The livelihood impacts of fishponds integrated within farming systems in Mymensingh District, Bangladesh

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By

Manjurul Karim

UNIVERSITY OF STIRLING

Aquaculture Systems Group, Institute of Aquaculture
University of Stirling
Stirling, Scotland, UK

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Dedicated

to

My family

Declaration

I hereby declare that this thesis has been composed entirely by myself and has not been previously submitted to any other degree or qualification.

The work of which it is a record has been carried out by me. The nature and extent of any work carried out by, or in conjunction with, others has been specially acknowledged by reference.

Manjurul Karim

Abstract

Links between the pond and surrounding land for horticulture is a distinctive feature of farming households in Bangladesh. It was hypothesised that the role of fishponds in integrated aquaculture systems has potential towards improving livelihoods and poverty alleviation. Rural and peri-urban settlements in Mymensingh District, Bangladesh were selected for assessing the importance and role of pond-dike systems on the livelihoods of households of different socio-economic level.

The study was carried out in view of the sustainable livelihood approaches of the Department for International Development, U.K. Participation of all levels of stakeholders was ensured in the first and last phase of the study. The combination of quantitative and qualitative analysis at community and household level was a major strength and challenge of the study, and was used to explore the potential of integrated farming and factors that undermine such potential to contribute to a sustainable livelihood. The research commenced with a comprehensive situation appraisal and baseline survey to explore the context and characterize farming systems, followed by a longitudinal household survey to understand the effect of seasons on livelihoods. Households with access to ponds were identified as active or passive integrators based on a simple set of criteria and their resources and livelihoods assessed in comparison with non-pond households. During the last phase of the study a farmer participatory research (FPR) trial, based on a priority issue identified during the 1st phase of the study, was launched to investigate the potential of the integrated systems.

The situation appraisal conducted within four communities revealed the effects of gender, well-being and location on farmers' regular activities and food consumption patterns. Fish culture was equally important as an enterprise among richer and poorer men, whereas vegetable cultivation was more important to men than women but wealth and location also affected its importance. Lack of knowledge was a particular problem for farmers growing fish and vegetables in the rural areas. Fish disease, high price of input, lack of money were also identified as constraints by fish producers. The expected use and current use of ponds, problems and benefits associated with fish culture were also found to be affected by groups emphasising vegetable, orchard and fish culture within their systems. The role of the pond for family use, which was a major objective for pond construction, was found to be significantly different between rural and peri-urban areas. Fish culture is now the dominant use of ponds for households irrespective of their focus on vegetable, orchard or fish production and they are utilised less for general domestic use. Ponds are relatively more important as a source of irrigation water in rural than in peri-urban communities.

Significant differences were observed between locations and well-being categories for the percentage of fish retained for consumption and that sell. Rice bran was the most commonly used pond input (80% of all pond households) but active integrated farmers applied rice bran more frequently than passive groups (91 compared to 63 times/season). ‘Ease of production’ was a major incentive for farmers to integrate fish and vegetable production and this opinion was related to household type i.e. active integrators were more aware and confident about the practice.

The literacy levels of household heads, access to information and capital and contact with formal and informal institutions of active producers and the better-off households was significantly higher than other groups and poorer households respectively.

It is revealed from the longitudinal households' analysis that the consumption pattern in terms of food types and amount are linked with income, expenses and food availability in different well-being categories between seasons across locations. The empirical analysis showed that as active households' income increased, expenditure on food purchases, agricultural labour, pond inputs and poultry per household also increased. However, on-farm contributions as a source of fish and vegetables were important during the lower income and least productive months.

Performance of integrated farming systems varied by location. Resource base, accessibility to market and information played key roles in the development of integrated farming system in the study area. Active integrated households in peri-urban areas, in response to higher demand in the nearby market, produced significantly more fish and vegetables than those in the rural areas. The result showed clearly the need for due consideration of these factors while promoting IAA systems in Bangladesh.

Farmer participatory research showed that production of fish could be increased by a substantial level through increasing pond nutrient inputs rather than stocking an additional species (tilapia), although this may be related to the 'improved' nutrition used by farmers still being well below the level required for optimal tilapia performance. Rural households benefited more than peri-urban through direct consumption of both fish and vegetables; in contrast peri-urban households benefited more through cash sales of both fish and vegetables than rural households. Higher production did not lead to increased consumption, rather households benefited financially through selling fish. Similar production levels of vegetables between groups followed different levels of fish culture practices suggesting that increased investment in fish production is complementary rather than competitive with associated vegetable production.

It could be concluded that considerable potential exists for further integration and development of pond-dike systems, which could contribute towards improved livelihoods of both better off and worse off people.

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Acronyms and Abbreviations

Abbreviation	Term
AFGRP	Aquaculture and Fish Genetics Research Programme
BBS	Bangladesh Bureau of statistics
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Fisheries Research Institute
BRAC	Bangladesh Rural Advancement Committee
NGO	Non-government Organisation
DAE	Department of Agriculture Extension
DFID	Department for International Development
DFO	District Fisheries Officer
DoF	Department of Fisheries
FAO	Food and Agriculture Organisations of the United Nations
GDP	Gross domestic product
GoB	Government of Bangladesh
Ha	Hectares
ICLARM	International Centre for Living Aquatic Resources Management
IFAD	International Fund for Agricultural Development
IFADEP	Integrated Food assisted development project
MoFL	Ministry of Fisheries and Livestock, Government of Bangladesh
NAEP	National Agricultural Extension Policy
NFEP	North west Fisheries Extension Project
NACA	Network for Aquaculture centres in Asia
NGO	Non Governmental Organisations
ODI	Overseas development institute
PPA	Participatory Poverty Assessment
PCA	Participatory Community Apprisal
PRA	Participatory Rural Appraisal
SLA	Sustainable Livelihoods Approach
SRL	Sustainable Rural Livelihoods
UNDP	United Nations Development Programme

Glossary of Terms

Amon	Rice sown in the monsoon season (September to January)
Aus	Dry season (irrigated) rice (May to August)
Beel	A depression which mostly retains water year all the round
Boro	Rice sown in the dry season (irrigated) and harvested before the monsoon (February to April)
Decimal	100 decimals is equal to 1 acre or $44m^2$
DTW	Deep Tube Well
DANIDA	Danish International Development Agency
Gher	Prawn and fish farm
Homestead	land Yard or compound of household
Household	A family unit stay together and use common resources for living
Haor	Normally connected into a neighbouring river system but do not represent dead rivers
Madrasha	Islamic school
Pacca	Brick and concrete structure
Patilwala	Fish seed traders
Community	A neighbourhood, cluster of households within a village
Thana/Upazilla	A geo administrative unit under a district comprises several unions
STW	Shallow Tube Well
Union	A lowest local government structure
Village	A community comprised of one or several cluster of households

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Chapter 1: Introduction

1.1 General introduction

Three principal causes of hunger and food insecurity have been identified by FAO (2003); first, low agricultural productivity due to technological, policy and institutional constraints; second, high seasonal and year–to-year variability in output and food supply often the result of unreliable rainfall and insufficient water for crops and livestock and third the lack of off-farm employment opportunities that contributes to uncertainty and low incomes in urban and rural areas. Global food production will have to increase 80 percent by 2030 in order to feed an extra 2 billion people - yet investment in agriculture and rural areas has declined in most developing countries (FAO, 2003). Some 1.2 billion people do not have access to water, while 80 percent of all disease in the world due to contaminated water or poor sanitary conditions - yet, the numbers of people without water or sanitation is expected to double by 2025 (FAO, 2003).

The world's population now exceeds 6 billion, consuming a daily average of about 2,700 kcal per caput, compared with a population of 2.5 billion in 1950 and an average daily intake of less than 2,450 kcal per caput (FAO, 1999). This means that, over the last 50 years, the increase in global agricultural production has been 1.6 times greater than the total production level obtained in 1950, after 10,000 years of agricultural history (Mazoyer and Roudart, 1998). World aquaculture production has been increasing rapidly in recent years contributing to food supplies and now accounts for 32 percent of total fisheries production (FAO, 2005). Alongside aquaculture, agriculture products such as vegetable and fruits are also major nutrient-rich food items providing both macro and micro nutrients (i.e vitamins and minerals) to the world's population.

It is clear that as there is limited scope for horizontal land expansion to cope up with the future food demand, rather vertical intensification through integration of different agricultural enterprises could help to meet expected increases in production demand and quality. Reductions in poverty and malnutrition would be a major expected benefit of such integration. A recent study covering 58 developing countries concluded that a one per cent increase in agricultural productivity was associated with a reduction by between 0.6 and 1.2 per cent in the proportion of people living on less than $1 a day (Thirtle et al. 2002). Vertical intensification of land use for alleviating poverty is identified as a potential technique in most of the population-dense and agriculture-dependent countries. Bangladesh is one of such countries where the current research was carried out.

Due to continuous increase in population, the available per capita land is decreasing and at present mean per capita cultivated land area is about 0.61 ha in Bangladesh (BBS , 2000b). We have a total of 14 million hectares of arable land, of which 1.5 million hectares is very flood prone, 5.05 million hectares are drought prone and 3 million hectares have a salinity problem. Arable land is decreasing by 1.6% per year in Bangladesh due to river erosion, house construction, road building, establishment of industries, expansion of towns and cities etc (Smith and Biggs, 1998). Due to increased population growth and problems such as environmental degradation and land and water scarcity, the integration of aquaculture with agriculture has been advocated in order to increase resource use efficiency (Barg et al. 2000).

Water is essential for developing rural livelihoods (bathing, livestock, homestead and field irrigation) and certain forms of aquaculture production can represent simple, low-risk activities providing a quick return to fund other activities and build confidence (Haylor and Bland, 2001). Level of water use in aquaculture can be very high, attaining values of up to 45 m^3 per kg produced in ponds (Verdegem et al. 2006). On average 1.17 m3 of water is needed to produce 1 kg of cereal, excluding rice. A major proportion of water consumption in aquaculture ponds is due to seepage and surface evaporation. However, reduction of water use could be achieved through integration of aquaculture with agriculture (Verdegem et al. 2006).

In 2005, Bangladesh was the ninth populous country in the world with approximately about 150 million people in its 147,570 km2 of land area, the population increases by about 2 million people per year which equals to an annual growth rate of 2.05 percent and estimates suggest a total of 165 million by 2015. The population density is presently about 950 per square km. and by 2015 it will be about 1150 per square km. Mean per capita incomes stand at US $ 440 in 2005 (Loader and Amartya, 1999), which is one of the lowest in the world.

The Bangladesh economy remains based on agriculture, although is becoming more diversified. The contribution of the agriculture sector to GDP was 65% in 1971, but declined to 22.8% by 2004, of which crops constituted 12.9%, animals 2.9%, forests 1.8% and fish 5.2%. About 66% of family units still depend on agriculture and 62% of employment remains in the agriculture sector. The GDP contribution of agriculture is falling and employment in the sector is also in decline (Smith and Biggs, 1998). However, improvement of existing agricultural practices and patterns remains central to fighting hunger, poverty and malnutrition and potentially, acting as focus point towards sustainable development.

1.2 Aquaculture for sustainable development

Progress on understanding the concepts of sustainable development has been rapid since 1980s. The terms 'sustainable development' and ‘sustainable livelihoods’ were popularized by the World Commission on Environment and Development (WCED) in its 1987 report entitled “Our Common Future” (also known as the Brundtland report) (WCED, 1987). In correspondence with the WCED (1987), sustainable development is generally defined as ‘development that satisfies the needs of the present without compromising the ability of future generations to meet their own needs’. Apart from satisfying basic needs, sustainable development implies sustaining the natural life-support systems on earth and extending to all the opportunity to meet their aspirations for a better life (Little et al. 2003).

Sustainable development concepts mainly focuses on three issues; ensuring the rights of the poor and of future generations (i.e. concern for quality and fairness); applying the precautionary principle (i.e. have a long term-view of all activities); and understanding the interconnections between the environment, economic and society (i.e. systems thinking) (Biggs and Smith, 1998). However, sustainability in aquaculture specially is receiving increasing attention. In a development context, the concept of ‘sustainable aquaculture’ is often linked with ‘sustainable livelihoods’. However, the emphasis to date has typically focused aquaculture development rather aquaculture for development (Haylor and Bland, 2001; Friend and Funge-Smith, 2002).

1.3 Aquaculture concepts

Aquaculture is defined as farming fish and other aquatic organisms (Edwards, 1999a). There are diverse types of aquaculture that includes the farming of plants and animals, and these occur in inland or rural, and coastal areas. They can be defined as land or water based systems. Land based systems in inland areas have the greatest potential because aquaculture can be integrated with existing agricultural practice of small-scale scale farming households involving ponds, pond-dikes and rice fields (Edwards, 1999b; Little and Edwards, 1999; Edwards, 2000; Edwards et al. 2002; Little and Edwards, 2003; Halwart, 2005). On the other hand, water based systems involve enclosed or existing water bodies such as lakes, rivers or bays through installation of cages, pens or other structures which might be an entry point for the landless people to become involved in aquaculture (Edwards, 1999c). If the purpose is to enhance stocks (enhanced fisheries or culture-based fisheries) or increase yields managed by a single entity such as individual or a group of poor people, these activities can be considered as aquaculture (Beveridge and Little, 2002).

Aquaculture systems might also be characterized based on the level of intensity as extensive, semi-intensive or intensive, similar in concept of equivalent terms in agriculture (Muir, 2005; Seawright et al. 1998; Edwards, 1999b; Dorward et al. 2004). FAO simply defined extensive aquaculture as a system which doesn't involve feeding; semi-intensive aquaculture ensures feed partially thorough fertilization and/or feeding and intensive aquaculture entirely depends on artificial feeding (Muir, 2005).

The term "rural aquaculture" has recently been introduced to differentiate intensive/industrial aquaculture (such as shrimp/salmon farming) to practices that meet the needs of small scale to medium farmers through extensive and semi-intensive culture (Martinez-Espinosa, 1992; Edwards et al. 2002). Rural aquaculture has also been defined as "the farming of aquatic organisms by small-scale households using mainly extensive and semi-intensive husbandry for household consumption and/or income"(Edwards and Demaine, 1997).

However, probably the majority of aquaculture production derived from freshwater and coastal pond aquaculture (Muir, 2005), contributes to alleviation of poverty both directly and indirectly. Poor households benefit through employment and income generation as well as enhanced subsistence production and improving livelihoods (Yap, 1999; Halwart, 2005).

1.4 Poverty and aquaculture

It is increasingly recognized that poverty is a complex and multi-dimensional concept (Chambers, 1995; UNDP, 1998; Maxwell, 1999; Sen, Undated). The words "poverty" and "vulnerability" are often used as alternating synonyms. However, poverty is often considered to be simply a matter of an income to meet basic subsistence needs (Maxwell, 1999), whereas vulnerability is not the same as income-poverty (Hediger, 2000). Poverty has also been defined as low consumption, which is easier to measure. This is the normal meaning of poverty among economists and is used for measuring poverty lines, for comparing groups, and regions, and often for assessing progress in development (Hediger, 2000). In addition to low incomes; it is characterized by poor health, under nutrition, low physical asset base, inadequate housing and living conditions. Poverty is often seasonal; poverty is about poor access to education, risks, uncertainty, vulnerability and crisis in coping capacities. Poverty is expressed in each of these and all of these together. However, in general poverty can't be reduced if economic growth has not occurred (Khan, 2001).

Poverty differences cut across gender, ethnicity, age, location (rural versus urban), and income sources. In general in households, children and women often suffer more than men. In the community, minority ethnic or religious groups suffer more than majority groups and the rural poor more than the urban poor. Among the rural poor, landless wage workers suffer more than small landowners or tenants (Khan, 2001). To understand poverty it is essential to examine the economic and social context, including institutions, markets, communities and households (Khan, 2001).

There are four broad avenues that can help us to think strategically about poverty. These are lack of pro-poor economic growth; lack of human development; lack of social safety net and lack of participatory governance (Sen, Undated). There are numerous causes for poverty for instance, economical, societal and external influences (Khan, 2001) includes the following;

- instability of political situation and civil conflict;
- discrimination on the basis of gender, race, ethnicity, religion, or caste;
- imprecise definition of property rights or unfair enforcement of rights to agricultural land and other natural resources;
- uneven tenancy arrangements;

- exclusion of rural poor from the development process in economic policies
- large and rapidly growing families with high dependency ratios;
- market imperfections owing to high concentration of land and other assets and distortionary public policies; and
- external shocks owing to changes in the state of nature (for example, climatic changes) and conditions in the international economy.

A major question is the relative contribution that aquaculture can make to alleviating poverty. If so, who and in what ways do people benefit from aquaculture. Can the poor be early adopters of aquaculture technology or can they only gain indirectly? What sorts of aquaculture technologies and in which contexts can benefits be gained by the poor? The answers to these complex questions is likely to depend on circumstance, the answers will vary between the areas where aquaculture has tradition and where it is a relatively new practice (Goulet, 1994; Seawright et al. 1998). Aquaculture certainly contributed towards alleviating poverty in poor rural societies in the past in the few area of the worlds in which it is traditional practice e.g China (Hoffmann, 1934), Vietnam (Chevey and Lemasson, 1937) and Indonesia (Ilan and Sarig, 1952). However, even in areas where aquaculture has a long tradition, many smallholders culture fish below their potential because of inadequate information (Edwards, 1999a).

Poverty alleviation could be taken as the strategic starting point through aquaculture intervention (Edwards, 2002). Some see aquaculture as a means of alleviating poverty in developing countries, others naturally see the profit motive as being more attractive (Edwards, 2002). For example, not all of the participants of a World

Aquaculture Society (WAS) meeting in 2002 agreed that aquaculture is a appropriate route towards poverty alleviation. It was argued by some of the participants that focus should be given towards creation of wealth (financial, knowledge, health etc) rather than food for the poor which address the symptoms of poverty but not its causes (Edwards, 2002). This statement might anticipate a shift from low-yield small-scale fish ponds to large-scale, high yielding units. From a macro-economic point of view it is indeed more attractive to aim at richer rather than poor pond operators (FAO, 2004). However, the WorldFish Center considers that the target beneficiaries should be small and subsistence farmers who don't have the resources for intensive, high-value, commercial activities (Kapadia, 2000), though many aquaculture interventions have not always directly addressed the needs of poorest people. Haylor and Bland (2001) proposed that we should 'put people first in planning and development, and give special consideration to poor people'.

Those currently involved in aquaculture may not be very poorest since aquaculture requires resources such as land, ponds, water, credit and other inputs. A recent study (DANIDA, 2004) showed that households farming owned ponds in the Greater Mymensingh, Bangladesh were not the poorest people. Only small landholders and better-off households tended to own ponds. Most direct beneficiaries of aquaculture technologies in Bangladesh are not the poorest people (Hallman and Hoque, 2001).

However, access to land and water is complex, for example tenancy is an important feature of agriculture in Bangladesh. In Bangladesh, land resources are extremely scarce and per capita resources have been shrinking under population pressure. The number of farmer households has increased 11.0 to 12.7 million, leading to an agrarian structure dominated by small and marginal farmers (Hossain et al. 2004).

The fact that leasing land by many households is an indication that the amount of land they wish to cultivate is not identical with the amount of land they own (Taslim and Ahmed, 1992).

The most common tenancy arrangement in Bangladesh is share cropping tenancy, which accounted for 75% of the total leased land in 1983-84 and fixed rent tenancy accounted for another 10% (Taslim and Ahmed, 1992). These arrangements are particularly attractive for the households who do not have family members available for farming or can not afford all inputs necessary for farming. In contrast, if leased land is cultivated properly, this might provide a fairly long-term solution of employing households with excess labour. An emerging trend in recent years is that the share of land held by the small farmers are increasing suggesting that such small farmers is that 'small' farmers are the most efficient group (Khan, 2004).

The situation described above suggests that there are considerable opportunities for poor people's entry into aquaculture in Bangladesh, if appropriately planned (Edwards, 2002). An important, though often overlooked benefit which is particularly relevant for integrated agriculture-aquaculture systems in their contribution to increased farm efficiency and sustainability (Little and Muir, 1987; Seawright et al. 1998).

1.5 Understanding poverty focused aquaculture development in a broader context

Small-scale aquaculture mainly occurs in ponds. There is evidence that pond aquaculture has improved the welfare of poor households; livelihoods of poor households in North West Bangladesh were found to be enhanced for example (DFID, 1997). Integration of aquaculture with land-based systems in inland areas such as rice field and ponds is most appropriate for poor farmers because they can often be integrated with existing agricultural practice (Seawright et al. 1998). Low-cost production technologies are widely considered to be appropriate for the limited resource base of poor farmers and an additional benefit for food security is that the produce is affordable also to poor consumers (Edwards, 1999c).

1.5.1 Sustainable livelihoods

The word livelihood is used often and in many ways: alternative livelihoods, supplemental livelihood and sustainable livelihoods. The concept of livelihood is widely used in contemporary writings on poverty and rural development, but its meaning can often appear elusive, either due to vagueness or to different definitions being encountered in different sources. Livelihood means a ‘‘means to a living”, which suggests the way of living, rather than income or consumption (Chambers and Conway, 1992; Ellis, 2000a) defines livelihood as “ that comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living”. However, several researchers adopting a rural livelihoods approach have utilized this definition, with minor modifications (Ellis, 2000a).

Scoones (1998) has identified five main categories of capital as contributing to assets in the livelihood definition, namely, natural capital, physical capital, human capital, financial capital and social capital. Natural capital refers to the natural resource base (land, water, trees…etc) that yields products utilized by human populations for their survival. Physical capital refers to assets brought into existence through the economic production processes. Human capital refers to the education level and health status of individuals and populations. Financial capital refers to stocks of cash that can be accessed in order to purchase either production or consumption goods and access to credit might be included in this category. Social capital refers to the social networks and associations in which people participate, and from which they can derive support that contributes to their livelihoods.

However, adoption of a livelihood approach has been valued as a conceptual tool for clustering individuals into meaningful groups and collection of information to construct profiles by different institutes (Carney et al. 1999). Identifying and characterizing the poor or vulnerable households is crucial for designing and implementing actions to improve their situation and reduce their number. As policies and programs don't commonly target single individuals, it is necessary to identify meaningful groups for practical assistance. By choosing the livelihood system as a classifying tool, it is possible to cluster individuals with similar characteristics into groups that are subject to similar factors and processes affecting their poverty and vulnerability.

Vulnerability refers to the full range of factors that place people at risk of becoming food-insecure. The degree of vulnerability for an individual, household or a community can be determined by their exposure to the risk factors and their ability to cope with or withstand stressful situations. The livelihood approach has proved to be effective in analyzing the vulnerability status of individuals or households (FAO and University of Florence, Undated).

The successful management of available resources would go a long way towards greater food security and increased income. There are two generally recognized categories of interventions that could help raise productivity: firstly, to improve the natural environment; and secondly, to develop enterprises. The former is often considered as conservation, enhancement and rehabilitation while the latter is often referred to as livelihood (Platt and Wilson, 1999). These activities are closely inter-linked: one is either dependent or greatly affected by the other.

There is a need to see aquaculture as one aspect of rural development rather than as an isolated technology (FAO, 1997) and aquaculture for development as opposed to 'aquaculture development'. Potential contributions of aquaculture technology to alleviate poverty could be analyzed using the sustainable rural livelihoods conceptual framework (Carney, 1998).

1.5.2 Technology adoption

The specific factors significantly influencing the adoption of technologies are extension service, farmers' religion, agricultural labour force size, landholdings, types of land, farmers' training, household heads' education, participation in joint land management activities, demographic characteristics of farm households, social background etc (Rauniyar, 1998; Ison, 2000; Paudel and Thapa, 2004). If certain groups of farmers are not adopting improved technologies or are adopting them at a lower rate than other groups, then it is crucial to determine why, because only by understanding the reasons will it would be possible to develop appropriate technologies that are adoptable (Doss and Morris , 2001; Nederlof et al. 2004).

Adoption of aquaculture by new entrants has been poor in some areas, for a variety of reasons such as the perceived high risk or the inappropriateness of the technology that was introduced (Edwards and Demaine, 1997). The degree of adoption of technologies varies from one farmer to another, depending on several institutional, social and ecological factors. Adoption of new technology varies significantly because of farmers' access to information and necessary support (Geertz, 1963; Ervin and Ervin, 1982; Tiffen et al. 1994). Farmers might be interested to learn about improved agricultural practices from non-formal institutions like relatives and neighbours and adopt once it had proved to be beneficial for their livelihood.

Farmers adopt cultivation practices based on crop suitability, for instance soil of low water holding capacity may not appropriate for particular crops due to its lower water retention capacity which might be suitable for lower water dependent crops (Paudel and Thapa, 2004). Farmers located in flood and drought-prone areas of countries like Bangladesh do not tend to invest time and finance in at-risk land or water bodies to avoid probable crop loss. The adoption of different farm management may vary from village to village, community to community and even household to household in the same community (Thapa and Weber, 1990).

Farmers' agricultural labour force size, profession, age, religious, household head's schooling period and farmers' participation in joint land management activities are social factors significantly influencing the adoption of technologies (Cuffaro, 1997).

Households possessing tiny landholdings that provide very little income are less interested in agriculture. Agriculture is often the least preferred profession, where the farmer derives a considerable proportion of his income from pensions and remittances from overseas (Messesrchmidt, 1976; Vansittart, 1993; Biot et al. 1995). Adoption of farming technologies is low among poorer households since adopting a new technology often implies a need for additional labour (Feder et al. 1985; Dvorak, 1996; Little et al. 1996; Doss and Morris , 2001).

However, many adoption studies indicated that adoption of technology is not something that happens overnight, but rather that it is the end result of a sequence of stages. The most widely used characterisation of stages in connection with the adoption derives from (Del Ninno and Dorosh, 2001; Del Ninno et al. 2003). The model built heavily on normative theories about decision-making consisted of the following stages (Leeuwis and van den Ban, 2004);

Stage	Process
1) Awareness	of the existence of a new innovation or policy measure
2) Interest	to collect further information on it
3) Evaluation	of its advantages and disadvantages
3) Trial	testing innovations/ behaviour changes on a small scale
4) Adoption/acceptance	applying innovations/behaviour changes

(Modified from Leeuwis and van den Ban, 2004)

An important finding from adoption research was that innovations/technologies were not adopted by everyone at the same time, rather some quickly and only taken up later by others, while others never adopt them (Leeuwis and van den Ban, 2004). However, an individual/community/country that didn't adopt a technology or failed in the past to raise land productivity does not imply that they cannot do so in the future. Often yield growth has been the basis of agricultural progress, resulting in improved food security in many countries. However, supportive policies, particularly those augmented promotion and diffusion of improved technologies and policies or other conditions (e.g., well-functioning markets) that provided economic incentives for their adoption seem to have been at the root of such achievements (Alexandratos, 2005). Bangladesh, dubbed in the 1970s by Henry Kissinger as a “bottomless basket” is making surprising progress in terms of social development, such as infant mortality, child vaccination, and employment of women – a striking turnaround over the past decade, and the country’s much-praised microcredit scheme operated by NGOs mainly has lent money to millions of people. The GDP has grown by at least 5% for three years running, and Asian Development Bank predicts that the growth will hit 6.5% in 2006. All of these developments have taken place mainly due to supportive policies (Perry, 2006).

1.6 Food production in Bangladesh

In a subsistence-oriented agrarian economy such as Bangladesh, domestic food production has an important role to play for food security. Major items of food produce in Bangladesh includes rice, fish, vegetable, wheat, pulses and potato (Hossain et al. 2004). These food items account for almost 85 percent of the total calorie and protein intake with rice particularly important for calories and carbohydrates, and fish providing proteins, and other essential nutrients, such as essential fatty acids, iron, zinc, calcium, vitamin A and vitamin C (Akpaniteaku et al. 2005).

There is disparity between rural and urban areas for food intake in Bangladesh (Hossain et al. 2004). The consumption of food continued (1983-2000) to increase in rural areas than urban, but the total intake is still 11% lower in rural areas than the minimum requirement, and the deficit is mostly in the form of non-cereal food. For urban areas, total intake has declined in the 1990s and currently intake level is still 13% lower than the minimum requirement (Hossain et al. 2004).

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1.6.1 Agriculture

The performance of agriculture sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty generation, poverty alleviation, human resources development and food security. Rice is the main crop in Bangladesh and other important crops include vegetables, fish, tea, sugarcane, oil seeds, fruits, spices, wheat, potato, tobacco and cotton. During 1995-2000 the contribution of GDP from crops and vegetables declined from 15.03 to 14.59, and livestock from 3.36 to 3.02, forestry 1.93 to 1.88 %, but fisheries showed an increase from 5.36 to 6.09 % in the corresponding period and contributed more than 11% of annual export earning (Sinha, 2003) The growth of the total fisheries sector has however, increased only from 8% in 90s to 8.9% in 1990-2000, yet its' growth and economic return are reportedly far less than the potential (Mazid, 2002).

Government in Bangladesh support for agricultural development having a structure at Upazila level (UNCTAD, 2004), Non-government organizations (NGOs) are also important actors in this regard. NGOs are contributing enormously to the sustainable development of agriculture. They have pioneered a wide range of participatory methods for diagnosis have developed and introduced systems approaches for testing new technology (Farrington, 1998). For instance in Bangladesh new technology such as soya production has been developed by NGOs (Buckland and Graham, 1990) who have supported local groups to produce vegetable seed (Cromwell and Wiggins, 1993). Improved poultry production technology was promoted for women and the landless by the Bangladesh Rural Advancement Committee (BRAC) and Association for Social Advancement (ASA) (Sharma and Zeller, 1999). NGOs have also helped to organize landless labourers to acquire and operate water-pumping technology (Mustafa et al. 1993).

Given the importance of agriculture in the national economy and due to the existence of important linkage effects of agriculture growth on overall development, satisfactory growth in agriculture is a necessary pre-condition for accelerating overall economic growth of Bangladesh. It is often argued that sound agricultural credit policies, efficient management of agricultural credit, sound banking systems and efficient input management practices are the key elements for agricultural development and to increase food grain production in this country (Planning Commission, 2000).

1.6.2 Aquaculture

Aquaculture is one type of agriculture activity, which can be called a ‘water-based farming system’. Bangladesh is uniquely endowed with diverse, rich aquaculture and fisheries resources. Being a country of rivers and floodplains with a high potential aquatic resource, fish plays a very important role in daily life of many people of Bangladesh. The Bangladeshi expression “Mache Bhate Bangali”, “fish and rice make a Bangali”, reflects the importance of fish in their life.

In Bangladesh, historically people depended mainly on natural stocks in unmanaged waters for fish. Declining catches of such wild fish due to an increased fishing effort by the growing population as well as environmental degradation have led to increase culture of fish in enclosed waters. According to DoF (2005) Bangladesh is fortunate in having an extensive water resource in the form of ponds, natural depressions (*haors* and *beels*), lakes, canals, rivers and estuaries covering an area of 4.56 million ha. Aquaculture accounted for about 43.5% of the total fish production during 2003-4, with inland open fisheries contributed 34.8% (DoF, 2005). FAO (2005) ranked Bangladesh as sixth largest aquaculture producing country with its estimated production of 856,956 tonnes in 2003 (FAO, 2005).

There are an estimated 1.3 million fish ponds in the country, covering an area of 0.151 million ha, of which 55.3% is cultured, 28.52% has good potential for culture and 16.18% is currently unused, but which could potentially also be brought under fish culture. In 2002 the percentage of production from the above three systems was 72.09, 20.01 and 7.90 respectively (BBS, 2002). At present the annual average fish production using pond culture is 2609 kg/ha (DoF, 2005). Over the last decade aquaculture in Bangladesh has grown by ~20% per annum (Muir, 2003).

The fisheries sector is considered to be a thrust sector for sustainable development and socio-economic advancement of rural fishermen and fish farmers (Mazid, 2002). Presently 1.4 million people are engaged full time and 11 million people indirectly earn a living through involvement in fisheries related activities, including the collection of seed, distribution, marketing, processing, exporting, and financial and technical support (Mazid, 2002). An estimated 9.5 million people (73% of rural people) are involved subsistence fisheries on the countries flood plains (Azim et al.

2002). There are 3.08 million fish farmers, 1.28 million inland fishermen and 0.45 million fry collectors (fish and shrimp) in Bangladesh (Mazid, 2002; DoF, 2003).

Fish production in Bangladesh is mainly a household level enterprise and has good prospects for women participation (Shelly, 1998). Fisheries activities in which women are involved include: (a) net making; (b) product processing; (c) shrimp fry collection; (d) fish-feed preparation; (e) fish drying and salting. In the commercial shrimp processing industry, women play an important role, principally as wage labours taking on tasks such grading, processing and packing products. The above review reflects the importance of aquaculture in all aspects of livelihoods of Bangladeshi people as a source of food and nutrition, employment and income generation.

