1958.4
Per farmer seed production training cost at first year (1958.4/550)X2		**7.2**

*Each FFS held 2 sessions (each of 2 hours) for RBFSP

Centralised tilapia hatchery

For developing a tilapia mono-sex hatchery, the first year total fixed and variable cost was US$ 42733.7 (Table 7.5). Considering 30% of depreciation of fixed materials, the total cost of operating a mono-sex hatchery in a third year was calculated at US$ 29984.1.

Table 7.5: Cost and benefit of tilapia seed production in mono-sex hatchery

Input/output items	**US$**
Fixed cost	
Building (Small overhead tank, office)	2857.1
Hatchery unit (jar 30, cistern 30, tray 30etc.)	2571.4
Labour cost (guard and others)	10714.3
Pump installation (pump and generator)	1428.6
Net	7142.9
Land use (10 acres, lease)	4285.7
Any transport device	714.3
Total fixed cost	**29714.3**
Variable cost	
Broodfish of tilapia (20,000 X 100g = 2 ton)	2857.1
Feed	3428.6
Hormones (100 g)	628.6
Ethyl alcohol (US$ 11.4/L) etc	714.3
Others	142.9
Total variable cost	**7771.4**
Interest on operating capital	5248.0
Gross or total cost	**42733.7**

Production performance for different systems

More fingerling producers developed in the Interfish research and Interfish areas than in the Go-Interfish areas. In the Interfish research area, about 30% farmers produced between 8,000-16,000 fingerlings and 10% produced more than 16,000 fingerlings per year (Figure 7.3).

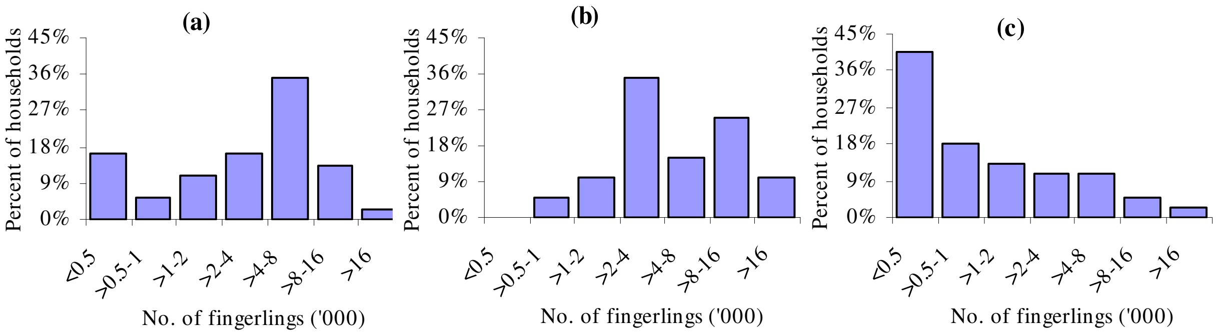


Figure 7.3: Scale of fingerlings production of households under different delivery systems (a = Interfish, b = Interfish resaerch and c = Go-Interfish area).

Comparatively, the majority of households produced fingerlings within the range of 500 to 1000 and the mono-sex tilapia hatchery produced 10,000,000 (approximate estimation) fingerlings over a year of operation.

7.3.1.2 Effectiveness of different decentralised promotions and centralised hatchery

Decentralised systems

Interfish project area

Net present value (NPV): The NPV calculated from fingerlings production in 12 Interfish project communities was US$ 4538.81. This value is positive and much higher than 1, indicating the project's investment in RBFSP extension delivery added a large amount of value (Table 7.6).

Table 7.6: Net present value for Interfish project area

Year	Gross benefit (US$)	Gross cost (US$)	Net benefit (US$)	Discount rate (14%)	NPV (US$)
0	0	1445.8	-1445.8	1.14	-1268.2
1	2398.7	20.3	2378.4	1.29	1830.1
2	2323.6	14.2	2309.4	1.48	1558.8
3	4094.1	9.9	4084.1	1.68	2418.1
				Total NPV	4538.8

Benefit-cost ratio (BCR): The calculated benefit cost ratio was 4.5, suggesting that investment of US$ 1 in fish seed production delivery brings US$ 4.5 of benefit with an increasing trend of BCR from initial to later years (Table 7.7).

Table 7.7: Calculation of benefit-cost ratio for Interfish area

Year	Gross benefit (US$)	Discounted Benefit (US$)	Gross cost (US$)	Discounted cost (US$)	Discount rate (14%)	BCR
0	0.00	0.00	1445.8	1268.2	1.14	0.0
1	2398.7	1845.7	20.3	15.6	1.29	118.3
2	2323.6	1568.4	14.2	9.6	1.48	163.8
3	4094.1	2424.0	9.9	5.9	1.68	412.3
		5838.1		1299.3	Average BCR	173.6
		Discounted BCR		4.5		

Interfish FFS cum research area

Net present value (NPV): The NPV of Interfish FFS cum research area was calculated as US$ 5842.2. The positive and higher value of NPV indicates investment in RBFSP added a great deal of value in the Interfish research area (Table 7.8).

Table 7.8: Calculation of net present value for Interfish research area

Year	Gross benefit (US$)	Gross cost (US$)	Net benefit (US$)	Discount rate (14%)	NPV (US$)
0	0	965.0	-965.0	1.14	-846.5
1	2867.3	44.7	2822.6	1.29	2171.9
2	3876.5	31.3	3845.2	1.48	2595.4
3	3267.2	21.9	3245.2	1.68	1921.4
				Total NPV	5842.2

Benefit-cost ratio (BCR): Calculated benefit-cost ratio was much greater than 1, suggesting the project investment through development and research increases benefits by more than 7.4 times than investment alone (Table 7.9).

Table 7.9: Calculation of benefit-cost ratio for Interfish research area

Year	Gross benefit (US$)	Discounted Benefit (US$)	Gross cost (US$)	Discounted cost (US$)	Discount rate	BCR
0	0	0.0	965.0	846.5	1.14	0.00
1	2867.3	2206.2	44.7	34.4	1.29	64.1
2	3876.5	2616.5	31.3	21.1	1.48	123.9
3	3267.2	1934.4	21.9	12.9	1.68	149.2
		6757.2		914.9	Average BCR	84.3
		Discounted BCR		7.4		

Go-Interfish area

Net present value (NPV): In the Go-Interfish project the NPV was found to be US$ 2322.1. Likewise in other project phases, the positive and higher value of NPV than 1 suggests investment in RBFSP was profitable (Table 7.10).

Table 7.10: Calculation of net present value for Go-Interfish project

Year	Gross benefit (US$)	Gross cost (US$)	Net benefit (US$)	Discount rate (14%)	NPV (US$)
0	0	1958.4	-1958.4	0.877	-1717.9
1	1519.6	37.2	1482.5	0.769	1140.7
2	2289.3	26.0	2263.3	0.675	1527.7
3	2334.9	18.2	2316.7	0.592	1371.6
				Total NPV	2322.1

Benefit-cost ration (BCR): The benefit-cost ratio in the Go-Interfish area was found to be 2.3 suggesting that inclusion of a fish seed component in FFS training as well as investment made the project profitable (Table 7.11).

Table 7.11: Calculation of benefit-cost ratio for Go-Interfish project

Year	Gross benefit (US$)	Discounted Benefit (US$)	Gross cost (US$)	Discounted cost (US$)		Discount rate	BCR
0	0	0	1958.4	1717.9		1.14	0
1	1519.6	1169.3	37.2	28.6		1.29	40.9
2	2289.3	1545.2	26.0	17.6		1.48	87.9
3	2334.9	1382.4	18.2	10.8		1.68	128.2
		4096.9		1774.8	Average BCR		64.3
			Discounted BCR	2.3			

Centralised tilapia hatchery

Net present value (NPV): Net present value was estimated at US$ 89459.4 for the centralised tilapia hatchery (Table 7.12). This high NPV calculated for the tilapia hatchery was due to large scale investment during the installation of the hatchery, its operation and commercial level of fingerling sales.

Table 7.12: Calculation of net present value for GIFT tilapia hatchery

Year	Gross benefit (US$)	Gross cost (US$)	Net benefit (US$)	Discount rate (14%)	NPV (US$)
0	0.0	42733.7	-42733.7	0.877	-37485.7
1	92857.1	33074.1	59783.0	0.769	46001.1
2	92857.1	29984.1	62873.0	0.675	42437.5
3	92857.1	27821.1	65036.0	0.592	38506.5
				Total NPV	89459.4

Benefit-cost ratio (BCR): Benefit-cost ratio was found to be 1.9 in the mono-sex tilapia hatchery which is much lower than the BCRs of all decentralised systems (Table 7.13). The lower BCR of centralised GIFT hatchery suggests that investment here was less profitable than the investment in decentralised systems.

Table 7.13: Calculation of benefit-cost ratio for mono-sex tilapia hatchery

Year	Gross benefit (US$)	Discounted Benefit (US$)	Gross cost (US$)	Discounted cost (US$)		Discount rate	BCR
0	0	0.00	42733.7	37485.7		1.14	0.00
1	92857.1	71450.5	33074.1	25449.5		1.29	2.81
2	92857.1	62675.9	29984.1	20238.4		1.48	3.10
3	92857.1	54978.9	27821.1	16472.3		1.68	3.34
		189105.4		99645.9	Average BCR		2.31
			Discounted BCR	1.9			

Based on an initial investment of US$ 10,000, a comparatively higher NPV was demonstrated for the Interfish research area followed by the Interfish and then mono-sex tilapia hatchery (Figure 7.4). Similarly, higher discounted BCR were found in the Interfish research area followed by Interfish, Go-Interfish and tilapia hatchery.

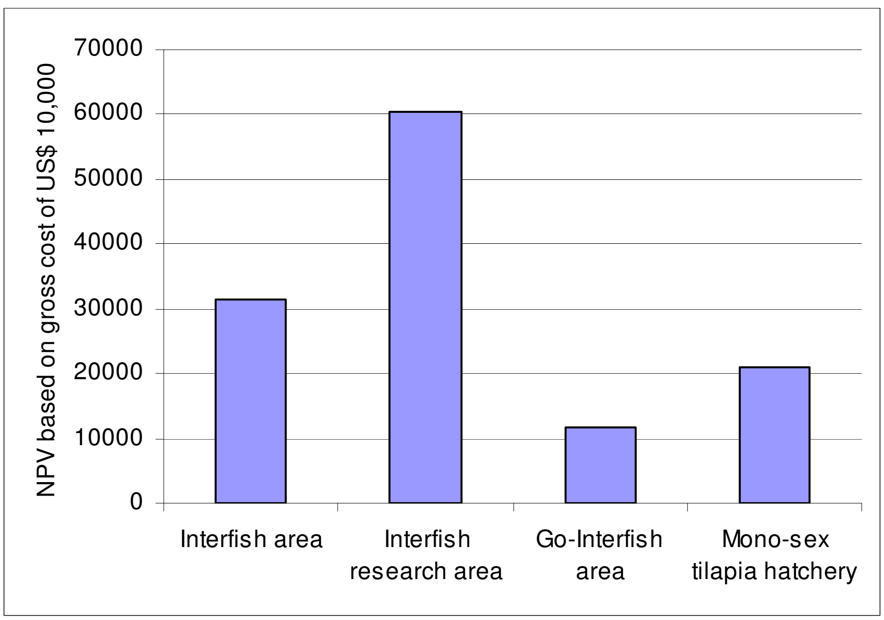


Figure 7.4: Comparative NPV of different decentralised promotions and centralised hatchery based on initial investment of US$ 10,000.

7.3.2 Development (economic) cost-effectiveness

7.3.2.1 Decentralised promotions

Interfish area

In the Interfish area, tilapia was introduced from the Interfish research area, when compared to the Go-Interfish area, increased the production of fingerlings and income (Table 7.14). This contributed to increasing benefits at the levels of secondary farmers, fry traders and grow-out farmers.

Table 7.14: Multiplier benefits in Interfish area

Domains and descriptions of cost and benefit	Benefit (US$)
Primary farmer =37 (calculated from community level survey) **<u>Fingerlings</u>** Cost of each primary farmer (US$) = 3.01 (CARE training) + 2.9 (Tilapia broodfish cost) + 6.2 (farmer own cost for ditch construction and fingerling production) = 12.1; For total 37 farmers in 12 communities initial cost = 37 X 12.1 = 447.7; Farmers learnt tilapia seed production from Interfish research communities. This cost of training was assumed as 'willingness to pay' for one day initial training in two communities given by researcher and research assistants = 8.6 + 2.6 = 11.2; Tilapia seed production training cost in one community = 11.2/2 = 5.6; Tilapia seed production training cost in 12 communities = 67.2; For total 37 farmers in 12 communities gross cost = 447.7 + 67.2 = 514.9 (each farmer total cost = 514.9/37 = 15.7); Total 37 farmers gross benefit = 2858.1; Total 37 farmers net benefit from fingerling production = 2858.1-514.9 = 2343.2 (each farmer net benefit from fingerling = 63.33) **<u>Pond</u>** Each farmer stocking their ricefield produced fingerlings obtained additional net benefit of 43.3 than a farmer did not use such fingerlings; Out of 37 farmers, 20 farmers had pond (average 54% farmers possess pond calculated in Chapter 3); Total 20 farmers net benefit = 43.3 X 20 = 866.0	Fingerling + pond = 2343.2 + 866.0 = 3,208.2
Secondary farmer =107 (calculated from two community level survey and conservative estimate for other communities) **<u>Fingerlings</u>** Cost of each secondary farmer = 6.2 (farmer own cost for ditch construction and fingerling production) + 2.9 (tilapia broodfish cost) + 1.8 (that would need for training of tilapia seed production) = 10.9; Total number of secondary farmers was calculated as 104; Total 104 farmers gross cost = 104 X 10.9 = 1135.3; Each farmer gross benefit from fingerling = 77.2 (considered as primary farmer) + 3.01 (cost that would need for CARE training) = 80.2; Total 104 farmers benefit from fingerlings = 80.2 X 104 = 8340.8; Total 104 farmers net benefit = 8340.8 – 1153.3 = 7187.5 **<u>Pond</u>** Each farmers net benefit from pond as primary farmer = 43.3; Out of 104 farmers, 56 farmers have pond (average 54% farmers possess pond calculated in Chapter 3). Total 56 farmers net benefit from pond = 43.3 X 56 = 2431.9	Fingerling + pond = 7187.4 + 2431.9 = 9619.3
Fry trader =23 (calculated from two community level survey and conservative estimate for other communities) Each fry trader traded 50 kg of fingerlings from fish seed producers (estimated from case studies); Benefit of a fry trader from each kg of fingerlings trading = 0.51; Total benefits from 50 kg fingerling trading = 0.51 X 50 = 25.5; Total number fry traders traded fingerlings from both primary and secondary adopters = 23; Total 23 fry traders benefit = 25.5 X 23 = 586.5	586.5
Pond fish producer = 575 (calculated from fry trader survey and conservative estimate) Each farmer cost for pond production was calculated in Chapter 3; As with primary and secondary farmers, each farmer who stocked decentralised fingerlings obtained additional net benefit of 43.3; Number of pond fish producers received fingerlings from each fry trader = 25; Total number of farmers received fingerlings from 23 fry traders = 23 X 25 = 575.0; Total pond fish producers net benefit = 575 X 43.3 = 24897.5	24,897.5

Interfish research area

In the Interfish research area, the net benefit at the level of fingerling producers was much higher than for other areas under CARE promotion (Table 7.15). Supply of good quality tilapia broodfish and intensive training and monitoring brought changes at multiple levels of beneficiaries.

Table 7.15: Multiplier benefits from Interfish research area

Domains and descriptions of cost and benefit	Benefit (US$)
Primary farmer =24 (calculated from community level survey) **<u>Fingerlings</u>** Cost of each primary farmer (US$) = 3.01 (CARE training) + 2.9 (Tilapia broodfish) + 6.2 (tilapia seed production training)+ 6.2 (farmer own cost for ditch construction and fingerling production) = 18.26; Total 24 farmers gross cost = 24 X 18.26 = 438.2; Total 24 primary farmers gross benefit from fingerling = 2904 (each farmer gross benefit = 121.0); Total 24 farmers net benefit from fingerling production = 2904.0 – 438.2 = 2465.8 **<u>Pond</u>** Excluding all cost, each farmer stocking their on-farm fingerlings obtained additional net benefit of 43.3; Out of 24 farmers 13 farmers have pond (average 54% farmers possess pond calculated in Chapter 3); Total 13 farmers net benefit = 43.3 X 13 = 562.9	Fingerling + pond = 2465.8 + 562.9 = 3028.7
Secondary farmer =102 (calculated from community level survey) **<u>Fingerlings</u>** Gross cost of each secondary farmer (US$) = 6.2 (farmer own cost for ditch construction and fingerling production) + 2.9 (Tilapia broodfish) + 6.2 (that would need for tilapia seed production) = 15.3; Total number of secondary farmers were identified = 102; Total 102 farmers gross cost = 15.3 X 102 = 1560.6; Each farmer gross benefit = 121.00 (considered as primary farmer) + 3.01 (cost that would need CARE training) = 124.01; Total 102 farmers benefit from fingerlings = 124.01 X 102 = 12649.0; Total net benefit of fingerlings of 102 secondary farmers = 12649.0 - 1560.6= 11088.4 **<u>Pond</u>** Each farmers net benefit from pond as with primary farmer = 43.3; Out of 102 farmers 55 farmers have pond (average 54% farmers possess pond calculated in Chapter 3); Total 55 farmers net benefit = 43.3 X 55 = 2384.9	Fingerling + pond = 11088.4 +2384.9 = 13473.3
Fry trader = 21 (calculated from community level survey) Each fry trader traded 76 kg of fingerlings from fish seed producers (calculated from Chapter 5); Benefit of a fry trader from each kg of fingerlings trading = 0.51; Total benefits from 76 kg fingerling trading = 0.51 X 76 = 38.8; Total number fry traders traded fingerlings from both primary and secondary adopters = 21; Total 21 fry traders benefit = 21 X 38.8 = 814.8	814.8
Pond fish producer n =735 (calculated from fry trader survey) Each farmer cost for pond production was considered from Chapter 3; As with primary and secondary farmers, each farmer who stocked decentralised fingerlings obtained additional net benefit of 43.3; Number of pond fish producers received fingerlings from each fry trader = 35; Total number of farmers received fingerlings from 21 fry traders = 21 X 35 = 735.0; Total pond fish producers net benefit = 735 X 43.3 = 31825.5	31825.5

Go-Interfish area

Net benefits in the Go-Interfish area were less than in other promoting areas of RBFSP (Table 7.16). This was due to a lower level of production resulting from limited access to good quality tilapia broodfish which caused lower benefits to the other domains of beneficiaries.