There is great potential to intensify current aquaculture production with proper scientific practice as the production of normal farmers' ponds is three times less (except some commercial farmers) than that of research ponds and still, a large part of inland and coastal waters are not scientifically managed to realize the potential (Mazid, 2002). Sixty percent of the animal protein consumption comes from fish, on average 32 g of fish /person/day or 5.6 g of fish protein/person/day (one kg of fish contains 17-18% protein) (Graaf et al. 2001).

However, there is a large gap between rich and poor people in the reported average fish consumption. The poor are not able to afford to consume sufficient amounts of fish and suffer from malnutrition (World Bank, 1991). Alongside fish, low intake of vegetables, fruits, pulses and animal products is a primary cause of micronutrient malnutrition, and contributes to poor resistance to infectious diseases (IFPRI, 1998).

Promoting horticulture has been considered as a long-term sustainable approach to reducing the prevalence of micronutrient deficiencies (Johns et al. 1992; de Pee et al. 2000).

1.6.3 Vegetable cultivation

Based on the growing season, vegetables are categorized as summer/ monsoon (May to October) season vegetables, winter season (November to April) vegetables, and all-season vegetables. Of the summer vegetables, various cucurbits, vegetable cowpea, hyacinth bean, stem amaranth, several aroids and Indian spinach are predominant. Winter vegetables include tomato, cabbage, Chinese cabbage, cauliflower, eggplant, carrot, spinach, bottle gourd, bush bean and radish. Crops like okra, heat-tolerant tomato, eggplant, carrot, spinach, many leafy vegetables and small onion are grown all year round (Weinberger and Genova, 2005). The production of vegetables is higher during the winter months (60 to 70% of total production of a year), though little produce is stored or preserved by households (Safilios-Rothschild and Mahmud, 1989; Talukder et al. 1997).

Vegetable production in Bangladesh has increased between 1980 and 2003 at an average annual growth rate of 2.8% (Weinberger and Genova, 2005). Most of this growth can be attributed to expansion in cropping area (2.6%) and only a small share to yield increases (0.2%). The share of area under vegetable cultivation in total arable land has nearly doubled from 1980 to 2002, from 1.9% up to 3.6 % (Weinberger and Genova, 2005). Several policy measures contributed to this increased growth, among them: (1) expansion of irrigation favoured greater land utilization during the dry season; (2) increased availability of improved variety seeds and fertilizer; (3) increased availability of credit; (4) greater dissemination of extension messages regarding profitability and marketing prospects, and (5) development of an improved transport/communication network (ADB, 2001).

Despite these policies and an increasing trend in production, about 80% of families in Bangladesh consume less than the minimum recommended daily requirement of vegetables and fruits (Taher et al. 2004). Per capita consumption of vegetables in Bangladesh is still one very low (50 g/person/day) and below the levels recommended amount (200 g/person/day) by WHO and FAO (West et al. 2002; Hossain et al. 2004; Bushamuka et al. 2005).

However, attempts have been made by projects/organizations in Bangladesh to promote vegetable cultivation alone and integrated with other farming components (such as pond and livestock) to meet the gap between need and demand, and improve households food and nutrition security as well as increase income (Little and Muir, 1987; Weinberger and Genova, 2005). The high productivity possible even in the small areas of land mean that even ‘landless’ people can grow vegetables. Such ‘homestead’ vegetable gardening has emerged as a potential strategy in recent studies (Bouis, 2000; Davidsson and Honig, 2003) for poverty focused intervention. HKI’s (Helen Keller International) vitamin A survey in rural Bangladesh showed that children of households without a home garden were at greater risk of vitamin A deficiency than children of households with a home garden, especially when neither of them had recently received a high-dose vitamin A capsule (Talukder et al. 2001).

Seventy-four percent of the poorest households own a homestead area in Bangladesh; they use it to cultivate vegetables that are an important part of households diet and the major source of minerals and vitamins (DFID, 2002). In Bangladesh, 50 percent households are functionally landless (Haylor and Bland, 2001). Landless households having a small piece of land in the homestead area has special significance in the context of Bangladesh. This is the place from where a substantial amount of family nutrition is derived (Bouis, 2000). Due to a shortage of agricultural land integrated homestead farming may be a good strategy for improving the life quality of the poor.

1.6.4 Integrated farming systems

'The word "integrated" is derived from the Latin "integrare" which means to make whole, to complete by addition of parts, or to combine parts into a whole' (Edwards et al. 1988). Integrated farming systems cope with the changes farm level, in a manner that balances food production, profitability, safety, animal welfare, social responsibility and environmental care (Little and Muir, 2003). Integrated farming seeks to reinforce the positive influences of agricultural production whilst reducing its negative impacts. It is a means of achieving sustainable agriculture and a crucial part of sustainable development.

The term integrated farming has been used for integrated resource management which may not include either fish or livestock components of the farm (Little and Edwards, 2003). In Asia, many farmers have been practicing integrated farming through their experience over generations. It has been a traditional way of subsistence livelihood of small-scale farmers in Asia (Marten, 1986). Little and

Muir (1987) distinguished simple from multi-component integrated systems; the former are characterized by only a single link such as crop/fish or livestock fish and the later by containing three or more linked components, including the use of commercial inorganic fertilizers and nutritionally complete or formulated feed (Edwards, 1998). Patterns of integrated farming practiced in Asia include crop-livestock, livestock-fish, crop-fish, and crop-livestock-fish systems (Hutanuwatr, 1988; Little and Edwards, 2003). The many types of integrated farming systems are characterized by the term integrated agriculture-aquaculture (IAA) systems (Little and Muir, 1987; Little and Muir, 2003).

Evaluation of integrating farming systems presents options for improvement of Low External Input Agriculture (LEIA) which may pave the way for a sustainable agriculture (Pant, 2002). It is a challenge to build proper linkages among the sub-systems of small farms, especially for a poor family in a relatively less developed rural area. To do so, fish ponds need to be integrated as much as possible with existing farming activities (Wahab et al. 1997).

1.6.5 Integrated Aquaculture and Agriculture systems

IAA systems occur when an output from one subsystem in an integrated farming system, which otherwise might have been wasted, becomes an input into another subsystem resulting in a greater efficiency of output of desired products from the land/water and are controlled by a farmer (Little and Muir, 1987; Edwards et al. 1988). Integrated farming involving aquaculture defined broadly is the concurrent or sequential linkage between two or more activities, of which at least one is aquaculture (Little and Edwards, 2003). The concept of integrated aquaculture is not new, possibly started first in densely populated parts of Asia and Central Europe and has been recognized as having potential for improving the position of the rural poor (Little and Muir, 1987). Integrated aquaculture can also be defined as fish culture closely integrated into the energy and nutrient pathways of conventional farming systems (Mathias et al. 1998) and more broadly to link aquaculture with human activities other than agriculture (agronomy and animal husbandry) such as management of water resources, industry and sanitation (Muir, 1981; Ryther, 1983; Little and Muir, 1987; Wahab et al. 1997).

The key characteristic of integrated agriculture-aquaculture systems is the flow of resource or synergisms among subsystem in such systems (Little and Muir, 1987; Ruddle and Zhong, 1988; Edwards, 1993; Lightfoot et al. 1993a; Dalsgaard and Prein, 1999; Prein, 2002). Integrated farming that includes aquaculture can be broadly defined as the concurrent or sequential linkages between two or more activities, of which at least one is aquaculture (Mukherjee, 1995). The advantages and purposes of the integration are increased diversification, intensification, improved natural resource efficiency, increased productivity and increased sustainability (Dalsgaard and Prein, 1999; Prein, 2002).

A wide range of integrated agriculture-aquaculture systems are practiced in south and South East Asia, for example in Bangladesh, China, India, Indonesia, Malaysia, Thailand and Vietnam (Pullin and Shehadeh, 1980; Little and Muir, 1987; Ruddle and Zhong, 1988; Guan and Chen, 1989; Edwards, 1993; Symones and Micha, 1995; WES (West-East-South program), 1997; Mathias et al. 1998; Rothuis et al. 1998; Dalsgaard and Prein, 1999; FAO, 2001; Prein, 2002). Integrated fish systems, using grass and aquatic plants as fish feed, are commonly found in many parts of

China (Yang et al. 2001). Traditional Chinese IAA system follows the concept of ecological agriculture emphasizing the relationship between agroecosystem with their natural and social environments (Luo and Han, 1990). In Africa, integrated farming systems can be found in Ghana and Malawi (Prein, 2002). In Europe IAA were developed and used in countries like Hungary and Germany (Buck et al. 1979; Sharma and Olah, 1986).

The IAA system types ranges from as simple a rice-fish integrated systems to as complex as crop-livestock-fish integrated systems. Traditional small-scale IAA systems involving crops, livestock and fish are believed to have evolved in China before the ninth century (Luo and Han, 1990; Edwards, 1993). In Malaysia, integrated farming has been practiced since 1930s, with the production of fish in paddy fields and pig-fish in ponds (Ahmad, 2001). In India, integration of fruit and vegetable farming on the fish pond dike have been demonstrated (Tripathi and Sharma, 2001). From the ninth century, records show fish farming in the paddy field in China. From the fourteenth to sixteenth centuries, there were records of rotation of fish and grass culture; and by the 1620s, the mulberry-dike fish pond (Luo and Han, 1990; Luo, 1993), the integration of fish and livestock farming and complex systems of multiple enterprises integrated with fish farming were developed (Little and Edwards, 2003).

Livestock-fish integration had received considerable attention in the past, though most livestock-fish integrated systems promotional programs failed to take into account the existing farming systems. For example, feedlot livestock-fish, poultry-fish, or pig-fish integration are often promoted uncritically as a means to improve the welfare of small-scale resource poor farms in Asia (Wahab et al. 1997; Little and Edwards, 2003). Such systems virtually rely on costly formulated feed, and therefore, rarely succeed on small-scale resource-poor farms (AIT, 1994; Edwards et al. 1996; Little and Edwards, 1999; Little and Edwards, 2003). On the other hand, livestock waste from non-feedlot traditional on-farm systems are not generally used successfully for ponds as farmers often use ruminant manure for fuel, house building and also use to fertilize field crop (Little and Edwards, 2003). Collection of waste may also not be convenient , especially if animals are raised free-range , without a pen to contain their wastes (Prein, 2002; Little and Edwards, 2003).

However, among all of the integrated systems, aquaculture-horticulture systems (rice-fish, pond-dike, grass-fish, hydroponics, fish pond-raised field systems etc) are probably most commonly practiced system in Asia. There has been considerable promotion of rice-fish culture in past two decades (Cruz, 1980; Huat and Tan, 1980; Singh et al. 1980; Little et al. 1996), though many efforts have been constrained by a lack of large-sized fingerlings and inadequate labour (Little et al. 1996). In Vietnam, VAC (Vuon-Ao-Chuong=garden-fishpond-animal stall/pig-sty) integrated systems has been practiced by a large number of small-scale farmers in Red River Delta for ages (Chung et al. 1995). These VAC systems, probably originated from China, are fascinating models of traditional IAA systems, as they are highly diversified, intensive, and strongly integrated. Hutanuwatr (1988) has listed quite a number of IAA systems practiced all over Asia whilst types and composition of these traditional systems are largely influenced by socioeconomic and biophysical settings, however, in general, bovine/swine–fish–crop systems and poultry–fish–crop systems are two major IAA systems practiced in Asia.

Promotion of IAA has often been part of promoting aquaculture to resource poor farmers in Bangladesh. In Bangladesh several initiatives has been taken for the promotion of IAA such as integrated rice fish (Haroon et al. 1992; Ali et al. 1999; Bhuiyan, 1999), poultry-fish (Ali et al. 1995; Samsuzzaman, 2002), duck-cum-fish (Ali et al. 1995) and duck-weed-fish based (Wahab et al. 1997; Azim and Wahab, 1998) farming systems. Farmers in Mymensingh district expressed satisfaction with the integration of aquaculture and other farm enterprises and planned to continue and expand short-cycle aquaculture, using fish species such as silver barb (*Barbodes gonionotus*) and Nile tilapia (*Oreochromis niloticus*) in seasonal (4-6 months), small (100-200 m^2) ponds, integrated into the existing agricultural production system (Ahmed, 1992; Gupta et al. 1992).

IAA systems have been most developed in parts of China. Various types of integrated 'fish pond-raised field systems' have been practiced by a large number of farmers in the Pearl River Delta of China. Delmendo (1980) stated that land and water resources planning in China, recognizing the role of pond in traditional integrated farms, has led to aquaculture being considered an integral component of agricultural development for many years. In the pond, polyculture of a number of herbivorous and omnivorous fish species was common, while a wide range of crops (fruits, vegetables, flowers or grasses) were grown in raised fields. The pond may provide various benefits to farms in addition to fish culture such as water storage and soil fertility management. Ponds can be used to process many forms of agricultural waste, including livestock and human manure and convert this manure into high-grade fish protein. Ponds and crops can be integrated using crops and crop residues as feeds and fertilizers for fish; and using pond sediments and water as crop fertilizers and irrigation water, respectively (Ruddle et al. 1983; Little and Muir, 1987).

1.6.6 Pond-dike systems: status, prospects and constraints

The pond-dike system, where fish are raised in ponds and crops are grown on the dikes or in the immediate vicinity of the pond, is well known for its ability to maximize energy input and minimize wasted energy output through the recycling of organic wastes among components of the system (Ruddle and Zhong, 1988; Little, pers.comm., 2006). The system integrates agriculture and aquaculture, two separate component of farming systems into one physically linked ecosystem (Lo, 1996).

Historical records reveal that the pond-dike system can be traced back to the 5th century B.C. with mulberry cultivation and fish farming (a system in which plants, silkworms and fish live in a mutually dependant and beneficial ecology); however, the widely developed pond-dike system did not appear until the 16^{th} century (NACA, 1989). The dike-pond system was first found to occur in the Zhejiang and Jiangsu region, at the lower course of the Yangtze River in China, but the interactive nature of the system was not appreciated at that time (Lo, 1996). The pond can be considered as the ecological heart of the Zhujiang Delta dike-pond system (Ruddle and Zhong, 1988).

People of the Shunde County in the Pearl River Delta, Chain, are involved in mulberry dike fish pond system since long because of its central location of the delta, its extensive laying land and excellent water transportation and used to export silk. But after 1926, the silk trade suffered a severe decline on the international market. Eventually this practice is now vanishing rapidly due to increase pressure coming from coastal area development projects for industrialization and urbanization purposes. At present, some of the mulberry dyke fish ponds in the delta have been transformed to sugar-cane dyke fish ponds due to the recent industrialization and resulted changing labour demands (Lee, 2004).

Integrating an aquacultural component into agricultural farming systems results in pond-dike systems, which are self-sustaining, efficient and ecologically sound, producing a diverse range of products on a sustained basis (Ruddle and Zhong, 1988; Lightfoot et al. 1996). Fish farming and crop cultivation can be combined because on the one hand, abundant silt deposited in ponds leads to deterioration in the water quality and, on the other hand, pond silt is a high quality input for crop cultivation (NACA, 1989). In principle fish-cum crop integration increases the number of feed and fertilizer sources and improves self-sufficiency of feed/fertilizers (NACA, 1989).

Integrated pond-dike systems have met with variable success in different parts of the World (Little and Muir, 1987). Traditional management of pond-dike systems in China show an intensive nutrient cycling over the pond-dike interface, resulting in a much higher nutrient retention of 50-70 % in the combined crops of aquatic and terrestrial produce (Gongfu et al. 1997) but such practices are relatively rare elsewhere (Little, 2006, Pers.com.).

In Bangladesh, vegetables were produced on pond-dikes with better economic benefit compared to fish culture alone (Shamsuddoha and Janssen, 2003). It was observed that poorer households preferred adopting aquaculture systems with vegetable cropping in dykes, while richer people practiced input based carp polyculture in Bhola Island, Bangladesh when freedom was provided to choose any of these two systems. In the integrated pond-dike systems, poorer households irrigated vegetable gardens with pond water while fertile run-off further enriches pond water fertility, additionally grass carps were fed with vegetable leaves raised on dikes (Shamsuddoha and Janssen, 2003).

However, in the above context, intensification of vegetables cropping in the homestead area integrated with a fishpond appears valid. It has high potential for improving rural and peri-urban livelihoods for the small-scale poorer households (Talukder et al. 2001; HKI, 2003). However, the system has not yet been sufficiently researched for further development (Korn, 1996) from its traditional basis.

1.6.6.1 Management of farm nutrients

Ponds need nutrient inputs to produce fish. Higher production can be achieved with greater amounts of nutrient inputs. On small farms these inputs are available mainly in the form of wastes from crops and other plants, as farming in Asia is crop dominated (Little and Muir, 1987; Dalsgaard and Prein, 1999). Manure from ruminants have a high carbon to nitrogen ratio, and are less useful as a pond inputs unless balanced with alternative nitrogen sources. A major constraint to the widespread use of ruminant manure in fishponds is related to alternative uses as a fertilizer for crops and as a fuel source, particularly in South Asia. Small-farm systems are usually nutrient limited and are not over-fertilised (Edwards, 1993; Dalsgaard and Prein, 1999).

Fertilizers and feeds are applied to ponds to promote shrimp and fish production, and normally, no more than 25% to 30% of the nitrogen and phosphorus applied to ponds as fertilizers and feeds is recovered in fish or shrimp at harvest (Boyd, 1995b; Korn, 1996). Ponds have a remarkable ability to assimilate nitrogen and phosphorus through physical, chemical, and biological processes (Schwartz and Boyd, 1994b). Nevertheless, ponds often have higher concentrations of nutrients, plankton, suspended solids and oxygen demand than the water bodies into which they discharge (Schwartz and Boyd, 1994b). Increased enterprise diversity may enhance opportunities for increasing nutrient linkages, and a possibility to meet increased nutrient requirements for enhanced production.

1.6.6.2 Nutrient rich pond water, a potential source for crop irrigation

Manipulation of water quality is a major tool in aquaculture (Diana et al. 1997). The suitability of pond water for aquaculture as well as for irrigation in vegetables or other field crops depends on the water quality. Many studies revealed that pond water is a good source of nutrients (William and Robert, 1992; Diana et al. 1997); it is a complex of nutrients, suspended organic material, living microorganisms including phytoplankton and zooplankton etc. Most of the nitrogen and phosphorus are contained in plankton cells and other particulate matter (Boyd, 1985; Daniels and Boyd, 1989). Nutrient parameters of pond water vary depending on the management strategy of aquaculture system. The concentration of soluble phosphorus and total nitrogen in the water increases over time up to a saturation level with greater feeding or fertilization rates (Boyd, 1985).

The nutrients entering the pond from the household, homestead gardens, surrounding embankments, livestock sheds, poultry droppings, fish faeces, and fish metabolites stimulate the production of large amounts of organic matter in the form of phytoplankton. A large fraction of the nutrients contained in fertilizers and feeds applied to ponds are trapped over time in the pond sediments.

1.6.6.3 Nutrient rich pond sediments, potential source of crop fertilizers

Pond nutrient budgets from literature show that 30-95% of the nitrogen applied to ponds accumulates in the sediment (Schroeder, 1987; Myint et al. 1990; Olah et al. 1994). Higher fractions of phosphorous compounds, which are highly insoluble in water, end up in the sediment (Boyd, 1995a). Traditional pond-dike systems in Asia show an intensive nutrient recycling over the pond-dike interface, resulting in a much higher nutrient retention of 50-70% in the combined crops of aquatic and terrestrial produce (Gongfu et al. 1997). Nitrogen, phosphorus and potassium are the three major nutrient elements available in sediment, and the value of these nutrients is potentially high (Voss et al. 1999). There has been relatively little effort to correlate properties of sediment with the production of fish or shrimp and surrounding crops.

Usually the bottom soil of a newly constructed pond is low in organic matter which is the storehouse of different nutrients, especially nitrogen. Once the pond is filled with water and stocked with fish, organic matter from uneaten feed, application of manure, dead plankton, and fish excrement continually reaches the pond bottom. Uneaten feed, dead plankton and fish excrement are high in nitrogen. The organic matter in ponds is largely derived from decomposition of plankton and the accumulation rate of organic matter is important for sediment management in tropical aquaculture ponds (Boyd, 1995b).

It has been shown that sediments deposited in fishponds with little organic input are not useful as crop fertilizers (Christensen, 1989). The amount of organic matter input may not be a problem in semi-input /intensive systems where organic matter inputs through feed are high. Organic matter accumulation rates of 100-1500 g/m2/day have been reported for intensive tilapia ponds in Israel (Avnimelech et al. 1995). In China, low quality agricultural wastes are applied to ponds to enhance sediment quality (Ruddle et al. 1983). But accumulation of organic matter in pond soils during the grow-out cycle causes severe oxygen depletion at the sediment-water interface (Boyd, 1990). Loading of organic matter in the pond environment should not exceed the carrying capacity of the pond to absorb and utilize the nutrients.

Removal of pond sediment can be labour intensive and its practicability is questionable however perhaps explaining the limited use of pond sediment (Edwards et al. 1986). In south China, sediments are removed while the pond is full with water and fish are being cultured using sludge pumps (Little and Muir, 1987). Manual sediment removal is labour intensive and if removal of sediments occurs after pond drying volatile nutrients, especially nitrogen are lost as ammonia.

It is generally accepted that the behaviour of small scale farmers in developing countries is 'economic', however factors such as location, production systems, supply, demand, marketing systems are also important which affects both better off and worse off households livelihoods (Edwards and Demaine, 1997). However, there is a need to assess the role of pond-dike system in livelihoods of better off and worse off farming households and to understand the importance of location. Most aquaculture has urban stimuli in Asia and elsewhere probably because of resource availability (Little and Bunting, 2005 ; Little, pers. comm., 2006).

1.6.7 Linkage between urban and peri-urban agriculture/aquaculture

Aquaculture, in general is associated with rural areas, though typically aquaculture has strong linkages with urban locations (Little and Bunting, 2005). The rapid development of urban aquaculture has been stimulated by access to markets and information, and availability of wastes. In contrast rural areas often lack nutrients restricting the productivity of fish culture (Little and Bunting, 2005). Urban aquaculture in Asia has been characterized by the reuse of waste and wastewater (Little and Bunting, 2005).

Urban, peri-urban and rural areas are interlinked however. Dwellers of urban cities such as in Dhaka 'suck in' huge amounts of food and depend largely on surrounding peri-urban areas for food supplies. Peri-urban and rural locations with good marketing access and communications provide opportunities for the poor people to migrate to the urban areas for better employment (Islam et al. 2004; Little, pers. com., 2006).

In principal urban and rural areas can enjoy mutual benefits. Urban aquaculture typically has many linkages with rural aquaculture, especially through exchange of products, labour and knowledge. For instance, it was reported that small carps and tilapias produced on feed-lot livestock waste around Bangkok are marketed to poor people in rural areas of the country (Little and Bunting, 2005). Improved urban management does not imply neglecting rural development, urban and peri-urban households acquire benefit when agricultural productivity increases in the rural areas while rural areas benefit from the growth of the cities which provide markets for agricultural products (Little and Bunting, 2005). It should also be recognized that rural-urban links may also have negative consequences. For example, increased agricultural production to satisfy urban demand may deplete environmental capital, urban expansion may compete for rural resources, such as land and water, and urban growth is likely to generate increased waste and pollution (Rakodi, 2002).

Urban aquaculture may be defined as the practice of aquaculture occurring in urban settings, or areas subject to urbanization, incorporating by definition, peri-urban areas (Bunting and Little, 2003), while peri-urban environments and communities share many facets with those areas regarded as urban. Usually the transition from urban to peri-urban to rural communities is regarded as a continuum (Laquinta and Drescher, 2000).

Peri-urban agriculture/aquaculture provides good access to food; a source of income and good quality food at low cost for the poor; and offers the possibility of savings and returns on investment for middle income families (UNDP, 1996). In addition, peri-urban agriculture can complement rural agriculture and increase the efficiency of national food supply in a number of ways (Drescher, 2000). For instance, products that rural agriculture cannot supply such as perishable products, exported crops that require delivery upon harvest might be produced in the peri-urban areas, while reducing pressure to cultivate new rural land, relieving stress on marginal rural lands.

In many rural areas where demand and markets for aquatic products are limited, it is common for producers to adopt extensive aquaculture practices, or semi-intensive approaches, but with only selected or restricted intervention, while in the peri-urban areas, access to larger markets and more consistent and reliable demand, mean producers are more likely to invest in a wider range of semi-intensive or intensive management strategies (Bunting and Little, 2003).

In almost all countries, the conditions in terms of personal consumption and access to education, health care, potable water and sanitation, housing, transport, and communications faced by the rural poor are far worse than those faced by the urban poor (Khan, 2001). Persistently high levels of rural poverty, with or without overall economic growth, have contributed to rapid population growth and migration to urban areas. In fact, much urban poverty is created by the rural poor's efforts to get out of poverty by moving to cities. Distorted government policies, such as penalizing the agriculture sector and neglecting rural (social and physical) infrastructure, have been major contributors to both rural and urban poverty (Khan, 2001). However, recently, both public and private agencies such as government departments, development agencies, nongovernmental and civil society organisations and research institutes emphasising institutionalization of "participation" in both rural and urban contexts to alleviate poverty (Pimbert, 2004).

1.7 Participation

Participation means taking part in an activity. People "participate" in rural development everyday through their family life, livelihood activities and community responsibilities. The degree of control that men and women have over these activities varies. Participation means not just sharing the work, but also sharing decision-making the control of benefits (Lawrence, 1998). However, control over the rationale for participating and the degree of participation is the choice of the individual (Ira, 1998).

Conceptually the terms ‘participatory’, ‘participation’ and ‘participant’ creates space for a range of applications, as well as confusion (Stoop et al. 2002). In the field of agriculture, Biggs (1989) distinguishes four modes of participation viz. contractual-people are contracted into the projects of researchers to take part in their enquiries of experiments; consultative-people are asked for their opinions and consulted by researchers before interventions are made; collaborative-researchers and local people work together on projects designed, initiated and managed by researchers; collegiate- researches and local people work together as colleagues with different skills to offer, in a process of mutual learning where local people have control over the process.

A more people-centered paradigm began to emerge as opposed to commodity or technology focused development in the mid-1970s, after experiencing top-down administrative and centralized decision making process (Stoop et al. 2002). The main goal of these progressive efforts was poverty reduction and empowerment of vulnerable groups. The democratization movements of the late 1980s and early 1990s in Africa, Latin America and Eastern Europe further expanded the scope and meaning of participation and empowerment (Martin and Sherington, 1997). Thus, participation denoted the active involvement of a significant number of persons in situations or actions which enhanced their well-being.

The role or contribution of participation in research is a matter of considerable debate. Participation has been defined to include passive participation, participation in information giving, participation in consultation, participation for material incentives, functional participation, interactive participation, and self-mobilization. The first four types are superficial and have no significant impact on people's live (Pretty, 1994). There are no blue-print prescriptions for ensuring participation and empowerment, rather is largely determined by the socio-political, cultural, ecological and economic contexts within which individuals and communities live.

1.7.1 Participatory research

Participatory research is theoretically situated at the collegiate level of participation and under real field conditions; it is unusual (Cornwall and Jewkes, 1995). There are lots of differences between participatory research and conventional research, for instance participatory research focuses on process whereas conventional research emphasized on outcomes (Stoop et al. 2002). Most conventional research is contractual.

Researchers in the 1980s recognized the need to understand the complexity of farming systems in poorer areas, and developed an applied approach known FSRE (Farming System Research and Extension). The development of participatory research methods has increased options for researchers to explore complementary approaches, for example by introducing some participatory elements into on-station work and linking on-station trials with farmer designed and managed investigation (Sperling et al. 1993). There is much to be learnt from the interaction between farmers' research and formal research, because participatory research can draw on both indigenous and scientific knowledge systems. One manifestation of indigenous knowledge is in farmers' experimentation and technology adaptation. There is a consensus in the literature on the importance of farmers' research activities, but there are differences of view on how 'support' might be provided. Some advocate training farmers in small-scale experimentation (Bunch, 1982; Ashby et al. 1995), others support farmers' own experimentation by providing information or materials.

A claim in much of the literature is that participatory research allows researchers to gain a better understanding of the role of technology in complex systems (Martin and Sherington, 1997). Practitioners of participatory research argue that it shortens the time between the productions of new ideas or technology on research stations and the opportunity for farmers to test, utilize and reflect back on performance (and sometimes reject inappropriate recommendations before more time and resources are wasted). Only higher levels of participation can lead to sustainable results (Pretty, 1994), although there is no 'best' level of participation (Okali et al. 1994), it has been advocated to 'hand over the stick' as much as possible (Chambers, 1994).

There has been a tendency among participatory researchers to assume that statistical methods are only applicable to formal, researcher-managed work. However, numerous features of data analysis in collaborative participatory research (e.g. analysis of trials where input levels and environments vary among sites) are now amenable to modern statistical methods, including techniques for the analysis of categorical (qualitative) data. Many of the statistical approaches to experimental design and sample selection are also relevant (Silverman, 2000). One of the most important challenges for maintaining a dynamic and relevant FPR (Farmer

Participatory Research) programme is for it to be situated in a sustainable institutional context.

‘Participation’ and ‘participatory’ are commonly used terms in the recent research and development world; however, differing perceptions and interpretations exist of what it constitutes. A wide disparity between actively engaging people in research and development decision-making processes or simply informing them of the process has been reported by Biggs (1989) and Pretty et. al. (1995). Therefore, the degree to which participation can be considered ‘empowering’ or ‘enabling’ is worthy of some element of questioning. However, the roles of formal and non-formal institutions are crucial for accelerating participation of farmers and researchers in the research and sustainable development.

1.7.2 Institutions as a vehicle to share learning and communication

According to the well-known definition by North (1990), institutions are the “rules of the game in society”. This includes the legal system, as well as the rules, habits and customs that define patterns of behaviour and shape human interaction. The problem of the definition of organizations and institutions are frequently confusing, which is not always very clear in many studies. Organizations are entities composed of people who act collectively to attain shared objectives. However, if institutions are the rules of the game, organizations are the players (Coriat and Weinstein, 2002). Organizations and individuals pursue their interests within an institutional structure defined by formal rules (constitutions, laws, regulations, contracts) and informal rules (ethics, trust, religious precepts, and other implicit codes of conduct). Organizations, in turn, have internal rules (i.e. institutions) to deal with personnel, budgets, procurement, and reporting procedures, which constrain the behaviour of their members (Burki and Perry, 1998).

Institutional or social learning are less familiar but equally important concepts, refer to the learning that takes place among individuals in different organizations and groups who work together to achieve a common end. Non-governmental organizations have also stressed the importance of internal learning as a means to develop individual and organizational capacity and to empower local groups (Kibel, 1999). The importance of institutional or social learning has been emphasized by those concerned with agricultural innovation and with complex social and environmental processes, such as community-based management of natural resources (Engel and Carlsson, 2002; Hall et al. 2002)

Government and international supported projects such as Kapasia Project (ICLARM) and MAEP (Mymensingh Aquaculture Extension Project), partly through engaging local institutions, showed tremendous success in the development of aquaculture sector in Bangladesh during 1990-1994. Afterwards TLEFP (Thana Level Fisheries Extension Project) supported by the Government of Bangladesh started implementing from 1994 and later on NFEP (Northwest Fisheries Extension Project) launched from 1996 as a continuation of the 1st phase started from 1988 and ended in 2001. The Government of Bangladesh had launched 'Patuakhali Barguna Aquaculture Extension project (PBAEP), supported by DANIDA (Danish International Development Agency) through its technical assistances in cooperation with the Department of Fisheries (DoF) of the Ministry of Fisheries and Livestock (MoFL), since 1997 to strengthen the socio economic status and physical well-being of the men and women and improve their participation in social and economic development as well.

The PBAEP emphasis on community based fisheries management (CBFM) in coastal area through Integrated Pond Farming (IPF) activities, integrating fishpond and dikes. Another project GNAEP (Greater Noakhali Aquaculture Extension Project) began in July 1998 as a conventional transfer of technology aquaculture extension programme developed by MAEP.

Broadly, the outcome of these projects have been positive in terms of adoption, adaptation, farmer capacity building, increased productivity and income generation (Thompson et al. 2006). For instance, providing training to fish seed traders by NFEP-2 project contributed to the development of aquaculture in the northwest region of Bangladesh (Government of Bangladesh (GoB) report, 2000). Additionally, around 312 NGOs are active in the fisheries development activities in this country (Islam and Barman, 2004).

Alongside formal institutions, informal groups, cooperatives have played significant roles to promote development activities; development of local networks to disseminate information is therefore advocated (Sen et al. 1997). Lack of access to information and limited knowledge about aquaculture are primary and probably the largest constraints for aquaculture to contribute to the improved welfare of poorer households (Edwards, 1999a). The institutional context for promoting the use of pond-based agricultural diversification is often problematic. Research has rarely focused on this issue, however, is directed in this study as one of the crucial factors for the development and adoption of integrated farming systems.