Table 7.16: Multiplier benefits from Go-Interfish area

Domains and descriptions of cost and benefit	**Benefit (US$)**
Primary farmer n=84 (calculated from community level survey) **Fingerlings** Cost of each primary household (US$) = 3.6 X 2 = 7.2 (CARE training) + 6.2 (farmer own cost for ditch construction and fingerling production) = 13.4; Total 84 farmers actual initial cost = 84 X 13.4 = 1125.6 (each farmer net benefit from fingerling = 10.5); Total 37 farmers net benefit from fingerling production = 10.5 X 84 = 880.3 **Pond** Each farmer stocking ricefield produced fingerlings obtained additional net benefit of 43.3; Out of 84 farmers 45 farmers had pond (average 54% farmers possess pond calculated in Chapter 3); Total 45 farmers net benefit = 43.3 X 45 = 1948.5	Fingerling + pond = 880.3 + 1948.5 = 2828.8
Secondary farmer =13 (calculated from community level survey) **Fingerlings** Cost of each secondary farmer = 6.2 (farmer own cost for ditch construction and fingerling production); Total number of secondary farmers was calculated as per observation from Interfish research area; Total 13 farmers actual operation cost = 13 X 6.2 = 80.6; Each farmer net benefit from fingerling = 10.48 (considered as primary farmer) + 7.2 (cost that would need for CARE training) = 17.7; Total 13 farmers benefit from fingerlings (US$) = 17.7 X 13 =229.8 **Pond** Each farmers net benefit from pond as primary farmer = 43.3; Out of 13 farmers, 7 farmers have pond (average 54% farmers possess pond calculated in Chapter 3); Total 7 farmers net benefit from pond = 43.3 X 7 = 303.1	Fingerling + pond = 229.8 + 303.1= 532.9
Fry trader =16 (calculated from community level survey) Each fry trader traded 27 kg of fingerlings from fish seed producers (calculated from Chapter 5); Benefit of a fry trader from each kg of fingerlings trading (US$) = 0.51; Therefore, benefits from 27 kg fingerling trading (US$) = 0.51 X 27 = 13.8; Total number fry traders traded fingerlings from both primary and secondary adopters = 16; Total 16 fry traders benefit = 13.8 X 16 = 220.8	220.8
Pond fish producer = 208 (calculated from fry trader survey) Each farmer cost for pond production was calculated in Chapter 3; As with primary and secondary farmers, each farmer who stocked decentralised fingerlings obtained additional net benefit of US$ 43.3; Number of pond fish producers received fingerlings from each fry trader = 13; Total number of farmers received fingerlings from 16 fry traders = 16 X 13 = 208; Total pond fish producers net benefit (US$) = 208 X 43.3 = 9006.4	9006.4

7.3.2.2 Centralised tilapia hatchery

Overall according to actual initial costs, aggregated benefit was higher in the mono-sex tilapia hatchery than from the Interfish research area. However, the number of beneficiaries was much higher for decentralised seed promotion compared to a centralised mono-sex tilapia hatchery (Table 7.17).

Table 7.17: Multiplier benefits from centralised mono-sex tilapia hatchery

Domains and descriptions of cost and benefit	**Benefit (US$)**
Hatchery owner (calculation from hatchery owner) Cost of a hatchery operation in third year of production including fixed depreciation (30%), variable and interest on operating capital cost = 29984.1; Hatchery owner average gross return = 92857.1; Hatchery owner net return = 92857.1- 29984.1 = 62873.0	Fingerling + pond = 62873.0
Secondary farmer No scope of secondary farmers	0
Fry trader Hatchery did not sell mono-sex tilapia seed to fry traders rather seed was sold seed to commercial farmers after having a contact for a larger amount of seed in oxygenated bags	0
Pond fish producer (conservative estimation from hatchery owner) Total number of farmers purchased seed from the hatchery = 500; Each farmer purchased the number of fingerling = 20000; Each farmer produced = 3500 kg fish (calculated considering 70% survival and each piece market size = 250 g); Gross income from each kg tilapia is = 0.86. Each farmer gross income (US$) = 3500 X 0.86 = 3000; Each farmer per kg production cost (US$) = 0.4; Each farmer total production cost (US$) = 3500 X 0.4 = 1400; Each farmer net benefit (US$) = 3000-1400 = 1600; Total 500 farmer net benefit = 800,000	800,000.0

However, based on a unit initial investment cost (US$ 10,000), the Interfish research area showed the highest effectiveness in terms of benefits amongt beneficiaries including primary farmers, secondary farmers, fry traders and pond fish producers. Comparatively, all decentralised promotion as found to be more effective than centralised systems in terms extent of monetary benefits and equity of benefits based on the number and type of beneficiaries (Figure 7.5).

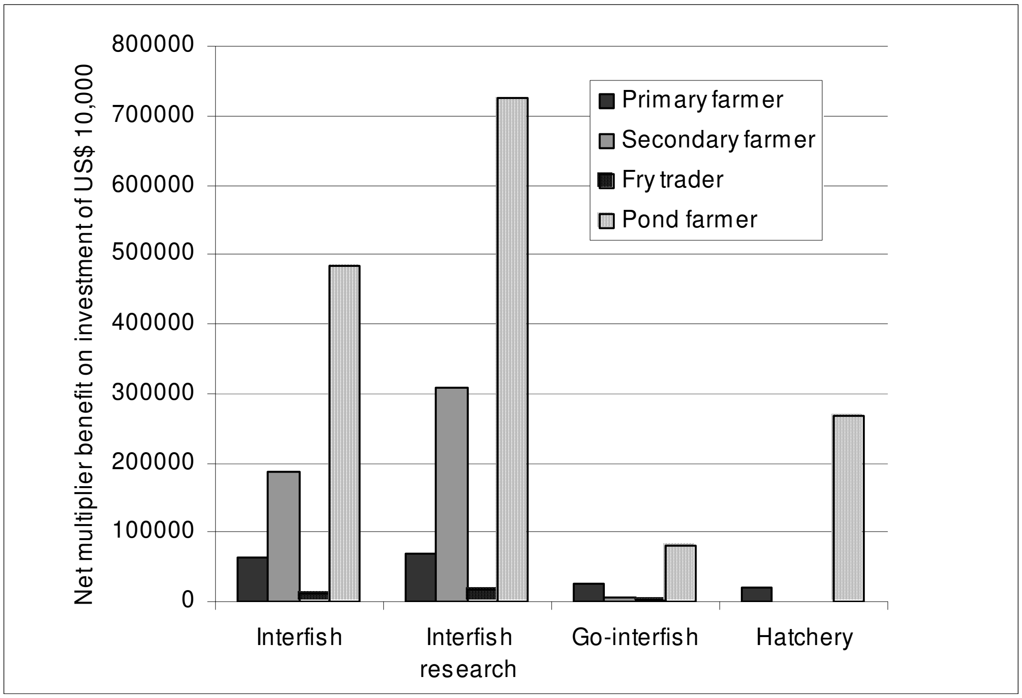


Figure 7.5: Multiplier benefits of fish fingerling production based on investment of US$ 10,000.

7.3.2.3 Sustainability of programme in PNGOs after withdrawal of CARE support

At the time of investigation during the on-going partnership between CARE and its PNGOs, the majority of them said that they would continue the RBFSP as well as other programmes keeping the trained staff obtained during the CARE partnership and that they would seek funds from other sources. Some of the NGOs mentioned that they were seeking funds to continue the programme (Table 7.18). However, during the investigation after withdrawal of CARE support, none of the NGOs were found to have continued promoting RBFSP. When asked their reasons for not continuing the programme, almost all NGOs replied that they were unable to continue without external funding support and without continuous support for salaries it is not possible to run such a programme.

However, almost all of the NGOs irrespective of size were working with common programmes such as micro-credit, sanitation, social forestry and child education. Of the programmes micro-credit was found to be the most common programme not only in small NGOs but also in large NGOs with a greater number of credit receivers and larger geographical coverage.

Table 7.18: Partner NGO's profile with regard to their existing programmes

Type of NGO	Name of NGO	Year of establishment	Situation of NGOs during partnership with CARE (2005)		Situation after withdrawal of CARE support	
			No. of existing programmes	Commitment to continue CARE partnership activities	No. of existing programme	Continuation of CARE programmes
Small (staff<20)	BOHUBRIHY	1996	5	Yes	4	No
	Jubok Shamity (JUS)	1995	5	Yes	3	No
	Rostamabad Mohila Unnayan Somity (RMUS)	1992	6	Yes	3	No
Medium (staff<100)	Al-Falah Aam Unnayan Sangstha (AFAUS)	1989	9	Yes	9	No
	Jhanjira Samaj Kallyan Sangstha (JSKS)	1983	8	Yes	5	No
	Bandhan Bohumukhi Samajik Unnayan Songsths (BBSUS)	1998	5	Yes	1	No
Large (staff>100)	Eco-Social Development Organization (ESDO)	1988	34	Yes	35	No
	Debi Chowdhurani Palli Unnayan Kendra (DCPUK)	1981	16	Yes	12	No
	Rangpur Development Samajik Sangstha (RDSS)	1986	9	Yes	3	No

Out of 9 NGOs only 2 NGOs (one medium and one medium large) have been able to keep the staff who were trained during from the partnership programme with CARE. This has only been possible as these NGOs were awarded projects immediately after the withdrawal of CARE support. They did not continue to utilize them in FFS programmes.

The final approach of the Go-Interfish project was to convert the FFS into a CBO involving all households within the community. The approach aimed to benefit all members of the community, so that people, irrespective of well-being categories and the availability of resources to them could gain from the development of the CBO. The number of the CBOs ranged from 3 to 41 per NGO and methods of direct delivery (Table 7.19).

Table 7.19: Statistics of community based organizations formed by 9 NGOs under CARE Go-Interfish project in the Northwest Bangladesh

Criteria	Number	Percentage of CBO	
Total number of FFS	682	In terms of FFS	In terms of community
Total number of community	341		
Total number of CBO	118	17.30	34.60
Registered CGO	14	2.05	4.10
CBO-A category[1]	45	6.59	13.19
CBO-B category[2]	47	6.89	13.78
CBO-C category[3]	24	3.51	7.03

[1]Well organized with saving account in bank and communication with the service providers in the Local Government and in Upazilla level

[2]Well organized with saving account in bank and communication mostly with local government but not with the service providers at Upazilla level

[3]Having the saving account in bank but no communication with the service providers of local government and Upazilla offices

Of the total 682 FFSs formed by the 9 NGOs, only 34% developed into a CBO after the project's complete departure. Out of those only 4% have been registered with the government to be recognised as a viable CBO. By building up linkages between the government and the CBO it is possible to obtain government assistance, particularly credit. In addition, at the end of the project, only 13% of the CBOs formed were within a standard category. The standard CBO is registered with the Ministry of Social Welfare and are well organised having a savings account in a bank and linkages with local government and the government service providers at the upazilla level. Partner NGOs were also contacted by CARE to monitor the CBOs, but in practice no NGOs presented evidence of this.

7.4 Discussion

Methodologically, assessment of cost- effectiveness regarding multiplier development benefits was carried out using empirical data as well as conservative estimates based on empirical data. Conservative estimates are widely used in medical science to make broader decisions for cost-effective medical service (Splett, 1996; Hawkins et al. 2005). Each estimate of impact or effectiveness has weaknesses however, logic and assumption for cost–effectiveness analysis greatly contributes to future improvement of a project intervention (Schreiner, 2003). In the evaluation of agricultural extension programmes, conservative estimates are often used to estimate the demand for a specific extension programme which could provide useful direction to extension organizations/administrators who make difficult financial decisions to achieve broader benefits (Roe et al. 2004).

The highest investment per household by CARE was calculated during the Go-Interfish phase and was nearly 50% higher than in the previous Interfish project. This effect was as a result of concentration of the Interfish Project on the improvement of rice field management capacity of rice growing farmers. This included the concept of fish seed production in ricefields, fish production in ricefields, dike-cropping, low external input rice production techniques and integrated pest management (CARE, 2001a).

This higher investment by CARE per household in its Go-Interfish phase was due to the fact that it not only worked with ricefields (fish seed, ricefish, dike cropping and low input rice production) but also worked with other technical and non-technical issues in a broader spectrum encompassing almost all aspects of livelihood and rural development. Estimating the cost of fish seed training in FFSs and and the associated effectiveness were of major interest in this study. Other technical issues included homestead vegetable gardening, integrated pest management, compost/manure preparation, rice seed collection and preservation, rice seedbed preparation, pest control on vegetables, plant grafting, cow fattening, poultry vaccination etc. The non-technical social development activities included advocacy of facilitating access to markets, linking farmer groups with other service providers (e.g. health and sanitation) and encouraging the formation of groups (e.g. community based organisation) to act as the engines of social mobilization in the community. In addition, Go-Interfish worked through local NGOs who played an important role in implementing FFS and delivering additional services to farmers. Building the capacity of local partner NGOs, and assisting them to work more effectively in alliances was an important objective of the project. The capacity building activities for local NGOs included training staff in financial management, advocacy, marketing, monitoring and evaluation and coordination. The diverse activities of the Go-Interfish project made it difficult to include an estimation of all benefits in the present study, so assessment was restricted to the benefits of RBFSP.

For the partner NGO delivery, investment per participant was less than the Interfish project and about three times lower than Go-Interfish. This was accounted for by vehicle purchase, the large administrative and management costs of CARE direct delivery based on retaining a large number of staff at several locations in Northwest Bangladesh and Dhaka. The investment in FFS training at the community level was low and accounted for less than 20% of the total programme budget. This was because field trainers' only costs were for snacks during each learning session. It was not possible to obtain budget-break-down of CARE direct delivery however, as the salary and other associated costs were much higher, the comparative budget for the actual FFS training was minimal.

Fish seed production training was a tiny part of the FFS curricula and incurred little expenditure in all promotions of decentralised fish seed production. Thus proportionately, investment in fish seed production training was a small amount of the overall expenditure. Comparatively, the time allocation for fish seed production training was higher in the Interfish compared to the Go-Interfish FFS due to the inclusion of additional activities in the Go-Interfish project. Although the time allocated to fish seed training was less in Go-Interfish project, per household investment was much higher than Interfish project due to the diversity of activities in the FFS curriculum and the training approach. Both male and female from each household participated in Go-Interfish FFS whereas, in Interfish FFS a participant from each household was either male or female.

Additional value of the FFS was provided through the supply of good quality tilapia broodfish and hands-on training on seed production could increase the number of adopters of RBFSP at the community level. This was indicated by the research intervention that supplied good quality broodfish of tilapia and seed production training in two Interfish communities (Barman et al. 2004). That greatly improved the performance of decentralised seed production with respect to an increased number of adopters and fingerling production. Good quality broodfish supply in the Interfish research communities contributed to stretch the impacts on Interfish area in terms of increased performance of fingerling production and income compared with the Go-Interfish area. Increased impacts were also evidenced through the dissemination of improved knowledge of tilapia fingerling production from Interfish research to Interfish communities. The intermediate level of performance in the Interfish communities could possibly have been due to a dilution factor whereby the introduced improved qualities of tilapia broodfish were reduced after mixing with feral tilapia species, resulting in lower productivity. The lower level of production in the Go-Interfish area suggests a need to supply improved quality tilapia broodfish along with better knowledge of seed production in ricefields as in the Interfish research area (Barman et al. 2004).

In terms of per unit project investment, decentralised fish seed production in the Interfish research and Interfish areas was more cost-effective than in the Go-Interfish area. This deviation reveals that the supply of good quality tilapia broodfish and seed production training in existing standalone farmer field schools in the Go-Interfish area is a critical step towards increasing the cost-effectiveness of RBFSP (Barman et al. 2004).

When cost-effectiveness is considered in terms of economic development, all types of decentralised fish seed production contribute substantially more than the establishment of a centralised hatchery. The introduction of secondary adopters in Interfish receiving high quality tilapia broodfish from the Interfish research area added considerable extra value to the chain of delivery. Spreading technological information and increasing the number of secondary adopters is a key component of effectiveness (Casley and Lury, 1987). An increased number of secondary adopters after withdrawal of external support made the programme cost-effective and sustainable and was beyond the initial community intervention level.

There are many difficulties in measuring effectiveness with respect to calculating the informal diffusion or the secondary spread of information from farmers who have been reached by particular methods through contact with other farmers in their social network who have not attended the training (Gilbert, 2005). However, the outcomes of earlier studies (Chapter 5) regarding the adoption process of RBFSP technology can inform the process of secondary adoption in this context. Although each participant in FFS training was assigned to a buddy (secondary farmers), in reality it was observed that more than 30% of secondary adopters were not buddies of primary farmers. This result suggests that there was considerable informal spread of technical knowledge (Barman et al. 2004) which makes the FFS extension approach more cost-effective than planned. The involvement of fry traders was reported to have contributed to spreading knowledge of RBFSP over a larger geographical area (Barman et al. 2004).

The rate of secondary adoption in the Interfish research area was probably higher due to easy access to improved quality tilapia broodfish and greater benefits from fingerling sale. There is evidence to suggest that farmers adopt a technology if they observe one of their neighbours or peers being successful after using it (Rogers, 1995b). Godtland et al. (2004) discussed how the rates of informal diffusion of IPM knowledge in communities where IMP training has occurred. They argued that those who did not attend the training adopted IPM demonstrating that the benefits of programme were extended beyond those who participated making the programme more cost-effective.

Empirical attempts to measure the informal transfer of IPM knowledge have had mixed results. Price (2001) found evidence of secondary transfer of information in a Philippino village where a FFS had occurred. In Price's study, farmers who did not participate in the FFS showed increased knowledge of IPM practices after the field school had taken place, indicating that they had received information from FFS graduates in the village through informal contact. Conversely, Rola et al. (2001) found no significant difference in IPM knowledge between farmers in the Philippines who did and did not participate in FFS, even though it occurred in their village. Feder et al. (2004a) and Tripp (2006b) found no significant evidence that FFS trained farmers share IPM information with their neighbours in Indonesia. This might be due to the differences between needs for technologies and socio-cultural interactions among farmers in different countries. Tripp (2006b) however argued while the effects of secondary spread of IPM knowledge and practices through informal social networks are uncertain, it is an important consideration when determining how many people an intervention reaches, and is also important in determining cost-effectiveness of development interventions.