1.8 The Pondlive project

The PondLive project, funded by EC was implemented in 2001 at sites in three countries of Asia: Bangladesh, Thailand and Vietnam. The partners involved include Wageningen University (Co-ordinator, Netherlands), Bangladesh Agricultural University, Mymensingh (Bangladesh), Can Tho University (Vietnam), Sisaket College of Agriculture and Technology (Thailand), Asian Institute of Technology (Thailand) and University of Stirling (United Kingdom).

The major objectives of the Pondlive project -

- At the system level, the main objective is to analyze the impact of pond aquaculture on the livelihoods of Asian farming households; and the potential to enhance the role of aquaculture ponds in nutrient cycling on farms.
- On the policy development and dissemination level, the main objective is to contribute to policies for enhancing the adoption of new aquaculture technology that are based on the livelihoods context of farm households and participatory approaches.
- In the area of developing tools, the main objective is to create a model for nutrient cycling in pond-dike systems that can be used in technology development and policy making for increased nutrient efficiency on integrated agriculture-aquaculture systems.

In Bangladesh, the project was based in Mymensingh, a District in which the majority of the agricultural systems in the country can be found and also the location of the Bangladesh partner, Bangladesh Agricultural University. The research was carried out within a livelihood framework to ensure that the impact of pond-dike systems was evaluated not only in terms of productivity, but also in terms of employment opportunities, well-being, improved resilience, and sustainability of the resource base. Apart from the on-farm research activities that aimed to develop improved pond-dike management systems, parallel data analysis and bio-economic modelling, supported by on-station research was carried out by the other partners. Research results were placed in a wider conceptual framework as part of an on-going process from the start of the project with a range of stakeholders including policy makers and extension agents. The author of this study was responsible for day-to-day project implementation in Bangladesh under supervision of principal (UoS, Stirling) and local supervisors (BAU, Bangladesh).

1.9 Rationale of the research

Fish yield alone is too narrow a criterion to measure the success of pond-dike systems development. There is evidence that ponds contribute to farm production and the livelihoods of producer households in a variety of ways: e.g., food security, water storage, sanitation or comfort. The role of ponds in water conservation and on-farm nutrient use efficiency is hypothesised as central. Researchable issues surrounding the development of pond-dike systems to improve people's livelihoods therefore require an interdisciplinary approach.

Research that is appropriate, well-targeted towards meeting the needs of the poor and that has a clear impact on people's livelihoods has become a major objective of donors (Cox et al. 1998; Hendry, 2000). It has become widely recognized that money income on its own is imperfect as an indicator and that non-monetary variables and the views of the poor themselves, need consideration.

Several approaches to promote integrated cropping of vegetables and fruit around a household managed pond stocked with fish or prawns have been used with varying success. Some of the outcomes may relate to broader issues such as availability of markets for the products and inputs such as improved germplasm and knowledge. Some work has challenged the impact of such interventions on household food security (IFPRI, 1998), despite the increase in availability and variety of vegetables and fruit that such strategies can deliver (Ali and Tsou, 1997). A more holistic understanding of the need and assets of the households involved might improve the targeting and outcomes of such initiatives. This gives rise to the necessity of identification, documentation and evaluation of such integrated farming systems adopted by the farmers in Bangladesh.

1.10 Research objectives

The focus of the study was to examine the prospects of the pond-dike system for sustainable agricultural development in Mymensingh district Bangladesh. Specifically, the study had the following objectives:

1. To determine the impact of pond-dike systems on the livelihoods of farming households of Mymensingh district of Bangladesh

2. To identify the degree of association between seasonality and livelihood in relation to location, wellbeing, gender and characteristics of integration pond-dike systems

3. To assess the effect of change through interventions on pond-dikes and associated livelihoods

3.1 To investigate the effect of potential improvements in the systems identified by key stakeholders on economic benefit and impact on the broader pond-dike system

4. To understand the major factors affecting the level of adoption of pond-dike systems

1.11 Outline of the thesis

The thesis has been divided into seven chapters commencing with **Chapter 1** that attempts to review the context of integrated farming systems in relation to the development, adaptation and adaptation throughout the world. The chapter described the current role of aquaculture and integrated farming on livelihoods and issues linked for the further development has also been described. Furthermore association between location and well-being and adoption of technology has also been explored. The rational for adopting participatory research methodologies and the roles of institutions for sustainable development have also been highlighted.

In **Chapter 2** that follows the major processes and concepts of the research are described. It is noteworthy to mention that methodologies are described in detail in later chapters. The design about qualitative and quantitative analysis of three different levels (households, community and policy) analyses has been illustrated.

In the **Chapter 3** the processes and outcome of the Participatory Community Appraisals (PCA) and SOS workshop are described. This chapter contributes towards an understanding of the general context, farming practices and livelihoods of four villages.

To develop a broader understanding of livelihoods at the household level and were detailed knowledge of pond-dike systems, a baseline survey was carried out in six villages indicative of different contexts. This is presented in the **Chapter 4**. An initial analysis of factors impacting on adoption of pond-dike systems is proposed as part of the outcome of the survey.

Chapter 5 presents the results derived from a year round household monitoring study carried out in the six villages with active integrated households. The major thrust of this chapter is the emphasis on food security issues in relation to income and expenditure. This chapter endeavoured to identify and understand household vulnerability, its causes and role of pond-dike systems to mitigate those. At the end results were also cross checked with the findings of former studies of this research.

A participatory technology development process is the focus of the **Chapter 6**. This chapter included the outcomes of participatory workshops which were carried out before the onset and during the trial.

An overall discussion of the research process is presented in the **Chapter 7**, and compared with the available findings and theories. Particular attention is paid on the role of pond-dike systems on livelihoods and poverty alleviation, adoption factors and sustainability of the system. Implications and follow on research need is discussed and concluded with highlighting the key issues derived from the research.

Chapter 2: General research methodology

2.1 Introduction

The study was designed to assess the impact of integrated aquaculture on the livelihoods of farming households in rural and peri-urban areas of Mymensingh, Bangladesh. The major thrust was to produce a comparative analysis of different farming households, adoption and adaptation of integrated farming systems and assess the institutional context in relation to their impact on livelihoods.

Both qualitative and quantitative data collection methods were used in the study in an interactive way (Sahn, 2003). Data were collected at different levels ranging from district to household, based on the livelihood approach (Carney, 1998). Moreover; data was collected in a way that both community and household level information were accumulated. At the initial stage, findings of Participatory Community Appraisals (PCAs) and also outcomes of the research were presented and cross checked /triangulated with different levels of stakeholders.

The research process incorporated data relating to different aspects covering the availability of the assets; the vulnerability context; transforming structures and processes including development policies, development strategies, and other related issues; agriculture practices; common livelihood strategies; and the livelihood outcomes of local people.

At the beginning of the study secondary data were collected from different sources which included books, journals, abstracts, dissertations, theses and bibliographies that were relevant to the study were used as useful resource to enrich the information for understanding analysis and evaluation. Information on government policy particularly on integrated aquaculture systems, current trends of aquaculture, socio-economic, environmental and institutional factors that can be considered as important to the study were gleaned from different sources.

A review of this literature has been presented in the preceding chapter and information related to institutional context is presented in the chapter 4.

2.1.1 Phases of the study

The study was carried out in the following 5 phases;

2.1.1.1 Phase one

A total of four villages were selected from two locations (rural and peri-urban) initially from four Upazilas of Mymensingh district where the first phase of the study carried out. Before incepting the study, community meetings with key informants and other villagers were organized to brief then about the objectives of the research. At the beginning of the study 5-6 key informants (female and male) in each village voluntarily helped draw a village map. Afterwards, a well-being ranking exercise was performed in each of the villages through assistance of village headmen and representatives of better-off and worse-off households. Every household was then categorized based on their well-being level and nature of pond use within the farming system. The detailed process of farmer selection is described in the Chapter 3. PCAs aimed to describe the general context of the community, characteristics of farming systems, existing agricultural practices, benefits and constraints. The research methods are presented schematically in the Figure 2.1.

Subsequently, results of PCA activities were presented at a State of System (SOS) workshop before four stakeholder groups i.e GOs, NGOs, fish traders, fish growers to cross–check and validate key findings. The major objective of the PCA /SOS was to identify researchable issues and develop the research design for the subsequent phases of the work.

2.1.1.2 Phase two

A broader understanding of livelihoods at the household level and role of pond-dike systems was assessed through baseline survey carried out with three categories of farming households viz. active integrated, passive integrated and non-pond farming households in six villages (two more villages were selected in addition to four villages).

2.1.1.3 Phase three

The PCA/SOS and baseline survey helped to understand community and household livelihoods and farming systems but were limited with respect to assessing how seasonal change could influence household activity, consumption, farming systems and in general household livelihoods. Active households were therefore sampled for monitoring over time to identify the degree of association between seasonality and livelihood in relation to location, wellbeing, gender and characteristics of active systems.

2.1.1.4 Phase four

The main objective of the intervention was to assess the effect of change through interventions on pond-dikes on associated livelihoods. Initial potential foci for on-farm trials were generated during the SOS workshop. Farmers and other participants expected to assess the effectiveness of altering farming systems on productivity and overall livelihoods. For example changes in fish and vegetable consumption patterns and income levels were monitored. It was hypothesized that modification of existing practices could raise farming income, availability of fish and vegetable for consumption and sell and thus improves livelihoods.

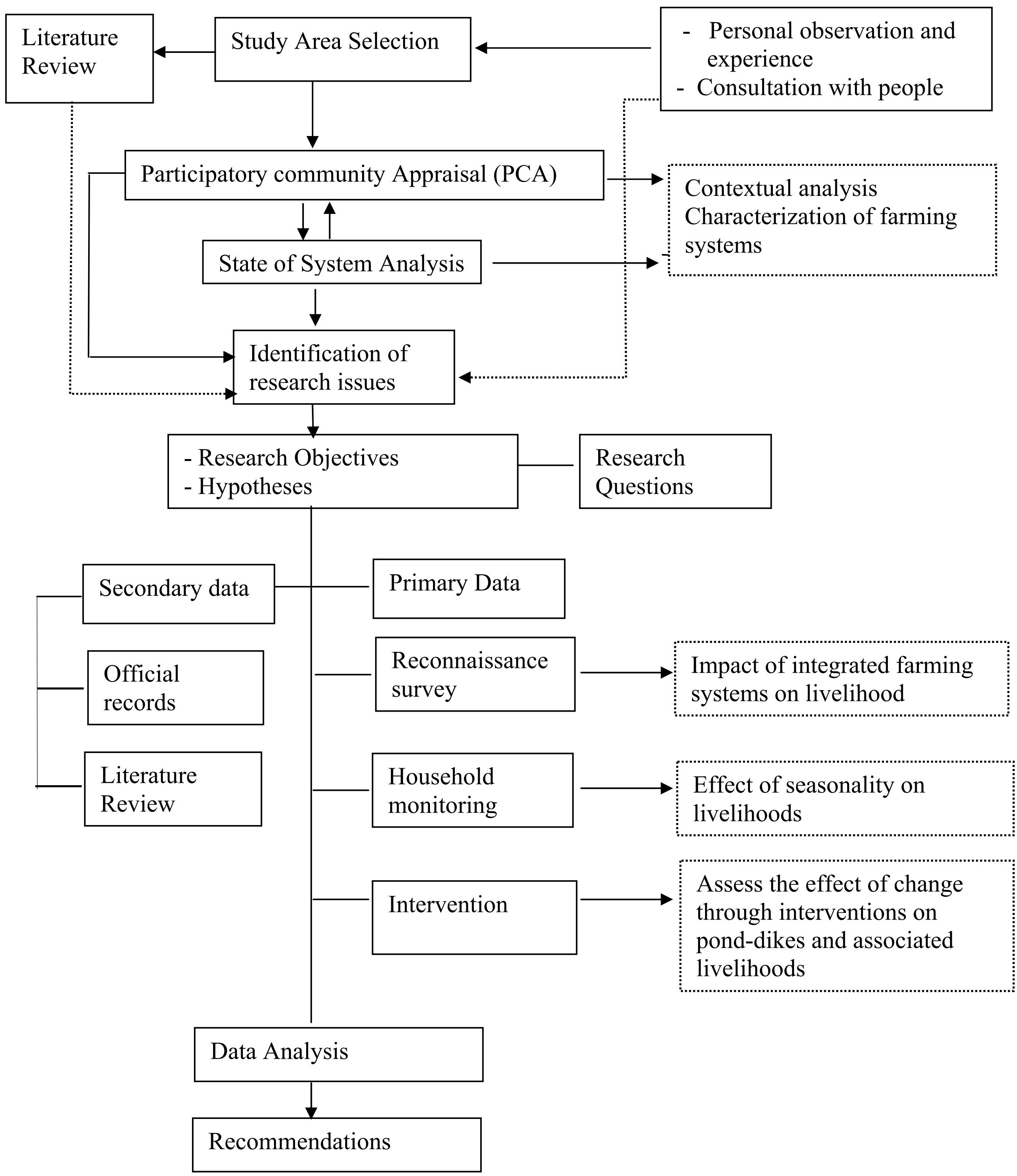

Figure 2.1 Schematic Presentation of Research Methods

Table 2.1 The research timetable 2002-2005

Year (Quarter)	2002			2003			2004			2005		
1.Secondary data collection	x											
2.Area selection	x											
3.Community level assessment												
PCA (Participatory Community Appraisal)		x										
SOS workshop		x										
4. Household level assessment												
Area selection & wellbeing ranking			x									
Baseline survey				x								
5. House hold monitoring												
Farmer selection				x								
Monitoring					x	x	x	x				
5. Intervention												
Tilapia seed nursing												
Pre-intervention workshop								x				
Farmer selection								x				
On farm trial									x	x		
Trial monitoring workshop									x	x		
Harvesting and result sharing									x			

2.2 Conceptual framework

The concept of Sustainable Livelihoods has been gaining increasing attention as a new focus for development research and aid programming. The concept was first used in the work of the Bruntland Commission in the mid-1980s, where the ideas of sustainable livelihoods began to be developed as an approach to maintain or enhance resource productivity, secure ownership of and access to assets, resources and income earning activities, as well as to ensure adequate stocks and flows of food and cash to meet basic needs (Goldman, 2000). The Institute of Development Studies at the University of Sussex has devoted substantial attention to the problem through a series of working papers and these have contributed to a framework for sustainable livelihoods adopted by the Department For International Development (UK) as a major programming thrust (DFID, 1999). Its importance as an organizing concept for development programming has also been recognized by the United Nations Development Programme (Carney et al. 1999).

A "Sustainable Livelihoods Approach" is an integrated package of policy, technology and investment strategies together with appropriate decision-making tools which are used together to promote sustainable livelihoods by building on local adaptive strategies. The sustainable livelihood approach has emerged as a bottom-up approach considering participation of all level of stakeholders in the development process. The livelihood approach put significant stress on the role of micro level, the "processes of collective empowerment taking place in localities" (Amalric, 1998). Rather than focusing entirely on "local" approaches to development however, sustainable livelihoods thinking advocates a combination of both macro and micro measures, such that local action is responded to and is in harmony with macro developments (Carney, 1998; Ellis, 2000a).

The major difference from SL approaches to other approaches is its basis on people and their strengths and constraints as starting point; meanwhile the other approaches start with structures and areas. The other difference is reflected in conceptions of poverty between SL approach and the other approaches; the SL approach expresses poverty as part of the multi-dimensional and complex external environment and embraces the concepts of risk and vulnerability. In addition, SL focuses on the sustainability with all its multiple dimensions as a core concern. Sustainability was not considered explicitly in other approaches, especially Integrated Rural Development approach in 1970s (Carney, 1998).

UNDP was the first international organization (apart from NGOs) to adopt the human development approach, which sees poverty not as a condition but as a process in which poor people are leading actors struggling against a process of impoverishment (Goldman, 2000). It also focuses on people's strengths and the assets they need to move out poverty (UNDP, 1998). But this approach was subsequently replaced by the promotion of sustainable livelihoods in the centre of its poverty eradication strategy. According to Goldman (2000), the poverty-focused development activity should be: (i) people centered; (ii) responsive and participatory; (iii) build on people strengths (assets) and address vulnerability; (iv) holistic; (v) multi-level; (vi) conducted in partnership; (vii) sustainable; and (viii) dynamic.

International non-governmental organizations, including CARE and Oxfam, were also early to adopt sustainable livelihoods approach and made a considerable contribution to the approach in 1998, following the 1997 DFID White Paper which focused on the eradication of poverty (Goldman, 2000). Different agencies used their owned sustainable livelihoods approach, however, it is clear that different agency's approaches have much in common but that there are also some variation and difference in emphasis. The DFID's Sustainable livelihoods approach is inherently responsive to people's own interpretations of and priorities for their livelihoods (Carney, 1998).

DFID sustainable livelihoods approach is based on five asset categories including natural, financial, human, social and physical assets (Carney, 1998), whereas UNDP's approach includes sixth asset, political asset, and strongly emphasizes the importance of technology and increase productivity (Goldman, 2000; Singh and Gilman, 2000). CARE stresses the importance of household livelihood security and considers natural resources and infrastructure as part of the context rather than as an asset, where they include human, social and economic capital. An important difference is that the CARE approach clearly focuses on an individual household, whereas in DFID and UNDP approaches the focus can also be a community (Goldman, 2000).

The common thread that unites all the agencies is that they link their ideas back to the work of Chambers and Conway in the early 1990s and most adopt the Chambers and Conway definition of livelihoods or some slight variation on this (Carney, 1998). However, gaining an understanding of sustainability and incorporating its different elements into programmes is perhaps one of the more challenging aspects of SL approaches (Ellis, 2000a).

The DFID’s sustainable livelihood approach also essentially combines elements from number of concepts, which can be seen as good development practice. Emphasis is given to links between the micro and macro levels – a key aspect of the sustainable livelihood approach. By its own core principles, DFID’s sustainable livelihood approach can be used for different objectives such as impact assessment of technology, programme identification, design, planning and reviewing existing activities as well (DFID, 1999).

Apart from properly assessing the impact of aquaculture technology on people's livelihoods, technology needs to be developed in such a way that the result is appropriate for the end users in terms of technical and economic feasibility and socio-cultural acceptability. To achieve this, technology development should take a participatory approach, which encourages farmers’, researchers’ and extension workers’ involvement in the research process right from the start. With this approach, most experiments are done by farmers on their own farms and the researcher plays more of a role of catalyst and facilitator (Chambers et al. 1989; Pretty, 1995), which is quite different from conventional research. In general participatory approaches are more effective for adoption of new technology by target groups than large groups of farmers (Garforth and Usher, 1997). There is a clear need for methods to convert small-scale successes of participatory research for larger scale development (FAO, 2000).

Participatory field methods are likely to be abandoned if there are no institutional innovations which support them (Merrill-Sands et al. 1991). However, the institutional context for promoting agricultural technology is often problematic which could be minimized involving a variety of stakeholders (Del Ninno et al. 2003), promotion of pond-based agricultural diversification could be fit into similar situation.

These above concepts of livelihoods, participatory research and institutional context are considered in all stages of the current research. The process also included qualitative and quantitative methods of data collection, analysis and interpretation from the beginning to the end of the study.

2.3 Framework Design for Analysis: Hierarchical Levels of Analysis

The framework designed for the analysis has been divided into three hierarchical levels viz. micro (households), meso (community/village) and their implication for the policies, planning and programs at macro (national) levels. Figure 2.2 presents the different hierarchical levels incorporating the micro level assessment of household livelihoods. At this level production and management of farming systems are analyzed and the factors contributing to socio-economic improvement identified. Comparative analysis with respect to location (rural and peri-urban), wellbeing and farming system were done to understand the socio-economic and institutional context. A descriptive analysis of households' economy by sources of earning, farm size, wellbeing and group were preformed and compared across locations. Beside this, farmers' perceived institutional participation and effectiveness were evaluated.

At the meso-level, for participatory community analysis (PCAs) were performed. These attempted to give an overview of the physical and social dimension of the community through the knowledge and perceptions of key informants and members of focus groups known from different sections of that community. Activities, consumption, seasonal effect on livelihoods, farming systems and resource use pattern were compared between communities and locations. The present level of natural resource use and adoption of pond-dike systems were identified and farmers' perceptions on the changing utility of ponds, existing problems associated with fish and vegetable culture are also evaluated.

Based on the identified issues, problems and priorities of households farming systems adjustment and management at micro and meso levels, macro level policy implication have been suggested by taking reference to national level agricultural development and management policies, plans and programs.

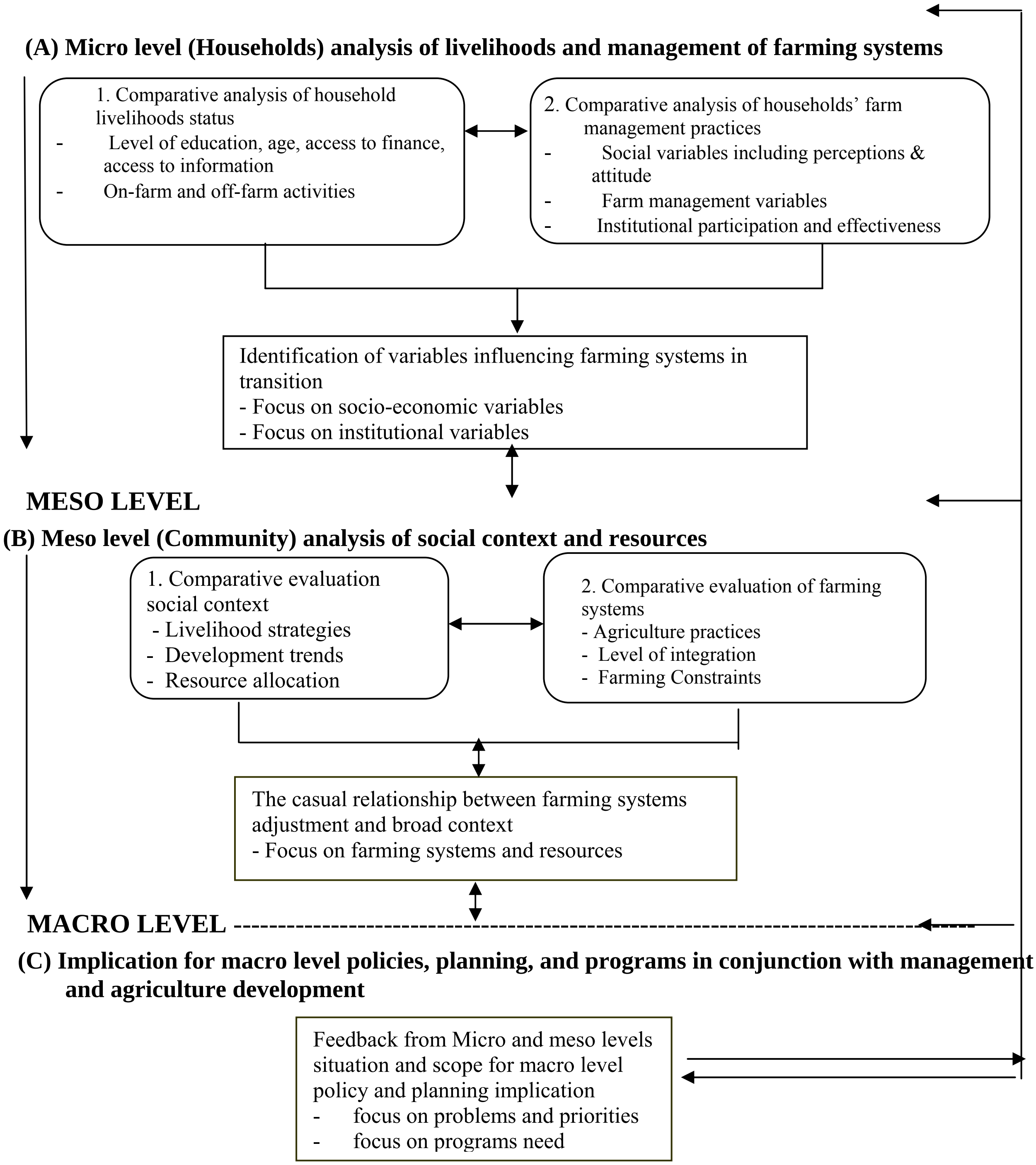

Figure 2.2 Hierarchical presentation of analysis levels

2.4 Indicators of Constructs

The indicators used as inputs in analysis and evaluation were grouped into two hierarchical levels of analysis i.e. micro (households) and meso (community) level (Table 2.2). Based on the analysis and feedback from meso and micro level information, strategic policy alternatives at macro level have been evaluated (presented in the Chapter 3, Table 1.9). To operationalize the measures, following detailed indicators were identified for each conditioning variable.

Table 2.2 Measurements of constructs/variables

Variables/indicators	Measurement	Evaluation/Remark	Levels of Analysis
Social demography			
Total family number (Male/Female) Family size Age structure of family members Age structure of household head Number of dependents Formal education of family members Occupation of household members House Type	Number (M/F) Average Year Year Number Year of schooling Type Number/Type	Comparative study of households composition and structure	Micro level
Farm enterprises (production and management practices)			
Average land holding Ownership Area for specific crop enterprises Production level Gross income from crops Food consumption/sell Total number of land parcels Land type Area under each crop species/varieties Production input use Compost Chemical fertilizer Pesticides/insecticides Gross production of different crops Sufficiency from crop production Problems related to crop production	Hectare Average size/type Area Kg/ha Kg Kg/Frequency/week /type Type Hectare Frequency/source Frequency/source Frequency/source Kg Months Respondent evaluation	Comparative study of resource ownerships Comparative study of crop production and management systems, and households economic and market participation	Micro level

Table 1.2 Measurements of constructs/variables (continuation)

Variables/indicators	Measurement	Evaluation/ Remark	Levels of Analysis
Assets			
Number of Tree House types and construction Household assets Agricultural equipment	Numbers Average numbers/type Average numbers/type Average numbers/type		
Livestock enterprises Number of livestock species Livestock holding and poultry Average livestock and poultry holding Gross income from livestock and poultry Sufficiency from livestock and poultry products	Number Livestock Standard Unit LSU per household USD Months	Comparative study of assests, and households economic and market participation from this enterprises	Micro level
Finance			
Income Expenses Source of credit Amount of money borrowed Source of credit	TK/year Tk/year Tk/year Tk/year Name of the source		
Sustainability of integrated farming			
Farmers' attitude to fish and vegetable culture Merits and demerits of pond-dike systems Social benefits derived from the systems	Respondent evaluation Respondent evaluation Respondent evaluation		
Institutional variables			
Level of participation Benefit of participation Source of information Types of information Type and number of institutions - Government - Non-government - Involvement of family members Male Female	Respondent evaluation Respondent evaluation Name of institutes Respondent evaluation Type and Number Number	Comparative study of institutional participation and effectiveness along with status and role of institutions	Micro and Meso levels
Macro level			
Field level situation analysis and suggestion for macro level policies and planning implications Problems and Constraints Priorities and programs Issues and Concerns	Workshop Meeting with different level of stakeholders	Feedback for micro and meso levels for suggesting alternative policies and programs for integrated farming systems development and natural resource management	Macro level

2.5 Selection of field research areas

The research area selected was Mymensingh district (Figure 2.3;

Appendix 1). This district has also been a focus of aquaculture development over the last two decades. Research communities (villages) were locations identified as rural and peri-urban on the basis of access to markets and information (Table 2.3).

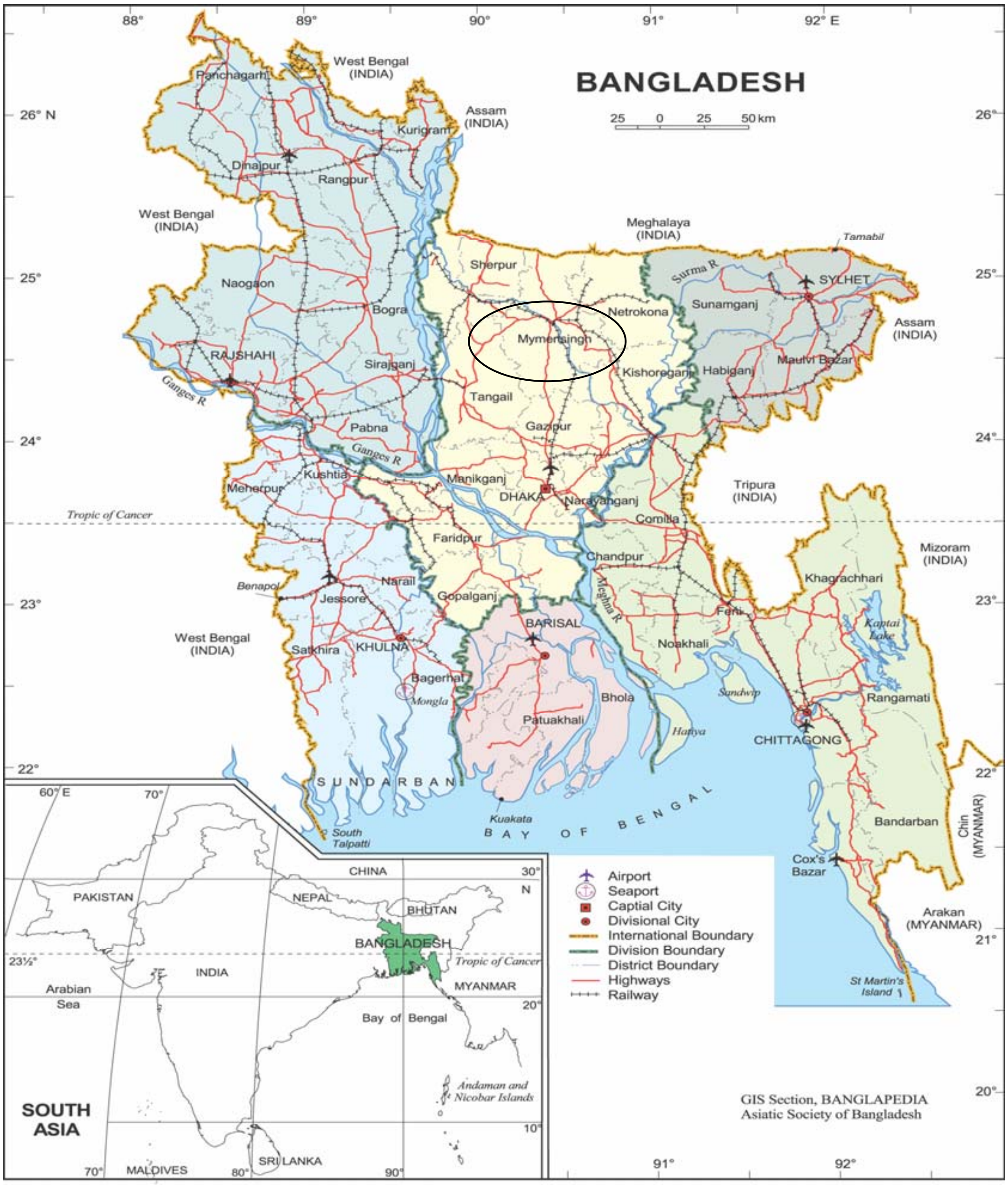

Figure 2.3 Map of Bangladesh indicating Mymensingh district.

2.5.1 Mymensingh district profile

Mymensingh district with an area of 4,363.48 sq km, is bounded by Meghalaya State of India and Garo Hills on the north, Gazipur district on the south, Netrokona and Kishoreganj districts on the east and Sherpur, Jamalpur and Tangail districts on the west . The main river is the Old Brahmaputra, but there are also numerous small rivers, marshes and canals in the district. The soil formation of the district is flood plain, grey piedomont, hill brown and terrace. The annual average temperature; maximum 33 ^{0} C, minimum 12 ^{0} C; annual rainfall 2174 mm (Wikipedia, Undated).

Greater Mymensingh district was established in 1787. Later on it was divided into six districts viz. Tangail, Jamalpur, Mymensingh, Kishoreganj, Sherpur and Netrokona. The district consists of 8 municipalities, 12 upazilas, 146 union parishads, 84 wards, 206 mahallas, 2201 mouzas and 2709 villages.

Main crops are paddy, jute, sugarcane, wheat, oil seed and pulse, betel leaf, karalla, sweet potato, turmeric, ginger, brinjal, cauliflower and chilli. The main fruits produced are jackfruit, banana, pineapple, papaya, kadbel, guava, boroi, amloki, palm, latko. A total of 322 hats (markets open on a fixed day of the week) and bazaars (general daily markets) exist in the district.

Operationally important NGOs include BRAC, PROSHIKA, CARITAS, Gonoshahajjo Sangstha, ASA, World Vision, Palli Unnayan Prayas, MCC, Gramous, Adarsha Samaj Sheba Samiti, Human Development Programme, Khagra Mohila Unnayan Samiti, NGO Forum, Sara and Sirak.