With respect to economic cost-effectiveness, a higher number of fry traders involved in Interfish research communities made the programme more cost-effective. Prior to the introduction of tilapia, seed production was limited to common carp at a subsistence level which was used for restocking in household ponds and for consumption. Following the introduction of tilapia broodfish, the higher production of fingerlings in the Interfish research area attracted proportionately higher number of fry traders that added further value in the promotion of the decentralised seed production system (Barman et al. 2004). Higher levels of fry trader involvement increased beneficiaries at the pond fish producer level which in turn made decentralised fish seed promotion more cost-effective overall.

Decentralised seed production in ricefields was found to be more cost-effective than centralised tilapia hatchery with respect to a unit monetary investment. This was attributed to the involvement of many co-beneficiaries towards their livelihood improvement compared to the centralised tilapia hatchery. Hatchery level tilapia seed production benefits the hatchery owner and grow-out farmers but does not benefit any intermediate poor actors such as fry traders. Mono-sex tilapia seed produced in hatcheries is sold directly mainly to better-off grow-out farmers. The value of the product includes delivery costs for transportation in oxygenated bags, sometimes over long distances which is much less affordable for poorer foodfish producers.

Mono-sex tilapia seed production systems have been developed to produce uniform and larger fish that are more valuable than those from typical harvest of mixed-sex tilapia (Green et al. 1997), but its demands are mainly associated with urban and export markets (Little and Edwards, 2004). The growth and survival, irrespective of new-season mono or mixed-sex tilapia, in culture ponds in Vietnam over a period of 110 days was about 200g and 75% respectively (Dan and Little, 2000). This corroborates the fact that there is a special advantage to the use of mixed sex tilapia fingerlings over mono-sex because relatively small-sized tilapias (< 200g) are more important for the food security of poorer households (Barman et al. 2002; Little et al. 2007) and are in greater demand in rural markets (Chapter 5) (Faruque, 2007). Another study showed that using mixed or mono-sex tilapia seed did not make any significant difference to growth in pond culture except with respect to the provision of external nutrients (fertilizer and supplementary feeds) inputs (Little and Edwards, 2004). This favoured poorer households to produce mixed-sex tilapia fingerlings in ricefields which made the decentralised approach more cost-effective in terms food security and pond production compared to hatchery based mono-sex tilapia seed production.

A recent study on integrated pond-dike systems in a centralised clustered hatchery dominated area (North-central part of Bangladesh – Mymensingh) showed that stocking of fingerlings in ponds had incurred the highest costs in terms of total inputs (Karim, 2006; Faruque, 2007). In this regard, recommendations and suggestions had been made for farmer level spawning and nursing of fish fingerlings to minimize the operation cost and maximize the benefits from pond-dike integrated aquaculture. The biggest share of impacts of decentralised seed on pond production has been evidenced through increased fish production of seed producers (Chapter 3) as well as non-seed producers who used decentralised seed (Chapter 5). This clearly suggests that to farmers in remote areas where hatchery produced seed particularly tilapia is not available, the relative degree of the problem regarding high price of seed will be acute. In this context, seed production in remote areas like Northwest Bangladesh is more cost-effective through the decentralised system. According to a recent investigation, there were 17 tilapia seed production hatcheries recorded in Bangladesh. Most of those were located in south and central parts of Bangladesh where demand was high especially for larger fish, however no hatchery was found in Northwest Bangladesh (WorldFish Center, 2004). The mixed-sex tilapia fingerlings produced at the farmer level were of high quality indicated by the greatly enhanced performance of grow-out in farmer's ponds. This explains the high cost-effectiveness of such project interventions.

Exclusively, higher investment in and focusing tilapia seed production in Interfish research communities made the programme highly cost-effective in terms of project based investment and economic development. The relatively lower cost-effectiveness of the Go-Interfish project was at least partly derived from the broader development approach and difficulty in quantifying in the short-term effectiveness. This suggests that RBFSP could be a component of any other developing endeavours being implemented by other government and non-government organizations in Bangladesh. CARE realised this potential and tried to encourage its partner NGOs to continue these farmer field school activities in further communities and to monitor the activities in ongoing communities.

7.4.1 Sustainability of programme in PNGO

The promotion of tilapia seed production in the Interfish research area was carried out by the research programmes with support from NFEP that included holding and supply of good quality tilapia broodfish and staff for the facilitation of farmer training (Barman, 2000). The capacity of holding good quality tilapia broodfish and staff for farmer level training were likely to be key factors for the sustainable promotion of RBFSP through local NGOs. The present study indicates that local partner NGOs were dependent on external support (CARE support) to run natural resource based development activities (e.g. RBFSP) due to their limited capacity in holding good quality broodfish and trained staff.

In Bangladesh, many of the NGOs were formed during the period immediately after the war of independence in 1971 (Garilao, 1987). Over 90% of villages had at least one

NGO in 2000 (Fruttero and Gauri, 2005), and foreign assistance to the country channelled through NGOs has been above 10% since 1993 (Ahmed, 2002). A recent study shows that number of NGOs in each the sub-district (upazila) of Bangladesh ranged from 1 to 192 (average 15.1) and that the majority were not located in the poorest areas (Gauri and Galef, 2005). The present study shows that NGOs normally provide beneficiaries with some continuous specific services, the major service being micro-credit support. According to Gauri and Galef (2005) in general, 92% of NGOs provide micro-credit as their main service. However it was demonstrated that although micro-credit was considered as a main component of poverty reduction, it is a major source of revenue for NGOs. Some 15% of small and 8% of large NGOs maintained a business or canteen to generate income to support their activities (Gauri and Galef, 2005) suggesting limited scopes for NGOs to generate funds.

In most developing countries, NGOs have limited internal resources and operate from project to project. External funding gives them a certain degree of security to maintain and even expand operations (Garilao, 1987). This sort of support makes the NGO dependent on external funds, hence the notion that NGOs are here today and may be nowhere tomorrow (Brodhead, 1987). Organizational sustainability incorporates more forward-looking attributes such as self-reliance, autonomy, learning capacity, and leadership which, in turn, help ensure sustainability (VanSant, 2003). NGOs having such self self-reliant characteristics in Northwest Bangladesh include the Rangpur Dinajpur Rural Service (RDRS) working since the independence of Bangladesh with the grass roots people. This organization runs by both external and internal funding sources and, it has developed a wide range of service facilities contributing to its revenue generation as well as implementation of several collaborative programmes (RDRS, 2007). Presently it is working in 46 Upazilas consisting of 357 unions with 337,661 beneficiaries in the

Northwest. This organization has established field offices in 40 locations along with 13 training centres with residential facilities for both trainers and trainees.

The fact that value addition in CARE FFS could be greatly enhanced through the supply of good quality tilapia broodfish suggesting that the inclusion of organizations such as RDRS with physical facilities and capacity could be a way to further promote decentralised fish seed production. In these FFSs, households already have knowledge on ricefield ecology where it would be easier to strengthen this approach through supply of good quality broodfish and improved knowledge of seed production.

With RDRS taking a leading role, based on research and development approach, delivery towards improvement of FFS effectiveness could be tested by employing a action research approach through several mechanisms such as i) providing training with good quality broodfish; ii) giving training and literature; iii) training a leader at the community level; iv) developing one-stop aqua-shop (OAS); v) giving training to community mosque imam; and vi) using audio-visual aid at community shop.

Testing these extension methods at the farmer level more cost-effective approach could be developed. Training and monitoring in the Interfish research community occurred over 10 months but this could be reduced to 3 months during a single *boro* season in FFS communities. Giving one-off training supported by provision of necessary information in the form of literature (leaflet) could another option for low-cost delivery. Training a leader at the community level as an opinion leader could also be a cost-effective delivery mechanism towards strengthening decentralised approach. The opinion leader, sometimes referred to as 'fellow farmer' was identified to be a relatively more important source of information than radio or extension agents for both males and females in Uganda (Adupa, 1999). One-stop aqua shops are a new approach of aquaculture service delivery system developed in rural India (Mukherjee, 2004) which could be tested at the community level to promote decentralised seed production towards broader aquaculture development.

Field level observations also suggest that promoters of RBFSP can be diverse. The imam who leads prayer in mosque in almost every community is respected by all regardless of social classes. Through the initiatives of the Islamic Foundation of Bangladesh under Ministry of Religious Affairs, the Government of Bangladesh undertook a project called Imam Training Project to educate imams in principles of Islam, mass education, family welfare, agriculture, fisheries, first aid, tree plantation, afforestation, livestock farming, etc. to enhance their capability of contribution to the socio economic development of the country (Banglapedia, 2007). A trained imam at the community level could be a better and more sustainable source of knowledge for decentralised tilapia seed production. Moreover, ponds which are commonly located around mosque premises could be used as a reservoir of good quality tilapia broodstock.

Over the years, in rural communities the number of small grocery shops selling essential commodities has increased (Rahman, 2005). These shops also sell tea in the evening time and show television programmes and movies with CD player to attract customers. After a day of agricultural activities, rural farmers gather to enjoy television programmes and movies along with a cup of tea. In such shops, documentary films on RBFSP based on successful farmers screened with background music of Northwest folk-song could be shown to disseminate knowledge of decentralised approach and sources of good quality broodfish.

7.4.2 Conclusion

Agricultural extension continues to offer hope for improving the lives of the rural poor in the developing world (Hanson and Just, 2004). New agricultural technologies and practices are important contributors to agricultural growth in developing countries. When innovations improve farmers' production practices by increasing yields or profit, farmers receive this information, through formal institutions, informal social networks, and their own trial and error (Conley and Udry, 2000; Bindlish and Evenson, 1997; Rogers, 1995a). The process of diffusing information to farmers, whether conducted by government agencies, NGOs or agricultural universities, should be improved by assessment of cost-effectiveness in order to ensure that the training and dissemination programs are sustainable (Gilbert, 2005).

The present study based on the hypothesis 'FFS promoting RBFSP delivery is the most cost-effective approach to achieving positive impacts through aquaculture' shows that whatever the expenditure in FFS training, it is cost-effective in terms of project based investment for promotion of RBFSP. Within the CARE FFS expenditure fish seed production in ricefield based systems incurred the smallest costs out of several cost components. Alongside this, through additional level of training support along with the supply of good quality tilapia broodfish, higher project investment and development benefits of decentralised fish seed production revealed a higher level of effectiveness. Such effectiveness of the decentralised system could surpass the effectiveness of any large investment in centralised mono-sex tilapia hatcheries. This suggests that in order to increases cost-effectiveness of standalone farmer field schools, training supports together with the supply of good quality tilapia broodfish at the community level is critical.

Local partner NGOs of CARE expected to support FFSs could not continue their activities due to their limited institutional capacity. It was estimated that during the period of 14 years since 1992 to 2005, CARE provided extension support to only 4% of households in Northwest Bangladesh. To strengthen and promote the decentralised fish seed production approach in standalone FFSs and untouched communities respectively, the creation of initiatives within capable grass root level institutions is required. Further research into the mechanisms of low-cost extension delivery at institutional level toward the large-scale promotion of decentralised seed production is required and could be carried out using action research and by employing the different mechanisms discussed above.

Chapter 8: General discussion

8.1 Introduction

This chapter reflects on the main findings in terms of their contributions to the main hypothesis ‘local production of fish seed in irrigated ricefields has positive, diverse and subtle impacts on rural livelihoods in Northwest Bangladesh’ and objectives as stated in Chapter 1. Firstly, differences between RF and NRF households focusing on their well-being status were assessed based on the sustainable livelihood framework. The second objective was to consider the livelihood impacts of this technology in relation to the seasonal behaviour of farming households. The extent to which this technology involved other actors (non-seed producers) as well as impacted on them was examined through the third objective. The fourth objective was to gain insight into the adoption process of this technology at the household level. Finally the fifth objective was to understand the dissemination mechanisms of this technology at the farmer level and their cost and benefits. The introductory Chapter provided a general overview of theoretical notions and empirical evidence relevant to these research objectives. The subsequent empirical Chapters dealt with these objectives in detail. This final Chapter includes an overview and discussion of the main findings drawn from the empirical studies.

A timely and adequate supply of good quality seed is the precondition in all localities, both for scaling up production and adoption of aquaculture by new entrants (World Bank, 2006). Ensuring local level fish seed supply, decentralised fish seed production in ricefield systems has been developed, adopted and promoted in Northwest Bangladesh during the 1990s (Little et al. 2007). This change has occurred in the context of a prevailing scarcity of quality seed which undermines the livelihoods of poor farmers and the integrity of the production chain and entire aquaculture economy (World Bank, 2006). In this context of the development of farmer level seed production, there was a research interest to assess livelihood impacts, adoption and promotion process of this technology in farming households.

Assessing the impacts of agricultural technology on poverty is difficult as there are so many ways in which agricultural technology can affect poverty (Kerr and Kolavalli, 1999; IFPRI, 2000). Many studies tend to simplify the linkages between agricultural research and poverty and measure only few aspects of those linkages. These sorts of studies could miss many important aspects of poor people's lives, including the diverse ways in which technology directly or indirectly affects their livelihoods (Adato and Meinzen-Dick, 2002). The sustainable livelihoods framework provides a common conceptual approach to examining the ways in which agricultural technologies fit into the livelihood strategies of households with different types of assets and other resources. The livelihoods framework however, has limitations in which the lack of attention to cultural capital was criticised (Stirrat, 2004). The suggestion to include cultural capital which include beliefs, traditions, language, identity, festivals and sacred sites has been made (Meinaen-Dick and Adato, 2001). However, application of this framework requires interdisciplinary research and a combination of quantitative and qualitative methods (Adato and Meinzen-Dick, 2002).

The findings of this thesis were derived from an interdisciplinary investigation based on the sustainable livelihoods framework which was carried out using both qualitative and quantitative investigation. At the beginning, participatory qualitative approaches were used to segregate the poorer section of seed producers which were the focal point of this research. Households were assessed through a cross-sectional survey in order to learn the context and livelihoods systems of seed producing households compared to non-seed producers. In order to understand seasonal dynamics of this technology a year long longitudinal survey was carried out with the same households from the preceding study.

Furthermore, both qualitative and quantitative investigations were carried out to understand broader scale livelihood impacts, adoption process and delivery mechanisms of this technology at the farmer level. The major findings derived from the preceding empirical studies are discussed with the support of the existing body of literature.

8.2 Impacts on human capital

8.2.1 Development of knowledge on natural resources management

Human resources including skills, acquisition of skills to narrow knowledge gaps and access to sources of information are important for small-sale aquaculture (ADB, 2005). Improvement in human assets has been identified as one of the most important factors for reduction of poverty (Sen, 2003). The surveyed seed producing farmers did not have much formal education, most no more than primary level. They had no experience with the RBFSP and had acquired the necessary skills for it from CARE through farmer field school training in an experimental learning process (Chapter 3). Farmer-to-farmer interactions, coupled with experience from learning by doing, were the key means of gaining seed production skills. Evidence from adoption studies show that secondary adoption occurred based on informal contact between farmers, illustrating the simple and low-cost nature of this technology (Chapter 6). The majority of non-adopting households, who had never tried this technology, were aware of fish seed production in ricefields being practised by their neighbours. A similar scenario was reported in FFS communities in Sri Lanka where half of the neighbouring farmers could report at least one piece of information received from FFS farmers (Tripp, 2006b). This suggests that accumulation of such knowledge or human capital can occur in farming communities which could be disseminated to other farmers without further formal institutional supports (Chapter 5).

FFS participants were reported to be generally enthusiastic about their experience and many eager to communicate their knowledge each other (Tripp, 2006b). Many farmers in seed producing communities acquired a high level of knowledge in terms of when to common carp eggs, identification of feral and improved broodfish of tilapia, broodfish management, stocking density in ricefields etc. (Barman et al. 2004). Fish seed producing farmers in the present study showed enthusiasm to share knowledge with other farmers (Figure 8.1). This behaviour is likely to improve decentralised fish seed production practices at community level.

The poorer sections of society often do not get access to knowledge necessary for implementing new technologies (van der Zijpp et al. 2007). The CARE intervention incorporated poorer sections of the community in its developing endeavour (Chapter 3) who earlier used to be excluded from conventional government and non-government interventions (Cox et al. 1998). As poorer people are more affected by illiteracy and low levels of education, improving their skills in fish seed production was relatively more important than for other well-being groups (Chapter 3). In terms of the economic concept of marginal utility[5], prioritizing the improvement of human capital of poor farmers is clear. While poor farmers lacked formal education status in the Northwest, the acquisition of technical and practical knowledge on RBFSP could be considered even more important than formal literacy.

[5] Marginal utility refers to the contribution of one additional unit of products or services to overall utility.