2.5.2 Site selection

The site selection procedure involved two stages. Firstly 4 out of 12 Upazilas (Bhaluka, Haluaghat, Muktagacha and Trishal) were identified using secondary information, observational visits and discussion with officials and farmers. Bhaluka and Haluaghat tended to have more rural characteristics than Muktaghacha and Trishal. However, the indicators for being rural and peri-urban are presented in the (Table 2.3).

Table 2.3 Indicators of rural and peri-urban areas

Variables/indicators	Locations	
	Rural	Peri-urban
Communication	Poor communication with other upazilas and district	Good communications compared to rural area
Marketing	Less developed marketing channel	Well established marketing channel
Technology adoption	Low adoption of improved agricultural technology	High adoption of improved agricultural practices
Information access	Poor	Good than rural

During village selection processes the following issues were also considered-

1. Farmers' eagerness to be involved in participatory research

2. Higher number of ponds compared to other villages

3. Higher number of farmers involved in pond-dike systems than other villages of the respective upazilas

4. Households are situated as a cluster geographically

Participatory Community Appraisal (PCA) was carried out in these villages. In a second step, in order to increase the number of research villages, another two villages were selected following similar process from another two Upazilas (Fulpur and Gouripur) and rest of the research were carried out in all six upazilas (Table 2.4).

Table 2.4 Distribution of research location

Location	Upazila	Village	Distance (km) from central Mymensingh (Approx.)
Rural	Haluaghat	Koirahati	50
	Fulpur	Goatola	40
	Bhaluka	Dholia	55
Peri-urban	Muktagacha	Nosirpur	25
	Gouripur	Damgao	22
	Trishal	Ainakhet	20

2.5.3 Upazila (Sub-district) profile

Table 2.5 presents the general profile of the Upazilas. Literacy levels were very low, especially of women in the respective villages. The average number of villages in each upazila was more than 200. Agriculture was the main occupation in all of the upazilas. In the rural upazilas agriculture was the main occupation of 59% households while in the peri-urban upazilas the percentage was 52%. Paddy and vegetables were the major crops grown in the upazilas, and the majority of cultivable lands were double cropped. A number of NGOs worked in each of the upazilas, though village level information was not available.

Table 2.5 General profile of the study community

Location	Name of the Uopazila	Area (sq-km)	Year of establishment	Number of villages	Population Total	M %	F %	Major crops
Rural	Haluaghat	356.07	1916	205	2,42,339	5,0.68	4,9.32	Paddy, jute, wheat, potato, sweet potato, mustard seed, ground nut and vegetables
	Bhaluka	444.05	1917	102	2,64,991	51.8	48.2	Paddy, jute, sugarcane, wheat, mustard seed and pulse and vegetables
	Fulpur	580.21	1915	411	4,59,046	5,0.98	4,9.02	Paddy, wheat, potato, pulse, onion, garlic and chilli.
Peri-urban	Gauripur	374.07	1981	280	24,7945	50.7	49.3	Paddy, wheat, potato, brinjal, pulse, onion, garlic, watermelon, mulberry tree and
	Muktagachha	314.71	1961	273	3,21,759	50.77	4,9.23	Paddy, jute, wheat, betel leaf, sugarcane and mustard seed
	Trishal	338.98	1909	160	3,36,797	5,2.36	4,7.64	Paddy, jute, wheat, vegetables.

General profile of the study community (continuation of Table 1.5)

Location		Occupation (% of households) Agricul.	Fors and fishing	Agri labor	Commer.	Wage labour	Service	Others	Cultivable land Total (ha)	Single crop %	Double crop %	Treble crop %	Name of the NGOs worked
Rural	Haluaghat	59.4	2.1	21.01	7.04	1.98	2.11	6.36					BRAC, ASA, CIDA, Grameen Bank, World Vision, Oxfam, Caritas, Concern and Save the Children, PHCP, Thangna, Swabalambi, Popy, Palli Bikash, Sheba and SSB
	Bhaluka	63.9	1.06	16.19	5.85	2.63	2.74	7.63	31,395.31	30.08	56.91	13.01	BRAC, Proshika, Caritas, Gonoshahajjo Sangstha, asa, CARE, ABC, Grameen Bank, CCDB, Gana Chetana.
	Fulpur	53.76	2.19	23.82	5.04	2.67	2.95	9.57	51,299.03				World Vision, caritas, brac, asa, Ahsania Mission, grameen bank, CIDA, TSS, Sujani, SS, Grameen Manabik Unnayan Sangshta, Palli Unnayan Prayas.
Peri-urban	Gourip	55.3	1.62	17.73	7.96	2.6	3.52	11.27	23,202	11	79	10	BRAC, ASA, Sara, Sheba and National-Mahila Unnayan Sangshta.
	Muk	47.71		22.76	8.3	2.82	3.53	14.82					BRAC, Grameen Bank, Proshika, Caritas, ASA, SDP, Atta Karma Juba Unnayan, Pratasha and SDS.
	Tris	52.69	1.12	20.06	9.99	2.78	3.54	9.87	23,576.49	8.6	86	17.5	BRAC, ASA, Grameen Bank, ITCL, Delta Nayan Foundation, Palli Unnayan Academy, Shoshi Foundation

(Agricul.- Agriculture; Fors.- Forestry; Commer.- Commerce)

2.5.4 Sampling methods

Sampling approach and number varied from one study to another (Table 2.6), however, sampling procedure is described in details in the respective chapters.

Table 2.6 Numbers of household participated of the study

Study	Criteria	Number of Households											
PCA (Appraisal of context)		**Peri-urban (8-10)**						**Rural (8-10)**					
	Village mapping	Men (4-6)						Women (4-6)					
	Time line	Men (3-4)						Men (3-4)					
PCA) (Appraisal of context	Seasonal calendar, activity and consumption Matrix	**Peri-urban (48)**						**Rural (48)**					
		Men (24)			Women (24)			Men (24)			Women (24)		
		Better off (12)	Worse off (12)		Better off (12)	Worse off (12)		Better off (12)	Worse off (12)		Better off (12)	Worse off (12)	
PCA) (Appraisal of systems)	Use of pond-dike, bio-resource flow, resource mapping, problems and benefits	**Peri-urban (36)**						**Rural (36)**					
		Aqua. (12)		Veg. (12)		Orchard (12)		Aqua. (12)		Veg. (12)		Orchard (12)	
Triangulation	Participants/non-participants	**Peri-urban (around 50)**						**Rural** (around 50)					
SOS	All level of stakeholders	**District** level (around 50 participants)											
Baseline sampling		**Peri-urban (93)**						**Rural (112)**					
	Overall Pond class	A (35)		P (35)		NP (23)		A (48)		P (32)		NP (32)	
	Well-being	Better-off (41)			Worse-off (52)			Better-off (54)			Worse-off (58)		
	Well-being & pond class	A (18)	P (15)	NP (8)	A (17)	P (20)	NP (15)	A (23)	P (15)	NP (16)	A (25)	P (17)	NP (16)
Monitoring sampling		**Peri-urban (36)**						**Rural (36)**					
	Well-being	Better-off (18)			Worse-off (18)			Better-off (18)			Worse-off (18)		
FPR sampling		**Peri-urban (33)**						**Rural (36)**					
	Well-being	Better off (13)			Worse off (20)			Better off (13)			Worse off (23)		

Key: NP= No pond; P=Passive pond use; A=Active pond use; FPR- Farmer Participatory Research
Aqua= Aquaculture; veg.=Vegetable; SOS= State of System workshop.

2.5.5 Data processing and analysis

Initially data were entered in Access, exported to Microsoft Excel. Errors were detected and necessary corrections were made accordingly after exporting. Primary analysis (descriptive, graphs, Pivot tables etc) was carried out using Microsoft Excel. Finally quantitative and qualitative data from the study, were analyzed by using SPSS/windows version 13.0, which offered statistical tools applied to social sciences (Field, 2005). Qualitative data were converted in to quantitative numbers if required after processing, scaling and indexing of the necessary and relevant variables to perform subsequent statistical analysis for drawing inferences. Statistical tests like ANOVA (Analysis of Variance), GLM (General Linear Model), Chi-square were used to identify the relationships between variables and significant differences/association among them. The tools and the programs used for different type of data analysis are summarized in Table 2.7

Although non-parametric tests are appropriate for normal or ordinal data and parametric test are appropriate for interval and ratio data (Wimmer and Dominick, 1987), many researchers (Roscoe, 1975; Gay, 1976) consider the two categories to be indistinct and proposed that both methods could be used successfully with any type of data.

2.5.6 Quantitative and qualitative analysis

Descriptive statistics such as frequency distribution, mean, and standard deviation (SD) were used for preliminary analyses. Other statistical analysis included univariate analysis, multivariate analysis, especially factor analysis, regression analysis, correlation coefficient, Chi-square and other as required to examine and understand the association of variables and its direction and magnitude. The statistical significance of results was examined by using appropriate methods such as t-test.

2.5.6.1 ANOVA (Analysis of Variance) and GLM (General Linear Model)

Due to heterogeneity of different locations, wellbeing and groups, there was variation within the sample that independently associated with other variables. In order to identify the intra and inter group variations between different wellbeing and locations that influenced the livelihoods, adoption, resources, production and management of farming systems, one-way analysis of variance with post hoc analysis and GLM techniques employed for comparing sample means. ANOVA is a powerful statistical test where two or more independent estimates of the variance for the dependent variables are compared (Girden, 1992).

Location, socioeconomic group, farming systems, sex and season were included as independent fixed variables and village as random. Household ID was used as random factor in the longitudinal study (Chapter 5).

Village was nested within location and households for all analysis (Appendix 2), except household monitoring (longitudinal study), in the longitudinal study village was nested within location, ID and season were included as random effects in the statistical model (Appendix 3). All main effects were evaluated as well as two-factor, three-factor and four-factor interactions among all fixed factors were done whenever appropriate.

2.5.6.2 Pearson's chi-square test

The chi-square test was used to test if a sample of data came from a population with a specific distribution. i.e. to find out relationship between two categorical variables (Snedecor and Cochran, 1989). Chi-square method was used to test whether two (or more) variables are: (1) independent or (2) homogeneous. The chi-square test for independence examined whether knowing the value of one variable helps to estimate the value of another variable. The chi-square test for homogeneity examines whether two populations have the same proportion of observations with a common characteristic. Though the formula is the same for both tests, the underlying logic and sampling procedures vary. Following formula used for this test-

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

where:

O_i = an observed frequency
E_i = an expected (theoretical) frequency, asserted by the null hypothesis

2.5.6.3 Correlation and regression analysis

The correlation coefficient, sometimes also called the cross-correlation coefficient, is a quantity that gives the quality of a least squares fitting to the original data. The correlation coefficient is also known as the product-moment coefficient of correlation or Pearson's correlation. The main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related (Miles and Shevlin, 2001).

Regression analysis is used to identify the linear association between independent variables used collectively to predict the dependent variables (Miles and Shevlin, 2001).

Following equation can be used:

$\Upsilon = \beta 0 + \beta 1X1 + \beta 2X2 \ldots\ldots\ldots\ldots \beta nXn + \varepsilon$
Where,
Υ = Dependent variable
$\beta 0$ = Constant
βn = Regression coefficients
Xn = Independent variables
ε = Error term

2.5.6.4 Discriminant analysis

Discriminant test was used to assess if the composition of variables was responsible for discriminating the different farming households. Discriminant analysis was done as a technique for classifying a set of observations into predefined classes. The purpose is to determine the class of an observation based on a set of variables known as predictors or input variables (Klecka, 1980). The model is built based on a set of observations for which the classes are known. The technique constructs a set of linear functions of the predictors, known as discriminant functions, such that

$L = b1x1 + b2x2 + \ldots + bnxn + c$, where the b's are discriminant coefficients, the x's are the input variables or predictors and c is a constant.

Examples of the GLM and Chi-square tests and also the models were used for GLM tests have been presnted in the appendix.

Table 2.7 Tools and programs used for data analysis

Sl.	Tool	Program	Area of analysis
1	Descriptive statistics	SPSS: Frequencies, descriptive	General frequency distribution of the results of the study. Example: Distribution of households based on age, sex, education, land property, livestock ownership.
2	Contingency tables and relationship measures	SPSS: Cross tabulation, compare means.	Identifying relationship between two or more than two variables, comparing means of different categories of a single variable. Example: Relationship between education and occupation type, relationship between household income and average monthly expenditure.
3	Univariate analysis	SPSS: ANOVA and GLM	Identifying significant difference among one dependant variable with more than one independent Example; location and group as independent and income as dependant
4	Association between categorical variables	SPSS: Chi-square test	Identifying association between two variable Example: Association between household age and groups
5	Multivariate analysis	SPSS; Discriminant analysis	Identifying composition of the variable was responsible for discriminating the different farming households
	Linear association	SPSS: Correlation and regression analysis	Correlation helped exploring whether and how strongly pairs of variables Regression analysis is used to identify the linear association between independent variables used collectively to predict the dependent variables.
6	Bar and Pie diagram	MS Excel and SPSS	Graphical analysis of the findings

Chapter 3: Identifying status and research issues of pond-dike systems in Mymensingh, Bangladesh through a participatory process

3.1 Introduction

At the onset of the research community level analysis was carried out as a key element of the research approach. It was assume that the context of community in which pond-dike systems were located might play an important role in the success of individual households. Participatory Community Appraisals (PCA) were carried out as an integral and starting point for understanding the local situation of the research area (Bee, 1985; Chambers, 1992; Campbell, 2001). The theory of “community” is much debated but here refers as an association of people living in a given area of sharing some general commonalities like common rights, privileges, or interests in addition to geographic proximity under the same laws and regulations (IIRR, 1998; Kay and Alder, 1999). Community level analysis was used to understand the overall context of each community/village as well as allowing local people to have an opportunity to participate in the research process from the onset. Community participation was considered as a critical need to both raise awareness and build on understanding about research as a process in addition to get answers of the research questions (Kay and Alder, 1999).

Participatory approaches were used in this study to understand the current situation, needs, attitudes, potential and social realities before designing a more detailed monitoring exercise and subsequent research (Scrimshaw and Gleason, 1992). Participatory Community Appraisal (PCA) methods were employed assuming they are capable of providing reliable village/community level database, similar to sample surveys (NCAER, 1992; NCAER, 1993; Garaway, 1999). Since Rapid Rural Appraisal (RRA) was formally introduced during 1978 in a workshop of rural development practitioners in the University of Sussex, UK, it has been used to denote a set of techniques or procedures for the quick study of land based resources systems and or activities such as agriculture, health and forestry (Chambers, 1980; Chambers, 1992). The philosophy, approaches and methods known as rapid rural appraisal (RRA) began to emerge in the late 1970s as an early version of PRA (Chambers, 1994). Other terms have since been coined for describing PRA, some of which are Participatory Rapid Rural Appraisal (PRRA) and Participatory Learning Method (PALM) (Mukherjee, 1995).

For many agencies and organizations, PRA is not just a tool which enables development planners to learn about rural conditions and consult with local community people so that they (researchers/development partners) can come up with more appropriate and better development planed. Rather PRA/PCA can sometimes be regarded as an exercise which transfers the role of planning and decision-making to the target group or community itself (Townsley, 1996).

Participatory Community Appraisal (PCA) involves a set of principles, a process of communication and a menu of techniques for seeking community participation in identifying local peoples' and a need based research agenda. PCA methods based around of systematic participation; and facilitate interactive problem analysis and interdisciplinary problem solving (Etling and Smith, 1994) but can also be a fundamental step in a longer-term research and partnership (Little, 2006 pers.com). However, the main goal of PCA was to obtain an overview of the community, in terms of their livelihoods and analyze existing farming systems in order to identify constraints & opportunity of the pond-dike systems, broadly develop an understanding about the community, people, and general context.

3.2 Methodology

A total of 12 participatory, group-based activities were used with 200 male & 120 female participants from four villages/communities over a 5 day PCA process in each community (Figure.3.1; Appendix 4). The ranking and scoring techniques followed in this study are one of the key strengths of PRA studies (Loader and Amartya, 1999). It has also been evident that participants are able to rank data effectively, and to produce useful groupings of individuals into wealth or other categories (Loader and Amartya, 1999).

On the 1st day, the researcher visited the village, introduced themselves to the village headmen and other available villagers, and collected the names of all household heads. Focus groups were selected on the basis of key informants of overall well-being, and gender and the characteristics of their pond-dike systems. At the beginning of the PCA process a well-being assessment exercise was carried out and which was the basis of farmer selection for the following PCA exercises and subsequent research.

The PCA exercises were categorized principally into two parts viz. appraisal of the general context, and appraisal of the pond-dike systems (Figure.3.1). The physical and social components of the village were investigated in the 2nd day in participation of people of different ages and gender. On the 3rd day male and female participants from different social groups (better off and worse off) from different parts of the village joined for the analysis of general context of the village.

At the end of the 3rd day activities with pond-fish culture households (those with specific interest on fish culture) were asked to participate in focus groups about farming systems of the households in general. Broadly three types of farming households were identified to allow a focus for understanding pond water use. Pond-dike (orchard) referred to households that concentrated on planting mainly perennial plants/fruit tree on the dikes but rarely used pond water to irrigate the crops while pond-dike (vegetable) households were distinguished by their habit of using water actively to irrigate mainly short-term vegetable crops grown on the pond-dikes and in the vicinity of the pond. Afterwards, the facilitators along with the village volunteers physically visited each of the different systems and the households' heads of different systems were sampled to join the 4th day's exercises. Consequently pond-dike systems were appraised on the 4th day. Lastly, key findings of the above exercises were shared with the villagers and validated on the 5th day. Methods for each exercise are described in Figure.3.1.

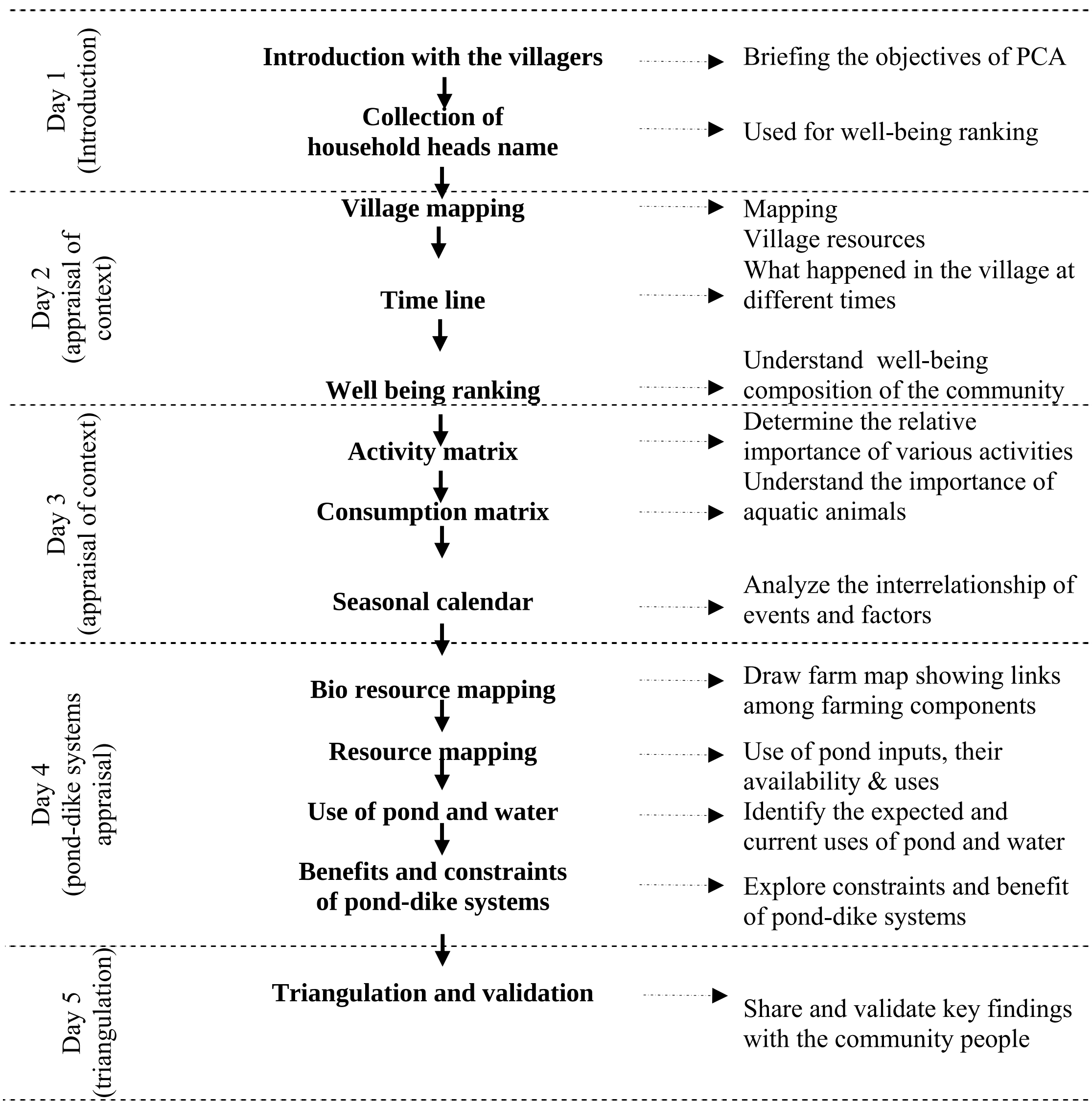

Figure.3.1: Flow diagram of Participatory Community Appraisal

3.2.1 Village mapping

Participatory mapping was used as a tool to develop a spatial, visual assessment of each community. It allowed information on variables like physical assets (eg. land, animals) and major aspects of interest as well as allows stratification /cross-classification of data collection at village level (NCAER, 1993).Village mapping exercises were performed by small groups (4-5) of men and women separately.

Groups were asked to draw a map to illustrate the major characteristics of their village (Lightfoot et al. 1991a; Lightfoot et al. 1991b; Lightfoot et al. 1994).

Participants were requested to draw the outline of the village on the ground including important features and resources like common infrastructure, trees, land use and cropping patterns, roads, canals, prayer centres (mosque, temple etc), schools, market, household location, fallow resources, water bodies, agricultural lands, water sources (natural, deep tube well, shallow tube well etc) etc. The participants were encouraged to illustrate their map using local resources such as beans, straw and leaves to indicate resources (Loader and Amartya, 1999). Subsequently, they copied the map on to a big flip chart using different coloured pens/pencils. Finally the map was copied on an A4 size paper by the researchers for further use (Appendix 5).

3.2.2 Well-being ranking

Wellbeing ranking is an appropriate way to begin building rapport with the villagers introducing oneself and knowing their names. Households with the community can be grouped through wealth ranking exercise on the basis of their own criteria of poverty and wealth (Mukherjee, 1993; Adams et al. 1997) and also well-being ranking exercise assesses a wide variety of aspects that contribute to wealth together, to allow participants and discussants to express an overall impression (Loader and Amartya, 1999).

Names of the household heads of the respective villages were collected through small group discussion and from the Upazilla/union office prior to entering the village. Wealth was defined in terms of access to or control over important economic resources (Grandin, 1988) but well-being was a broader term that can encompass social status, positive attitude etc. Each household heads name was written on a small card and participants of this exercise were asked to place the cards in piles according to the well-being of each household.

Three persons in each community (village headmen, randomly sampled representatives of better off & worse off groups) successively placed each household in turn into one of several groups (Guijt, 1992). These representatives were encouraged to allocate household in the same way. Each time the name cards were handed over to the participant to group the household based on his/her own judgment. After allocation of each card in a pile- the people were asked to re-consider the groupings and then identified what the best indicators of each group were.

Each of the cards was marked by the three facilitators based on the household well-being level and was written on the backside of the respective card, which was divided by the total number of groups done by the respective facilitator. Consequently, each of the cards had three scores, from which a mean score was derived (Grandin, 1988; Guijt, 1992). It is worthwhile to mention that the sequences of scoring the cards was similar, i.e every time the lower the numbers were used for better off and higher numbers referred to the worse-off. However, after averaging, the highest score was 1, which indicated extreme poor i.e the higher scores referred to poorer households and the lower scores indicated better off households.

Households that had been very inconsistently ranked (eg. assigned to both the richest and poorest group-2-4% in each village) were re-examined through discussions with the facilitators. Finally, the scores were plotted in the windows excel and 0.5 was considered as the mid point, scores above 5 considered as worse off households and below 0.5 as better off (Gregory, 1999). A similar method was followed for well-being ranking of participants of DFID funded Northwest Fisheries Extension Project in Bangladesh (Gregory, 1999). However, extreme (3-5%) poorer and richer households were not included during the sampling process.

3.2.3 Seasonal calendars

All four different well-being and gender segregated groups (5-6 persons/group) were requested to outline their major activities and events during the year. Subsequently the facilitator, using a flip chart with a calendar framework where months were on the top of the paper and activities/events were on left hand side allowing description of different parameters such as weather, traditions, agricultural practices, migration pattern, health, food deficit period etc, periods of health and food deficit status were also presented and discussed.

3.2.4 Activity matrix

Several cards were given to each of the participants for writing down their major day-to-day activities. Similar activities were then grouped with the assistance of facilitator on the left hand column of a flip chart. Names of the participants were then written at the top of the flip chart on top of a series of columns. Subsequently, each person scored his/her own activities in terms of overall importance by allocating a total of 30 beans within activities in their own column.

3.2.5 Consumption matrix

The main objective of this exercise is to understand the importance of fish and vegetables compared to other food groups. This exercise was done with the above focus groups, where respective group members wrote names of various food on cards, grouped those and kept in the left column on a flip chart. All of the individual group members combinely scored the food items with 100 beans in the next column based on the importance of each food.

Based on the groupings (described earlier) done at the end of day three exercises pond users were sampled and invited to participate in to the following exercises.

3.2.6 Expected and current use of pond and water

Three different groups of household representative with access to ponds participated to help develop an understanding about the current value of ponds and pond water and also the intentions/expectations for originally constructing the pond. A total of five participants from each group [(fish culture, pond-dike (orchard) and pond-dike (vegetable)] joined for appraising pond-dike systems. The participants were selected from each part of the villages taking assistance of some volunteers from the village.

Participants were requested to brainstorm the reasons for initially constructing ponds and the reasons were documented on small piece of papers, which were grouped and kept on the left hand column of a big flip chart and participant names were written on the right hand top of the papers. Each of the group members' then scored individually the overall importance of the various expected reasons for constructing the pond using a total of 30 beans which was documented on a paper (A4 size). Afterwards, the small papers were removed from the left hand column and they were asked what the uses/values currently were considered important, thus they scored using the same number of beans following the same process.

3.2.7 Problems and benefits of pond-dike systems

Similar to the above exercise (use of pond and water) participants brain-stormed the problems first, listed and scored the problem using 30 beans and later they identified the benefits and scored following the same process.

3.2.8 Triangulation and validation

The findings of the PCA were shared and validated in each village as well centrally in the Mymensingh district.

3.2.8.1 Village level triangulation

At the end of the PCA process key findings were shared with participants and non-participants in each of the four villages. At the end of presenting the results they were asked to comment and suggest if any findings were be contradictory reality.

3.2.8.2 Central level triangulation

In a daylong workshop, termed as “State of System (SOS)”, was organized to again validate the key findings and explore researchable issues, to guide plan to the follow-on research. Representatives of GOs, NGOs, fish traders, fish growers and different institutes took part in the workshop along with the local Pondlive project staff and other partners from different countries.

After formal introduction, key findings of PCA were presented by the author and Pond Live project co-ordinators. After presenting the results participants were requested to comment on the overall findings and also after discussion as focus group(s) requested to answer the following questions;

- Are the presented data similar with your thinking about current situation?
- Do you want to add something more?
- Is the situation presented here similar with other areas of Mymensingh and other regions of Bangladesh?

The individual group accomplished their own assignments and representatives from each group shared their own group output with other participants (Table 3.1). Afterwards, the groups were again requested to explore the researchable and implementation issues on pond-dike systems, and prioritize the issues.

Table 3.1 Focus groups and their assigned discussion

Group	Tasks
Fish traders (Table fish traders)	What are the major trends in aquaculture? What are the effects of pond dike culture on pond management and your fish trade?
Fish traders (Fry/fingerling)	What are the major trends in aquaculture? What are the effects of pond dike culture on pond management and fry demand?
Farmer representatives	What are the major problems in case of vegetable/crop cultivation in pond dyke and surrounded areas?
Government officials	Working in your own sector, how did you become involved in integrated fish and pond dike cultivation? If you are not involved, do you think its' a good idea and how do you think pond dike culture can be encouraged more?
NGO officials	What are the 5 best ways pond dike can be utilized? What are the 5 major problems for pond dike cultivation?

3.3 Results

3.3.1 Village mapping

It was revealed from the mapping that there were similarities among the villages in terms of existing physical and natural capitals. It can be observed from the maps that the various infrastructures in rural villages is less well established than in peri-urban villages, even though one of the rural villages (Koirahati) was situated close to a main road. The other rural village (Dholia) was located far away from the main road and was very undeveloped in terms of communication, water sources, number of institutions/organizations, number of husking mills etc. During period of heavy rainfall, mobility of households in this village is very constrained. On the other hand, peri-urban villages tended to have good communications with markets and Sub-district headquarters. They also tended to have better educational institutions (school and *Madrasha*), water sources (DTW and STW) and hospitals than rural areas.

However, all of the maps showed that rice was the dominant crop occupying the major proportion of agricultural land in each area. Out of four villages one peri-urban village (Ainakhet) had its own fish hatchery. Other than Dholia, all of the villages had a deep tube well. Households of Dholia village were largely dependent on *beels*, canals and ponds for irrigation. Male and female participants drew the maps in a similar way, only the female groups of Ainakhet village didn't draw the DTW which was located in the village.

3.3.2 Well-being ranking

The village headman, representatives of worse off and better off households categorized the households into 4-6 categories based on their individual perceptions using diverse indicators. The general criteria used by the participants were income, profession/work, size of land holdings, education, number of domestic animals, access to services (drinking water, electricity), types of house, types of latrine etc. The well-being categories were finally grouped and the combined categories were rich, medium rich, lower medium rich, poor and very poor. It was revealed from the exercise that community in the rural areas tended to have a higher proportion of very poor households than in peri-urban areas and the percentage assessed as 'poorer' was higher in the peri-urban than in rural areas (Figure 3.2).

Among all of the indicators used by the facilitators (village headmen, better off and worse off representatives) for well-being ranking, three common and quantifiable indicators were used to compare perceptions. Indicators such as land holding, level of education and number of poultry/livestock were commonly used though not all of these three indicators were used by all of the facilitators in each village (Table 3.2).