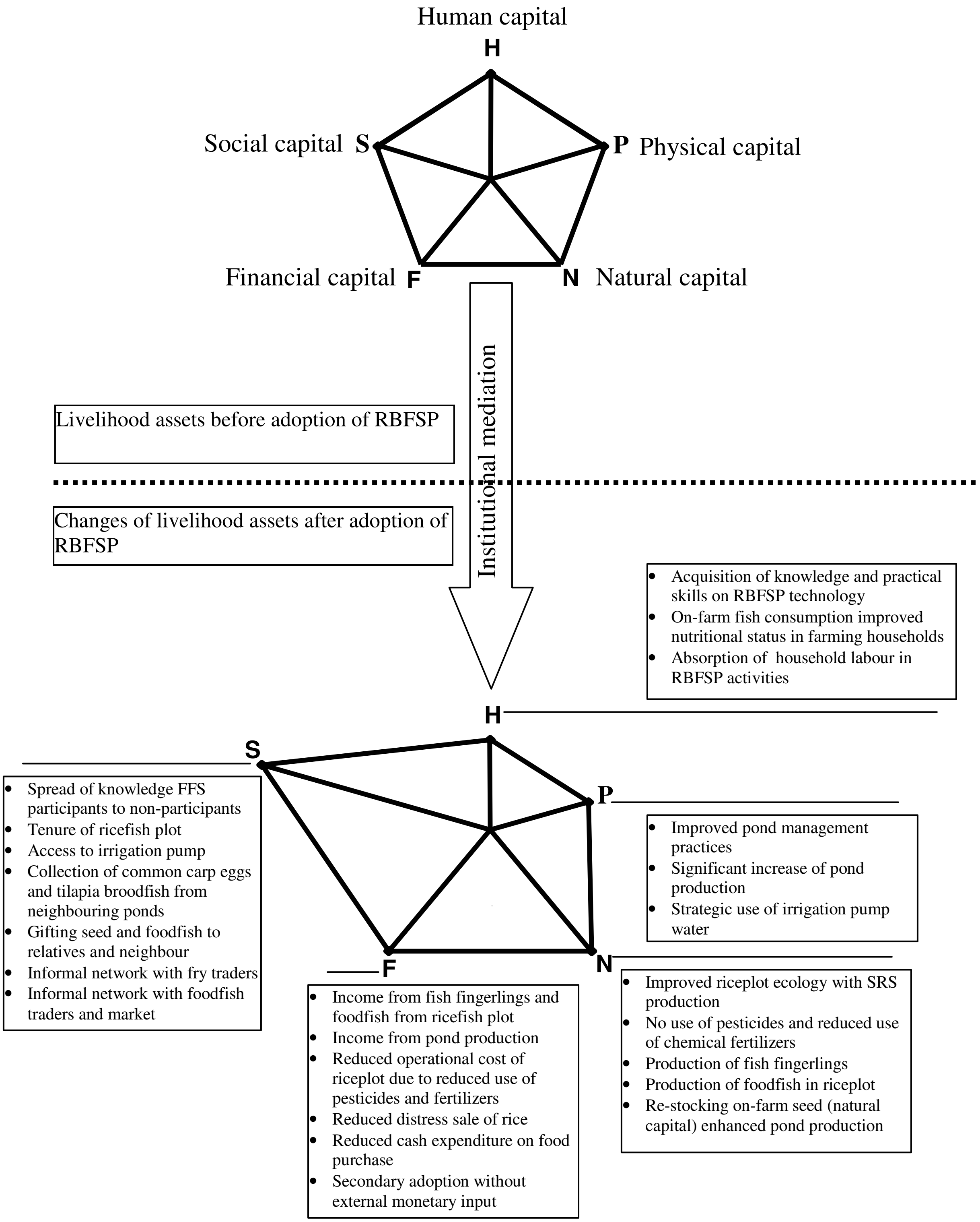


Figure 8.1: An imaginary schema showing changes in the accumulation of assets in adopting households of RBFSP; drawn based on the number of major livelihood impacts on each asset (DFID, 1999).

Knowledge generation that could foster the better utilization of capital assets is very important for overall development. As evidenced by previous studies, poor countries and poor people differ from rich ones not only because they have less capital but also less knowledge. Knowledge is often costly to create, and that is why much of it is created in industrial countries. Developing countries can however, acquire external knowledge as well as create their own. For instance, forty years ago Ghana and the Republic of Korea had virtually the same income per capita. By the early 1990s Korea's income per capita was six times higher than Ghana's. Half of this difference can be attributed to Korea's greater success in acquiring and using knowledge (World Bank, 1998).

In the present study, knowledge of fish seed production technology was developed by the farmers on the basis of available natural resources in their farm households. In rural household ponds, common carp produce a large amount of fertilized eggs at the onset of the *boro* season following certain climatic and physical conditions (e.g. presence of adequate water quality, temperature and vegetation). Initially fish seed production was promoted by encouraging the use of fertilized common carp eggs obtained from farmers' household ponds. Later on improved strain of Nile tilapia (GIFT) seed production has been adopted alongside common carp in the same ricefield system. The combination of tilapia and common carp fostered decentralised seed production systems through increased production, sale, household level consumption and income (Barman et al. 2004). Sustainable agricultural development requires more than just acquisition of ecological knowledge by individual farmers. It also requires development of the capability to generate, adapt and extend this knowledge within farming communities (Tripp and Louwaars, 1997).

8.2.2 Participation of household member in RBFSP

The present study (Chapter 4) showed that RBFSP is a male dominated activity carried out by the household head and his son (s). Previous studies reported that 44% of the labour force in the crop sector of Bangladesh was surplus (Hossain, 1991). Involvement of household males in seed production activities suggests the use of surplus family labour in productive activities. Fish seed production activities did not require much time or appear to conflict with other agricultural activities of farming households. This was due to that RBFSP was not a standalone activity for the farmers rather the activity was carried out with their traditional ricefield based activities in which they spent most of their working time.

Investigations carried out to understand the seasonal dimensions (Chapter 4) and the adoption process (Chapter 6) showed that women also contributed their time to RBFSP activities in addition to their domestic activities. Despite the nearly equal sex ratio of the Bangladeshi population, society is still characterized by patrilineal and patrilocal family dynamics, where a strict division of labour and a systematic bias towards male dominance and superiority exists (Nazneen, 2004). Traditionally women work within the boundary of *purdah* (seclusion) (Kabir, 1999). In recent years however, relatively poorer people have started to act against *purdah*, to engage themselves in activities outside the homestead consequently, their role in agriculture is gradually expanding (Mallorie, 2003).

The involvement of women in fish seed production activities appears to be an extension of their traditional activities which have been facilitated by the most favoured location of the riceplot being in the vicinity of their homesteads (Chapter 3). In the development and biological diversity discourse there is a growing consensus that women’s knowledge and practices are not only necessary and relevant, but also essential for sustainable development (Oakley and Momsen, 2005). In Bangladesh, although men are most active in field preparation and planting, women are very important in post-harvest processing and seed management activities of field crops (Abdullah and Zeidenstein, 1982; Elahi, 1998; Safilios-Rothschild and Mahmud, 1989; Scott and Carr, 1985) and in primary management of home gardens (Shah and Nuri, 2000; Wilson, 2003). Women also play a unique role in household poultry breeding which reflects their important function in relation to seed production (Juma, 1989). The contribution of women to traditional seed management practices for crops and poultry coupled with RBFSP deserves further attention during fish seed development interventions.

Children, along with women were also found to contribute to fish seed production activities including looking after of riceplot, harvesting of fish from riceplot etc. (Chapter 4 and 6). Harvesting of large size tilapia fingerlings was also carried-out by children in farming households. Tilapia is highly responsive to angling for harvesting from ricefields which was reported as a recreational activity for the children (Barman et al. 2004). Involvement of children shows potential to develop knowledge of this technology at the primary level education which has been expanded throughout the country over the years. Food for education programme in Bangladesh has increased the presence of students at the primary schools substantially (Hossain et al. 2005). Creating knowledge of such natural resource management at primary level could be a useful strategy for the students who cannot continue their study after primary education due to poverty and subsequently taking part in agricultural activities. Eventually, as farmers they could adopt RBFSP as part of their agriculture activities in their livelihood systems.

8.3 Impacts on natural and physical capital thorough farm diversification

8.3.1 Ricefields

Ricefields were considered as natural capital as farmers did not make any changes except to dig a small ditch at a corner of ricefield. The present study confirmed higher dependencies of households on rice-based activities occupationally (Chapter 3), mono-crop rice cultivation agriculturally (Chapter 3), and rice-based food nutritionally (Chapter 4). Occupationally agricultural dependence was due to the limited scope of non-farm activities in the study area, which was also common phenomenon in other rural areas of Bangladesh (Gill, 2002). The later dependencies were due to limitations in available land, growing population and a dietary reliance on rice (Oakley and Momsen, 2005). In order to increase production of rice and to ensure that yields keep pace with demand, Bangladesh had to adopt high yielding rice varieties for higher production (Oakley and Momsen, 2005). Cultivation of high yielding rice varieties imposed threats to crop diversification as it was grown in 75% of the total crop area. Fields that were previously sown with blackgram, mustard seed, wheat, barley, millet, and spices have been displaced by high yielding rice varieties (Oakley and Momsen, 2005). Such lack of diversification has been recognised as a basic limitation of agricultural development in Bangladesh (Rasul and Thapa, 2004). The basic purposes of farm diversification are to improve natural resource efficiency, increase productivity and increase sustainability of human food. Considerable potential exists for aquaculture through integrated diversification in Asia, with notable improvements in the livelihoods of rural small-scale farmers (Prein, 2002).

In this potential context, RBFSP contributed to crop diversification with various livelihoods benefits (Chapter 3 and 4). In general, diversifying crops simultaneously or sequentially can yield valuable benefits and relatively simple practices can be taken up quite widely. Various forms of diversification can be recognized however it is not practical to generalize them with respect to the demand of labour, skills and other inputs (Muir, 2005). Diversification of fish seed production simultaneously with irrigated rice required very little labour or monetary inputs (Chapter 3, 4 and 6). Diversification, can also reduce the available area for staple food production (Little and Edwards, 2003), but seed production in ricefields did not cause any negative consequences on staple crop rice production (Chapter 6). This is because of a win-win fundamental and complete ecological relationship between fish and rice in ricefield (Halwart and Gupta, 2004).

Furthermore, the diversification of fish seed production in ricefields improved natural capital (Figure 8.1) with direct and indirect benefits. Apart from many direct benefits (e.g. fingerling production, income etc.) indirect benefits contributing to natural capital included improved nutrient cycling, reduced level of fertilizer use and elimination of the repeated use of harmful pesticides that negatively impact on ricefield ecology (Chapter 6). A review study carried out previously in Northwest Bangladesh showed similar findings where incorporating fish in ricefields completely stopped the use of pesticides (Lewis, 1997).

Rain-fed rice cultivation has 4,000 years of history suggesting that traditional rice farming is basically sustainable. However, what is less certain is whether the dramatic increase in rice production made possible by the Green Revolution is sustainable. Additionally, global warming and rising sea level, increased ultraviolet radiation and other environmental consequences are predicted to have an adverse impact on ricefield ecosystem as well as its productivity (Greenland, 1997). Culture of fish in ricefields could possibly enhance the sustainability of rice farming, since indications are that the presence of fish makes the ricefield ecosystem more balanced and stable (Halwart and Gupta, 2004). In the present study, fish seed production in ricefields appeared to contribute to diversify the existing rice-based agriculture and to make farming sustainable (Chapter 3, 4, 5 and 6).

8.3.2 Relationships to pond management

Ponds were considered as physical capital as they were constructed for household use and fish culture (Little et al. 2007). RBFSP facilitated farmers to produce large sized fingerlings and to restock into their ponds as well as into non-seed producers' ponds. Lewis (1997) reported that the strengthening of aquaculture programmes among government and development organizations was hindered by the problem of availability of fingerlings at the farmer level. He also stated that pond based foodfish producers were often deliberately misled by the fry traders, who could sell fish at the hatchling stage without the pond owner being able to ensure that they were receiving the correct species. This poses additional risks to those farmers who use small sized fry. Pond operators could protect their interests by purchasing fish seed at the fingerling stage when species are identifiable and mortality much lower, though costs are higher and they are generally unavailable locally due to the incentives to deliver larger seed over long distances (Lewis et al. 1996). The use of large size fingerlings has a considerable impact on reducing mortality as well as expenditure. Realizing this potential, the government fisheries extension department (DoF) put emphasis on increasing awareness among the farmers of stocking larger sized fingerlings in ponds and other waterbodies (Rahman, Undated). Stocking of on-farm produced fingerlings has increased pond production substantially (Chapter 3) due to the larger size and higher survival rate (Chapter 5). The contribution of on-farm seed to increasing pond production showed a regenerative effect on decentralised seed in farming households. Similar approaches have been suggested by Pretty et al. (2003) to improve food production through introduction of new regenerative elements into the farming systems such as legumes, new and locally appropriate crop varieties and animal breeds. Increased pond production through the stocking of decentralised seed suggests that no separate external extension support for pond aquaculture is required which could minimize the transaction cost being incurred in different aquaculture extension projects in Bangladesh.

Higher production by seed producers in multi-owner ponds compared to non-seed producers indicated the successful development of management practices of multi-owner ponds. Multi-owner ponds had typically been sub-optimally managed and this was identified as one of the major constraining factors for pond culture development in Bangladesh (Gregory and Kamp, 1999a). On-farm seed production encouraged farmers to restock into their multi-owner ponds, which possibly facilitated other non-seed producing shareholders to consume more fish, to earn income and to reinforce the social relationships among them. According to Barman (2000), the increased importance of ponds as income earning assets rather than securing foods of subsistence encouraged owners of multi-owner ponds to solve management problems through mutual arrangements among themselves. Since seed requires a major investment in pond culture (Mazid, 2002; Karim, 2006), such on-farm seed production could be a simulating factor to solve the management problems of multi-owner ponds throughout the country.

8.3.3 Other waterbodies

In broader livelihood impacts studies, local level tilapia seed production was found to contribute to increased production in large waterbodies (*beel*) being managed by a group of poor people (Chapter 5). This suggests that decentralised tilapia seed production could be critical to the intensified management of larger, often common property waterbodies to obtain a higher production of fish. Globally tilapia has been recognized as the third most cultured fish after carps and salmonids (van der Zijpp et al. 2007). Its production has expanded in recent years and the annual growth of tilapia production in 1990s was above 12%. The production of farmed tilapia had surpassed 380,000 metric tons in 1990 to over 1500,000 metric tons in 2004 (FAO, 2006). This indicates potential for researchers, policy makers and other developers to rethink about fish fingerling production at the farmer level, which in turn could stimulate local foodfish producers to engage themselves in aquaculture using unconventional waterbodies.

8.4 Impacts on food security

RBFSP provided households with opportunities for fish consumption in the deficit months of high quality foods, especially pulse and meat. Traditionally fish and pulses were two most important non-cereal protein supplementing food items for the poor in Bangladesh. Rice cultivation had been expanded for increasing rice production to meet staple food demand for increased population (Hossain et al. 2005).

The rapid expansion in rice production in Bangladesh was achieved partly through a reduction of area and production of pulses and oilseeds (Hossain et al. 2005). *Boro* production has been rising steadily, while the area under pulses fell by 12% between 1983-84 and 1990-91 and by 5% between 1991-92 and 1997-98 (Gill, 2002). Consequently, the consumption of pulses has reduced significantly in rural areas (Rasul and Thapa, 2004) and daily per capita intake of pulses reduced by almost half, from 11 g during the mid 1960s to 6g during the mid 1980s (Hossain, 1991). The prices of pulses and fish have soared over the years indicating a relative scarcity (Hossain et al. 2005). In the context of a growing gap in protein supplementing food, fish consumption from the riceplot assumes an even greater importance through “consumption smoothing” (Ellis, 2000). Moreover, households had to purchase pulses from the market because they did not cultivate in their own farm. Regarding pulse consumption, farmers tended to use the money from selling fingerlings to purchase food items (Chapter 6) suggesting the use of money to purchase pulse in the low income months (Chapter 4).

Year round household monitoring showed a higher level of rice consumption among the poor than the better-off households. Through adoption of modern *boro* rice in the dry season, rice production has increased rapidly, particularly since the late 1980s, and the country is nearly self-sufficient in rice (del Ninno and Dorosh, 2001; Rasul and Thapa, 2004). Being self-sufficient in staple food-rice however, Bangladesh faces malnutrition problem due to unbalanced diet (Ray et al. 2001). A higher level of rice consumption has been coupled with a substantial deficit in fish, pulses, oils and livestock products that are the main sources of protein and micro-nutrients (Hossain et al. 2005). This dependency on rice has seriously negative implications for those with special nutritional needs, particularly children and pregnant and lactating women (Gill, 2002). In favour of this category of household members, small fish producing in ricefields appears to contribute substantially to the improvement nutritional and health status (Ross et al. 2004b).

In terms of socio-economic status of households, there are considerable disparities in fish consumption between the poor and rich households and this is believed to be widening (Gupta and Shah, 1992). In this context, the contribution of on-farm fish as a high quality food, particularly during periods when other substitutes are expensive or less available, has very important nutritional implications for the poor households. Farmers typically consumed fingerlings from their ricefields which were smaller in size than large carps however, the relative nutritional value is higher as fingerlings were likely to be eaten whole (Ross et al. 2004a).

8.5 Impacts on financial capital

Financial capital refers to stocks as well as flows of money. The stock financial capital includes cash and liquid assets (e.g. livestock, jewellery etc.) whereas the regular flow of money includes job salary, pension, remittance etc. (ADB, 2005). According to the present study, households tended to have limited livestock as liquid financial capital and very few of them had regular flows of money. Agriculture, particularly the sale of rice, was the main source of cash income in the majority of households. In farming households most of their paddy production was used to fulfil household level food requirements. If they earned some income from the sale of a small amount of surplus paddy, it was mostly utilized for buying non-food items, including clothes and other daily necessities (Rasul and Thapa, 2004). This suggests that households suffer from cash deficits (DFID, 2004). Sometimes farmers had to 'distress sell' their rice usually motivated by acute cash needs to undertake production expenditure and to repay loans (CARE, 2001c). The present investigation of the adoption process (Chapter 6) showed that even small income flows from selling fish seed protected households from such distress sales.

The longitudinal survey (Chapter 4) confirmed that farmers had to combat a financial crisis seasonally during the pre-harvest period of rice. In a previous study it was reported that poorer households suffered from cash deficit in the slack season, that were often met by selling animal and tree resources, thus exacerbating the cycle of poverty (Biswas et al. 2004). The longitudinal survey showed that farmers earned money from the sale of seed/foodfish not only at particular times but also over a number of months suggesting the development of financial capital and a critical improvement in cash-flow. Although amounts of money were small, fish seed revenues facilitated the farmers to cope with the seasonal cash crisis i.e. the problem of "income smoothing" (Ellis, 2000) which not only benefited seed producers but also fry traders. Sales of fingerlings extended over several months of the year (Chapter 4) suggesting that the demand for fingerlings changed as foodfish producers adopted multiple stocking strategies (Chapter 5).

Farmers were found to have received credit from different credit providing organizations suggesting that farmers, irrespective of fish seed production status, faced financial constraints. Many farmers however, do not have sufficient access to credit, savings or remittances to finance the input costs of agriculture such as seed and fertiliser. Micro-credit is often not available to poor farmers for agricultural activities, except where there are relatively concentrated populations and quite well-diversified economies (DFID, 2005). Many poorer households faced additional constraints to borrowing due to their lack of collateral or the small scale of income generating activities (Biswas et al. 2004). In many cases, lack of credit resulted in vulnerability of households with a range of negative livelihood impacts, including decreased food and health security and the loss of productive assets such as land and livestock. Households that had experienced difficulty in the repayment of their debts also reported negative social impacts, ranging from public humiliation to social exclusion within the community and including, in some cases, problems of verbal and physical violence against women (CARE, 2005b). Credit has been seen however, as a resource to borrower households, but also as a debt and a risky strategy for the poorest and most vulnerable to economic stress (Rahman, 1999). Although farmers received credit from different organizations, they did not use credit directly for RBFSP activities, as this technology requires a negligible amount of investment. A previous study has also shown that credit is not a precondition for increasing fish production for most farmers in Bangladesh (Ahmed et al. 1995).

8.6 Compatibility with the poor

In order to involve poorer households directly in aquaculture as a farming practice, they need either access to land for culture in rice fields or ponds, or to a water body for cage culture, culture of molluscs or seaweeds, or involvement in enhanced fisheries (Edwards, 1999b). However, the unequal distribution of land resources in Bangladesh and the unusually high prevalence of landlessness, complicate attempts to develop the aquaculture sector in the interests of the rural poor (Lewis, 1997). Even if under-utilised resources are accessed by the poorer rural groups through lease or rental arrangements, and economic gains are achieved thorough aquaculture work, wealthier owners and operators are likely to assert claims over such resources (Lewis, 1997). The ICLARM action research project (which ended in 1994) in Kapasia, Bangladesh showed that better-off farmers tended to benefit from aquaculture suggesting the need to develop such aquaculture technologies relevant to the needs of the poor (Lewis, 1997).

In this context, fish seed production in ricefield systems is an appropriate technology for the poor as it does not require much initial investment (Chapter 3, 4, and 6). Small-scale pond based fish fingerling production has emerged through the development of local nurseries in different parts of Bangladesh. These small-scale nurseries tended to be operated by better-off rural entrepreneurs with the ability to bear initial risks in search of high profits (Lewis, 1997). On the contrary, the present study confirmed a higher involvement of poorer farmers in RBFSP thus suggesting relative compatibility of this technology for the poor.

Interestingly, production efficiency (kg/ha) of fingerlings by the poor and intermediate households was found to be higher than the better-off, suggesting the effective use of their smaller riceplots and the importance of this technology to the low-income farmers. Similar pattern has been shown by the poor and marginal farmers in terms of modern variety of rice cultivation in Asian agriculture (Ellis and Biggs, 2001) suggesting RBFSP is a poor friendly technology to produce high quality fish seed using their smaller riceplots.

However, the longer term retention of RBFSP by poorer farmers was threatened by their sustained access to land. Very poor and very rich households did not get involved in FFS due to poor access to land and a reluctance toward this technology respectively

(Chakrabarty et al. 2001) but critical components of broader network of service actors (e.g. fry trader, foodfish producers etc.) linked to decentralised seed are important.

8.7 Development of social capital and network

Social capital relates to the formal and informal social network and relationships (or social resources) from which various opportunities and benefits can be drawn by people in pursuit of livelihoods (DFID, 2000). Critical benefits of social capital include access to information, to influence or power, and to claims or obligations for support from others (DFID, 2000). Ricefield based fish seed producers in Northwest Bangladesh gained knowledge substantially from CARE-based farmer field school training, but the subsequent spread of information relied on farmer-to-farmer contact and the development of a favourable social network with and between rural communities. Secondary adopters (Chapter 6) acquired their knowledge of seed production practices informally through information and advice on seed production from local primary farmers who were kin, relatives and neighbours. According to Rola et al. (2001), this sort of informal communication for knowledge dissemination made farmer field schools more cost-effective (Chapter 7). The relatively better-off status of secondary adopters compared to primary adopters (Chapter 6) suggests a trickle-up extension dissemination. As better-off secondary farmers have the ability to expand RBFSP using their available riceplot which in turn could be shaped as an enterprise linking the livelihoods of many poor fry traders.

Networks, cultural norms and social cooperation among rural households are important parts of social capital (DFID, 2000). Social relationships among people led to gain access to resources which are important to their livelihoods (Nahapiet and Ghoshal, 1998). Poorer households tended to get access to the ponds of better-off households to collect common carp eggs to stock in their riceplots to produce fingerlings. About a century old literature shows that construction of ponds was the pious ambition of every well-off Hindu and Muslim person in Bangladesh to benefit other people and livestock in terms of using water (Gupta, 1908). Seed producing households were found to gift seed and foodfish produced in riceplots to their relatives and neighbours. Gifting something to relatives and neighbours is a social obligation (DFID, 2000) which strengthens social capital.

The social resources are also formed through working and sharing of interests which increase people's ability to work together (DFID, 2000). The need for farmers to sell seed and the need for fry trader to buy and sell seed means they interact which in turn develops linkages. Local level seed production also enhanced trust between farmers and landless local fry traders and foodfish traders. Seed producers did not find any problem selling their seed (Chapter 5) and poor landless fry traders traded them alongside hatchery produced seed suggesting the compatibility of decentralised with centralized produced seed. Such relationships of trust facilitate co-operation and sometimes help in the development of an informal safety net amongst the poor. Poor landless fry traders tended to buy seed from producers on credit pending payment after selling seed to grow-out pond owners. Trading of decentralised larger and hardy fingerlings locally probably reduced risks to the business and improving safety net for poorer fry traders. A poverty focused approach to aquaculture needs to address actors other than producers in the network of aquaculture activities (Lewis, 1997). Such categories include the small fingerling traders who have supplied village ponds, and the fishermen who are traditionally hired by pond owners to harvest their pond. Both of these categories of people working in aquaculture service roles tend to be at a lower economic status than most of the pond owners. These groups of people were rarely addressed directly by the development interventions in Bangladesh (Lewis, 1997). Furthermore, about one-third of rural people are unemployed or under employed in Bangladesh, which is one of the major causes of poverty. Any activities that create employment opportunities (e.g. decentralised fish seed production in ricefield) will have a higher equity effect, through a process of chain reaction across the rural economy (Rasul and Thapa, 2004).

8.8 Adoption process of this technology

The adoption studies unpacked various technical and socio-cultural reasons responsible for adoption of RBFSP in farming households (Chapter 6). Using ricefield produced fingerlings for pond production was an important factor in the adoption process of this technology which was discussed in an earlier section (8.3.2). The impacts of conventional pond based aquaculture on livelihood improvement of poorer households is severely limited due to higher investment costs (Wahab and Kadir, 2005) of which fingerlings are one of the major components (Mazid, 2002; Karim, 2006).

Meeting the household's demand for fish consumption from the riceplot was one of the important stimulating factors for adoption of this technology (Chapter 6). Culturally fish as a food and particularly ricefield produced fish has a core relationship in Bengali society. For centuries fish has been central to the diet of Bangalis and ninetieth and early twenty century historical sources show 85% to 95% of the Bangali population ate fish and remaining minorities (e.g. Jains, Brahmins in Bihar, widows of few high castes Hindus etc.) ate meat (Day, 1873; Gupta, 1908). A typical meal of the Bengali people consists of a plate of rice to which relatively a small portion of fish and vegetable curries are added (CBF, 2007). To this day fish and rice form the mainstay of the diet of the Bengali people reinforcing the common saying: *mache bhate bangali* (fish and rice make *Bangali*).

Fish production in ricefields showed a relationship of need for fish, with the preparation of everyday meal for household members which is carried out solely by women (Chapter

4). Additionally, responsibility of women is to care for the elderly and to provide quality food items, of which fish is critical. Women are believed to possess knowledge about food items with high nutritional and medicinal value including different plants, fruit, fish and animals (Akhter, 2001). Previous studies on intra-household food distribution showed disparity between household members where female members were known to take their meal only after men and children had eaten (Hossain et al. 2005). These sorts of behaviours and responsibilities of women indirectly influenced them to share the decision making process with respect to the adoption of fish seed production technology.

Overall, fish as a staple of the Bengali diet has importance with respect to cultural history and nutrition which also contribute to the adoption process of seed production technology. Over a century ago, fish diet was encouraged as it is more wholesome than meat and because fish is more easily digested (Day, 1873). From a nutritional point of view, Bangladesh has some of the world's highest rates for stunting, wasting and low bodyweight (Gill, 2002). Micronutrient deficiencies and high intake of carbohydrates are likely to be increasingly limiting factors in terms of improving nutritional status. Nutrient deficiencies in the diet limit growth and can lead to cognitive problems and increased morbidity (Gill, 2002). Domestic agriculture like fish seed production leading to food production will therefore have to continue to provide the bulk of the country's growing food needs using limited land resources. Further assessment anthropometrically could unpack the differences in health condition of RF and NRF households.

Increased production of self recruiting species (SRS) in riceplots stimulated FFS farmers to adopt the RBFSP technology which has a close relationship with enhanced food production and biodiversity. In ricefields, pesticide use not only eradicate nuisance insects but also beneficial ones, thereby reducing species diversity and ability of rice to withstand further pest attacks (FAO, 2000b). On the contrary, fish production enhances whole ricefield ecosystem through reduction and elimination of pesticide use, this helps to support biodiversity by increasing wild fish (ITAD/ODI/OPM, 2001). The SRS catch is used mainly for consumption within the household and often accounts for a large part of animal protein intake in Asia having high nutritional value, especially important during the dry season when access to other waterbodies becomes limited (Morales et al. 2005). A similar finding was found through the longitudinal survey (Chapter 4), where there was a large catch consisting of SRS and other fish from the riceplot during the hungry months of September and October.

Elimination of the use of pesticides from the ricefield to reduce cost was one of the important reasons for adoption. Modern rice farming has come to depend on a great variety of insecticides, herbicides and fungicides to control pests, weeds and diseases respectively, and each year some 5 billion kilogram of pesticides active ingredients are applied to farms throughout the world (BAA, 2000). Many development projects across the globe gained success in the reduction of pesticide use applying integrated pest management (IPM) tools in ricefields (Pretty et al. 2003). The most widely applied tool of IPM was use of reduced levels of pesticide spray (Van den Berg, 2004). Applying such IPM tools through the FFS approach, farmers became able to grow rice entirely without pesticides: 25% of FFS participants in Indonesia, 20-33% in the Mekong Delta of Vietnam and 75% in parts of the Philippines (Pretty et al. 2003). In the present study rejection of pesticide use by almost all of the RF farmers indicates how effective RBFSP is as an IPM tool and how it should be included at the heart of IPM in rice production.

The pesticide residues absorbed by rice grains in Bangladesh could concentrate in the human body at the rates of up to 15 times higher than the WHO recommends (FAO, 2000b). As fish seed production could reduce pesticide use significantly, pesticide free rice production is another important outcome of RBFSP. In the Bangladeshi market there is currently no premium for pesticide free products (Rasul and Thapa, 2004). In recent years however, a number of supermarkets have appeared in the capital city, Dhaka as well as in other large cities (Shepherd, 2005) where health conscious people shop. In the near future, pesticides free rice will probably be economically attractive, if increasingly health-concerned urban people will be ready to pay higher prices (Rasul and Thapa, 2004). Thus in future, a higher value rice crop might encourage fish seed and foodfish production increasing its attractiveness to new entrants in rural communities.

8.9 Rejection and sustainability of technology

As with the adoption process, rejection of this technology was the result of complex socio-cultural reasons. Farmers not attempting the RBFSP technology had no access to land. The early rejection was often caused by conflicts with non-farm activities. Long-term adoption was hindered by changes of land tenure of farming households. A considerable proportion of poor ricefish farmers gained access to riceplots to produce fish seed through weak tenural arrangements (Chapter 3). But changes in tenure arrangements such as loss of leases and sharecropping tenure (Chapter 6) were common after some time. Losing access to land was found to be an important vulnerability factor for poorer households in Northwest Bangladesh (CARE, 2005b) severely affecting livelihoods of many rice (only rice) producing poor households (Awal, 2003).

In terms of sustainability, similar problems were experienced by many development projects across the globe where landlord had taken back land from tenants who had adopted more sustainable agriculture (Pretty et al. 2003). In the case of pond based aquaculture in Bangladesh, eviction was found to be common when access was not secure, and interrupted operations can result in the loss of investment from which the poorer cannot recover (ADB, 2005). Eviction of the poor from access rights to riceplots is not likely to cause major loss as initial monetary investment is very low. However, for

RBFSP, access and tenure rights to riceplot are the major prerequisites. When the landless gain access to riceplots through sharecropping and other access arrangements, secure access rights are critical. Without binding, long term arrangements on access rights, poor seed producers are vulnerable (ADB, 2005).

Tenant rights, including securing tenure are enshrined in legislation however, these are currently almost invariably ignored in practice and where there is a scope for intervention. Measures are also in place for landless people to prioritize their access to alluvial areas of government owned land as well as to a range of waterbodies. NGOs concerned with land access issues have tended in recent years to focus their attention on the different means by which these rights may, in practice, be secured (CARE, 2003b; ADB, 2005). As with this intervention in government owned land, NGOs however, could take motivational programmes to the better-off farmers to secure access of the poor to ricefields.

Changed ricefish plot tenure was also affected by family separation which was one of the important reasons for rejection of this technology by farmers after long term practice. Hossain (2005) argued that there should be long term planning for sustaining access to land for the poor towards the overall development of agriculture. Land area managed by rural households declined from 9.2 million ha in 1983-84 to 8.2 million ha in 1996, indicating that on average 82,000 ha of land is going out of cultivation every year. At the same time, the number of farming households has increased from 11 to 12.7 million, leading to an agrarian structure dominated by small and marginal farmers. Furthermore, the medium and large holdings are becoming subdivided under population pressure, leading to an increase in the number of small and medium farms. In 1996, small and marginal farms with holdings of less than 1.0 ha accounted for 81% of farms, operating 41% of the cultivated area (Hossain et al. 2005).

In an analysis of household expenditure, it was observed that ceremonial/festival costs had greatly increased and were linked to excessive expenses during the marriage of daughters and dowry payments. Since 1990s, trends in increased level of payments for dowry had severely affected rural households in Bangladesh (Davis, 2007). It is a common long term economic shock for the household as it needs to be arranged through credit and repayment of credit takes 5-6 years (CARE, 2005b). Some farmers were found to lease out or sell all riceplots to pay the marriage dowry which then resulted in rejection of this technology. Although there is strong legal measure to control dowry, it is not respected as a whole (CARE, 2005b).

8.10 Promotion of RBFSP technology

RBFSP technology was not promoted as a single technology in FFS but rather promoted as a part of several technologies aiming at reduced external dependence and enhancing sustainability of ricefield management. Expenditure for farmer level training, particularly for the training of RBFSP, was estimated as a small amount out of the whole programme budget. This suggests the dissemination of RBFSP technology per se requires limited extension support. As a result, adoption of this technology and practices was achieved through the participatory and problem-solving approach among FFS farmers, which served as the focal strategy for extension activities within the community (CARE, 2001c).

The FFS approach evolved after realization of the many drawbacks of previous top-down trickle down extension approach. In the trickle down approach, there have been a number of criticisms, chiefly that while ‘lead’ farmers are given incentives to pass on their training (and are often drawn from among the better-off farmers), there is little motivation for the next group of farmers to continue the trickle down process (Lewis, 1997). In the FFS approach, the secondary adoption that occurred appeared to be a 'trickle up' effect resulting from the exposure of non-participants to the new practices and activities embraced by direct project beneficiaries. The selected and trained farmer leaders were expected to act as informal extension agents within the community and to develop links between field school activities, community members, and local networks and institutions. Partnership with local NGOs attempted to develop and foster geographically broader and lower cost replication of project extension approaches (CARE, 2001c). In terms of sustainability, however (Chapter 7), the partner NGOs did not continue the FFS programmes after withdrawal of CARE support because of their limited capacity and risk taking ability.

In the Department of Fisheries (DoF), the main government aquaculture extension authority in Bangladesh, insufficient capacity is available to carry out such FFS programmes. In DoF there is a little evidence that the official extension service offers much of value to local fish farmers. There is only one extension officer, with two staff, for each Thana/Upazila (sub-district), each of which can contain around a quarter of a million people. Official extension staffs tend to be office-based and rooted within an institutional culture which hinders their extension activities (Lewis et al. 1996). On the contrary, the Department of Agriculture Extension is a large organization with large numbers of root level staff able to provide farmers with an extension service. Therefore, in collaboration with NGO and DAE, DoF could take the initiative to disseminate this technology at the farmer level to give a wider coverage in the high potential parts of Bangladesh.

Value addition through supply of good quality tilapia broodfish in FFSs through CARE Interfish and Go-Interfish projects, could scale-up the benefits which based on per unit investment, greatly surpass the benefits of a centralised mono-sex tilapia hatchery in terms of total economic value and equitable development. Timely supply of good quality tilapia broodfish was identified as an important prerequisite for promotion of this technology in new areas (Barman, 2000) as well as in established areas to ensure genetic quality remains constant. Long term supply of broodfish from any single centre to farmers in distant areas might be problematic. Maintaining good quality strains is also an issue which can be difficult because of the relative ease of contamination with feral strains (Barman, 2000). Evidence shows that uncontrolled introduction, accidental or intentional release of good quality tilapia in rivers and streams has led to genetic contamination through free cross-breeding of wild dwelling populations. Such contaminated brood of tilapia that reproduce at small sizes has resulted in low growth rates of fry when stocked in village ponds in Fiji (Lal and Foscarini, 1990). Locally based competent NGOs therefore, could take the initiative to supply germplasm. For instance, in case of crop germplasm in developing countries, many government seed companies and an increasing number of NGOs in recent years have set up schemes to involve small farmers in seed production. Small farmers are involved as contract growers and provided with source seed by the organizer of the scheme. They are then supervised in the production of a seed crop following formal field standards usually laid down by the national seed certification authority. The farmer involvement with the crop ends after harvest when it is sold to the scheme organizer for a premium above prevailing grain prices. The organizer then takes responsibility for arranging the processing and certification of the seed, and its distribution - usually using a national input distribution network, either government- or company-run. Most of these schemes deal exclusively with seed of modern varieties (here tilapia broodfish can be considered as analogous of seed). The Ministry of Agriculture in Zambia runs its own scheme; the governments of Nepal and The Gambia have mandated NGOs working locally to assure responsibility for a substantial portion of national seed supply using smallholder seed growers (Cromwell et al. 1992; Cromwell and Zambezi, 1993; Wiggins and Cromwell, 1995). Increasingly NGOs seeking to consolidate their rural development activities have started seed production projects based on this approach - often in areas where government and private sector services fail to reach. Examples include the Mennonite Central Committee's vegetable and soybean seed schemes in Bangladesh, and the take-over of abandoned government seed facilities in Niassa Province, Mozambique by the Italian NGO Crocevia (Cromwell and Zambezi, 1993). In decentralised approaches, strategies could be developed testing various options (Chapter 7) through participatory action research to build capacity for local competent organizations to supply quality broodfish at the farmer level. Knowledge on improved ricefield management acquired by both man and women in CARE Go-Interfish FFSs could lead to address gender development involving women in promotion strategies of decentralised RBFSP. In this connection, this could be carried out by NGOs with both institutional and physical capacity to support the broodfish needs of households in the vicinity. Experience and capacity in action research in the field of aquaculture and necessary resources in remote field areas such as staff offices and training centres with ponds for keeping good quality of tilapia broodfish are essential.