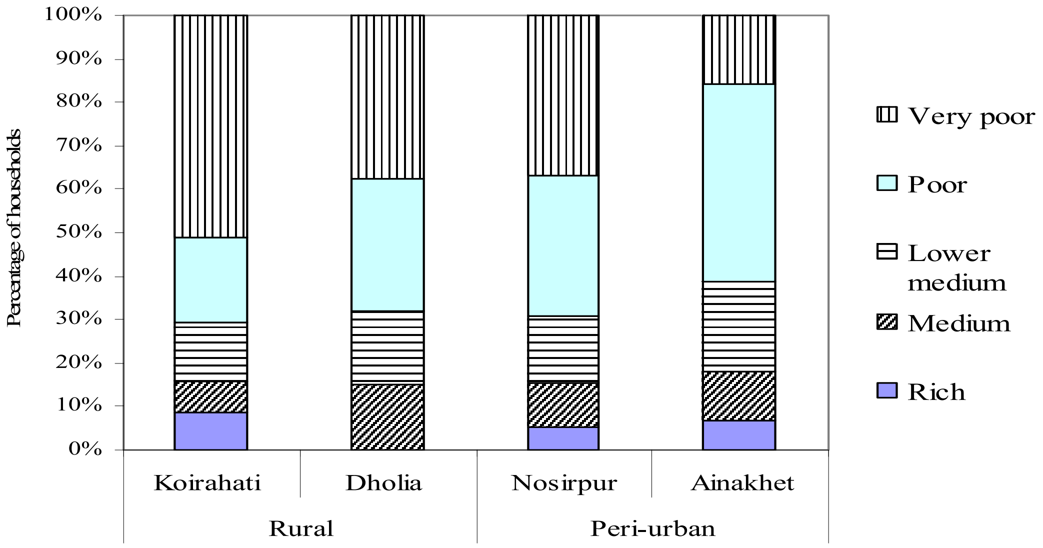

Figure 3.2 Well-being ranking in the rural and peri-urban location

Table 3.2 Well-being indicators used by different facilitators (headman, worse off and better off household representative) by villages

Well-being level	Village	Headmen			Worse off			Better off		
		Land	Edu.	Livestock/poultry	Land	Edu.	Livestock/poultry	Land	Edu.	Livestock/poultry
Richer	Ainakhet	>3-20	1-M.Sc	2-4 cows	>2-15	0-M.Sc	3-6 cows	>5-25	SSC-M.Sc	2-8cows
	Nosirpur	>2-8			>3-8			>2-6		
	Dholia	>8-20	1-Honors.	90% hh have 3-4 cows &2-3 goats	>5-15	1-honors.	70% hh have 2-4 cows and 1-2 goats	>6-12		80% hh have 2-3 cows and 3-4 goats
	Koirahati	>3-20	0-Honors.	4-5 cows and 1-2 goats	3-20	0-HSC		2-15	0-M.Sc.	
Medium	Ainakhet	>1-3	0-H.S.C	1-3 cows	>1-2	8-H.S.C	2-4 cows	>.5-5	1-Hons.	2-6 cows
	Nosirpur	1-2			1-3			1-2		
	Dholia	1-8	0-SSC	90% hh have 1-2 cows	2-5	1-HSC	Most of the hh have 2-3 cows	.2-6	1-SSC	
	Koirahati	1-3		4-5 cows and 1-2 goats				1-2		
Lower medium	Ainakhet	.5-1	0-S.S.C	2-4 cows 1-2 goats	.3-1	1-S.S.C	1-2 cows and 2-5 goats	.2-.5	1-H.S.C	2-3 cows and1-2 goats
	Nosirpur									
	Dholia	.3-1	1-SSC	90% hh have 1-2 cows and 1-2 goats	..2-1	1-SSC	90% have livestock 2-3 goats	1-2 acre	1-SSC	80% hh have 2-3 goats
	Koirahati	1-3	0-HSC					.5-1		
Poor	Ainakhet	*No land	0-5	90% hh have 4-5 chickens	*No land	0-5	80% have poultry 8-10 chickens	*No land	0-5	90% have poultry 5-6 goats
	Nosirpur									
	Dholia	.2-.5	0-5	60% hh have 5-6 chickens	0-.2	0-5	50% have poultry 7-8 chickens	.2-.5	0-5	50% have 1-2 goats
	Koirahati	.25-1	0-SSC					*No land		
Very poor	Ainakhet	No land	0- signature	Most of the hh have 2-3 chickens	No land	0	Most of the hh have 4-5 goats	No land	Signature	All of the hh have 2-3 chickens
	Nosirpur	No land	0	Some of the have have 3-4 chickens	No land	0	40% hh have 4-5 chickens	No land	0	Most of the hh have 3-4 chickens
	Dholia	No land	0-5	40% hh have-4 chickens				0	0-5	50% hh have 4-5 chickens
	Koirahati	No land	O	Majority hh have 3-4 chickens	No land	O	Some hh have 2-4 chickens	No land	O	Most of the hh have 3-4 chickens

(*only homestead, 0= illiterate) (HSC-Higher Secondary school Certificate; SSC- Secondary School Certificate; hh- Household)

The results presented Table 3.2 indicate that the heads of better off households' and village headmen used larger land holdings as key criteria during well-being ranking than representatives of worse off people, whereas level of education and inventory of livestock/poultry were common to all three key informants assessment of well-being.

3.3.3 Seasonal calendars

Table 3.3 and Table 3.4 presents food availability and health status respectively over a year based on the raw data (gender and well-being segregated seasonal calendars). It was observed in general that the pre-harvesting period of the two rice seasons *amon* (mid Sept. to mid Oct.) and *boro* (mid Feb. to mid Mar.) were the two main food deficit periods.

Food deficit months were perceived differently by households of different well-being levels and also between locations. Better off men and women were found to suffer less from food shortages than worse off households. On the other hand, rural households were more vulnerable than peri-urban households during the *amon* pre-harvesting period. Vulnerability to food shortages of worse off households was also identified prior to the *boro* harvesting period, but there was no major difference between locations (peri-urban/rural) for food shortage related vulnerability during this period.

Table 3.3 Health status of better off and worse off men and women in different villages

Well-being level	Village	Mid April - mid May	Mid May - mid June	Mid June - mid July	Mid July -mid Aug.	Mid Aug. - mid Sept.	Mid Sept - mid Oct.	Mid Oct. -mid Nov.	Mid Nov. - mid Dec.	Mid Dec. - mid Jan.	Mid Jan. – mid Feb.	Mid Feb. – mid Mar.	Mid Mar. - mid Apr.
Worse-off men	Ainakhet	pox	pox							Fever, dysentery	Fever, dysentery	Fever, dysentery	Fever, dysentery
	Nosirpur		Fever, cough, cold, hum, Pox, diarrhoea	Fever, cough, cold, hum, Pox, diarrhoea				Hum, pox	Fever, cough, cold			Fever, cough, cold, hum, Pox, diarrhoea	
	Dholia	pox	pox							Fever, dysentery Diarrhoea	Fever, dysentery Diarrhoea	Fever, dysentery Diarrhoea	
	Koirahati												
Better- off men	Ainakhet	Cold										cold, diarrhoea	
	Nosirpur	Diarrhoea										Pox, diarrhoea	
	Dholia	Pox						pox				Fever, pox	
	Koirahati	Tonsil	Influenza				diarrhoea					cold	
Worse- off women	Ainakhet					Fever		Diarrhoea				Pox	
	Nosirpur	Pox							Fever, cough				
	Dholia							Fever, skin disease, pox, cholera	Fever, skin disease, pox, cholera	Fever, skin disease, pox, cholera	Fever, skin disease, pox, cholera		
	Koirahati	Pneumonia, fever, cold	Pneumonia, fever, cold									Small pox	Small pox
Better-off women	Ainakhet							Fever, diarrhoea					
	Nosirpur	Skin disease/ diarrhoea											
	Dholia								Fever & diarrhoea	Fever & diarrhoea			
	Koirahati						Cholera		Fever, cold				

Table 3.4 Food and financial deficit months by well-being level and villages

Well-being level	Village	Mid April - mid May	Mid May - mid June	Mid June - mid July	Mid July -mid Aug.	Mid Aug. - mid Sept.	Mid Sept - mid Oct.	Mid Oct. -mid Nov.	Mid Nov. - mid Dec.	Mid Dec. - mid Jan.	Mid Jan. – mid Feb.	Mid Feb. – mid Mar.	Mid Mar. - mid Apr.
Worse off men	Ainakhet												
	Nosirpur												
	Dholia												
	Koirahati												
Better off men	Ainakhet												
	Nosirpur												
	Dholia												
	Koirahati												
Worse off women	Ainakhet												
	Nosirpur												
	Dholia												
	Koirahati												
Better off women	Ainakhet												
	Nosirpur												
	Dholia												
	Koirahati												

Level of food and financial deficiency

	comparatively low
	comparatively high

Households irrespective of location and well-being level suffered from different health problem mainly from mid October to mid March and also during the period from April to June. There were no important differences between location and gender, while worse off households irrespective of gender and location appeared to be affected more by health problems in terms of duration and types of diseases than better off households.

3.3.4 Activity matrix

Results from this matrix showed that rich men focused on rice cultivation ($P<0.05$) whereas poor men depended to a greater extent on day labour ($P<0.05$). Fish culture was important to both richer and poorer men. There was a significant difference ($P<0.05$) between the perceived importance of fish culture between men and women; womens' involvement in aquaculture was minimal, and mainly limited to fish feeding (Frankenburger et al. 2000). Vegetable production was more important to men than women but this importance also affected by wealth X location. Vegetable production was relatively more important to richer men and poorer women in peri-urban areas, and poorer men and better–off women in rural areas. Better-off men tended to have more business and social activities than poorer (Figure 3.3).

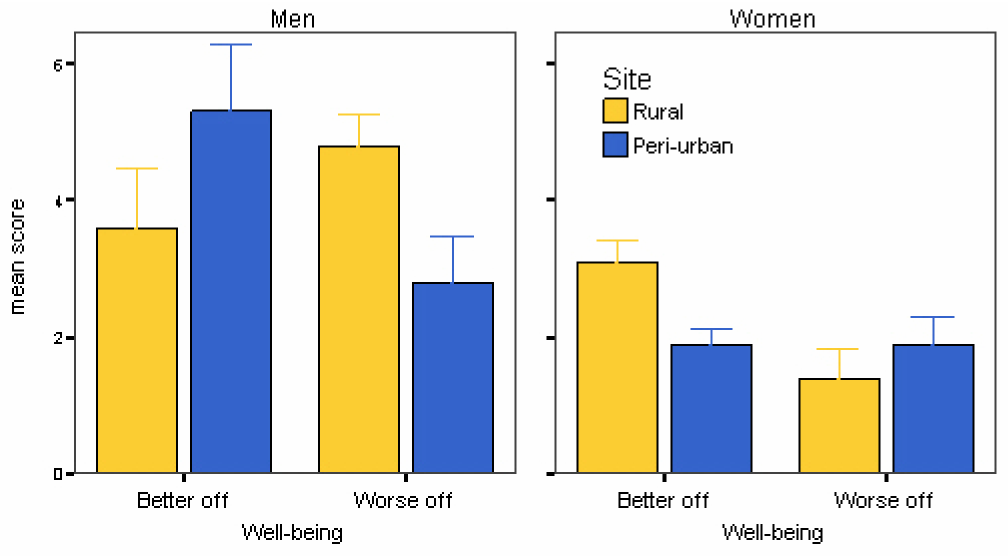

Figure 3.3 Importance of vegetable cultivation by well-being, gender and location

Activities were affected by well-being, gender and the location of the community. Men and women spent their time very differently. Men were mostly involved with agriculture and other income generating activities, whereas women were mainly concerned with a large range of household and domestic activities, which were significantly different from men but location depended (Figure 3.4).

Although household activities dominate the lives of all women, activities such as rice post harvest, vegetable and poultry production that occur close to the house were also important. The stakeholders explained that these are often incompatible activities. In general, rural women spent 6 hours per day in performing 84% of the homestead farming activities in Bangladesh (Miah et al. 1994). In addition to taking care of children and preparing and serving food to the members of the family, women were responsible for diverse agricultural, usually post-harvesting and non-agricultural activities. This includes processing of rice and other crops, care of livestock, vegetable and fruit production, maintenance and repair of houses and household equipment, collecting cowdung and firewood, fetching water and other domestic works (Ahmed et al. 1992). There was a significant difference ($P<0.05$) in the importance of poultry/livestock rearing between people of different well-being level (worse off>better off) at peri-urban location.

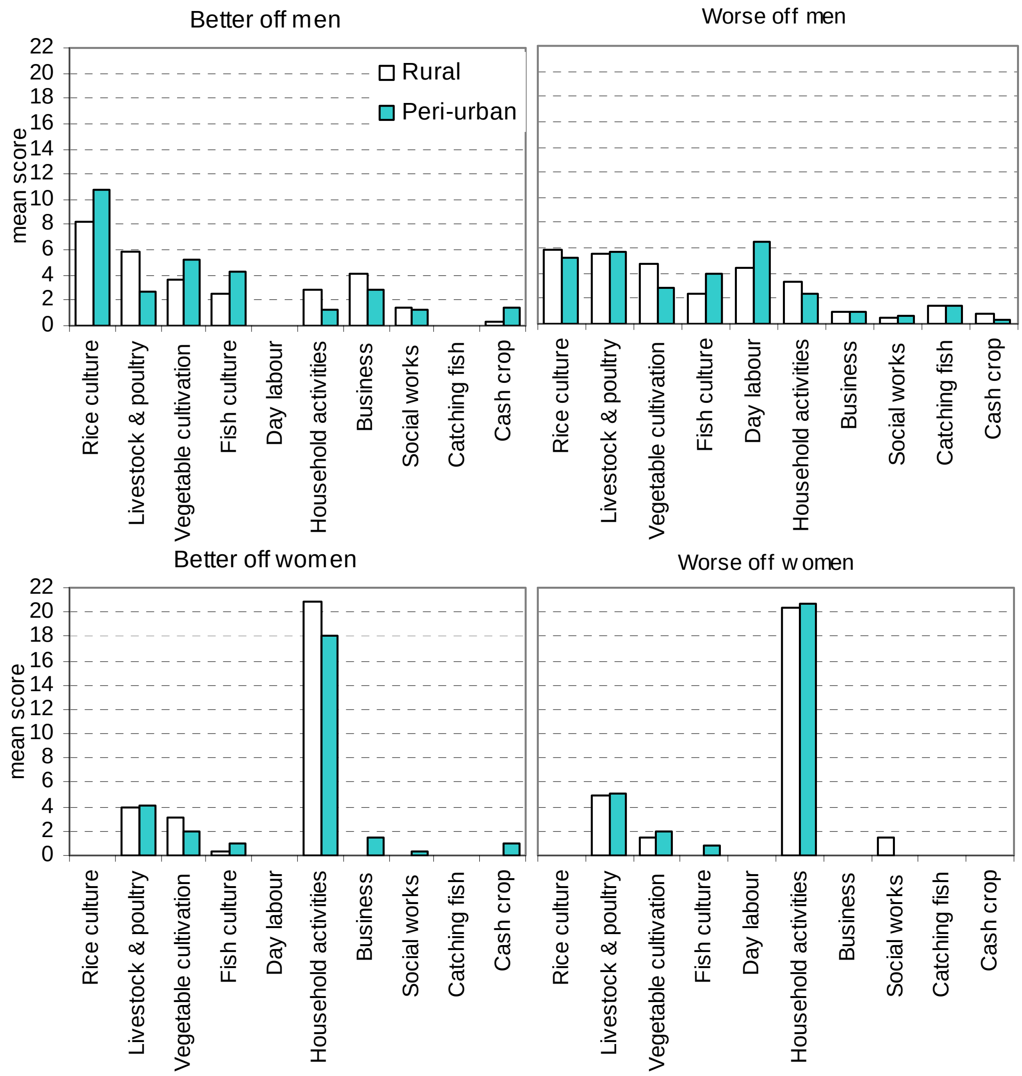

Figure 3.4 Activity matrix of better off and worse off men and women

3.3.5 Consumption matrix

It was revealed that rice, fish and vegetables dominated the diets of all groups. Fruits are also highly valued as part of diets that are highly diverse. There were few differences in consumption between those living in peri-urban and rural areas or between rich and poor, rice was more important to worse off men in rural than peri-urban area, and the better off consumed significantly more meat than the poor (Figure 3.5).

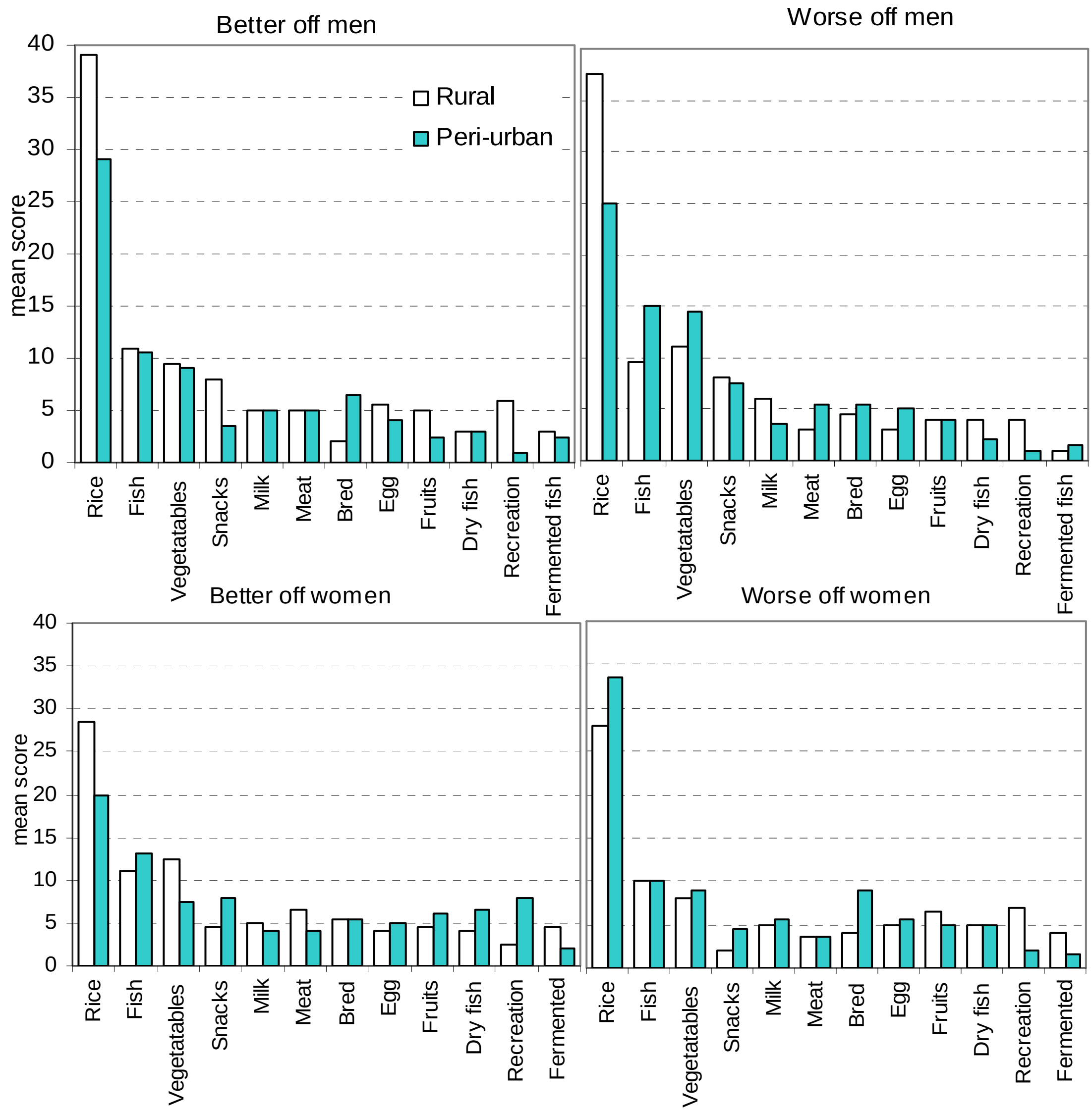

Figure 3.5 Consumption matrix of men and women

3.3.6 Expected and current use of pond and water

3.3.6.1 Expected use

There were many reasons identified for the original construction of ponds. In addition to raising fish, ponds were excavated to raise the ground level for house construction, domestic use, catching wild fish and to store water for the households. The role of ponds for family use (such as bathing, cleaning of utensils, washing cloths etc) was significantly different between rural and peri-urban communities (Figure 3.6). Households focusing on using pond-dikes for tree crops (orchard) were more likely to use water for irrigation, which is significantly different than other groups and this group were less interested in their ponds being used for trapping wild fish or as source of household water.

3.3.6.2 Current use

Current use of ponds is now dominated by fish culture and their role in the trapping of wild fish is unimportant. Households were also less reliant on ponds for general use, although bathing and watering of livestock remain popular. There was a significant difference in the importance of family use among groups and locations (Figure 3.6). When ponds were originally excavated a common expectation was for people to use the water for irrigation, particularly by the orchard group. In contrast, the orchard group currently scored this use as less important than other groups presumably as once established, watering was passive compared to vegetable production on dike, which requires active irrigation. Ponds were used as a source of irrigation water in both rural and in peri-urban communities. The importance of watering was significantly different (rural>peri-urban; $P<0.05$) among the groups in rural and peri-urban communities.

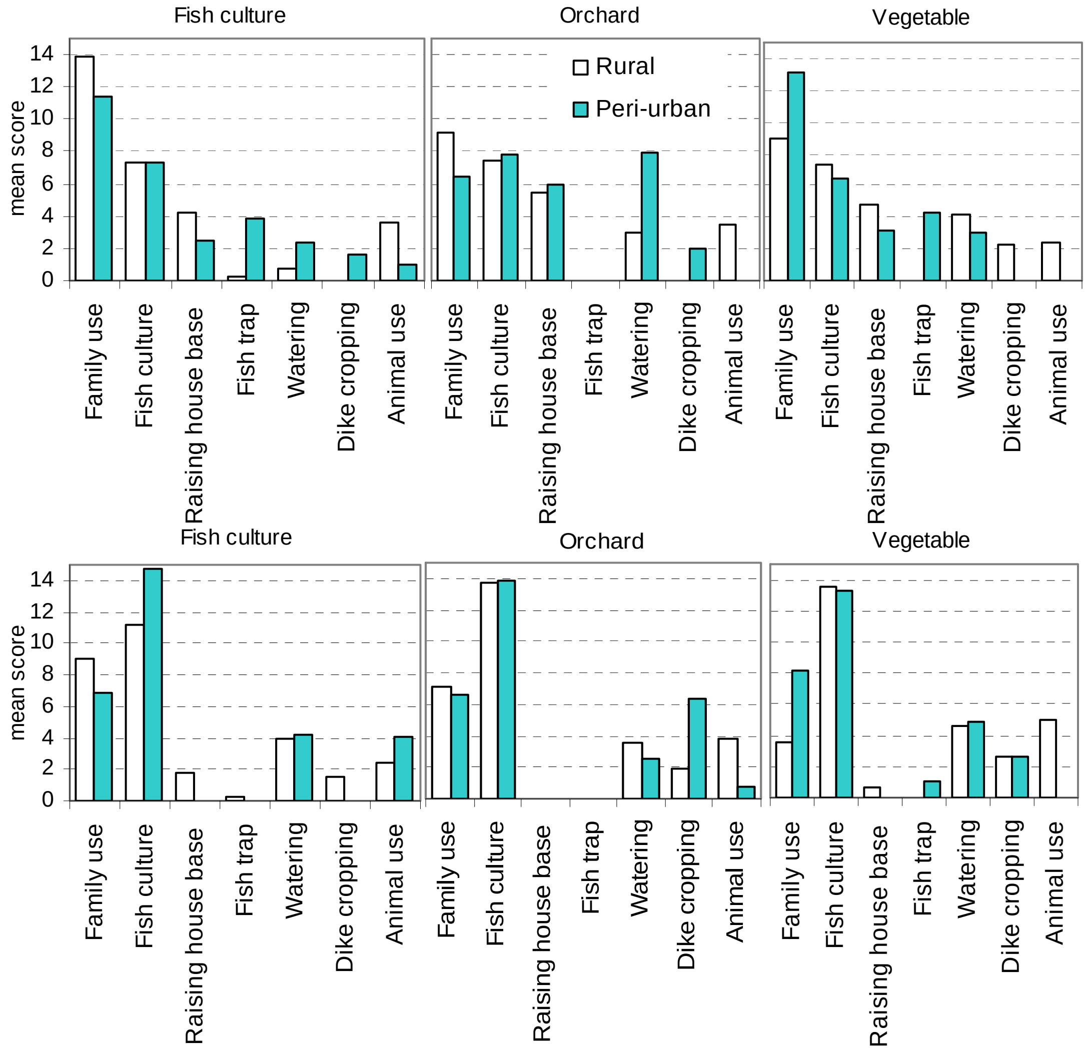

Figure 3.6 Expected (above graph) and current use (below) use of pond and water

3.3.7 Problems & benefits of pond-dike systems

3.3.7.1 Problems

Lack of knowledge was identified as a particular problem of farmers that principally produce fish and vegetables in rural areas, and was a significantly greater problem for peri-urban farmers (Figure 3.7). Lack of money was noticed as a relatively greater problem in the peri-urban area. Lack of inputs was more of a problem for farmers mainly raising fish than those raising fish as a secondary crop. Fish disease was also considered a major problem, although many stakeholders suggested that its impacts had substantially declined in recent years. Both the group and location affected the perception that fish disease was a major problem similar to the findings of other studies carried out in Bangladesh (Islam et al. 2002; Nandeesha et al. 2002). Fish and vegetable farmers in peri-urban areas ranked it as a major problem whereas in rural areas orchard growers found it more of a problem. The importance of water shortages during the dry season was found to vary mainly affecting vegetable growers.

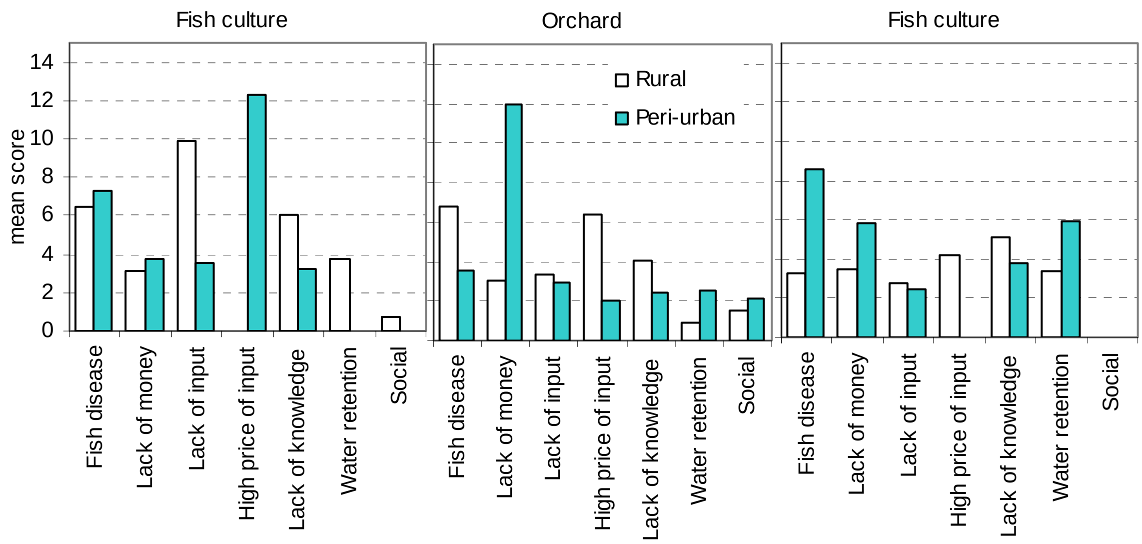

Figure 3.7: Problems of pond-dike systems

3.3.7.2 Benefits

The overall economic benefits of pond-dike system were highly valued by all groups of farmers. This was particularly the case for households who focused on producing fish or fruits in peri-urban areas (Figure 3.8).

Increased fish consumption was considered as the second largest benefit of pond ownership. Both the importance of fish consumption and economic benefit are significantly affected by group and location. Using pond water for irrigation and watering livestock as much more important for vegetable farmers and, generally, in rural areas. Rural fish farmers were more likely to use pond water for watering vegetable and tree crops, and the importance of this benefit is significantly different among groups at particular locations. Nutrition and income are the direct benefits derived from integrated aquaculture. Other major benefits include availability of fresh fish and employment.

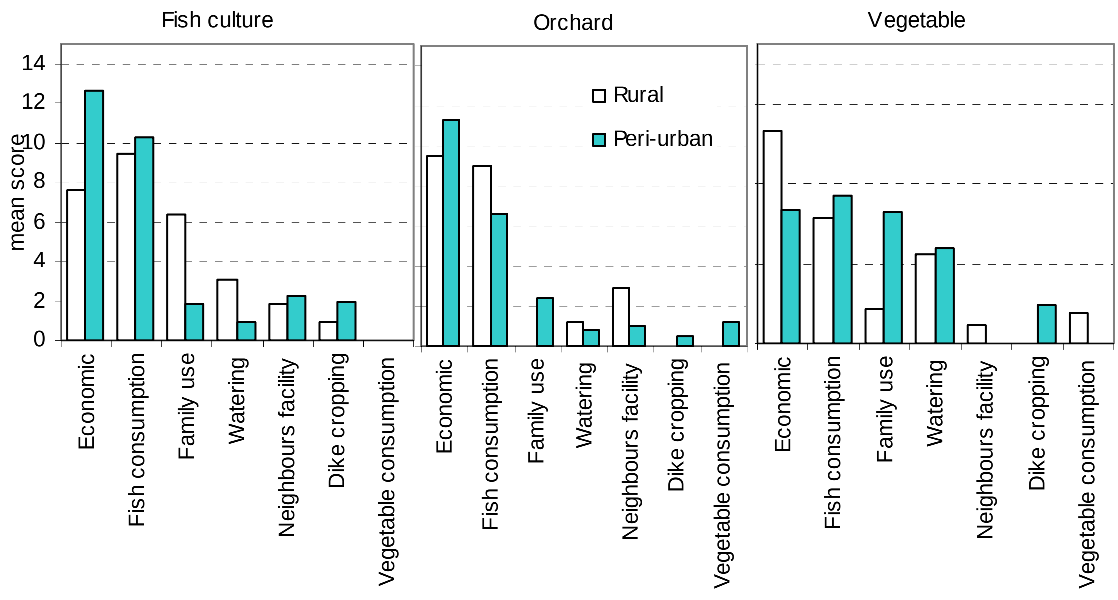

Figure 3.8: Benefits of pond-dike systems

3.3.8 Triangulation and validation

3.3.8.1 Village level triangulation

There was no major disagreement with the findings of PCA when the results were presented before the participants in each community, but participants wanted to know how this research would be benefited to them. Some of them were interested to know if the project would help providing training, reading materials on fish and vegetable cultivation, credit and some of them were interested to get quality fish and vegetable seed.

3.3.8.2 Central level triangulation

Trend analysis of aquaculture development carried out by fish and fish seed traders (fry/fingerling) of fish traders reflects increased interest of households on fish and vegetable cultivation compared to previous times (Table 3.5). Fish traders, during their group work, mainly focused on vegetable cultivation rather than fish while seed traders focused discussion on fish. Fish traders indicated that farmers don't usually cultivate vegetable on dikes if the ponds are not located close to their residence. Fish seed traders informed that multiple ownership was one of the constraints hindering development of aquaculture; they also mentioned that increased application of feed to the pond make the pond water quality less valuable for general household activities. Crucial problems of pond-dike systems identified by the fish growers were lack of knowledge about pond-dike systems, fish & vegetable disease, lack of inputs (fish and vegetables) and improper marketing.

GOs participants informed that they don't have any mandate to promote IAA systems though they were optimistic about the potential of IAA in Bangladesh and suggested that result demonstration programs by DAE might be an appropriate method of broader dissemination, motivation and adoption of IAA systems. On the other hand, NGOs explored five appropriate ways how to utilize pond dikes. They also identified five major problems of pond-dike systems which were very similar to the problems identified by the fish growers themselves (Table 3.5).

Researchable issues identified by the different groups are presented in the Table 3.6. It was revealed that the first priority researchable issue identified by the farmer was to understand the status of pond-dike systems, while fish traders were more interested to understand the relative benefits of fish and crops which was the second priority of the NGOs. NGOs were more interested to explore appropriate fish species and vegetables while GOs raised questions as to the broader combination of pond-dike components. Major policy issues explored by the stakeholders were to improve institutional linkages for enhancement of information access, promote integrated farming and pond-dike adopting households' attitude assessment (Table 3.7).

Table 3.5: Outcome of different participating groups of SOS workshop

Table fish traders	Fry/fingerling traders
Major trends of aquaculture and effects of pond-dike systems on pond management and fish trade;	Major trends of aquaculture and effects of pond-dike systems on pond management and fry demand;
Bottle gourd, sweet gourd, cucumber, country bean, Indian spinach etc are the most common vegetables for pond dykes	Fish culture has been increased by 10 times as compared to the previous years
Earlier pond dykes were planted with big fruit/timber trees, farmers currently started planting coconut, papaya & banana trees on pond dykes	Pangus culture has been increased but price reduced (current market price- Tk 30-50 /kg, earlier it was Tk. 100 /kg)
As big trees create shading on ponds, farmers started planting small trees instead of big trees	Farmers stock common carp, catla, rohu & silver carp with pungus i.e poly culture is a common practice
Farmers' don't cultivate vegetable crops if the ponds are far away from their house	silver carp, pungus, sarputi, tilapia, catla, grass carp, common carp mirror carp, rohu, big head carp and african catfish are the most common species, although they face problem with combination
Due to lack of money farmers do not able to make fence for vegetable crops, as a result goat damage the plants & thief take the crops	Farmers tried to culture prawn but did not success as per their expectation
Vegetable cultivation practices has been increased and they make fence by the fine & less expensive net	Common carp has become a popular species at it breeds naturally and eventually farmers used to get fry without cost
Farmers sometimes avoid vegetable cultivation on pond dykes to avoid conflict with the neighbours	Poor people stock fish seed more frequently than richer Multi ownership problem still a big issue in the village
Vegetable growers sell the vegetables by themselves, although if the quantity is high they sell the product through wholesalers	Recently increased application of feed/fertilizers has led to pond water quality deterioration for general households activities and in such case they try to use tube- well water for households activities
In case of emergency vegetable growers apply less toxic pesticide to the vegetable field if it is close to the pond to safeguard fish and try to avoid applying in rainy days to prevent residual runoff to the ponds	Application of mustard oilcake in the ponds has been increased extensively Farmers apply grass & banana leaf for grass carp

Continuation of the Table 3.5.

Farmer representatives	GO representatives	NGO representatives
Problems of pond-dike systems; Lack of knowledge about pond-dike system and appropriate time of vegetable cultivation Lack of money Lack of good quality fish and vegetable seed Lack of organic fertilizers Insect and disease of vegetable crops Conflict with the neighbours due to plantation of trees on dykes and scavenging poultry/livestock damaging neighbours crop fields Cost of vegetable garden fencing materials is high Difficulties to throw cast net due to presence of vegetable fence on dyke Lack of knowledge about the residual effect of pesticide on fish that are applied in the vegetable field Lack of proper marketing facilities and availability of reliable seed dealer Chicken eat seedling of vegetables & damage plants Perching of birds the trees leads to predation fish in ponds The turbidity of pond water might increase due to dike soil erosion Uncontrolled fertilization from duck and hen faeces can be harmful for pond water Flood and poaching cause financial harm	Current role; Currently DoF has a training program on integrated farming however which does not directly focus on pond-dike systems. However, the idea of pond-dike systems seems good for the agricultural development Bangladesh. Way of encouragement; Exhibition plot with the integrated pond dyke system might motivate the farmers DAE (Department of Agriculture Extension) can play significant role in this regard. Mechanisms need to be developed to inform them about the financial benefit of pond-dike farming system Focus needs to be given first in the areas where amount of arable land is less, existing ponds could play significant roles to increase crop production using water and soil from pond. If number of ponds are not sufficient new ponds could be excavated	The best 5 ways ; Cultivation of crops like spinach ,country bean, gourds etc using trellis on pond Tree nursery on pond dyke, Tall tree like coconut plantation Livestock could be reared (eg. chicken , goat and rabbit rearing) Insect trapping and use as fish feed Organic compost preparation on dikes Five major problems; Lack of quality seed (both fish and vegetable) Lack of knowledge about integrated pond-dike systems Fish and vegetable disease (mainly ulcerative disease of fish and vegetable diseases such as tomato & ladies finger leaf curling, brinjal fruit and shoot borer) Less growth of fish and vegetable Lack of money

Table 3.6: Researchable issues identified by different group of participants

Priority	Farmers	Traders	NGOs	GOs
1	the status of integration of fish and dike-based crop production.	relative benefits between fish culture alone and integrated pond-dike culture	criteria for selection of appropriate fish and crop varieties for pond-dike integration	potential combinations of vegetable, fruit, nursery, poultry and wood tree in pond-dike systems
2	alternatives to cow-dung for fertilising pond dike crops.	the nutritive value of pond bottom mud as organic fertilizer	relative benefits between fish culture alone and integrated pond-dike culture	potential of integration between fish, livestock and crops
3	strategies to produce high quality vegetable seed locally.	the relative efficiency of pond bottom mud compared to other organic and inorganic fertilizers for growing crops/vegetables	potential of integration between fish, livestock and crops	strategies to use seasonal pond bottom during dry season for crop production
4	the qualitative value of pond bottom mud as organic fertilizer.	the relative value of pond water and ground water for irrigation of dike crops	constraints to and opportunities for participation of women in pond-dike systems	approaches to further improve existing pond dike systems
5	criteria for selection of fish species for different pond environments	potential of self-recruiting species of fish (SRS) within different pond-dike systems	strategies for year-round vegetable cultivation in pond-dike systems	
6	the suitable vegetable varieties for growing on pond dikes in terms of their value as fish feed	the reasons for fry mortality during transport and possible preventative measures	the potential of short-term fruit crops (e.g. Papaya & Guava) in pond dike system	
7	the effects of different inorganic and organic (cow dung, poultry litter, compost etc.) fertilizers on the crop/vegetable grown in pond dike.	the causes of fish diseases occurring in culture ponds and preventative measures		
8	vegetable varieties for use on pond dikes that optimize production and household incomes	the underlying factors affecting seed quality to enhance fish growth		
9	The processes by which the water holding capacity of ponds can be improved through using organic materials	strategies to improve brood fish performance after transportation		
10		the causes responsible for fry mortality after stocking		
11		the dynamics of fish marketing systems		
12		nature and extent of pest infestation in vegetables and integrated pest management		

Table 3.7: Policy / Implementation issues

Priority	Farmers	Traders	NGOS	GOS
1	Improve links between different agencies and local organizations to improve availability of information	Duck cum fish culture	Integration between fish and poultry production	Monitor impact of farmers attitude on pond-dike technology adaptation
2	Facilitate access to improved varieties of crop seed for pond-dike use	Chicken cum fish culture	Integration between fish and tree nursery on pond dikes	Encourage participation of women in pond-dike activities
3	Encourage biological pest control for crop/vegetables grown on pond dyke instead of using chemical insecticide/pesticides		Integration of fish, api-culture & vegetable production	
4	Minimize the residual effects of pesticides/insecticide s used in the pond dykes systems for fish in the ponds		Aquatic weed (azolla)-based fish culture	

3.4 Discussion

The participatory methods used in this study were useful in gaining entry to a community and beginning a dialogue with farmers. Such a process has been reported to shift the focus of agricultural research from being commodity-specific towards a more farmer-centered approach, which can empower community people in the process of technology development and dissemination (Spring et al. 2000).

A menu of participatory techniques and principles were followed in this study to ensure involvement of researchers and the community people and the level of participation can be considered as collaborative rather than consultative (Biggs, 1989; Pretty, 1995), where researchers and farmers collaborated as partners. An advantage of these methods was that they tended to emphasize visualization and included tools such as well-being ranking, time line, informal mapping, diagramming, as well as the scoring and ranking of different actions. The mapping exercise helped understanding the general resources of the village and perceptions of the men and women of the communities. It was observed that the perceptions of men and women were nearly similar. Relative consistency was also observed between male and female mapping elsewhere (Adams et al. 1993). Finally the SOS workshop contributed enormously to validate PCA findings and for generating researchable issues.

The well-being ranking technique using cards pioneered by Barbara Grandin during her work in Kenya with pastoral communities was revealed to be an effective process in this study for identifying well-being, wealth and complex resource base of the people (Grandin, 1988). Well-being ranking was the most complicated and time consuming methods among all of the tools used in the PCA. It was observed that most of the key informants from rural areas used land holding as a criterion during ranking compared to peri-urban area, probably explained by the increased relative importance of agriculture in rural than peri-urban area. However, it was revealed (Table 1.3) that better off and village headman tended to use higher educational levels and holdings of land and livestock/poultry as criteria during well-being ranking than the worse off representatives. This reflects perceptional and attitudinal disparity of the representatives of different well-being levels (Sarch, 1992). However, averaging the scores derived from categories done by the facilitators reduced the biasness/error of the process; a similar process has been adopted in Zimbabwe (Scoones, 1988), India (Shah et al. 1991), Gambia (Sarch, 1992), Bangladesh (Gregory, 1999) and elsewhere.

The result of well-being exercises showed that the poorer were the most dominant groups, and were not homogenous, whereas smaller percentages of the households were richer, which is a common well-being pattern of Bangladesh (Hossain, 2005). However, well-being ranking was done based on the perception, attitude of the facilitators within a specific area (Guijt, 1992), so it could not be concluded that the indicators and categories of the households would be similar in other parts of Bangladesh.

Seasonal calendars helped understanding the complexity of vulnerability of the households in different locations. It was clear that there is shift in the most vulnerable months from *amon* to *boro* pre-harvesting periods due to the changes in focus towards *boro* rice resulting from the increased availability of irrigation sources and development of new technologies (Tetens et al. 2003). The intensity and duration of the food deficit period was higher in the *boro* pre-harvesting period followed by *amon*, which is reverse situation to that previously reported (Alderman and Sahn, 1989; ADB, 2001).

Though rural households were relatively more vulnerable than peri-urban in the post harvesting period of *amon* season. This may be explained by lower earnings, at this time, whereas peri-urban households had greater resilience because of the situation probably due to increased employment opportunities as a consequence of recent industrial development in urban areas (UNDP, 2005).

Health status was similar between genders in all locations, while worse off households were found to suffer more than better off households during the change over in seasons perhaps due to their lower immunity to disease as a result of poorer nutrition than richer people; this supports the findings of 'Helen Keller International' in Bangladesh (HKI, 2002a). In Bangladesh seasonality and food, nutrition and health factors are closely linked (Chaudhury, 1980; Abdullah and Wheeler, 1985; Abdullah, 1989), which explains the extent of vulnerability as well as poverty (Chaudhury, 1980; Messer, 1989b; Tetens et al. 2003; Tetens and Thilsted, 2004). However, both better off and worse off households in all locations have illustrated a similarity in the importance of major food items through the consumption matrix exercise, but rural better off men's higher preference on rice probably suggests increased availability of rice or less substitutes in the rural area as compared to peri-urban area.

Pond-dike systems are valued more for their income earning potential rather than as a source of food suggesting the households' aspiration to earn money from this system and support other family expenses. Fish and vegetable cultivation were prioritized by all groups, though the similar importance of fish culture to the better off and worse off households seems a bit surprising. However, it might be due to an involvement in fish culture irrespective of location by any household with access to a pond and this trend reflects the current role of fish pond as an important food source for people of Bangladesh (Bestari et al. 2005).

Richer men preferred vegetable cultivation more in peri-urban than in the rural communities as an important enterprise possibly due to better access to markets. Lack of access to market has also been identified by the 'farmer' group as a constraint during SOS workshop, though specific locations were not mentioned. Women's preference for vegetable cultivation varied between the peri-urban and rural communities due to access to marketing facilities, poorer women preferred vegetable cultivation probably as investment costs for vegetable cultivation were low while richer women preferred business and other crops rather than vegetable because of better access to money for investment.

Through the PCA exercise it became clear that fish culture is now the dominant use of ponds irrespective of groups which was confirmed during SOS the workshop, and now considered a common development in Bangladesh (Bestari et al. 2005). Reduced use of ponds for general household activities (which was a major original objective of pond construction) also reflected intensification of ponds for fish culture was revealed during the PCAs and confirmed by the SOS workshop. People do not use pond water for domestic use if they use cowdung for fish culture as they prefer to use tube well water, however poorer households with poorer access to tube wells tend to use less cowdung (DANIDA, 2004).

In Bangladesh fishponds were originally constructed as borrow pits which were dug soil mainly to raise the ground level of village settlements and pathways (Bestari et al. 2005). Ponds were relatively more important as a source of irrigation water in rural than peri-urban communities revealed from both 'current use' and 'benefit' exercise perhaps may be largely depend on pond water whereas peri-urban farmers probably use other inputs (feed/fertilizers) more than rural. However, intensification of aquaculture and a widespread introduction of deep and shallow tube-wells probably explain the change in the relative importance of ponds towards fish production and away from general household use.

Irrigation and pond water management could play a vital role for the success of pond-dike systems. The participants did not directly mention pond and water as a source of nutrients perhaps as they did not have knowledge about the potential benefits of pond and water resources. However, their feelings about pond-dike systems might be explained that valuing this system potentially reflects pond water as an important source of nutrients (Little and Muir, 1987). There are about 23,000 Deep Tube-Well (DTW) with availability of 5-6 ponds per deep tube-well in Bangladesh (Annonymous, 1986). All over Bangladesh, there exists a scarcity of water during dry season (January-April/May), which severely reduces crop production, which has been identified as one of the major problems especially by the vegetable growers, who depend more on pond water than others. Integration of ponds close to existing DTWs can be a potential way to improve water availability at virtually no or little additional cost (Karim et al. 1983; Fazal et al. 1996).

'Lack of knowledge' was identified from PCAs and the SOS workshop as a particular problem of both fish and vegetable growers in rural areas; this reflects their poorer access to education and information. Fish disease, high price of inputs, lack of money were also identified as major constraints in general, however, to overcome these constraints it was suggested during SOS workshop to develop appropriate technology to integrate aquaculture and horticulture through proper utilization of farm resources. It can be concluded that considerable potential exists for further integration and development of pond-dike systems, which could contribute towards improved livelihoods of both better off and worse off people.

Chapter 4: Broad characterization of livelihoods and farming systems

4.1 Introduction

The findings from the previous phase of research (Chapter 2) allowed us to get an insight about the general context of the villages, village people and farming systems, but did not generate detailed household level information. A household is commonly defined as ‘ a person or co-resident group of people who contribute to and /or benefit from joint economy in either cash or domestic labour’- that is, a group of people who live and eat together (Rakodi, 2002). However, the specific assets/resources accessed by different households and the prevailing institutional/organizational context which might have influenced adoption of different farming systems was unclear. It was anticipated that the level of well-being and location are likely to affect households’ level of adoption and adaptation of pond-dike systems that the level of integration between fish culture and dike cropping would vary.

It was decided to assess the impact of integrated farming at the household level through a structured survey rather than individual level assessment which in general fails to distinguish between individual impacts and group impacts (Hulme, 2000). Though impact assessment at household level is less easy to conduct than individual level, it is much broader in terms of coverage than individual assessment.
The following questions were used to focus the enquiries;

- What are the impacts of pond dike systems on the livelihoods of different people of different socio-economic status? Is location of pond-dike systems in rural or peri-urban areas an important factor? How pond-dike systems make contributions to the health, nutrition and income of rural and peri-urban households?

- Are there any major differences of livelihood status between pond-dike and non-pond households? Do the pond-dike operators utilise their farm resources more efficiently compared to only pond operators?
- Do pond-dike operators depend more on the fish/vegetable enterprise for their livelihood than that of non-pond dike operators?
- Do the pond dike operators consume and sell more fish and vegetable than the pond and non-pond operators? Is there any variation in fish/vegetable intake among different households from different socio-economic categories in rural and peri-urban areas?
- What is the relationship between the uptake and success of integrated aquaculture and access to critical inputs (physical/financial/information) provided by different promoters (organizations/institutes)?

4.2 Objectives and research hypothesis

Finding suitable aquaculture development approaches to open up livelihood opportunities for the resource poor households remains a challenge. The poor face many constraints for adopting any technology because of lack of access to capital and resources, vulnerability, and aversion to risks (Ellis, 2000b). Considering the above issues, the baseline study was designed informed by the livelihood framework (Carney, 1998; Carney et al. 1999; Ellis, 2000a).

For the analysis, this study examined the channels through which the integrated farming households are affected in their farming operations, such as access to livelihood assets, access to services and facilities, key transforming process, including institutions and policies. The survey includes interviewing farming households as the main tool for data collection (Theis and Grady, 1991; Neuman, 1994; Reid and Gough, 2000).

However, major objectives of the baseline study were as follows-

4.2.1 Objectives

- To determine the impact of pond-dike systems on the livelihoods of farming households of Mymensingh district of Bangladesh.
- To develop a deeper understanding of livelihood status of adopting pond-dike systems households and non-adopting households.
- To define and characterize the livelihood/socio-economic status of those households involved in pond-dike and non-pond farming systems.

4.2.2 Hypothesis

Pond-dike systems adopting households' have a different livelihood status compared to non-adopting households. The level of well-being, education, age, access to finance, access to information and location affects adoption, adaptation and rejection of pond-dike systems.

4.3 Methodology

This chapter summarises the findings of the survey carried out with 209 farming households from December 2002 to January 2003 in three rural and three peri-urban areas of Mymensingh district, Bangladesh. Prior to the survey two more villages as rural and peri-urban were selected in addition to the previously selected four villages through following the process elaborated earlier (Chapter 2) to have more replication of the areas. In these two villages well-being ranking was an initial first step to understand the social profile of the community.

4.3.1 Design of the research

Broadly households were divided into two socio-economic groups viz. richer and poorer through the PCA well-being exercise. Each group was further categorised into the following three groups through discussing with the villagers residing in different parts of the village and later cross checked through household visits.

- Pond-dike households with active integration (households use pond dikes for growing vegetables and apply pond water to the vegetables grown on dike and/or vicinity of the pond)

- Pond-dike households with passive integration (households grows mainly perennial plants on the dikes and do not use water frequently like active groups)
- Non-pond households (households without pond)

Subsequently separate lists were developed from each of the villages based on supplementary and basic information such as household location in the village, households name, fathers/husbands name and pond ownership pattern (Table 4.1). During the PCA exercise the farming households were categorized into three types i.e. fish culture, fish culture with orchard and fish culture with vegetable crops though the number of fish culture households were negligible, after completing the PCAs. It was observed that this group was passively integrated to some extent planting small numbers of seasonal/perennial trees, eventually this group was also merged with the passive groups.

Table 4.1: Categorization households based on type of ownership

Location	Village	Passive		Active		Non-pond	Total
		Single	Multiple	Single	multiple		
Peri-urban	Nosirpur	48	47	28	5	59	187
	Ainahket	31	54	42	8	54	189
	Damgao	40	29	37	10	35	151
Peri-urban total		119	130	107	23	148	527
Rural	Koirahati	46	18	19	6	123	212
	Dholia	31	52	17	8	35	143
	Goatola	69	30	40	6	54	199
Rural total		146	100	76	20	212	554

4.3.2 The questionnaire

The questionnaire was structured in a way which covered household level information to assess the nature and level of different assets (natural, social, financial, human and physical) implicit with the livelihood framework. It also included questions related to the vulnerability, coping strategies, and transforming structures and processes.

Initially a draft questionnaire was developed in English in participation with other Pond Live project staff. This questionnaire was then translated into Thai language and revised after pre-testing in Sisaket, Thailand where a similar survey process was underway. Afterwards, corrections were made on the English questionnaire based on the revision of the Thai questionnaire and later translated to Bengali language and again field tested in Bangladesh with households in a non-study village. The survey questionnaire was designed into eight major sections (Appendix 6) based on the livelihood framework.

Section 1 of the questionnaire covered general information of farming households. Section 2 and 3 covered information on agricultural crops and household assets. Section 4 covered the institutional context, while nutrient flow dynamics in the farm level and households perception about pond-dike systems were included in the sections 5 and 6, respectively. Information on consumption and finance were incorporated in the sections 7 and 8 respectively.

4.3.3 Survey team

The enumerator team, comprising graduate students of the Bangladesh Agricultural University, Mymensingh, were recruited by the project to carry out the survey. They were trained theoretically and subsequently practically over a period of four days. On the first day all aspects of the questionnaire were presented and each member allowed developing their understanding of how to collect the information from household including protocols for entry to household introductions etc. Over the following two days, the questionnaire was pre-tested with 4-5 households in two non-sample villages by the enumerators and on the last day, all enumerators were involved in making final necessary amendments to the questionnaire.

4.3.4 Sampling and survey

Prior to the survey date a random sampling process was used to select the households. Household head's names along with well-being status and farming system were written on small cards and were kept separately based on farming systems and further on level of well-being.

However, after arriving to the field the researcher and other facilitators decided which part of the village will be surveyed by whom, irrespective of household category. It was targeted to survey 30 households, which is much higher than the recommend sample size. If the total population is 20,000 the recommended sample size is 392 (Arens and Loebbecke, 1981). However, the sample size was 30 (2 well-being X 3 farming systems X 5 representatives) from each village totalling 180 households from 6 villages, but the number finally reached to 209. However, final data for four households were excluded during data checking because of lack of information in several sections of those questionnaires (Table. 4. 2).

Table 4.2: Number of households surveyed by location, well-being and farming groups

Location	Village	well-being	Groups			Grand Total
			Pond-dike (active)	Pond-dike (passive)	Non-pond	
Rural	Dholia	Better off	7	7	1	15
		Worse off	5	7	4	16
	Gotla	Better off	10	4	4	18
		Worse off	13	5	5	23
	Koirahati	Better off	6	4	11	21
		Worse off	7	5	7	19
	Rural Total		48	32	32	112
Peri-urban	Ainakhet	Better off	5	7	3	15
		Worse off	4	7	5	16
	Damgao	Better off	6	4		10
		Worse off	8	8	5	21
	Nosirpur	Better off	7	4	5	16
		Worse off	5	5	5	15
Peri-urban Total			35	35	23	93
Grand Total			83	67	55	205

(Better off total- 95; worse off total – 110)

In general, the head of the household was interviewed; however, his/her spouse and other family members were also commonly participated. A brief introduction to explain the purposes and process of the interview was given prior to the interview to acquaint interviewer with the context and importance of the survey.

4.3.5 Quality control

At the end of each day's survey the enumerators handed over the questionnaires to the researcher to verify if any information was missing or improperly collected. Questionnaires requiring clarification were returned to the enumerator to the following day for a follow up visit for amendment. It is noteworthy that any confusing information was shared with all facilitators to minimize the possibility of similar mistakes occurring. Interviews started at around 10 am and were completed by around 4 pm on each day. Each of the facilitators was able to interview of 3-4 households per day and about 1-1.30 hours was required for interviewing one household. On an average, around 3 days were needed to complete the survey in each village.

4.3.6 Data analysis

Descried in the methodology Chapter 2.

4.4 Results

The results has been presented based on the livelihoods framework though not all aspects of livelihoods are covered in this chapter rather focus has been given on the livelihoods assets (human, physical, social, natural and financial), transforming structures and process, livelihoods strategies (mainly farming systems) and outcomes. Issues relating to health, vulnerability and coping strategies are presented in the Chapter 5. Health issues have been presented in Chapter 3 and with sections discussing with sections discussing vulnerability and coping strategies in the final discussion (Chapter 7).

4.4.1 Livelihood assets

4.4.1.1 Human capital

Households occupancy and age

The mean household size of the survey population was 6 (±2) ranging from 2 to 18. Household size was not affected (P>0.05) by location, well-being or group (Appendix 7). The age of the respondents, in general the head of the households, ranged between 20 to 90 years with an average age of 47.41 (±14.3) years. Aggregating into three age group categories to analyse the households' age dynamics, indicating no differences (P>0.05) between the groups. A higher percentage of active (43%) and passive (47%) household heads' were in the 41-60 years age group compared to non-pond households (29%). A majority (55%) of the non-pond farming household head were in the 20-40 years age group (Table 4.3).

Table 4.3 Age group distribution by groups (percentage of households)

Groups	20-40 years	41-60 years	61-90 years
Active	34	43	23
Passive	40	48	12
Non-pond	55	29	16
Total	41	41	18

Education

Four different education categories were used in this study to define educational level; 1) primary level: 1 to 4 years education, 2) secondary level: 6-10 class, 3) higher secondary level: 10-12 year, and 4) Degree: Bachelor and Masters. Literacy level was significantly higher [$\chi^2(2)=14.98$, P=0.001] among the household heads of active integrated (76%) farming, than for passive (58%) integrated and non-pond (44%) (Figure 4.1; Appendix 8).

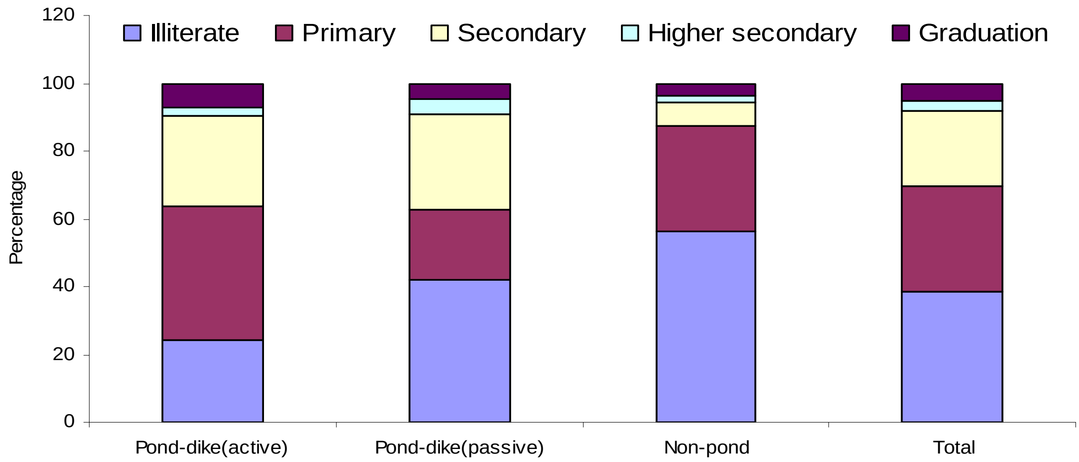

Figure 4.1 Level of literacy among the household groups

Illiteracy rates of the worse off household heads was more [$\chi^2(1)=25.68$, P= 0.001] than double (55%) that of better off (20%) households (Table 4.4; Appendix 9). Among the literate people the majority proportioan attained primary level education, followed by secondary, higher secondary and graduation (Table 4.4). The literacy rates in the rural and peri-urban areas were 57 % and 68%, respectively, although the difference was not significant.

Table 4.4 Household heads education by system and well-being level

Well-being	Groups	Primary	SSC	HHC	Graduation	Illiterate	Total
Better off	Active	15 (37)	12 (29)	2 (5)	5 (12)	7 (17)	41(100)
	Passive	8 (27)	12 (40)	2 (7)	2 (7)	6 (20)	30 (100)
	Non-pond	11(46)	4 (17)	1(4)	2 (8)	6 (25)	24 (100)
Better off total		34 (36)	28 (29)	5 (5)	9 (9)	19 (20)	95 (100)
Worse off	Active	18 (43)	10 (24)	0	1 (2)	13 (31)	42 (100)
	Passive	6 (16)	7 (19)	1 (3)	1 (3)	22 (59)	37 (100)
	Non-pond	6 (19)	0	0	0	25 (81)	31 (100)
Worse off total		30 (27)	17 (15)	1 (1)	2 (2)	60 (55)	110 (100)
Total		64 (31)	45 (22)	6(3)	11(5)	79 (39)	205 (100)

(Figures in the parentheses are percentages) (SSC- Secondary School Certificate; HHC- Higher Secondary Certificate)

Out of 1,317 households members including the household head, a total of 147 children aged five years, or less, were excluded from the household members' educational status analysis (Table 4.5). Active households' literacy levels were higher ($P<0.05$) than passive and non-pond households; conversely, illiteracy rates of non-pond and worse off farming household are higher than any other groups. Men are more literate than women irrespective of group and location (Table 4.6).

Table 4.5 Level of literacy in the household by well-being and groups

Criteria	Groups	Illiterate	Primary	SSC	HHC	Graduation	Total
Rural	Active	80 (47)	58 (34)	30 (18)	0	2 (1)	170 (100)
	Passive	62 (20)	112 (36)	99 (32)	14(5)	21(7)	308 (100)
	Non-pond	51 (24)	55 (26)	78 (37)	15(7)	10 (5)	209 (100)
Rural total		193 (28)	225 (33)	207 (30)	29(4)	33 (5)	687 (100)
Peri-urban	Active	49 (43)	32 (28)	28 (24)	4(3)	2 (2)	115 (100)
	Passive	29 (16)	75 (41)	58 (31)	9(5)	14 (8)	185 (100)
	Non-pond	54 (30)	55 (30)	62 (34)	8(4)	4 (2)	183 (100)
Peri-urban total		132 (27)	162 (34)	148 (31)	21(4)	20 (4)	483 (100)
Better off	Active	30 (12)	86 (34)	99 (39)	14(6)	23 (9)	252 (100)
	Passive	32 (16)	47 (24)	87 (44)	21(11)	11(6)	198 (100)
	Non-pond	20 (16)	52 (41)	48 (38)	4(3)	4 (3)	128 (100)
Total of better off		185 (32)	82 (14)	234 (40)	39(7)	38 (7)	578 (100)
Worse off	Active	61 (25)	101 (42)	58 (24)	9(4)	12 (5)	241 (100)
	Passive	73 (38)	63 (32)	53 (27)	2(1)	3 (2)	194 (100)
	Non-pond	109 (69)	38 (24)	10 (6)	0(0)	0	157 (100)
Total of worse off		202 (34)	243 (41)	121 (20)	11(2)	15 (3)	592 (100)
Active		91 (18)	187 (38)	157 (32)	23(5)	35 (7)	493 (100)
Passive		105 (27)	110 (28)	140 (36)	23(6)	14 (4)	392 (100)
Non-pond		129 (45)	90 (32)	58 (20)	4(1)	4 (1)	285 (100)
Total		325 (28)	387 (33)	355 (30)	50 (4)	53 (5)	1170 (100)

(Figures in the parentheses are percentage) (SSC- Secondary School Certificate; HHC-Higher Secondary Certificate)

Table 4.6 Level of literacy by age and gender categories

Group	Gender		Total
	Men	Women	
Active	232(58)	170(42)	402(100)
Passive	150(52)	137(48)	287(100)
Non-pond	92(59)	64(41)	156(100)
Total	474(56)	371(44)	845(100)

(Figures in parentheses indicate percentage)

Skill and knowledge

It was observed from the occupational pattern analysis that majority of the households primarily engaged in agriculture which is the traditional occupation of most Bangladeshi people. In addition there were several secondary occupations such as service, labour, business, fish culture etc. adopted with which they are familiar and reflected household heads and family members' level of skill and knowledge. Details of the occupational status are presented in the section 4.4.3.

4.4.1.2 Natural capital

Land holding

Land holdings are a critical requirement for livelihoods of farming households and play a significant role in the socio-economic status of rural and peri-urban people of Bangladesh (Khan, 2004). Cultivable land can be used to grow crops for sale and/or consumption or rented out. There were some households among the groups, who had virtually no land and depended on a small piece of land for food and family income.

The overall average used land holding was 9 (±0.9) ha but ranged from 0.02 to 5.51 ha. Explicitly the households were very close to being small or marginal land holders, as small and marginal farmers are those who have less than 0.81 ha land (Rutherford, Undated).The average land holdings did not vary significantly ($P>0.05$) between active (0.967±0.84) and passive groups (0.997±1.04 ha) while non-pond households (0.636±0.604) had significantly less ($P<0.05$) land than both groups of pond owners. Land holdings also varied significantly ($P<0.05$) between better off (1.31±1.06) and worse off (0.5±0.36) households (Table 4.7), but was unaffected by location (P>0.05).

Table 4.7 Average land holdings (hectare) by well-being and groups

Well-being	Group	Mean
Better off	Active (n=41)	1.344 (1.027)
	Passive (N=30)	1.605 (1.265)
	Non-pond (n=24)	0.920 (0.709)
Better off total (n =95)		1.319 (1.064)
Worse off	Active (n =42)	0.598 (0.355)
	Passive (n=37)	0.503 (0.388)
	Non-pond (n=23)	0.339 (0.241)
Worse off total (n=102)		0.505 (0.357)

(Figures in the parentheses are standard deviation)

Land ownership pattern

Land was further categorized into five groups based on access i.e owned, share, lease in, lease out and mortgaged in. The term “share” refers to land which is owned by more than two households, “lease in” refers to the arrangement where by the land owner makes a contract with the user for certain period of time, provided that the user will share a certain percentage (usually 50%) of the yield of the land to the owner, and the term “lease out” stands for reverse arrangement. “Mortgaged in” refers to a type of arrangement between land owner (usually poorer) and land user (usually richer), this is such an arrangement where the land owner takes a certain amount of money from the user, but there is a risk of changing the ownership if the real owner fails to return the money to the user within a settled time.

Active and passive groups own land holdings were larger (P<0.05) than non-pond households. Also pond owners had similar areas of shared land whereas non-pond households' had no shared land. Non-pond households had the smallest own land area and the greatest area of mortgaged in land (Table 4.8).

Table 4.8 Land ownership pattern by systems

Group	Parameters	Lease in	Lease out	Mortgage in	Own	Share
Active	Mean	0.364 (0.269)	1.141 (0.664)	0.196 (0.077)	0.706 (0.701)	0.284 (0.295)
	% of total	14	42	7	26	11
	n	17	9	3	83	16
Passive	Mean	0.473 (0.371)	1.179 (0.716)	0.243 (0.234)	0.694 (0.953)	0.207 (0.319)
	% of total	17	42	9	25	7
	n	13	9	1	64	26
Non-pond	Mean	0.467 (0.359)	0.682 (0.230)	0.698 (1.070)	0.483 (0.536)	
	% of total	20	29	30	21	
	n	18	3	5	33	

(Figures in the parentheses are standard deviation)

Better off households' owned significantly (P<0.05) more land compared to worse off households (Figure 4.2), but active (worse off) had less land than passive (better off) households.

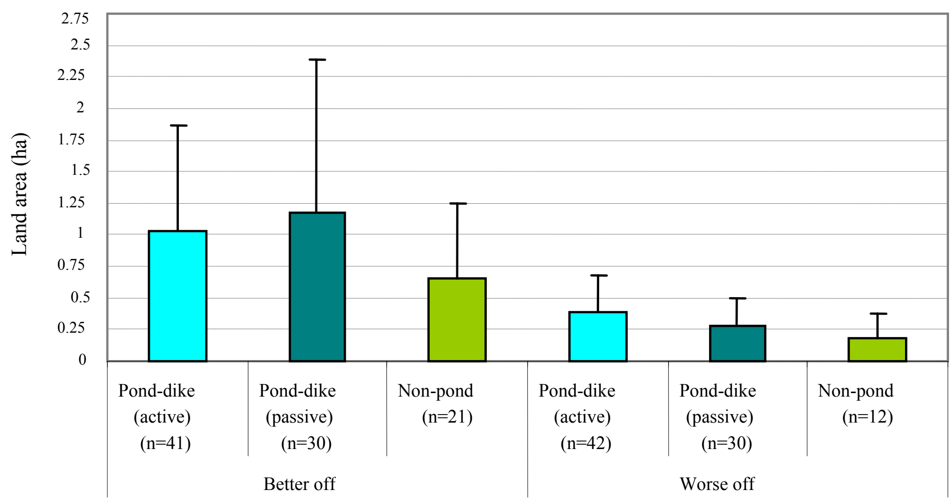

Figure 4.2 Own land ownership pattern by well-being and groups

4.4.1.3 Social capital

Access to information is considered as an important social capital which depends largely on non-formal relationships among farmers at the village level and their linkages with local and national organizations. During the survey period farmers were asked who their main information providers were, what sort of information they received and usually who (in the household) received the information. Irrespective of category, the household head in most (88%) families was the key person who had access to information, followed (in 10% of households) by his/her son. In a very small number of families (5% and 2%), wives and fathers respectively played such a role of main information conduit (Table 4.9).