8.11 Summary and conclusion

Poverty affects the farming households in many developing countries of which Bangladesh is one of the most densely-populated and non-industrialised countries in the world. The increased density and on-going growth of population is reducing the cultivable land for agricultural production. Given this loss of land and continuing population growth, per ha food production will have to have risen by several times in order to maintain existing and future per capita food production (Gill, 2002). Over the years with the drive towards cereal-sufficiency, the cropping system has become increasingly rice-dominated affecting the health and nutritional status of the poor (Gill, 2002). In the food bundle of the Bangladeshi people, just after rice, fish is the main part of the diet contributing 63% of animal protein. Currently the major proportion of foodfish is derived from inland aquaculture systems which are dominated by traditional pond based polyculture (DoF, 2005).

A supply of good quality fish seed is an important prerequisite of aquaculture which was reportedly constrained by hatchery produced poor quality seed reaching farmers (Little et al. 2002b; Mazid, 2002), high purchase costs of seed (Alam, 2002; Karim, 2006) and lack of and timely seed delivery as per the farmer's need (World Bank, 2006). Strategies for decentralised fish seed production in ricefields have been developed and promoted in Northwest Bangladesh towards ensuring quality seed supply in farming communities. At the development stage of decentralised seed approach, DFID-NFEP piloted common carp seed production in ricefields with the collaborative support of CARE-Bangladesh. Realising the potential benefits CARE disseminated RBFSP through the FFS approach in Northwest Bangladesh. Later the introduction of an improved strain of tilapia (GIFT) through NFEP's research-based trial in common carp seed producing communities diversified the impacts of decentralised seed in farming communities (Barman et al. 2004).

There is only limited documentary evidence that aquaculture technology helps to reduce poverty. Many projects have aimed at reducing poverty but there are few documented examples of impacts on poverty (Edwards, 1999b). Similarly, a review of donor experiences in about 800 livestock projects by most of the main funding agencies indicated little evidence of sustainable impact on the poor (Anon, 1998). Most projects were technology driven and did not support poverty focused delivery of services. The limited documented impact on poverty was due to inadequate project approaches and lack of impact assessment on poverty (Edwards, 1999b). In the present study however, a poverty focused analysis of the livelihood impacts of RBFSP on both producer and non-producer level was carried out. Analysis shows various livelihood impacts of RBFSP on both producer and non-producers level.

Accumulation of human capital in poorer households through improvement of knowledge-base on ricefield management for production of fish fingerlings was very important livelihood impact in the context of their lower level of education and technical skill. The livelihoods benefits were not only gained by fish seed producers, but also fry traders, foodfish producers and other beneficiaries. At the producer level, the considerable benefits included income from sale of fingerlings and foodfish from ricefield, increased pond production, increased level of fish consumption and social benefits through gifting seed and foodfish to relatives and neighbours.

Towards increasing multiplier livelihood benefits, decentralised RBFSP contributed to the improvement of physical capital (ponds) through increased levels (60%) of pond fish production which in turn improved human capital providing increased level of nutrient dense food (fish) and financial capital (income) in farming households. Increased pond fish production suggests that dissemination of RBFSP could scale-up pond aquaculture without further external extension support which could substantially minimize transaction costs of pond-based aquaculture intervention.

Income from fish seed and consumption of fish from riceplot in low-income and hungry months were very important seasonal impacts for the poorer households. This contributed to the coping strategy of poorer households to reduce their seasonal vulnerability. Involvement of poor landless fry traders in decentralised fish seed network and their early income from RBFSP compared to hatchery produced seed showed compatibility of RBFSP with existing hatchery based seed supply network. Fry traders supplied ricefield produced fingerlings with in the proximity to seed producing communities which shorten long distance transportation and increased survivility of fingerlings in farmers' ponds with higher production.

The adoption and rejection processes of this technology were attributed to many technical and socio-cultural reasons. The major reasons for adopters included elimination of pesticide use from ricefields, reducing distress sale of rice because of income from fingerlings selling immediately after *boro* harvest, meeting demand for fish consumption of household members, gifting fish fingerlings and foodfish to their relatives and neighbours etc. In rejection process, losing riceplot tenure was however, the vulnerable factor to poorer households affected their adoption process RBFSP. Considering a unit level of monetary investment, overall multiplier benefits of decentralised seed, including the benefits of primary and secondary producers, distributors and end users together amounted to a large value which was much higher than that of conventional centralised hatchery.

For promotion, this technology required very minimal support in terms of external extension and expenditure once established. The transition towards more sustainable agriculture requires specific types of external support (Pretty et al. 2003), such as that from locally based competent organizations that can scale-up and - out the impacts of RBFSP identified in this study through a variety of extension approaches including i) training framers and providing good quality broodfish, ii) training farmers and providing them with printed literature, iii) training a farmer leader in the community, iv) developing a one-stop aqua-shop, v) training community mosque imam and vi) using audio-visual aids at community shop, but not limited to farmer field schools.

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Appendices

Appendix 1: One-off survey (baseline) questionnaire

1. Basic information of farming household

1.1. Date of interview: 1.2 Name of Interviewer:

1.3 Name of interviewee:

1.4 Name of the household head:

1.5 Address:

Community (*Para*): Village: Union:

Upazila: District: Region:

1.4 Religion: Muslim/Hindu/ Christian/Others (………………….). For Hindu (caste):

For Muslim (category): Munshi/Sardar/Chowdhury/Sayed/others

1.5 Institutional involvement:

a. Care FFS member ☐ Year:

b. Care PNGO member ☐ Year:

c. Care scheme member ☐ Year:

d. Member of other institution ☐ Year:

e. Non-member ☐

1.6 If Care PNGO member then name of the PNGO with location:

1.7 If member of other institution then name of the institution with location:

1.8 FFS membership: Only man/ only woman/Both man and woman

1.9 Technology Adoption: Rice-fish/Fish seed in rice-field/Low input rice/dyke cropping/others (……………….)

1.10 Rice-fish Adoption: Primary adopter /Secondary adopter/Drop-out/Non-adopter

1.11 Migration status (district/country): Non- migrant / Migrant If migrant (no. of years migrated):

1.12 Well- being status: (wealth ranking exercise already carried out)

1.13 Household profile

Serial No.	Name	M/F	Age (Year)	Education
1	2	3	4	5
1				
2				
3				
4				

Serial No	Profession			Relationship with household head	Remarks
	Main	Secondary	Tertiary		
	6	7	8	9	10
1					
2					
3					
4					

2.0. Resource Mapping

2.1 Map of Resources (location of homestead area, location of plots of land, pond, other water resources having access like community *beels,* canals, rivers and community ponds). Should be plotted in A4 size paper for each individual household.

2.2 Land resources (descriptions of rice and other crops produced in last year in plots except rice-fish plot)

Sl. No.	Plot area (decimal)	Ownership	Crops Description											
			1st crop	Prod (kg)	Value (Tk.)	Exp (Tk.)	2nd crop	Prod (kg)	Value (Tk.)	Exp (Tk.)	3rd crop	Prod (kg)	Value (Tk.)	Exp (Tk.)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1														

2														
3														

2.3. Crop Calendar: One for each individual household for 5 main crops produced in the last year.

Crops	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1.												
2.												
3.												

2.4 Descriptions of pond resources

Sl. No.	Pond area (dec)	Ownership	Production (kg)	Value (Taka)	Expenditure (Taka)	Species	Source of fingerlings
1	2	3	4	5	6	7	8
1							
2							

2.5 Activity calendar for pond-based fish culture

Activities	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Pond re-excavation/repair												
Pond preparation												
Stocking of fingerlings												
Fish harvest for household consumption												
Fish harvest for sale												

2.6 Land Resources (rice-fish plot)

Plot no.	Area (decimal.)	Distance from homestead	Soil type	Level of plot	Water holding Capacity	Water Supply	Frequency of water supply
1							
2							

2.7. Configuration of rice-fish plot/s with surrounding conditions and important remarks about the overall physical conditions of the plot/s

2.8 Ditch and Dyke of rice-fish plot/s

Plot No	Ditch				Dyke		
	Number	Area (m2)	Shape	Depth (m)	Width (M)	Height (m)	Remarks
1							
2							

2.9 Rice production with management (Ricefish plot)

Number of plot	Rice variety.	Organic manure (Kg)		Other fertilizers (kg)			Urea (kg)		
		Cowdung		TSP	MP		1st	2nd	3rd
Boro									
Amon									

Crop	Method of pest control	Rice Production (kg)	Expenditure (Taka)	Income (Taka)	Remarks
Boro					
Amon					

2.10 Rice-fish Calendar

Rice-fish Activities	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Plot preparation												
Rice transplantation												
Egg/brood fish /fry/fingerlings												
Fingerlings harvest for stocking												
Fingerlings harvest for sale												
Food fish harvest for household consumption												
Fish harvest for sale												
Rice harvest												

2.11 Fish seed and or food fish production in rice-fish plot/s

Plot No	Plot area (decimal)	Production Systems	Production method	Fish species	Fertilization for fish (kg)	Feeding (kg)	Fish production
1	2	3	4	5	6	7	8
1							
2							

2.12 Uses of fish seed/ foodfish from rice-fish plot

Plot no.	Production	Sale	Household Consumption	Stock	Gift	Selling System	Expenditure	Income
1	2	3	4	5	6	7	8	9
1								
2								

3 Fish Seed production system

3.1 Common carp seed production system

- Stock egg at plot ditch
- Stock fry after hatchling in chari/ ditch/ hapa in pond
- Stock fry after purchasing
- Stock broodfish in plot
- Fry hatchling in pond with giving shelter (water hyacinth etc.).

3.2 Tilapia seed production system

- Stock broodfish in plot
- Stock fry/fingerlings after purchase
- Stock fry/fingerlings from pond

3.3 Fingerling production system of others fish species

- Stock fry after *boro* harvest
- Stock fry during *amon*

3.4 Constraints and Potentials of rice-fish production Systems

3.4.1 Constrains of rice- fish based seed production: (Just ✓)

- Quality broodfish problem
- Look after problem due to distance
- Look after problem due to shortage of manpower

- Water supply problem
- Water holding problem
- Problems of sudden flooding of the plot/s
- Predator or scavenger duck problem
- Marketing networking problem
- Poaching problem
- Change of ownership of land for sharecropper
- No stocking or selling -not sufficient amount to sell
- Option after harvest - farmers who don't have suitable plot for grow out in amon or pond
- Escape of fish or fingerlings from one's plot to another due to heavy rain (mainly in Amon season)

3.4.2 How you coped such constraints

3.5.2 Advantages/Potentials of rice-fish

- Near homestead and having look after facilities
- Suitable plot for fry rearing and partial harvesting
- Plot with water inlet and outlet facilities
- Scope of stocking in rice-field or pond after harvest
- In a command area of good marketing facilities (such as Bahagili, khidra)
- Having good water supply facilities
- Plot not in a flood-prone area
- Have previous knowledge of fry rearing
- Previous knowledge of marketing of fry as well as fish
- Previous knowledge of aquaculture
- Knowledge of IPM
- Have own source of quality broodfish and manage it
- Have scope to attract SRS and rear with cultured fish at plot
- Have own equipment (net or other tools) to do fry/fish harvest
- Have hapa to hold fry after harvest for sale.

3.5.4 To what extent and how you are using such potentials

3.5.5 What are the important reasons for conducting rice fish base seed production after its introduction?

- Easy source of egg/ fry
- Less investment
- Broodfish production by own

- Food fish production
- Early availability of fingerling for stocking
- Local availability of fingerling
- Cash income from selling of fingerling
- Household Consumption
- Less or no use of pesticide

3.5.6 What social benefits rice-field based seed production bring in the community?

- Relationship development with neighbours through access to eggs of common carp/broodfish of tilapia/fry from pond
- Strengthening relationship with relatives through providence of fish seed/foodfish as gift
- Fry traders benefited by getting easy source of fingerlings for sale
- Fishers benefited by getting easy source of food fish from rice-fish for harvesting and marketing
- Sharing of rice-fish technology with relatives, friends, neighbours

4 Livestock Resources

4.1 Description of livestock resources

Type of animal	Total number	Number of adult	Number of (young)	Total Value (Taka)	Total annual income (Taka)	Ownership (Man/Woman/ Both)	
1	2	3	4	5	6	7	8
Cow							
Buffalo							
Goat							
Chicken							
Duck							
Pigeon							

4.2 Does introduction of rice-fish systems causes any problems in management of livestock? What are the problems and how it affects? How you try to overcome such problems?

4.3 What are the advantages of rice-fish on livestock resource development? (Production of Napier grass/maize/pulses in the rice-field dyke can be used as feed for cattle/goat; the maize can be used as feed for poultry)?

5. Housing

Housing details (Note; Concrete-1, Semi concrete-2, Soil- 3, Tin- 4, Wood-5, Bamboo-6, Straw-7, Leaves-8)

No. of house	Wall	Floor	Roof	Purpose of use	Boundary	Estimated value of homestead	
						Land	Tree/ fruits
1	2	3	4	5	6	7	8
1							
2							
3							

6. Household equipments

Use of household level equipments (household - television, radio, cassette player, VCD, fan; farming – bicycle, motorcycle, net and others):

Sl. no	Household	Number	Fishing	Number	Transport	Number	Farming	Number	Remarks
1	2	3	4	5	6	7	8	9	10
1									
2									

7 Drinking water and toilet facilities

7.1 Drinking water source: Tube well (own)/Tube well (others)/Well/Pond/Rain water/other

7.2 Toilet facilities: Concrete/Semi-concrete (slab)/ non-concrete/_________________

8 Off-farm income: (service, small business, day labour, van/ rickshaw puller)

Name	Profession	Annual Income	Remarks
1	2	3	4
1.			
2.			

9 Training Received

Name	What Kind of training received	Where from	Duration	Year
1	2	3	4	5
1.				
2.				

10 Basic knowledge on fish culture and or fish seed production

10.1 Liming

10.2 Fingerlings stocking

10.3 Feeding and fertilization

10.4 Disease prevention and control

10.5 Pest control for rice-fish

11 Health Issues: (Did any of your family member get sick last twelve months? (Yes / No)

Name	Type of illness	Frequency	Duration	How recover
1	2	3	4	5

12 Major stress/shocks

- Death of household members
- Flew away of household members
- Separation of households
- Burning of houses
- Loss of cattle
- Damage/disorder of shallow/deep tube well
- Loss of crops due to storm, flooding
- Extreme cold
- Drought

13 Access to credit:

Source	Name	Form of credit	Amount	Condition for received credit
1	2	3	4	5
Bank				
N.G.O				
Private lender				
Others				

14 Institutional linkage of rice-fish based seed producer

Name of organization	Who communicate	Support received	How frequently	Where (you go there/ they come)
1	2	3	4	5

15 Fish consumption

15.1 Source of fish with variations and consumption

Source	Starting period	Peak period	Amount (Kg)	Value (Taka.)	Gear used	
					Mainly	By whom
1	2	3	4	5	6	7
Rice-fish plot						
Pond						
Wild source						
Purchase						

15.2 What you do when get large amount of fish from any source?

- Consume frequently
- Sale
- Short-term preserve
- Long-term preserve
- Gift to relatives.

16 Annual expenditure of the households?

Item of expenditure	Amount (Taka)
1	2
1. Food	
2. Clothing	
3. Education	
4. Housing	
5. Treatment	
6. Ceremony/Festival	
7.Others	

Appendix 2: Longitudinal survey questionnaire

1 General information

Cycle No.

1.1 Household code:

1.2 Date of interview: 1.3 Name of the Interviewer:

1.4 Name of interviewee:

1.5 Name of household head:

1.6 Name of community:

1.7 Technology Adoption: Food fish in rice-field/Fish seed in rice-field/Dyke cropping /Others (………………………………..)

2 Agricultural Activities (using household resource map)

2.1 Agricultural activities on household land (crop production, livestock, homestead gardening*) IN THE LAST SEVEN DAYS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.2 Major agricultural activities on household land (crop production, livestock, homestead gardening) *DURING THE LAST THREE WEEKS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.3 Agricultural activities in others land (crop production, livestock, homestead gardening*) IN THE LAST SEVEN DAYS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.4 Major agricultural activities in others land (crop production, livestock, homestead gardening) *DURING THE LAST THREE WEEKS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.5 Pond based aquaculture activities *IN THE LAST SEVEN DAYS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.6 Major pond based aquaculture activities *IN THE LAST THREE WEEKS*

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.7 Rice-fish-dyke cropping activities IN THE LAST WEEKS

Household member	Activities	Where (code)	Frequency	Time spent (hour)

2.8 Rice-fish activities IN THE LAST THREE WEEKS

Household member	Activities	Where (code)	Frequency	Time spent (hour)

3.0 Household and non-farm activities

3.1 Non-farm activities in the last month

Household member	Activities	Where (code)	Frequency	Time spent (hour)

3.2 Household activities in the last 7 days

Household member	Activities	Where (code)	Frequency	Time spent (hour)

4 Management activities in and around the rice-fish plot

4.1 Configuration of rice-fish plot/s with surrounding conditions and important remarks about the overall physical conditions of the plot/s

4.2 Rice production with management (rice-fish plot) IN THE LAST SEVEN DAYS

Number of plot	Plot area	Rice variety.	Organic manure (Kg)		Other fertilizers (kg)			Urea (kg)		
			Cowdung		TSP	MP		1st	2nd	3rd
1										
2										
3										
4										

Number of plot	Method of pest control	Rice Production (kg)	Expenditure (Taka)	Income (Taka)	Remarks
1					
2					

4.3 Rice production with management (rice-fish plot) IN THE LAST THREE PRECEEDING WEEKS

Number of plot	Plot area	Rice variety	Organic manure (Kg)		Other fertilizers (kg)			Urea (kg)		
			Cowdung		TSP	MP		1st	2nd	3rd
1										
2										

Number of plot	Method of pest control	Rice Production (kg)	Expenditure (Taka)	Income (Taka)	Remarks
1					
2					

4.4 Fish seed production or food fish production in rice-fish plot/s IN THE LAST SEVEN DAYS

Plot No	Plot area (decimal)	Production Systems	Production method	Fish species	Fertilization for fish (kg)	Feeding (kg)
1						
2						

4.5 Fish seed and or food fish production in rice-fish plot/S IN THE LAST THREE PRECEEDING WEEKS

Plot No	Plot area (decimal)	Production Systems	Production method	Fish species	Fertilization for fish (kg)	Feeding (kg)
1						
2						

4.6 Use of fish seed/ foodfish from rice-fish plot for last month

Plot no.	Production (kg/number)	Sale (kg/number)	Household Consumption (kg)	Stock (number)	Gift (kg/no)	Selling System	Expenditure (Taka)	Income (Taka)
1								
2								

4.7 Crop / Homestead / Plant nursery production with management in other than rice-fish plots (Own + Leased in + Share crop)

No. of plot	Plot code	Crop	Organic manure (Kg)		Other fertilizers (kg)			Urea (kg)		
			Cowdung		TSP	MP		1st	2nd	3rd
1										
2										

Number of plot	Method of pest control	Crop production (kg)	Expenditure (Taka)	Income (Taka)	Remarks
1					
2					

5 Condition of fish Seed production system in the last seven days

5.1 Common carp seed production system

Activities	Who	Time spent	When	Remarks
Place of water hyacinth for egg collection				
Stocking of egg/ hatchling/ fry/ brood fish				
Fertilization				
Feeding				
Harvesting				
Selling				

Activities	Stock eggs at plot ditch	Stock own fry	Stock purchase fry	Stock brood fish	Eggs hatch in pond
Date of stocking					
Interval after rice transplantation					
Amount					
Number of brood fish					
Size of broodfish					

5.2 Tilapia seed production system

Activities	Stock own brood fish	Stock purchased brood fish	Stock own fry/fingerlings	Stock purchased fry/fingerlings	Remarks
Date of stocking					
Interval after rice transplantation					
Total number of brood fish					
Total number of male brood fish					
Total number of female brood fish					

5.3 Fingerling production system of others fish species

Activities	Stock own brood fish	Stock purchased brood fish	Stock own fry/fingerlings	Stock purchased fry/fingerlings	Remarks
Date of stocking					
Interval after rice transplantation					
Number					
Size					
Male brood fish					
Female brood fish					

6. Fish production in pond and other waterbodies

6.1 Production and cost of pond fish and other water bodies

Household member	Activities	Frequency	Where	Total time	Wages		
					Kind	Quantity	Tk.