Table 4.9 Information recipient by groups

Groups	Self	Son	Father	Wife
Active (n=77)	71(92)	8(10)	2(3)	0(0)
Passive (n=58)	49(84)	5(9)	1(2)	3(5)
Non-pond (n=40)	34(85)	4(10)	1(3)	2(5)
Total (n=175)	154(88)	17(10)	4(2)	5(3)

(Figures in the parentheses are percentage)

4.4.1.4 Physical capital

The physical capital owned by households included houses constructed of various qualities of materials (tin, wood, break, soil and tin), transportation means (bi-cycle and motor-bike) and other property (radio, tape recorder, television, water pump and agricultural machinery). In this study house construction (walls and roof) quality were categorized into five types such as (1) built brick walls and tin roof, (2) earthen wall and rice straw roof, (3) earthen wall and tin roof and (4) wood walls and tin roof and (5) built with brick. The majority (70%) of the houses had earthen wall and rice straw roof followed by wooded wall and tin roofs (61%) (Table 4.10).

Table 4.10 House types by groups

Groups	Wooden wall and tin roof	Earthen wall and rice straw roof	Earthen wall and tin roof	Brick wall and tin roof	Brick made	Grand Total
Active	55(66)	62(74)	9(11)	9(11)	3(4)	138(166)
Passive	42(76)	37(67)	7(13)	2(4)	2(4)	90(164)
Non-pond	28(51)	44(80)	1(2)	3(5)	2(4)	78(142)
Total	125(61)	143(70)	17(8)	14(7)	7(3)	306(149)

(Figures in the parentheses are percentage)

A total of 12% of households owned a television, 16 % a radio, 6 % a cassette player, 3 % owned torchlight. Only two households had an electric fan. A higher percentage (16%) of active households' had TV, compared to passive (13%) and non-pond (5%) group (Table 4.11). A bicycle was the most common (28%) form of transportation. Only a few households owned a pulling van (4%), rickshaw (5%) or motorbike (1%). The highest (35%) percentages of households with a bicycle were in the pond-dike active group. Ownership of a bicycle was much higher (46%) among better off than worse off (12%) households.

Table 4.11 Households assets by farming systems

Group	Radio	TV	Cassette player	Torch light	Sewing machine	Fan	Grand Total
Active	11(13)	13 (16)	6 (7)	3 (4)	3 (3)	1 (1)	37(45)
Passive	13 (19)	9 (13)	4 (6)	3 (4)	2 (3)	1 (1)	32 (48)
Non-pond	9 (16)	3 (5)	2 (4)	0	0	0	14 (25)
Total	33 (16)	25 (12)	12(6)	6 (3)	5 (2)	2 (1)	83 (40)

(Figures in the parentheses are percentage)

Table 4.12. Means of transportation by location, well-being and groups

Criteria	Bicycle	Rickshaw	Pulling van	Motor bike	Grand Total
Better off	44(46)	0	7(7)	2(2)	53(56)
Worse off	13(12)	10(9)	2(2)	0	25(23)
Active	29(35)	2(2)	7(8)	1(1)	39(47)
Passive	19(28)	2(3)	2(3)	1(1)	24(36)
Non-pond	9(16)	6(11)	0	0	15(27)
Grand Total	57(28)	10(5)	9(4)	2(1)	78(38)

(Figures in the parentheses are percentage)

Chicken is a very common form of poultry, reared by almost all (92%) of the households followed by cattle and duck. Integrated (active and passive) farming system households had more chickens and ducks compared to non-pond households. The average number of chickens and ducks raised among groups varied (P<0.05) significantly and better off households had more (P<0.05) chicken than worse off (Table. 4.13).

Table 4.13 Number of poultry and livestock owned by location, well-being and groups

Criteria	Stat.	Types of livestock and poultry					Total
		Cattle	Goat	Chicken	Duck	Pigeon	
Rural	Mean	3	2	13	9	3	8
	(SD)	(1.73)	(1.24)	(12.36)	(17.61)	(1.00)	(11.94)
	n	75	34	105	62	7	283
	(%)	(67)	(30)	(94)	(55)	(6)	(253)
Peri-urban	Mean	3	2	11	7	12	7
	(SD)	(3.17)	(0.84)	(10.50)	(7.53)	(17.63)	(8.97)
	n	52	27	84	60	10	233
	(%)	(56)	(29)	(90)	(65)	(11)	(251)
Better off	Mean	4	2	14	6	8	8
	(SD)	(2.88)	(1.16)	(13.33)	(5.94)	(14.33)	(10.18)
	n	64	31	90	65	16	266
	(%)	(67)	(33)	(95)	(68)	(17)	(280)
Worse off	Mean	3	2	10	10	3	7
	(SD)	(1.67)	(1.04)	(9.29)	(18.71)		(11.23)
	N	63	30	99	57 (52)	1	250
	(%)	(57)	(27)	(90)		(1)	(227)
Active	Mean	3	2	15	12	3	9
	(SD)	(1.66)	(1.02)	(14.80)	(19.40)	(2.33)	(14.09)
	n	53	29	80	53 (64)	8	223
	(%)	(64)	(35)	(96)		(10)	(269)
Passive	Mean	4	2	10	5	8	6 (6.53)
	(SD)	(3.31)	(1.27)	(8.54)	(3.69)	(5.18)	
	n	48 (72)	20	64	42	5	179
	(%)		(30)	(96)	(63)	(7)	(267)
Non-pond	Mean	3	2	8	5 (4.97)	17	6 (7.22)
	(SD)	(1.20)	(0.97)	(6.00)		(28.68)	
	n	26	12	45	27 (49)	4 (7)	114
	(%)	(47)	(22)	(82)			(207)
Total	Mean	3	2	12	8	8	7
	(SD)	(2.41)	(1.10)	(11.57)	(13.59)	(13.94)	(10.70)
	n (%)	127	61	189	122	17	516
		(62)	(30)	(92)	(60)	(8)	(252)

4.4.1.5 Financial capital

Farming households accessed different finance sources, which could be categorized into two; the first included 'credit' institutions such as banks, NGOs, village cooperatives etc and second, 'interest free credit' from either neighbours or relatives. Around 39% households took credit from different formal and non-formal institutions (Table 4.14). Among all formal and informal institutions, the highest parentage of households had access to credit from their neighbours (53%) followed by national NGOs, banks, village cooperatives and some local NGOs respectively.

Credit

A higher percentage of households' accessed credit from neighbours followed by NGOs, Bank and village cooperatives (Table 4.14). Active and passive households borrowed more money than non-pond groups. A higher percentage of worse off households' accessed credit though the amount was lower than better off households (Table 4.15). Only a small proportion of the households, who borrowed money (3%), had more than one source of money. The households who took credit from their relatives paid the highest interest rate (94%/year), while the average NGO interest rate (16%) was the lowest (Table 4.16).

Table 4.14 Sources of loan by systems

Groups	Neigh.	NGO	Bank	VC	Relatives	BRDB	Total
Active (n=33)	16 (48)	9 (27)	7 (21)	6 (18)	2 (6)	2 (6)	42 (127)
Passive (n=23)	10 (43)	5 (22)	5 (22)	3 (13)	2 (9)	0	25 (109)
Non-pond (n=23)	16 (70)	5 (22)	2 (9)	2 (9)	0	0	25 (109)
Total (n=79)	42 (53)	19 (24)	14 (18)	11 (14)	4 (5)	2 (3)	92 (116)

(Figures in the parenthesis are percentage) (Neigh-Neighbours; VC-Village cooperatives; BRDB- Bangladesh Rural Development Board)

Table 4.15 Amount of money (Tk.; 1 US$=60 Tk.) taken as loan by systems, well-being and locations

Criteria	Mean	SD	Minimum	Maximum
Rural (n=43)	6,412.00	6,427.00	350.00	25,000.00
Peri-urban (n=36)	6,661.00	8,511.00	500.00	50,000.00
Better off (n =28)	7,964.00	6,881.00	500.00	25,000.00
Worse off(n= 51)	5,735.00	7,620.00	350.00	50,000.00
Active (n=33)	7,059.00	5,862.00	500.00	24,000.00
Passive (n=23)	7,254.00	10,984.00	350.00	50,000.00
Non-pond (n=23)	5,030.00	4,494.00	500.00	20,000.00
Total (n=79)	6,525.00	7,400.00	350.00	50,000.00

Table 4.16 Interest (%/year) rate of credit of different lenders

Sources	Mean
Relatives (n=4)	94.00(67.11)
Neighbours (n=42)	44.71(48.81)
Village cooperatives(n=11)	27.73(52.12)
BRDB (Bangladesh Rural Development Board) (n=2)	25.50(13.44)
Bank (n=14)	21.57(28.41)
NGOs (n=19)	16.21(7.83)
Total (n=92)	35.00(44.23)

(Figures in the parentheses are standard deviation)

Interest free credit

A higher proportion of pond-dike (active) farming households accessed interest free credit in significantly greater ($P<0.05$) amounts compared to other groups. Double the number (44) of rural people borrowed nearly double the amount (5,085.22 Tk) of money than peri-urban farming households (Table. 4.17). About one third of the sample surveyed could borrow money from their neighbours and relatives without incurring interest charge (Table 4.18).

Nearly the same number of households of the two different well-being categories had access to money although better off households tended to take on more debt ($P<0.05$) than worse off households. The majority of households borrowed money from one source, only one household had borrowed from two sources. More households borrowed money from their neighbours than from relatives (Table 4.18). The borrower did not pay any interest to their neighbours and relative other than refunding the principal amount of money.

Table 4.17 Amount (Tk) of money borrowed by locations, well-being levels and groups

Criteria	Mean	Minimum	Maximum
Rural (n=44)	5,085.22(5,210.75)	250.00	20000.00
Peri-urban (n=22)	2,859.09(4,424.24)	200.00	20000.00
Better off (n=31)	5,354.83(5,849.32)	200.00	20000.00
Worse off (n=35)	3,447.14(4,076.49)	250.00	20000.00
Active (n=38)	5,344.73(5,519.23)	500.00	20000.00
Passive (n=15)	3,690.00(5,336.20)	200.00	20000.00
Non-pond (n=13)	2,169.23(1,276.96)	700.00	5000.00
Total (n=66)	4,343.18(5,040.25)	200.00	20000.00

(Figures in the parentheses are standard deviation; 1 US$=60 Taka)

Table 4.18 Sources of money by groups

Groups	Source		Total
	Neighbours	Relatives	
Active (n=38)	31 (82)	10 (26)	41 (108)
Passive (n=15)	10 (67)	7 (48)	17 (115)
Non-pond (n=13)	7 (54)	6 (46)	13 (100)
Total average (n=66)	48 (73)	23 (39)	71 (112)

(Figures in the parentheses are percentage)

4.4.2 Transforming processes and structures

4.4.2.1 Access to information

A higher percentage (32%) of active households had multiple sources of information than passive (16%) and non-pond (5%) farming households.

Neighbours were found to be the most important source of information to all of the households compared to other sources (Table 4.19).

A significantly higher percentage of active households had access to information from DoF [$\chi^2(2)=16.71$, P= 0.001] and relatives [$\chi^2(2)=6.62$, P=0.037] compared to passive and non-pond households. Higher percentage [$\chi^2(1)=6.68$, P=0.01)] of better off households had access to DAE than worse off, while more worse off households [$\chi^2(1)=3.41$, P=0.035] had access to NGOs than better off households. A higher percentage of rural households had access to both DAE [$\chi^2(1)=6.73$, P=0.009) and DoF [$\chi^2(1)=7.61$, P=0.006] than peri-urban households. On the other hand, NGOs were more important as a source of information to a higher percentage [$\chi^2(1)=8.48$, P=0.004] of peri-urban households than rural households.

Table 4.19 Frequencies of citation of information sources by groups, location, and well-being categories

Criteria	Neighbours	DAE	Relatives	NGOs	DoF
Rural (n=92)	41 (47)	38 (41)	30 (33)	6 (7)	15 (16)
Peri-urban (n=83)	35 (42)	19 (23)	25 (30)	18 (22)	3 (4)
Better off (n=89)	34 (38)	37 (42)	29 (33)	8 (9)	11 (12)
Worse off (n=86)	42 (49)	20 (23)	26 (30)	16 (19)	7 (8)
Active (n=77)	30 (39)	29 (38)	32 (42)	8 (10)	16 (21)
Passive (n=58)	30 (52)	17 (29)	13 (22)	12 (21)	2 (3)
Non-pond (n=40)	16 (40)	11 (28)	10 (25)	4 (10)	0
Total(n=175)	76 (43)	57 (33)	55 (31)	24 (14)	18 (10)

(Figures in the parentheses are percentage)

Farmers received different types of information which also varied from one farmer to another, however, information were grouped into three major categories, viz. agricultural technology, fish culture and crop and fish disease. There were some other responses presented as “other” category. Hence, “other” includes quality inputs, rice IPM, livestock rearing and improved rice varieties. It was revealed that all categories (group, well-being and location) generally received information on "agricultural technology" (75%) which includes rice, field crops and vegetable cultivation, followed by "others" (17%), "fish culture" (15%) and "crop and fish disease" (11%) (Figure 4.3). A significantly higher percentage of active households [$\chi^2(2) = 15.43$, $P = 0.001$] received information on "fish culture" (26%) than passive groups (10%) (Figure 4.3).

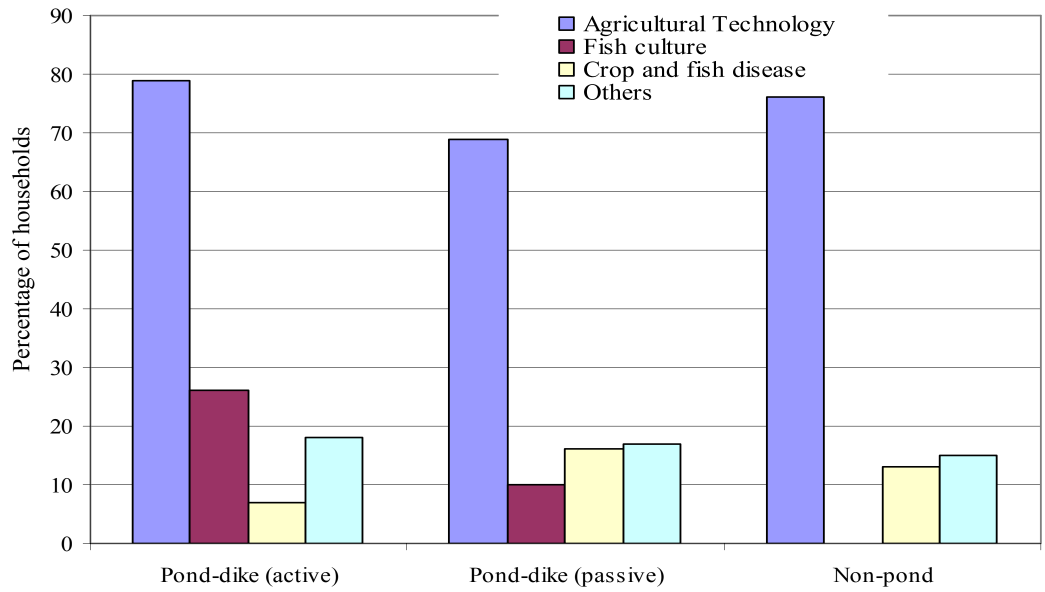

Figure 4.3 Types of information received by the groups

A total of 30% of farming households had an affiliation with an organization (local, international, autonomous) as a participant and/or employee. A total of 18% of active households had links with more than one organization, whereas a lower percentage (6%) of passive and non pond households had linkages with more than one organization. While affiliations of peri-urban households with NGOs was common (42%) whereas less than one quarter (21%) of rural households had such a link. On the other hand, double the number of worse off people (40%) had an affiliation with the NGOs compared to the better off.

Large numbers of households were affiliated as participants with both local (80%) and national organizations (98%) rather than as employee. As a result of being associated with the organisations a higher proportion (86%) of active households obtained financial support (received credit) compared to passive (63%) and non-pond (59%) from national organizations.

4.4.2.2 Access to market

The majority of farming households sold the majority of farm products either at the farm gate or market (local/sub-district/district/city) directly and/or through intermediaries. Marketing of farm commodities were broadly categorized into direct sales or sale through intermediaries.

It was revealed that a higher percentage of active (69%) households sold fish than passive (52%). A higher percentage of peri-urban households (70%) sold fish than rural households (54%) regardless of group. Regardless of group, location and well-being category, a total of 79% households sold fish through intermediaries. A higher percentage (93%) of households in rural areas sold fish through intermediaries than in peri urban locations (82%), the remaining households sold fish directly.

The majority of households sold fish to intermediaries at the local market (54%), followed by the farm gate (29%) and auction market (22%) (auction market; Sub-district, district and city market). More rural households (45%) tended to sell fish at the farm gate than peri-urban (13%), whereas a relatively higher proportion (33%) of peri-urban households sold to the auction markets than rural (10%). A significant association was observed between location and the specific marketing location (farm gate, local market and auction market), where the fish was sold [$\chi^2(2)=12.7$, P=0.002] (Table 4.20).

Table 4.20 Marketing of fish through intermediaries by location

Location	Local market	Farm gate	Auction market	HH Numbers
Rural	20 (50)	18 (45)	4 (10)	40 (105)
Peri-urban	23 (60)	5 (13)	13 (33)	39 (106)
Total	43 (54)	23 (29)	17 (22)	79 (105)

(Figures in the parentheses are percentage)

Active integrated farming households were most likely to sell vegetables (77%) followed by passive (31%) and non pond (21%) farming households (Table 4.21). An average of nearly half (47%) of the sampled households sell vegetables through intermediaries (83%) and directly (20%) to the consumers. A significantly higher percentage [$\chi^2(2)=12.32$, P=0.001] of active households sold vegetable to auction market than others. Non-pond households did not use auction markets at all. Rural households were found to have less access (8%) to the "auction market" than the peri-urban (21%).

Table 4.21 Marketing of vegetable through intermediaries by groups

Groups	Local market	Farm gate	Auction market	Numbers of households
Active	34 (64)	25 (47)	11 (21)	53 (132)
Passive	11 (65)	7 (41)	1 (6)	17 (112)
Non-pond	4 (40)	6 (60)	0	10 (100)
Total average	49 (61)	38 (48)	12 (15)	80 (124)

(Figures in the parentheses are percentage)

4.4.3 Livelihood strategies

4.4.3.1 Occupation

Primary occupation of household heads

The occupation of the respondents were divided broadly into two categories of primary and secondary occupation, based on time spent in securing food supply and by income contribution to the households' economy. The primary occupation of the household head is in general the most productive livelihood activity of the household.

Primary occupation was found to be significantly associated by group [$\chi^2(10)=22.63$, P=0.012]. Among farming groups, agriculture was the primary occupation of 70% of active integrated households, 76% of passive integrated households and 56% non-pond households (Table 4.22). A higher proportion (72%) of better off household heads reported agriculture as their primary occupation compared to worse off (65%) households. Rural people were found to be more dependent on agriculture (74%) and less on service, whilst peri-urban households were relatively more service oriented.

It was also observed that there were a significant association between primary occupation and well-being categories [$\chi^2(7)=88.71$, P=0.001]. Labour was only the profession that made distinction between better off and worse off households (Table 4.23).

Table 4.22 Primary occupation (numbers of household head) by systems and well-being and location

Criteria	Groups	Agriculture[1]	Service[2]	Labour[3]	Business[4]	Petty business[5]	Fish culture	Total
Rural	Active	37(77)	4(8)	1(2)	3(6)		3(6)	48(100)
	Passive	27(84)	2(6)	2(6)	0(0)		1(3)	3(100)2
	Non-pond	19(59)	1(3)	6(19)	1(3)		5(16)	32(100)
Rural total		83(74)	7(6)	9(8)	4(4)		9(8)	112(100)
Peri-urban	Active	21(60)	3(9)	1(3)	3(9)	5(14)	2(6)	35(100)
	Passive	24(69)	5(14)	3(9)	1(3)	0(0)	2(6)	35(100)
	Non-pond	12(52)	3(13)	6(26)	2(9)	0(0)	0(0)	23(100)
Peri-urban total		57(61)	11(12)	10(11)	6(6)	5(5)	4(4)	93(100)
Better off	Active	29(71)	5(12)		4(10)		3(7)	41(100)
	Passive	24(80)	4(13)		2(7)		0(0)	30(100)
	Non-pond	15(63)	4(17)		5(21)		0(0)	24(100)
Better off total		68(72)	13(14)		11(12)		3(3)	95(100)
Worse off	Active	29(69)	2(5)	2(5)	1(2)	6(14)	2(5)	42(100)
	Passive	27(73)	3(8)	5(14)	1(3)	1(3)	0(0)	37(100)
	Non-pond	16(52)	0(0)	12(39)	0(0)	3(10)	0(0)	31(100)
Worse off total		72(65)	5(5)	19(17)	2(2)	10(9)	2(2)	110(100)
Total	Active	58(70)	7(8)	2(2)	5(6)	6(7)	5(6)	83(100)
	Passive	51(76)	7(10)	5(7)	3(4)	1(1)	0(0)	67 (100)
	Non-pond	31(56)	4(7)	12(22)	5(9)	3(5)	0(0)	55 (100)
Total		140(68)	18(9)	19(9)	13(6)	10(5)	5(2)	205(100)

(Figures in the parentheses area percentage) (Involvement in rice and vegetable cultivation in own managed land [1]; part time or full time job in government/non-government organization[2]; off-farm/on-farm agri/non-agricultural labour[3]; buying and selling agricultural and non-agricultural commodities with substantial amount of money investment[4]; Small stationeries, shops, invest small amount of money and get quick return, for instance retailing and selling fish, vegetable etc[5]).

Table 4.23: Primary occupation of all members (%) of the households' by groups, location and well-being categories

Criteria	Student	House wife	Agricul.	Service	Labour	Business	Fish culture	Child (5 and <5 years)
Rural (n=765)	231(30)	205(27)	160(21)	32(4)	31(4)	25(3)	2(.3)	79(10)
Peri-urban (n=552)	145(26)	152(28)	103(19)	32(6)	27(5)	21(4)	3(.3)	69(13)
Better off (n=637)	225(35)	168(26)	113(18)	44(7)	2(0)	26(4)	3(.4)	56(9)
Worse off(n=680)	151(26)	189(33)	150(26)	20(3)	56(10)	20(3)	2(.3)	92(16)
Active (n=545)	187(34)	135(25)	109(20)	29(5)	7(1)	21(4)	4(1)	53(10)
Passive (n=432)	116(27)	132(31)	93(22)	24(6)	15(3)	11(3)	0(0)	41(9)
Non-pond (n=340)	73(21)	90(26)	61(18)	11(3)	36(11)	14(4)	1(.3)	54(16)
Total average	376(29)	357(27)	263(20)	64(5)	58(4)	46(3)	5(.4)	148(11)

(Figures in the parentheses are percentage) (Agricul. - Agriculture)

Secondary occupation

In general, the majority of the households of Asia whether in rural or peri-urban locations are "pluri-active" to cope with family need (Ellis, 2000b). In this study around half (48%) of the sampled household heads' had a secondary occupation in addition to primary occupation. Agriculture (37%), business (18%), labour (16%) were the most important secondary occupations regardless of location, well-being and groups (Table 4.24). A total of 10% of households heads were found to choose fish culture as secondary occupation, a similar level to service. Similar percentages (36%) of non-pond households' secondary occupation were agriculture and labour followed by business (21%) and petty business (7%).

Fish farming was a significant secondary occupation of active group household heads (18%) after rice (41%). Fish culture was more important to the active integrated households (24%) in the rural area than peri-urban area (11%) and envisaged as a similar priority secondary occupation to both better-off (11%) and worse off households (10%). However, agriculture (33%) and service (29%) were more important among better off households since they typically require substantial material resources that may be unavailable to worse off households (Table 4.24). Dependency on agriculture as a secondary occupation was higher in peri-urban area than rural areas.

Table 4.24 Secondary occupation (numbers of household head) by well-being, location and groups

Criteria	Groups	Agriculture	Business	Labour	Fish culture	Service	Petty business	Total
Rural	Active	7(28)	4(16)	2(8)	6(24)	4(16)	2(8)	25(100)
	Passive	3(27)	3(27)	2(18)	1(9)	1(9)	1(9)	11(100)
	Non-pond	4(29)	3(21)	5(36)	0(0)	0(0)	2(14)	14(100)
Rural total		14(28)	10(20)	9(18)	7(14)	5(10)	5(10)	5(100)0
Peri-urban	Active	11(58)	1(5)	1(5)	2(11)	3(16)	1(5)	19(100)
	Passive	5(33)	4(27)	1(7)	1(7)	2(13)	2(13)	15(100)
	Non-pond	6(43)	3(21)	5(36)	0(0)	0(0)	0(0)	14(100)
Peri-urban total		22(46)	8(17)	7(15)	3(6)	5(10)	3(6)	48(100)
Better off	Active	7 (33)	4(19)		4(19)	6(29)		21(100)
	Passive	5(36)	6(43)		1(7)	2(14)		14(100)
	Non-pond	6(55)	5(45)		0(0)	0(0)		11(100)
Better off total		18(39)	15(33)		5(11)	8(17)		46(100)
Worse off	Active	11(48)	1(4)	3(13)	4(17)	1(4)	3(13)	23(100)
	Passive	3(25)	1(8)	3(25)	1(8)	1(8)	3(25)	12(100)
	Non-pond	4(24)	1(6)	10(59)	0(0)	0(0)	2(12)	17(100)
Worse off total		18(35)	3(6)	16(31)	5(10)	2(4)	8(15)	52(100)
Active		18(41)	5(11)	3(7)	8(18)	7(16)	3(7)	44(100)
Passive		8(31)	7(27)	3(12)	2(8)	3(12)	3(12)	26(100)
Non-pond		10(36)	6(21)	10(36)	0(0)	0(0)	2(7)	28(100)
Total		36(37)	18(18)	16(16)	10(10)	10(10)	8(8)	98(100)

(Figure in the parentheses are percentages)

4.4.3.2 Farming systems

Rice cultivation occurred on about 65% of the total agricultural land area followed by fish production (11%), vegetable (7%), fruits (7%), field crops (6%) and spices (3%) respectively. It is noteworthy that the same land might also be used to cultivate different crops in different seasons of the year, which was not taken into consideration in this study.

Rice cultivation

Households were involved in variety of agricultural enterprises, but in general rice was the most important crop, 90% of households were involved in rice farming. In the study area rice was cultivated in three different seasons termed as *boro* (irrigated, duration-February to April), *aus* (irrigated, duration May to August) and *amon* (rain fed, duration September to January). Active and passive households rice production (kg/hh, i.e kg/household) was significantly (P<0.05) higher than non-pond households. Rice production (kg/hh) and (kg/ha) was affected by well-being x location (Table 4.25).

Table 4.25 Rice production (kg/hh) and (kg/ha) by location and well-being

Criteria	Well-being	Kg/hh	Kg/ha
Rural	Better off (n=52)	3,749.52 (3,106.11)	2,997.54 (1,431.65)
	Worse off (n=52)	1,381.04 (997.10)	3,143.15 (1,673.53)
	Total (n=104)	2,565.28 (2,585.62)	3,070.35 (1,551.44)
Peri-urban	Better off (n=39)	2,998.44 (3,286.14)	3,502.90 (1,437.21)
	Worse off (n=41)	631.63 (461.87)	2,531.85 (1,542.05)
	Total (n=80)	1,785.45 (2,592.22)	3,005.24 (1,560.82)
Total	Better off (n=91)	3,427.63 (3,188.46)	3,214.12 (1,448.04)
	Worse off (n=93)	1,050.66 (885.34)	2,873.65 (1,636.93)
	Total (n=184)	2,226.22 (2,610.35)	3,042.04 (1,551.60)
Active (n=78)		2,280.32 (2,168.21)	3,178.10 (1,513.94)
Passive (n=60)		2,647.12 (3,428.29)	3,142.27 (1,594.49)
Non-pond (n=46)		1,585.50 (1,896.08)	2,680.58 (1,534.94)

(Figures in the parentheses are standard deviation)

Fish culture

Estimated fish yields were 2,069.88 ±1,944.93 kg/ha/year irrespective of location, well-being and groups (Table 4.30). Fish production (kg/ha) varied between well-being (P<0.05) categories and also between active passive groups in peri-urban areas. Production (kg/hh) also varied significantly between groups and well-being level. There was no difference (P>0.05) in the amount (kg/hh) retained for consumption between locations and between groups, but better off households consumed (kg/hh and kg/capita) more than worse off households. Active households in peri-urban areas sold more (P<0.05) than (kg/hh) passive. The quantities of fish sold by better off households' (kg/hh) was significantly higher (P<0.05) than worse off households (Table 4.26).

Table 4.26 Fish production and sale (kg/hh/year), and consumption (kg/hh/year and g/capita/day) by location, well-being and groups

Criteria	Production	Sale	Consumption	
			Kg/hh	g/capita
Rural (n=80)	127.98(155.23)	55.39(123.97)	72.59(93.47)	32.29 (42.70)
Peri-urban (n=66)	208.58(228.99)	126.14(222.05)	82.38(98.72)	40.94 (44.82)
Better off (n=68)	222.78(248.43)	131.82(138.85)	90.93(101.72)	38.96 (38.00)
Worse off (n=78)	113.53(112.72)	48.62(82.68)	64.88(88.95)	33.80 (48.29)
Active (n=79)	175.33 (209.03)	104.71(197.63)	70.62(87.88)	32.95 (42.98)
Passive (n=67)	151.54(179.15)	66.93(150.86)	84.55(104.28)	40.03 (44.62)
Total average (n=146)	164.41(195.59)	87.37(178.12)	77.01(95.67)	36.20 (43.73)

(Figures in the parentheses are standard deviation)

The average area of ponds was 0.136 ±0.152 ha. A significant variation in pond size was noticed between group, location and well-being groups (Table 4.30). No variation in the number of pond holdings was noted between active and passive households. Eighty percentage and two percentage ponds of the active group households were owned and shared, respectively and were located in the homestead area. The balance (18%) of the ponds were shared and located away from the homestead area. On the other hand, 65% of the ponds of the passive group were located in the homestead area, which were owned by themselves and the remaining 35% ponds were shared but located away from the homestead [$\chi^2(1)=7.96$, P=0.004). A higher percentage of better off households owned ponds (81%) compared to poorer households (69%). Worse off households had more access to shared ponds than better off households (31% and 24% respectively). Access to shared ponds and group had a significant association [$\chi^2(1)=6.42$, P=0.009].

Vegetable cultivation

Vegetable cultivation was practiced by 60% of the households among the overall sample. All active, 50% passive and 38% non-pond households were involved in vegetable cultivation. The mean amount (4,499 kg/ha) of vegetable produced (kg/ha) by active households was significantly higher ($P<0.05$) than passive groups (2,750 kg/ha) and non-pond (3,132 kg/ha) groups (Table 4.27). Passive and non-pond groups' vegetable production (kg/ha) were similar ($P>0.05$). There was no significant difference between locations and well-being categories ($P>0.05$) in terms of vegetable production (kg/ha).

Table 4.27 Production of vegetable (kg/ha) by location, well-being and groups

Criteria	Mean
Rural (n=71)	4,155.79(4,334.94)
Peri-urban (n=57	4,921.87(4,592.27)
Better off (n=63)	4,779.75(4,606.78)
Worse off (n=65)	4,232.43(4,315.63)
Active (n=83)	5,389.57(5,023.74)
Passive (n=30)	2,750.66(2,506.18)
Non-pond (n=15)	3,132.50(2,462.32)
Total (n=128)	4,499.62(4,450.84)

(Figures in the parentheses are standard deviation)

Vegetable production (kg/hh) was significantly different between well-being categories (Table 4.28). There was no difference ($P>0.05$) in consumption (kg/hh/year and g/capita/day) by location, group and well-being level. The amount of vegetable sold (kg/hh) was affected ($P<0.05$) by location X group, and well-being X groups (Figure 4.4). A higher percentage of worse off households [$\chi^2(4)=10.53, P=0.032$] cultivated vegetables in share, mortgage in and leased in land than better off households (Table 4.28).