6.2 Fish harvesting from pond, river and other water bodies

Who collected	Location	Collection method	Frequency	Species	Quantity (Kg.)	Use of fish	Price (Tk.)

7. Household level food intake

7.1 Food intake for last three days

Food item	Quantity (Kg.)	Frequency	Source	Preparation	Who eat

7.2 Major food intake for remaining days of 27 days of the last month

Food item	Quantity (Kg.)	Frequency	Source	Preparation	Who eat

8. Income and expenditure

8.1 Income of last month from non-farm source (service, business, money lending, credit receive etc.)

Source	Who	Time spent/ frequency	Amount (Tk.)	Control by
Service (Salary)				
Wages (day labour)				
Rental of land/ equipment (Shallow pump, power tiller)				
Business				
Livestock				
Land cultivation with own equipment to others land				
Money lending				
Credit received				
Dairy (milk)				
Dowry received				
Tree				

8.2 Expenditure (food, clothing, treatment, travel, education, housing, travel, credit repayment, credit repayment/deposit, livestock treatment, tools and equipment, Installation of tube well and toilet, livestock purchase, presentation, dowry, land purchase, occasion/festival, amusement and others

Item	Who	Quantity (Kg./No.)	Amount (Tk.)	Remarks
Rice				
Fish				
Vegetables				
Meat				
Others food				
Clothing				
Treatment				
Education				
Housing				
Travel				
Credit repayment/ Cash deposit				
Livestock treatment				
Tools and equipment				
Installation of tube well & toilet				
Livestock purchase				
Presentation				
Dowry				
Land purchase				
Occasion/ Festival				
Amusement (T.V, Radio,______)				

9. Other household's livelihood issues

9.1 Visitors (Officials from different organizations) in the last month

Name/ Designation and Organization	Why/ Purpose	Frequency	Achievement

9.2 Relatives in the last month

Relation with H.H.	Where from	Frequency	Duration of stay	Purpose

9.3 Occasion and festival

Name	Duration	place	Remarks

9.4 Health Aspects (Sickness) in the last month

H.H. member	Type of sickness	Duration	How recover	Remarks

9.5 Livestock died or born in the last month

Type	Born	Died		
	No.	No.	Price	How

9.6 Participation in Training, Meeting, Workshop, Fair, social, institutional programme

Name	Where	Duration	Achievement/ Purpose	Remarks

9.7 Natural hazard (flood, draught, extreme cold, heavy rain, tornado)/ Shocks/ stress/constraints occurred in the last month

9.8 Participation in Training, Meeting, Workshop, Fair, social, institutional programme

9.10 Household and Social conflict arrived and solved in the last month

9.11 Potential for Rice-Fish (through observation)

9.12 What are the factors for no adoption?

Appendix 3: Results of non-parametric Chi-square test showing difference between RF and NRF households in terms of having *barshi* (hook gear)

FarmerType * BARSHI

Crosstab

			BARSHI		Total
			No	Yes	
FarmerType	Control	Count	38	20	58
		% within FarmerType	65.5%	34.5%	100.0%
	Rice fish	Count	24	36	60
		% within FarmerType	40.0%	60.0%	100.0%
Total		Count	62	56	118
		% within FarmerType	52.5%	47.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.701[b]	1	.006		
Continuity Correction[a]	6.712	1	.010		
Likelihood Ratio	7.791	1	.005		
Fisher's Exact Test				.006	.005
Linear-by-Linear Association	7.636	1	.006		
N of Valid Cases	118				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.53.

Appendix 4: Results of parametric univariate analysis of variance on household size

Univariate Analysis of Variance

Between-Subjects Factors

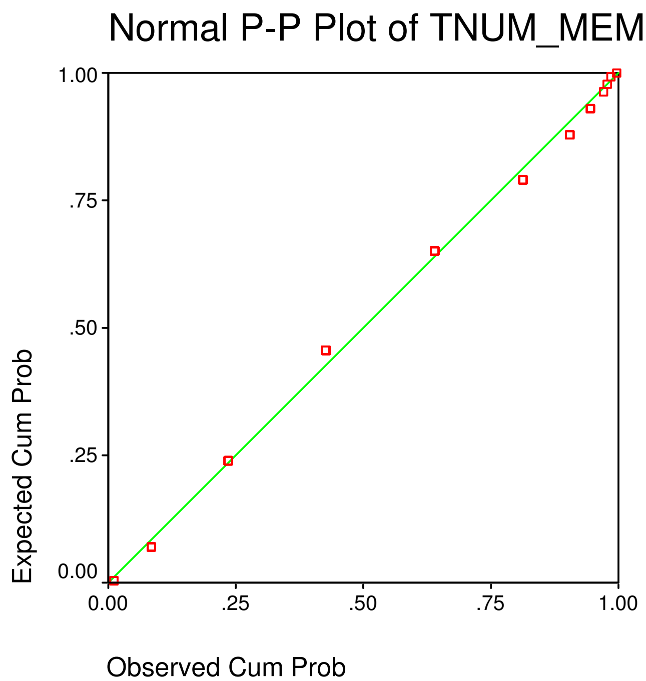
		Value Label	N
FarmerType	1	Control	58
	2	Rice fish	60
Q112WBS	1	Poor	55
	2	Intermediate	35
	3	Better-off	28

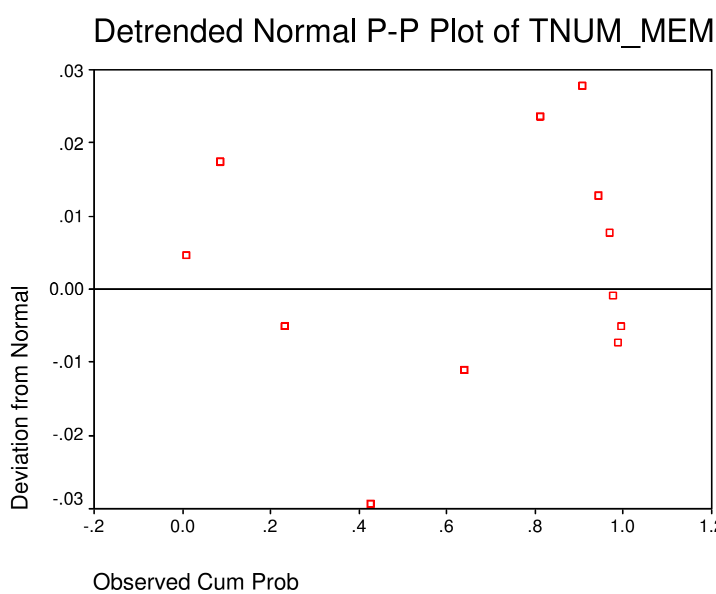
Tests of Between-Subjects Effects

Dependent Variable: TNUM_MEM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.603[a]	5	.121	5.602	.000
Intercept	56.703	1	56.703	2636.049	.000
FARMERTY	.124	1	.124	5.779	.018
Q112WBS	.370	2	.185	8.598	.000
FARMERTY * Q112WBS	7.941E-02	2	3.970E-02	1.846	.163
Error	2.409	112	2.151E-02		
Total	63.517	118			
Corrected Total	3.012	117			

a. R Squared = .200 (Adjusted R Squared = .164)


Normal P-P Plot of TNUM_MEM
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob


Detrended Normal P-P Plot of TNUM_MEM
Deviation from Normal
.03
.02
.01
0.00
-.01
-.02
-.03
-.2
0.0
.2
.4
.6
.8
1.0
1.2
Observed Cum Prob

Appendix 5: Questionnaire for study of adoption, adaptation and rejection process of ricefield based fish seed production

1) Primary adopters

Name of the farmer:------------------ Community: --------------Upazilla:-------------------

District:------------------

1.1 How did you get involved with rice fish activities?

Year of involvement	CARE interventions	Other interventions
2000	Yes	

1.2 When and where did you get information on rice fish?

1.3 What were your qualifications/capacities to get involved with the rice fish program?

1.4 Who got training from your family on rice fish?

1.5 Which part of the rice fish based technologies was most interesting and benefiting? Please score them and mention reasons

Technologies	Scoring	Ranking	Reasons
Rice fish (grow-out for food fish production)			
Fish seed production			
Low input rice production (Apply line transplantation, use of organic fertilizers, less use of inorganic fertilizers)			
Dyke cropping (production of vegetable on the dyke of rice fish plot)			

1.6 How long are you continuing RF based fish seed production?

1.7 Did you face any constraints during the time of practice RF based seed production? If yes how did you cope that?

Constraints	Year	Cope at that year of constraint appeared	If not at that year of constraint but cope in the next year
Cannot collect cc seed from the pond			
Brood fish overflowed by heavy rainfall			
Broodfish was affected by theft			
Community pond owner did not allow me to collect CC eggs from his pond last year			

1.8 Why are you continuing the RF based seed production? Please mention the reasons.

1.9 What is system you are using for RF based seed production?

1.10 What are the changes did you did over the period of adoption? Please describe (periodical changes)

a) Developed a business relationship with a better-off farmer
b) Changed the timing of the harvest
c) Extended his production area

1.11 How has the change in system affected/strengthened/weakened this and other relationships in the community?

1.12 How has the change in harvest practice affected rice /or other livelihoods options

1.13 Has the extended area resulted in any other changes?

1.14 Do you find that production of RF based seed adoption met the demand of fish consumption in your household level? If yes how do you get benefits? (Answers with the fish consumption calendar and some qualitative expressions)

Fish consumption calendar from rice fish plot

Sources of fish	Boishak	Jestha	Ashar	Sravan	Vhadra	Ashin	Kartic	Agrahyon	Poush	Magh	Falgun	Choitra
Boro season												
Amon season												
Market												
Open water												
Other places												

a)

b)

c)

1.15 Do you find that RF adoption facilitated to gift fish to the relatives? If yes how do you feel benefits?

1.16 Do you find that RF based seed adoption facilitated to gift fish to the neighbours and strengthen the relationship? if yes how?

1.17 How do you sell fish seed and why? Is selling of seed related to fry traders? If yes how and why?

1.18 When do you sell fish seed?

1.19 How do you use the money?

1.20 How does the money contribute to household? Describe the nature of cash flow?

1.21 Did you have any remarkable change (purchase/modify anything in your household) in your household from RF based seed over the period of adoption?

1.22 Did anybody receive the RF based seed production technological idea from you? If yes how many of their number?

Name of the idea receiver	Year	Within the community		Outside the community	
		Relative	Neighbours	Relative	Non-relative

1.23 How did you give the idea to them?

1.24 Do you think that they are following RF based seed production according to your advice? If not why and how they are continuing?

1.25 Are they used to take suggestions from you time to time for RF based seed production?

1.26 Do you think that other people in your community could do RF based seed production? How many people could do RF based seed production in your community? Why they did not do that? Please mention reasons.

1.27 Do you exchange your idea on RF based seed production with other household or agricultural activities? If yes, please describe.

2 Secondary Adopter

Name of the farmer:----------------------Community:-------------------------Upazilla:-----
------------------District:-------------------

2.1 How did you get involved with rice fish activities?

2.1 When and where did you get information on rice fish?

2.3 What is the relationship with the primary farmers/advisors?

2.4 Who received the idea of RF based fish seed production from your family on rice fish?

2.5 Do you know other technologies related to riceplots? If yes please mention those.
a)
b)
c)
d)

Please rank those technologies with specific reasons

Technologies	Scoring	Ranking	Reasons
Rice fish (grow-out for food fish production)			
Fish seed production			
Low input rice production (Apply line transplantation, use of organic fertilizers, less use of inorganic fertilizers)			
Dyke cropping (production of vegetable on the dyke of rice fish plot)			

2.6 How long are you continuing RF based fish seed production?

2.7 Did you face any constraints during the time of practice RF based fish seed production? If yes how did you cope that?

Constraints	Year	Cope at that year of constraint appeared	If not at that year of constraint but cope in the next year
8.11.1.1.1 Cannot collect cc seed from the pond			
Brood fish overflowed by heavy rainfall			
Broodfish was affected by theft			
Community pond owner did not allow me to collect CC eggs from his pond last year			

2.8 Why are you continuing the RF based fish seed production? Please mention the reasons.

2.9 What is system you are using for RF based fish seed production?

2.10 What are the changes did you do over the period of adoption? Please describe (periodical changes)

2.11 Are you still sharing the ideas with the previous adopters/advisers? If yes how? When? And which purpose?

2.12 Do you find that adoption of RF based fish seed production met the demand of fish consumption in your household level? if yes how? (Answers with the fish consumption calendar and some qualitative expressions)

Fish consumption calendar from rice fish plot (I will use this calander later on)

Sources of fish	Boishak	Jestha	Ashar	Sravan	Vhadra	Ashin	Kartic	Agrahyon	Poush	Magh	Falgun	Choitra
Pond												
Boro season												
Amon season												
Market												
Open water												
Other places												

a)

b)

c)

2.13 Do you find that adoption of RF based fish seed production facilitated to gift fish to the relatives and strengthen the relationship? If yes how?

2.14 Do you find that adoption RF based fish seed production facilitated to gift fish to the neighbours and strengthen the relationship? if yes how?

2.15 How do you sell fish seed? Is selling of seed related to fry traders? If yes how and why?

2.16 When do you sell fish seed?

2.17 How do you use the money?

2.18 How does the money contribute to your household? Describe the nature of cash flow?

2.19 What is the major contribution to your household from RF based fish seed production over the period of adoption?

2.20 Did anybody receive the RF based fish seed production technological idea from you? How many of their number?

2.21 How did you give the idea to him?

2.22 Do you think that they are following RF based fish seed production according to your advice? If not why and how they are continuing?

2.23 Are they used to take suggestions from you time to time for RF based fish seed production?

2.24 Do you exchange your idea on RF based fish seed production with other household or agricultural activities? If yes, please describe.

3 Person never tried RF based fish seed production

Name of the farmer:------------------------------Community:--------------------------------

Upazilla:-------------------District:--------------------------------

3.1 Do you know about the ideas of rice fish farming? If yes please describe. When and how do you know that?

3.2 Do you know about RF based fish seed production in the rice field?

3.3 Why don't you practise RF based fish seed production? Mention the reasons please (personal, familial, social and rice plot related matters)

3.4 Did you discuss about the RF based fish seed production with the RF based seed producing farmers? What type of discussion you did, please describe?

3.5 Has anybody from your household/community affected your decision to adopt RF based fish seed production?

3.6 Do you have any plan to adopt RF based fish seed production future? If yes – how? And if no-why?

4 Initially tried during FFS but not continued

Name of the farme:---------------------------------Community:-------------------------------

Upazilla:--------------------------District:----------------------------

4.1 When and how did you get idea of RF based fish seed production?

4.2 How did you try to produce fish seed in rice field?

4.3 What were your outcomes during trying to do RF based fish seed production?

4.4 Why didn't you continue RF based fish seed production? Please mention the reasons.

4.5 Did the discontinuation of RF based fish seed production reduce labour use/or other cost/investment to your household anyway?

4.6 Has anybody from your household/community affected your decision to continue that? If yes why?

4.7 Has anybody from your household/community influenced your decision to continue that? If yes how and why?

4.8 Do you have any plan to adopt RF based fish seed production future? If yes – how? And if no-why?

4.9 Does the production of fish in ricefields affect you anyway? Has it increased/reduced your access to food (rice)/seasonality/water availability?

5 Continued for few years but rejected

Name of the farmer:----------------------Community:------------------------------

Upazilla:------------------------District:----------------------

5.1 When and how did you get idea of RF based fish seed production?

5.2 When did you start fish seed production in rice field?

5.3 How long did you continue RF based fish seed production in your rice field?

5.4 Why and how did you reject the RF based fish seed production? Please mention the reasons.

5.5 Did the rejection of RF based fish seed production reduce labour use/or other cost/investment to your household anyway?

5.6 Has anybody from your household/community asked you to reject that? If yes why?

5.7 Has anybody from your household/community asked you to continue that? If yes why?

5.8 Do you have any plan to adopt RF based fish seed production in future? If yes – how? And if no - why?

5.9 Does the production of fish in rice fields affect you in anyway? Has it increased/reduced your access to food (rice)/seasonality/water availability?

6 Women in adopting households

Name of the housewife/women:-------------------------------Community:-----------------

Upazilla:----------------------------District:--------------------------Date:

6.1 Do you know about rice fish culture? If yes, how do you know about that?

6.2 Could you please explain about rice fish culture?

6.3 Do you know about fish seed production in ricefield? If yes, how do you know about that?

6.4 Could you please describe about fish seed production in rice field based systems?

6.5 Which part of the rice fish based technologies was most interesting and benefiting? Please score them and mention reasons.

Technologies	Scoring	Ranking	Reasons	
			Advantages	Disadvantages
Rice fish (grow-out for food fish production)				
Fish seed production				
Low input rice production (Apply line transplantation, use of organic fertilizers, less use of inorganic fertilizers)				
Dyke cropping (production of vegetable on the dyke of rice fish plot)				

6.6 Do you involve in fish seed production activities in ricefields?

6.7 If yes, why (willingly, force from husband), how and what type of activities with you involve?

a) Direct activities

b) Indirect activities

6.8 What type of supports to your husband comes-out from your involvement? Please point-out the outcomes.

6.9 Did you find any problems due to your involvement with seed production activities? If yes, please describe. If not, why not.

6.10 How your family members got benefited from fish seed production?

a) Husband

b) Children

c) Others

d) Me

6.11 Do you sell fish seed? If yes, who take the decision to sell seed and why?

Me/My husband

6.12 Do you use the money? If yes how do use the money of seed selling? Please describe.

6.13 If you don't use the money, why? Who and how do use the money?

6.14 Did you find any major contribution from the income of seed? Please describe.

6.15 Did you find any problems over the period of seed production? If yes, how did you contribute to solve the problems?

6.16 Do you find that adoption of RF based fish seed production met the demand of fish consumption in your household level? If yes how do you get benefits? (Answers with the fish consumption calendar and some qualitative expressions)

Fish consumption calendar from rice fish plot

Sources of fish	Boishak	Jestha	Ashar	Sravan	Vhadra	Ashin	Kartic	Agrahyon	Poush	Magh	Falgun	Choitra
Boro season												
Amon season												
Market												
Open water												
Pond												

a)

b)

c)

6.17 Do you find that adoption of RF based fish seed production facilitated to gift fish to the relatives? If yes how do you feel benefits?

6.18 Do you find that adoption of RF based fish seed production facilitated to gift fish to the neighbours and strengthen the relationship? If yes how?

6.19 Did anybody receive technological idea of RF based fish seed production from you? If yes how many of their number?

Name of the idea receiver(s)	Year	Within the community		Outside the community	
		Relative	Neighbours	Relative	Non-relative

6.20 How did you give the idea to them?

6.21 Do you think that they are following RF based fish seed production according to your advice? If not why and how they are continuing?

6.22 Are they used to take suggestions from you time to time for RF based fish seed production?

6.23 Do you find that your involvement with RF based fish seed production affected your other households' works? If yes, how?

6.24 Do you find that you involvement with RF based fish seed production empowered you? If yes how?

6.25 Do you exchange your idea on RF based fish seed production with other household or agricultural activities? If yes, please describe.

6.26 How do your neighbors (men and women) evaluate your activities in fish seed production?

6.27 Do you think other type of women can take part in seed production activities in the community? If yes why, if not why?

6.28 Could you please describe what type of women can take part in RF based fish seed production activities (what should be their criteria)?

6.29 Does your children take part in fish seed production activities? If yes, how? Please describe.

7 Women in non-adopting households

(a) Initially rejected/ (b) Rejected after few years/ (c) Never tried households

Name of the housewife/women:----------------------------Community:--------------------

Upazilla:--------------------------District:-----------------------Date:----------------------------

7.1 Do you know about rice fish culture? If yes, when how do you know about that?

7.2 Could you please explain about rice fish culture?

7.3 Do you know about fish seed production in ricefield? If yes, how and when did you know about that?

7.4 Could you please describe about fish seed production in rice field based systems?

7.5 Did you involve in fish seed production activities in ricefields? (a) and (b)

7.6 If yes, why did your household reject that technology? Please describe the reasons. for (a) and (b)

7.7 Why did not involve your household in seed production activities in ricefield based system? Please describe the reasons. for (c)

7.8 How did your family members get benefited from fish seed production activities? for (a) and (b)

a) Husband

b) Children

c) Others
d) Me

7.9 Did you find that your involvement with RF based fish seed production affected your other households' works? If yes, how? for (a) and (b)

7.10 How did your neighbors evaluate your involvement in the activities of ricefield based system seed production? for (a) and (b)

7.11 How do you evaluate the women, those are involve in fish seed production activities? for (c)

7.12 Could you please describe what type of women can take part in RF based fish seed production activities (what should be their criteria)?

<u>Socio-economic information for adoption studies</u>

Name of the farmer/women-------------------------------Community----------------------------
---

District-------------------------Well-being-------------

Group of the farmer

Primary adopter		Rejecter after few years	
Secondary adopter		Adopting women	
Never tried		Non-adopting women	
Initially rejecters			

1) Main occupation of household head------------------

2) Secondary occupation of household head-----------

3) Number of earner in the household (excluding household head)-------------

Off-farm------------On farm---------------

4) Number of household member: Male-----------Female-------------Total--------------------
-

5) Age of household head---------------

Age distribution of other household members

Sex	Age groups			
	1-14	14-30	31-60	60 above
Male				
Female				

6) Education level of household head---------------

Education level of other household members

Sex	Education attainment				
	Illiterate	Primary	Secondary	Higher secondary	Above higher secondary
Male					
Female					

7) Land owner ship

Amount of land (decimal)					
Own land	Lased in	Leased out	Share in	Share out	Multi-owner

8) Pond ownership

Amount of pond (decimal)					
Own pond	Lased in	Leased out	Share in	Share out	Multi-owner

9) Annual household income

On-farm		Off-farm	
Rice		Business	
Wheat		Job	
Vegetable		Day labor	
Fish		Rickshaw/van pull	
Cattle		Fishing	
Poultry			
Jute			
Fruit			
Rice fish			
Total		**Total**	

10) Who is the main operator of rice-fish plot in the household? Describe this answer.

11) Additional comments

Appendix 6: Comparative technological preferences of the primary adopters

Technology	**Advantages**	**Percent of farmer**	**Disadvantages**	**Percent of farmer**
Fish seed	No cost production	83.33	Common carp borrow and destroy the dyke	3.33
	Additional income	63.33	Cannot collect eggs every year	3.33
	Can stock to the pond	60.00		
	Increased pond production	53.33		
	Can gift to others	33.33		
	Can consume at household level	33.33		
	Can get quality fry	26.66		
	Grow faster	20.00		
	Stock to the other riceplot	10.00		
Food fish	Additional income	80.00	Escaping of fish due to heavy rainfall	20.00%
	Meet the demand of household consumption	76.66	Need additional security	16.66
	Grow faster	13.33	Fish growth not well	10.00
	Can gift to the relative	13.33		
	Low input production	13.33		
	Easy to catch	10.00		
Vegetable production	Meet the demand of household consumption	83.33	Destruction of dyke by rat	23.33
	Additional income	60.00	Additional cost	10.00
	Can gift to relatives	20.00	Need additional cost	10.00
	No other land for vegetable cultivation	10.00	Need additional labour	3.33
	Low input production	6.66	Need to use pesticides	3.33
			Pouching of vegetable	3.33
Low-input rice production	Low cost production	66.66	Need additional labour for rice transplantation; labour does not want to do that	13.33
	No use of pesticides	33.33	Difficult to use pesticides	6.66
	Easy to weeding	13.33	Difficult to manage organic fertilizers	3.33
	Increased rice production	10.00		
	Fish can move freely in riceplot	6.66		
	Increased use of organic fertilizer	6.66		

Appendix 7: Comparative technological preferences of the secondary adopters

Technologies	Advantages	Percent of farmers	Disadvantages	Percent of farmer
Fish seed Production	Additional income	50.00	Can not stock as not have pond	6.66
	No cost production	40.00	Difficult to harvest tilapia	6.66
	Can stock to the pond	36.66	Can not collect common carp eggs	3.33
	No need to purchase seed	30.00		
	Increase pond production	20.00		
	Can consume at household level	16.66		
	Can gift to others	13.33		
	Can stock to other riceplot	10.00		
	Own source production	10.00		
Foodfish production	Additional income	86.66	Can not produce food fish due to heavy rainfall	6.66
	Meet the demand of household	73.33	Can not produce food fish because of draught	3.33
	Can gift	46.66	Disease on silver barb	3.33
	No need to buy from the market	16.66	Social vandalisms	3.33
	Fish grow faster in the riceplot	10.00		
	Fish destroy pest	6.66		
Dyke cropping	Meet the demand of household consumption	43.33	Less interest to do	33.33
	Can gift	33.33	Need additional investment	26.66
	Additional income	26.66	Attack of rat on dyke and vegetable	23.33
	No need to buy from the market	13.33	Disturbance of cattle	20.00
			Destroy vegetable during heavy rainfall	6.66
			Need wider dike	6.66
			Attack of pest and disease	3.33
			Stolen by man	3.33
Low-input rice production	Reduced cost of rice production	70.00	Labour cost is higher in transplantation; labour does not want to do that	10.33
	Easy to pest control	13.33	Scarcity of cowdung	6.66
	Easy to weeding	10.00	Using pesticides is problematic	6.66
	Increased rice production	10.00		
	Easy to fertilization	3.33		
	Easy to rice harvest	3.33		

Appendix 8: Problems faced and measures taken by the primary adopters

Problems faced by primary adopters	**Percent of farmer**	**Measures taken by the farmers**
No problems faced	36.66	These farmer did not face any problems during the period of their adoption
Broodfish escaped from the plot because of heavy rainfall. Sudden heavy rainfall particularly during night causes escaping of brood fish from the plot	13.33	Out of 4 farmers 1 raised the dyke in following year, others did not do as it is costly
Pouching of tilapia brood fish. Farmers used to stock broodfish of tilapia and common carp in the riceplot ditch. Where brood fish is stolen sometimes	13.33	One farmer collected stocked broodfish from neighbour source at free of cost. Others provide safety and security
Cannot collect common carp eggs from the pond. The collection of common carp eggs depends on the specific time and availability of fish in the household pond, which act as a limiting factor sometimes	13.33	Out of four 3 farmers has collected eggs from neighbour pond. One farmer brought fry from fry trader
Ploughing before *Amon* season using power tiller causing death of fry	10.00	Farmers became conscious about mechanized tilling later on keeping the fry in the ditch
Fry escaped from the plot because of heavy rainfall. Sudden heavy rainfall particularly during night causes escaping of fry from the plot	6.66	Did not take any measure during heavy rainfall
Using excess dose of fertilizers caused less production of fish. During *Boro* season farmers used to use excessive fertilizers in their rice field, which becomes problematic in the ricefish plot	6.66	Afterwards the farmers became conscious about using of fertilizers learning about that from neighbour adopters
Water supply insufficiency due to fall down the ground water level. Due to concurrent exploitation of ground water in the *Boro* season, water head of pump falls down in some places	6.66	After taking out the fry from ditch farmers deepened the ditch and restock again fry
Destruction of dyke by rat. Vegetable production on the riceplot dyke causes availability of rat. Rat is used to hollow out the dyke and make vulnerable the plot to hold and water and fish	3.33	Next year the farmer repaired the dyke

Appendix 9: Problems faced and measures taken by the secondary adopters

Problems faced by secondary adopters	% of farmer	Measures taken by the farmers
No problem faced	40.05	These farmer faced any problems over the period of their adoption
Farmers could not collect eggs from the household pond as pond was dried-out for repairing	16.66	Four farmers collected brood fish from the neighbours and stocked into the riceplots. Two farmers stocked fry into the riceplots from the neighbour.
Tilapia brood fish escaped due to heavy rainfall	6.66	One farmer raised his plot dyke in the following year and other collected from a neighbour farmer
Tilapia seed was not produced	6.66	In the following year one farmer collected tilapia brood fish from a neighbour and another one from his elder brother
Water supply problem due electric voltage ups and down, load shading problems	6.66	After taken out fish from the ditch, ditch was deepen to hold more water
Escape of fish from the rice plot due to heavy rainfall	6.66	Fortunately some amount of fish was in the plot of one farmer, which acted as a brood stock in the following year. Another farmer changed the plot and start seed production in the other suitable plot
Broodfish was stolen from household pond	3.33	Very few brood fish was in the pond and eventually seed production was poor. This sees was raised in the pond to make brood fish for the next year
Could not manage good quality tilapia	3.33	In the following year farmer purchased tilapia brood fish from a neighbour farmer
Excessive use of fertilizers caused mortality of fish seed	3.33	Farmer dewatered the plot to reduce the fertilizer effect and watered again
Fish seed was stolen from the plot	3.33	Then the farmer stocked carp fry from the fry traders
Some body killed fish using toxic substance	3.33	Strengthen the security to the plot in the following time

Appendix 10: Photographs showing case study, observation, triangulation and validation findings at the field level

Case study with a fish seed producing farmer.

Case study with a fry trader.

Observation on the installation of a shallow irrigation pump in ricefield.

Observation on collection process of common carp eggs using water hyacinth in perennial household pond.

Observation on tilapia broodfish management in a farmer's riceplot.

Observation on water management in fish seed producing riceplots during heavy rainfall.

Catching of fish fingerlings from ricefields during *boro* harvest.

A harvest of fingerlings of different sizes from ricefields.

Observation on fingerling purchased by fry traders from a decentralised seed producing household.

Triangulation and validation of findings with farmers.

Appendix 11: Data/information collection from CARE and its PNGOs for cost-effectiveness analysis of FFS

Figure: Interview with CARE official (Manager, Thakurgaon Field Office, Go-Interfish Project, CARE Bangladesh).

Figure: Interview with NGO Executive Director, (CARE partner NGO, JUS, Badargonj, Rangpur).

Appendix 12: Report on expenditure for implementation of FFS

CARE Bangladesh
GO-Interfish Project

Name of PNGO: Gopinathpur Boardahat Jubok Samity (JUS)
Budget for the Period of: February 2001 - June 2002

Sl.	Head of expenses	Notes	Budget Feb' 01 June' 02 Taka
A. Staff salaries			
A.1	Field Trainer	(3000x3m+4000x1.5m)x4FT+(1200x13m)x3FT+(3000x3m+4000x7.5m+1350x1m)x1FT+(3000x3m+4000x1.5m)x2	292,150
A.2	Project Officer	Tk. 4500x3+6000x1.5m+6300x5m+6000x7m+2000x1mx1PO	98,000
A.3	ED (Honorarium)	Tk. 2500 x 16.5 months x 1 ED	41,250
A.4	Accountant (Honorarium)	Tk. 1000 x 16.5 months x 1 Acct.	16,500
	Sub-total		**447,900**
B. Transport cost			
B.1	Motorcycle (80 cc)	Tk. 108000 x 3 Motor cycle	324,000
B.2	Motorcycle (50 cc)	Tk. 87000 x 2 Motor cycle	174,000
B.3	Motorcycle helmet	Tk. 1000 x 5 helmet+650x1 helmet	5,650
B.4	Bicycle	Tk. 4500 x 2 bicycle	9,000
B.5	Motorcycle fuel	Tk.24x18ltr.x7.5mx2MC+28x18ltrx6mx5MC	21,600
B.6	Bicycle maintenance	Tk. 50x7.5mx2 BC	375
B.7	Motorcycle mobil / maintenance	Tk.200x7.5mx2MC+200x6mx5MC	9,000
B.8	Rain coat	Tk. 800 x 5 no.	4,000
B.9	Travelling for PO/FT(When MC cannot move/Pregnant stat	Tk.150x20 days+100x10 days	4,000
	Sub-total		**551,625**
C. Fixtures and Fittings			
C.1	Table (1 for PO and 1 for FTs)	Tk.3500 x 2 nos	7,000
C.2	Chair	Tk.600x4nos+400x3nos	3,600
C.3	White board	Tk. 900 x 2 nos	1,800
C.4	Display board	Tk. 1200 x 1 no.	1,200
C.5	File cabinet	Tk. 3300 x 1no.	3,300
C.6	Almirah	Tk. 5000 x 1 no.	5,000
C.7	Pegion box	Tk. 2500 x 1no.	2,500
C.8	Fan	Tk. 1500 x 1 no.	1,500
	Sub-total		**25,900**
D. Project Implementation			
D.1	FFS training materials	Tk. 2000 x 20 FFS	40,000
D.2	FFS study plot cost	Tk. 600 x 20 FFS x 2 season	24,000
D.3	Cross visit	Tk.50x25personsx20 FFSx2season	50,000
D.4	Field Day	Tk. 400x10 field dayx2 season	8,000
D.5	Agruculture fair	Tk.500x1 team	500
	Sub-total		**122,500**
E. Food, Transport and Lodging (CARE organize)			
E.1	Executive Director	Tk. 190 for food & transport x 30 visits x 1 ED	5,700
E.2	Project Officer	Tk. 210 for food & transport x 20 visits x 1 PO	4,200
E.3	Field Trainer	Tk. 210 for food & transport x10visits x 4 FT	8,400
	Sub-total		**18,300**
F. Project Support			
F.1	Stationery	Tk. 530x13.5 months for stationery and photocopy	7,155
F.2	Communications	Tk. 30 x 16.5 months	495
F.3	Office Rent	Tk. 1000 x 14 months	14,000
F.4	Utilities and Electricity	Tk. 300 x 14 months	4,200
F.5	Office Cleaning	Tk. 120 x 14	1,680
F.6	Bank Charges	Tk. 1590 for 3 installment	1,590
	Sub-total		**29,120**

G	Total cost		
	Total (A+B +C+D+E+F)		1,195,345

G	Administrative fee		
G.1	Administrative fee		9,550
	Sub-total		9,550

H	Grand Total (G+H)	1,204,895

Payment Schedule	
Amount paid in 1st installment (April'2001) In word: Taka Three lac eighty thousand seven hundred fifty one	380,751
Amount paid in 2 nd installment (July'2001) In word: Taka Three lac fourty seven thousand seven hundred fourty seven only	347,747
Amount payable in 3rd installment (January'2002) In word: Taka Four lac seventy six thousand three hundred ninety seven only	476,397

Total payable: Taka **1,204,895**
In word: Taka Twelve lac four thousand eight hundred ninety five only

Budget approved signatures:

For CARE Bangladesh

Signature

Name: Mike Brewin

Designation: Team Leader
GO-Interfish Project

Witness

Signature

Name: Faruk Hossain [illegible]

Designation: A A
GO-Interfish,

For, Gopinathpur Boardahat Jubok Samity (JUS)

Signature

Name: M. A. [illegible]

Designation: Director

Witness

Signature

Name: [illegible]

Designation: [illegible]