Table 4.28 Vegetable land ownership pattern

Well-being	Own land	Share	Mortgage in	Lease in	Lease out	Total
Better off	62(95)	1(2)	0	1(2)	3(5)	67(103)
Worse off	56(89)	5(8)	1(2)	6(10)	0	68(108)

(Figures in the parentheses are parentage)

Table 4.29 Vegetable production and sale (kg/hh/year), and consumption (kg/hh/year and g/capita/day) by location, well-being and groups

	Production (kg/hh/year)	Sale (kg/hh/year)	Consumption	
			kg/hh/year	g/capita/day
Active (n=83)	468.12(783.84)	461.39(844.89)	101.72(195.55)	45.14 (89.32)
Passive (n=30)	345.70(715.13)	372.87(759.07)	108.07(125.05)	41.77 (42.68)
Non-pond (n=15)	256.53(243.06)	354.93(512.19)	129.93(143.27)	51.52 (43.69)
Rural (n=71)	402.61(709.96)	427.07(807.58)	126.84(219.86)	51.21 (96.32)
Peri-urban(n=57)	428.46(748.52)	428.93(773.05)	81.63(89.52)	37.59 (37.95)
Better off (n=63)	466.13(763.37)	507.55(884.08)	124.10(227.63)	52.49(101.64)
Worse off (n=65)	364.69(688.11)	351.94(684.89)	89.82(100.81)	38.04 (37.48)
Total average (n=128)	414.21(724.71)	427.91(789.15)	106.55(174.77)	45.10 (75.94)

(Figures in the parentheses are standard deviation)

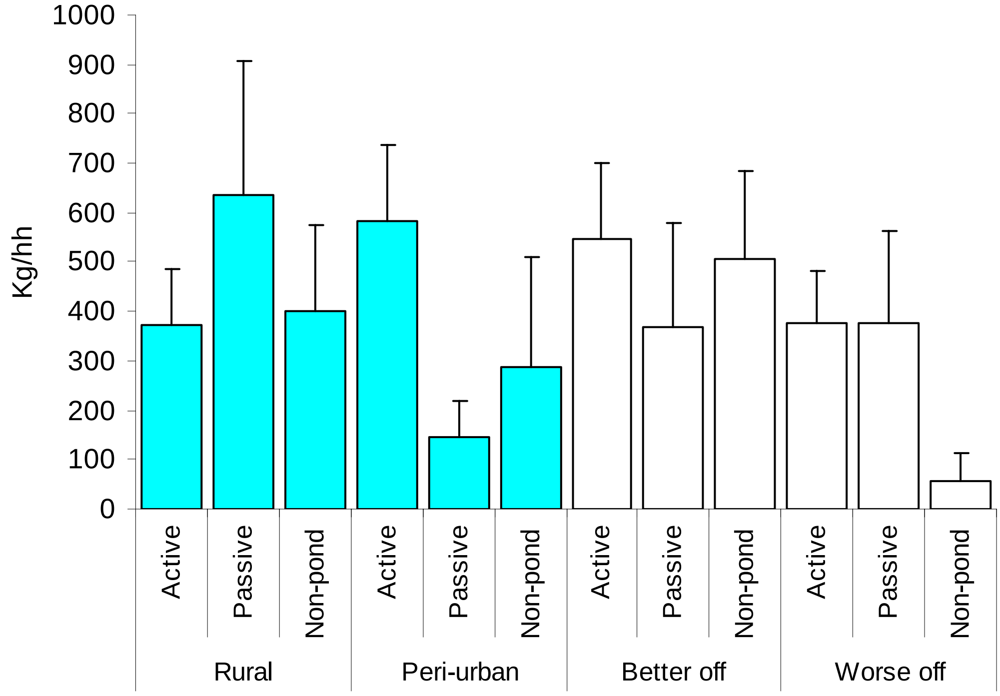

Figure 4.4 Amount of vegetable sold (kg/hh) by locations, well-being and groups

Table 4.30 Area (ha) under different crops by location and groups

Criteria	Fish	Vegetables	Rice	Spices	Field crops	Fruits
Rural	0.111 (0.108)	0.095 (0.105)	0.912 (0.862)	0.039 (0.034)	0.072 (0.074)	0.107 (0.112)
Peri-urban	0.166 (0.188)	0.080 (0.086)	0.588 (0.683)		0.071 (0.055)	0.050 (0.028)
Better off	0.180 (0.191)	0.096 (0.096)	1.143 (0.969)	0.025 (0.024)	0.078 (0.071)	0.114 (0.113)
Worse off	0.097 (0.091)	0.081 (0.098)	0.407 (0.309)	0.057 (0.042)	0.053 (0.047)	0.046 (0.031)
Active	0.148 (0.167)	0.077 (0.079)	0.780 (0.753)	0.049 (0.036)	0.071 (0.088)	0.074 (0.086)
Passive	0.122 (0.130)	0.119 (0.139)	0.886 (0.981)	0.014 (0.009)	0.073 (0.049)	0.114 (0.119)
Non pond		0.091 (0.074)	0.605 (0.591)		0.070 (0.059)	0.054 (0.040)

(Figures in the parentheses are standard deviation)

Table 4.31 Production (kg/ha) from different components by well-being and groups

CR	Groups	Stat.	Fish	Field crops	Fruits	Spice
Better off	Active	Mean(SD) n	2,741.55 (2,496.76) 37	1,613.51(1,207.70) 6	6,073.51 (5,500.38) 4	4,281.33 (1,397.24) 2
	Passive	Mean(SD) n	2,501.60 (2,364.36) 31	3,962.34 (3,774.44) 10	7,050.86 (10,076.48) 5	4,693.00 (3,842.42) 2
	Non-pond	Mean(SD) n		5,185.30 (2,705.87) 5	1,084.06 (1,631.33) 3	
Better off mean		Mean(SD) n	2,634.11(2,423.02) 68	3,582.43 (3,180.77) 21	5,233.38 (7,218.77) 12	4,487.17 (2,372.48) 4
Worse off	Active	Mean(SD) n	1,697.57 (1,174.46) 42	2,295.45(1,168.94) 5	5,022.33 (6,869.78) 2	2,058.33 (2,295.02) 3
	Passive	Mean(SD) n	1,454.16 (1,307.95) 36	2,778.75 (1,309.92) 2	1,236.54 (766.76) 4	
	Non-pond	Mean(SD) n		6,586.67. 1	3,499.17 (2,270.52) 2	
Worse off mean		Mean(SD) n	1,585.22 (1,235.71) 78	2,952.68 (1,797.13) 8	2,748.65 (3,267.25) 8	2,058.33 (2,295.02) 3
Rural	Active	Mean(SD) n	1,980.55 (1,627.62) 48	1,899.01(1,215.03) 9	6,401.94(5,176.63) 3	2,947.53(2,145.73) 5
	Passive	Mean(SD) n	1,913.65 (2,328.58) 32	2,654.83(2,493.62) 7	6,021.52(9,347.09) 6	4,693.00(3,842.42) 2
	Non-pond	Mean(SD) n		1,389.38 1	2,089.21 4	
Rural mean		Mean(SD) n	1,954.30 (1,919.08) 80	2,180.25(1,803.35) 17	4,899.37(6,793.37) 13	3,446.24(2,501.10) 7
Peri-urban	Active	Mean(SD) n	2,505.44 (2,399.38) 31	2,033.63(1,478.75) 2	5,044.29(6,444.77) 3	
	Passive	Mean(SD) n	1,944.98 (1,507.43) 35	5,319.42(4,308.44) 5	1,357.13(1,157.00) 3	
	Non-pond	Mean(SD) n		6,224.76(1,691.11) 5	1,893.67 1	
Peri-urban mean		Mean(SD) n	2,208.23 (1,981.20) 66	5,149.02(3,208.22) 12	3,013.99(4,234.86) 7	
Mean	Active	Mean(SD) n	2,186.52 (1,969.02) 79	1923.48(1184.34) 11	5723.12(5280.72) 6	2947.53(2145.73) 5
	Passive	Mean(SD) n	1,930.27 (1,921.31) 67	3765.08(3467.62) 12	4466.72(7770.38) 9	4693.00(3842.42) 2
	Non-pond	Mean(SD) n		5418.86(2486.91) 6	2050.10(2090.28) 5	
Mean		Mean(SD) n	2,069.88 (1,944.93) 146	3408.70(2848.88) 29	4239.48(5971.76) 20	3446.24(2501.10) 7

4.4.3.3 Pond inputs

In general, households with ponds applied rice bran, cooked rice, organic fertilizers from their own farm source, and purchased inorganic fertilizers for growing fish. A higher percentage of active households applied organic and inorganic fertilizers, rice bran, wheat bran, oil cake and insecticide to their ponds compared to passive households (Table 4.32). Around 86% households' stocked some fish seed in their pond in the study year, the remainder of the households continuing fish culture with the previous year's stock.

Table 4.32 Inputs used (number of households/year) in the ponds by location, well-being and groups

Criteria	Fish seed	Rice bran	Quick lime	Oil cake	Organic fertilizers	Inorganic fertilizers	Insecticide	Wheat bran	Water	Grass
Rural	70 (89)	66 (84)	53 (67)	44 (56)	44 (56)	40 (51)	9 (11)	2 (3)	6 (8)	
Peri-urban	55 (83)	50 (76)	45(68)	40 (61)	27 (41)	29 (44)	5 (8)	8 (12)	4 (6)	2 (3)
Better off	59 (88)	56 (84)	49 (73)	42 (63)	36 (54)	36 (54)	11 (16)	5 (7)	7 (10)	2 (3)
Worse off	66 (85)	60 (77)	49 (63)	42 (54)	35 (45)	33 (42)	3 (4)	5 (6)	3 (4)	
Active	67 (85)	66 (84)	53 (67)	50 (63)	44 (56)	45 (57)	11 (14)	9 (11)	7 (9)	2 (3)
Passive	58 (88)	50 (76)	45 (68)	34 (52)	27 (41)	24 (36)	3 (5)	1 (2)	3 (5)	
Total average	125 (86)	116 (80)	98 (68)	84 (58)	71 (49)	69 (48)	14 (10)	10 (7)	10 (7)	2 (1)

(Figures in the parentheses are percentage of households)

Fish seed

Active households stocked fish seed more frequently ($P<0.05$) (2.58 ± 2.26 times/year) compared to passive groups (1.5 ± 0.707 times/year). Fish seed stocking frequency was also affected ($P<0.05$) by location and well-being (Table 4.33).

Table 4.33 Fish seed stocking frequency (times/year)

Location	Well-being	Mean
Rural	Better off (n=32)	2.75(2.68)
	Worse off (n=38)	2.08(1.82)
	Total (n=70)	2.39(2.26)
Peri-urban	Better off (n=27)	1.56(0.80)
	Worse off (n=28)	1.82(0.82)
	Total (n=55)	1.69(0.81)
Total average	Better off (n=59)	2.20(2.12)
	Worse off (n=66)	1.97(1.48)
	Total (n=125)	2.08(1.80)

(Figures in the parentheses are standard deviation)

In general a larger percentage (76%) of households purchased seed from itinerant traders (*patilwala*) followed by nursery (22%) and a small number of households received seed from their neighbours (2%) and stocked seed they produced themselves (4%). Around 80% of rural households brought seed from the *patilwala* compared to 71% peri-urban households. There was no significant association between seed source and group (Table 4.34). The majority (97%) of the households obtained their seed from a single source, only 3% households obtained seed from two types of source.

Table 4.34 Fish seed source by location, well-being and groups

Criteria	Source				Total
	Nursery	Neighbours	Own	*Patilwala*	
Rural (n=70)	14 (20)	0 (0)	2 (3)	56 (80)	72 (103)
Peri urban (n=55)	13 (24)	2 (4)	3 (5)	39 (71)	57 (103)
Better off (n=59)	12 (20)	1 (2)	3 (5)	46 (78)	62 (105)
Worse off (n=66)	15 (23)	1 (2)	2 (3)	49 (74)	68 (103)
Active (n=67)	12 (18)	1 (1)	3 (4)	54 (81)	70 (104)
Passive (n=58)	15 (26)	1 (2)	2 (3)	41 (71)	59 (101)
Total average (n=125)	27 (22)	2 (2)	5 (4)	95 (76)	129 (103)

(Figures in the parentheses are percentage)

Organic fertilizer for fish

Around 49% of households used organic fertilizers. The frequency of organic fertilizer application was related ($P<0.05$) to group and well-being category at the respective locations (Table 4.35). Most (86%) of the farming households had access to organic fertilizers from their own farm, but some purchased from the market (14%) or obtained from neighbours (11%). There was no significant association between sources, groups and well-being level. A higher number [$\chi^2(2)=9.382$, P=0.009] of rural households used organic fertilizer from own source than peri-urban (Table 4.36). Overall, around 89% of the households had a single source of organic fertilizers and only 11% households had multiple sources.

Table 4.35 Use (times/year) of organic fertilizers by location, well-being and groups

Location	Well-being	Group	Mean
Rural	Better off	Active (n=13)	79.15(101.70)
		Passive (n=10)	65.10(57.03)
	Worse off	Active (n=14)	45.79(57.01)
		Passive(n=7)	43.86(62.92)
Peri-urban	Better off	Active (n=8)	46.38(44.69)
		Passive(n=5)	1.20(0.45)
	Worse off	Active (n=9)	12.78(15.99)
		Passive(n=5)	27.00(41.15)
Total average	Better off	Active (n=21)	66.67(84.68)
		Passive(n=15)	43.80(55.35)
	Worse off	Active (n=23)	32.87(47.80)
		Passive(n=12)	36.83(53.39)
Active total average (n=44)			49(69.25)
Passive total average (n=27)			40.70(53.56)
Total average (n=71)			45.85(63.46)

(Figures in the parentheses are standard deviation)

Table 4.36 Source of organic fertilizer by location

Location	Market	Neighbours	Own
Rural (n=44)	3(7)	2(5)	43(98)
Peri-urban (n= 35)	7(26)	6(22)	18(67)

(Figures in the parentheses are percentage)

Other inputs for fish (inorganic fertilizers/ oil cake/ rice bran/water)

A total of 48% households used inorganic fertilizers. Generally all of the households purchased inorganic fertilizers from the market. The frequency of inorganic fertilizer application was similar between locations, while active households applied inorganic fertilizers more frequently than passive households in peri-urban areas (Table 4.37).

A total of 58% households, 63% from active and 51% from passive used oil cake. Most of the households (96%) bought oil cake from market. There was a significant difference for oil cake use frequency among the groups as peri-urban households used more frequently than in rural areas (Table 4.37).

Rice bran was the most commonly used input at all locations. Around 80% of the households used rice bran as a pond input with an average frequency of 79 times/year. Active households applied rice bran more frequently (> twice weekly) than passive and better off households used rice bran more frequently than worse off households. Peri-urban households used rice bran more frequently than those located in rural areas.

Among the rice bran users 83% of the active households and 58% passive households applied rice bran from their own farm. There was a significant association between rice bran source and group [$\chi^2(1)=6.55, P=0.01$]. Significantly [$\chi^2(1)=7.299, P=0.007$] higher numbers (82%) of rural households used rice bran from their own source than peri-urban (60%), who were more likely to purchase (Table 4.38).

Table 4.37 Inorganic, oilcake and rice bran use frequency (time/year) by locations and systems

Location	Group	Inorganic			Oil cake			Rice bran		
		Mean	SD	n	Mean	SD	n	Mean	SD	n
Rural	Active	6.54	11.17	28	49.03	64.00	29	72.20	74.62	41
	Passive	9.67	12.06	12	19.73	37.39	15	60.88	77.41	25
	Rural total av.	7.48	11.38	40	39.05	57.62	44	67.91	75.30	66
Peri-urban	Active	9.88	8.24	17	89.81	72.07	21	123.00	71.03	25
	Passive	3.92	6.08	12	34.05	45.02	19	64.52	65.40	25
	Peri-urban total av.	7.41	7.89	29	63.33	66.29	40	93.76	73.75	50
Total average	Active	7.80	10.19	45	66.16	69.81	50	91.44	76.85	66
	Passive	6.79	9.79	24	27.74	41.84	34	62.70	70.94	50
	Total average	7.45	9.99	69	50.61	62.72	84	79.05	75.41	116

Table 4.38 Source of rice bran by location and groups

Criteria	Source		Total
	Market	Own	
Rural (n=66)	14(21)	54(82)	68(103)
Peri-urban (n=50)	23(46)	30(60)	53(106)
Active (n=66)	15(23)	55(83)	70(106)
Passive (n=50)	22(44)	29(58)	51(102)
Total (n=116)	37(32)	84(72)	121(104)

(Figures in the parentheses are percentage)

Only 7% households supplied water to their ponds from either DTW or STW. Out of the 10 households using ground water, seven households are from the active group and three from the passive.

4.4.3.4 Vegetable inputs

Vegetable seed

The majority of households preserved and sowed their own vegetable seed followed by those purchasing from the market, DAE and neighbours (Table 3.39).

Table 4.39 Source of vegetable seed

	Own	Market	DAE	Neighbours
Active	41(61)	30(46)	3(5)	1(3)
Passive	14(82)	14(60)	1(6)	1(2)
Non-pond	6(54)	2(54)	1(4)	1(4)

(Figures in the parentheses are percentage)

Organic fertilizers for vegetables

A higher percentage of active group households (83%) used organic fertilizers than non-pond (79%) or passive group (74%) households (Table 4.41). There was no difference for organic fertilizer use frequency for vegetables by location, well-being and group.

In rural locations all vegetable producers applied organic fertilizers collected from on-farm and some also purchased from the market (8%) and neighbours (2%). On the other hand, a higher number [$\chi^2(2)=9.38$, $P=0.009$] of peri-urban households depended on neighbours (18%) and the market (12%) compared to rural areas (Table 4.40). Around 87% households obtained organic fertilizers from one source, whereas 13% used fertilisers from two of the three sources. A total of 22% households used kitchen waste to fertilise their vegetable crops. A small number (2 households) of active and passive (3 households) used pond bottom soil to fertilise vegetable crops (Table 4.41).

Table 4.40 Source of organic fertilizers by location

Criteria	Source			
	Purchased	Neighbours	Own	Total
Rural (n=63)	5(8)	1(2)	63(100)	69 (110)
Peri-urban (n=49)	6(12)	9(18)	43(88)	58(118)
Better off (n=58)	6(10)	2(3)	55(95)	63(109)
Worse off (n=54)	5(9)	8(15)	51(94)	64(119)
Active (n=66)	9(14)	4(6)	61(92)	74(112)
Passive (n=31)	2(6)	5(16)	30(97)	37(119)
Non-pond (n=15)	0	1(7)	15(100)	16(107)
Total average (n=112)	11(10)	10(9)	106(95)	127(113)

(Figures in the parentheses are percentage)

Inorganic fertilizers for vegetables

Active households applied inorganic fertilizers more frequently (P<0.05) than others. A higher percentage of rural households used inorganic fertilizer, and more frequently, than peri-urban households (Table 4.41). All types of inorganic fertilizers were purchased from the market.

Table 4.41 Input use frequency (times/year) to the vegetable field by households

Criteria	Stat.	Organic fertilizers	Inorganic fertilizers	Vegetable seed	Kitchen waste	Pond bottom soil	Oil cake
Rural	Mean(SD)	5.44(10.09)	10.43(10.39)	5.84(6.26)	1.52(0.81)	1.00(0.00)	1.50(0.71)
	n	63	58	44	21	2	2
Peri-urban	Mean(SD)	3.04(2.75)	6.07 (5.64)	2.51(1.60)	1.10(0.32)	1.00(0.00)	3.00
	n	49	43	41	10	3	1
Better off	Mean(SD)	4.86(10.09)	8.45 (9.38)	4.06(5.02)	1.24(0.56)	1	
	n	58	56	48	17	1	
Worse off	Mean(SD)	3.89(4.36)	8.73(8.42)	4.46(4.81)	1.57(0.85)	1	2(1)
	n	54	45	37	14	4	3
Active	Mean(SD)	4.86(9.52)	10.23 (9.68)	5.60(5.86)	1.63(0.89)	1.00(0.00)	2.00(1.00)
	n	66	61	50	16	2	3
Passive	Mean(SD)	3.35(3.73)	6.37 (7.10)	2.42(2.00)	1.09(0.30)	1.00(0.00)	
	n	31	27	26	11	3	
Non-pond	Mean(SD)	4.47(5.83)	5.38 (7.02)	1.89(1.27)	1.25(0.50)		
	n	15	13	9	4		
Total	Mean(SD)	4.39(7.85)	8.57 (8.92)	4.24(4.91)	1.39(0.72)	1.00(0.00)	2.00(1.00)
	n	112	101	85	31	5	3

Water for vegetables

A total of 70% growers used irrigation water for vegetable cultivation, the rest of the households cultivated vegetables only in the wet season. Watering frequency was affected (P<0.05) by group and well-being (Table 4.42). Among the worse off, active households applied water more frequently than passive.

Table 4.42 Water use frequency (times/year) by well-being and groups

Well-being	Group	Mean
Better off	Active (n=31)	10.74(6.97)
	Passive (n=11)	9.91(10.68)
	Non-pond (n=5)	2.40(1.14)
	Better off mean(n=47)	9.66(7.94)
Worse off	Active (n=35)	16.29(11.55)
	Passive (n=14)	10.71(15.63)
	Non-pond (n=3)	10.00(2.00)
	Worse off mean (n=52)	14.42(12.60)
Mean	Active (n=66)	13.68(10.00)
	Passive (n=25)	10.36(13.42)
	Non-pond (n=8)	5.25(4.17)
	Group mean (n=99)	12.16(10.86)

(Figures in the parentheses are standard deviation)

Ponds were the main water source (87%) used by vegetable growers followed by STW (21%) and DTW (7%). A very small percentage of households used water from natural (3%) sources such as *beels*. All active households used water from their ponds; in addition about (20%) and (3%) households also used water from STW and DTW, respectively (Table 4.43). There was a significant association between location [$\chi^2(3)=16.32$, P=0.001] and group [$\chi^2(6) = 21.9$, P=0.001] for the source of water. A large percentage (76%) of passive integrated households also depended on pond water and 25% non-pond households (25%) had access to their neighbour's pond water. The majority (82%) of the households used a single type of water source but 18% used multiple sources.

Table 4.43 Source of water per households by location, well-being and groups

Criteria	Pond	STW	DTW	Beel	Total
Rural (n=54)	44(81)	19(35)	2(4)	3(6)	68(126)
Peri-urban (n=45)	42(93)	2(4)	5(11)	0	49(109)
Better off (n=47)	41(87)	9(19)	2(4)	2(4)	54(115)
Worse off (n=52)	45(87)	12(23)	5(10)	1(2)	63(121)
Active (n=66)	66(100)	13(20)	2(3)		80(121)
Passive (n=25)	19(76)	4(16)	3(12)	3(12)	29(116)
Non-pond (n=8)	2(25)	4(50)	2(25)		8(100)
Total average (n=99)	86(87)	21(21)	7(7)	3(3)	117(118)

(Figures in the parentheses are percentage)

Pesticide for vegetables

Less than half of all vegetable growers (42%) used pesticides to protect their vegetable crops. Rural households used pesticides more frequently (P<0.05) than peri-urban households (Table 4.44). Although more (P<0.05) active households used pesticide than passive, the frequency (times/year) was affected (P<0.05) by group X location.

Table 4.44.Pesticide use frequency (times/year) by location and groups

Location	Group	Mean
Rural	Active (n=29)	10.69 (11.23)
	Passive (n=7)	19.71 (29.30)
	Non-pond (n=4)	1.50 (0.58)
	Rural mean (n=40)	11.35 (15.67)
Peri-urban	Active (n=14)	7.50 (6.60)
	Passive (n=5)	1.80 (1.30)
	Non-pond (n=19)	6.00 (6.20)
	Peri-urban mean (n=19)	6 (6.2)
Mean	Active (n=43)	9.65 (9.99)
	Passive (n=12)	12.25 (23.53)
	Non-pond (n=4)	1.50 (0.58)
	Group mean (n=59)	9.63 (13.54)

(Figures in the parentheses are standard deviation)

4.4.3.5 Rationale for fish culture

Producing fish is one of the major sources of income and food of both better off and worse non-farming household of Bangladesh. The sample households mentioned multiple reasons why they were involved in fish culture. The reasons are categorized and presented in the Table 4.45. Most of the households (74%) mentioned that selling fish was a major benefit of fish culture followed by “a lower requirement to purchase fish from the market” (70%) and “fish consumption can help improve the health” (58%).

A higher number of active households (44%) mentioned “fish are easy to produce” as a reason for producing their own fish compared to passive households (29%). Among the well-being categories “easy to produce” as a reason also differed significantly [$\chi^2(1)=5.073$, P=0.024]. For instance, “no need to spend money to buy fish” [$\chi^2(1)=4.91$,P=0.027] and “no need to visit market to buy fish” [$\chi^2(1)=4.91$, P=0.041] were reasons that varied significantly between locations i.e both of these advantages were identified by higher numbers of rural households than peri-urban (Table 4.45).

Table 4.45 Motivational factors for fish cultivation

Criteria	CAN_SAL	NO_MAR	GD_HEA	NO_M	E_PR	INS_FRE	Total
Rural	57 (69)	65 (78)	48 (58)	46 55)	30 (36)	10 (12)	83 (308)
Peri-urban	56 (80)	42 (60)	41(59)	26 (37)	25 (36)	4 (6)	70 (277)
Better off	50 (69)	51 (71)	45 (63)	29 (40)	33 (46)	7 (10)	72 (299)
Worse off	63 (78)	56 (69)	44 (54)	43 (53)	22 (27)	7 (9)	81 (290)
Active	66 (77)	54 (66)	51 (60)	39 (43)	36 (44)	11 (13)	82 (302)
Passive	47 (71)	53 (76)	38 (58)	33 (50)	19 (29)	3 (5)	66 (288)
Total	113 (74)	107 (70)	89 (58)	72 (47)	55 (36)	14 (9)	153 (294)

(Figures in the parentheses are percentage) (CAN_SAL- Fish could be sold to the market, NO_MAR- No need to buy fish from the market, GD_HEA- fish produced in own ponds are good for health, NO_M- No need to spend money for buying fish E_PR- Easy to produce, INS_FRE- Insecticide free fish could be produced in own farm)

4.4.3.6 Rationale for vegetable culture

Households were asked to perceive the driving factors for them to grow vegetables. Most of the households (81%) responded, the remainder abstaining from comment. The majority (75%) of the respondents who answered mentioned “no need to buy from market” as the most important incentive while the lowest proportion (14%) of them reported “access to pesticide free vegetable” as a reason of growing own vegetables.

"Vegetables are easy to produce" was one of the important motivations observed to be significantly associated with active household type [$\chi^2(1)=8.45, P=0.015$], as a higher percentage (49%) of this group chosen this factor followed by passive (31%) and non-pond (23%) groups respectively. "Selling vegetable" was one of the important reasons mentioned by a higher [$\chi^2(1)=7.84$, $P=0.005$] percentage (77%) of rural and worse off households (75%) compared to peri-urban (57%) and better off households (60%) respectively. A higher number [$\chi^2(1)=4.15$, $P=0.041$] of active households also emphasised more on this reason than passive and non-pond households (Table 4.46).

Table 4.46 Motivational factors for vegetable cultivation

Criteria	NO_MAR	CAN_SL	GD_HEA	NO_M	E_PR	INS_FR	Total
Rural	71(81)	68(77)	57(65)	58(66)	37(42)	13(15)	88(345)
Peri-urban	55(70)	45(57)	43(54)	41(52)	28(35)	10(13)	79(281)
Better off	63(76)	50(60)	55(66)	44(53)	44(53)	12(14)	83(323)
Worse off	63(75)	63(75)	45(54)	55(65)	21(25)	11(13)	84(307)
Active	60(71)	64(75)	56(66)	46(54)	42(49)	11(13)	85(328)
Passive	41(79)	31(60)	29(56)	30(58)	16(31)	9(17)	52(300)
Non-pond	25(83)	18(60)	15(50)	23(77)	7(23)	3(10)	30(303)
Total	126(75)	113(68)	100(60)	99(59)	65(39)	23(14)	167(315)

(Figures in the parentheses are percentage) (NO_MAR- No need to buy vegetable from the market, CAN _SL- Vegetable could be sold to the market, GD_HEA- Vegetables produced in the own farm are good for health, NO_M- No need to spend money for buying vegetable, E_PR- Easy to produce, INS_FR- Insecticide free vegetables could be produced in the own farm).

4.4.4 Livelihood outcomes

4.4.4.1 Income

A large proportion (74%) of income derived from on-farm sources (such as rice, fish, vegetable, poultry etc) while non-farm income sources (service, business, labour etc) contributed 26% to the total income of the households irrespective of location, well-being and groups (Table 4.47). The majority of the households (98%) depended on on-farm and 59% on non-farm income sources. All active and passive households were dependent on on-farm activity for their livelihood, whereas 87% of non-pond households were engaged with on-farm enterprises. All better off households earned income mainly from on-farm activities, which contributed 77% of their total income, while 95% of worse off households were involved in on-farm activities; it only contributed 67% to their total income.

Total income (US$/hh) and (US$/capita) varied among groups ($P<0.05$) and between well-being ($P<0.05$) categories. Active and passive households earned more ($P<0.05$) than non-pond households, non-farm income was similar ($P>0.05$) for all groups. Better off households on-farm and non-farm income also varied significantly ($P<0.05$) than worse off households (Table 4.47). Fish and vegetable culture contributed 17% and 8% to overall on-farm income sources, respectively. Income from vegetables made up 12%, 6% and 5% of on-farm income of active, passive and non-pond households respectively.

Table 4.47 Average on-farm and non-farm income (US$/household) and (US$/capita) by location, well-being and groups

CR.	Group	On-farm (US$/hh)	Non-farm (US$/hh)	Total (US$/hh)	Total (US$/Capita)
Rural	Active (n=48)	889.75(638.56)	158.98(246.28)	1048.73(749.14)	163.58 (119.86)
	Passive (n=32)	785.76(625.87)	133.24(249.13)	919.00(645.32)	151.28 (114.53)
	Non-pond (n=32)	408.71(384.48)	272.36(238.86)	681.07(495.87)	119.95 (83.20)
	Mean (n=112)	722.60(604.13)	184.02(249.43)	906.62(667.87)	147.60 (109.61)
Peri-urban	Active (n=35)	712.59(624.91)	259.90(333.57)	972.49(697.84)	197.50 (179.14)
	Passive (35)	768.45(929.65)	361.13(470.69)	1129.58(1005.20)	195.11 (155.36)
	Non-pond (n=23)	323.99(330.08)	327.59(378.40)	651.57(484.02)	122.71 (101.66)
	Mean (n=93)	637.51(723.19)	314.74(399.05)	952.24(802.58)	178.10 (155.79)
Better off	Active (n=41)	1103.85(740.80)	274.98(355.95)	1378.83(829.78)	248.13 (177.72)
	Passive (n=30)	1236.04(976.56)	272.07(469.98)	1508.11(1005.01)	237.75 (156.12)
	Non-pond (n=24)	608.20(394.84)	398.56(383.24)	1006.76(500.70)	178.72 (89.19)
	Mean (n=95)	1020.38(791.93)	305.28(401.21)	1325.66(838.91)	227.32 (154.06)
Worse off	Active (n=42)	533.11(326.40)	129.84(180.45)	662.96(344.94)	109.30 (55.52)
	Passive (n=37)	404.29(258.99)	236.25(329.07)	640.54(416.48)	122.64 (96.18)
	Non-pond (n=31)	191.41(194.94)	215.63(193.99)	407.03(268.13)	76.50 (62.64)
	Mean (n=111)	393.48(303.07)	189.81(246.33)	583.29(366.37)	104.54 (75.09)
Mean	Active (n=83)	815.04(635.12)	201.54(288.82)	1016.58(724.58)	177.88 (147.73)
	Passive (n=67)	776.71(793.27)	252.29(395.52)	1029.00(852.85)	174.18 (138.14)
	Non-pond (n=55)	373.28(361.98)	295.45(303.06)	668.73(486.64)	121.10 (90.48)
	Mean (n=205)	683.99(660.50)	243.32(331.55)	927.32(730.56)	161.44 (133.10)

(Figures in the parentheses are standard deviation; CR.-Criteria)

Table 4.48 Contribution (US$/ household) farm components to the on-farm income

CR.	Stat.	Rice	Fish	Vegetable	Livestock	Poultry	Tree	Field crop	Fruit	Spice
RU	Mean	505.69	81.78	55.32	20.80	4.64	15.09	5.72	7.32	2.15
	SD	493.59	134.28	92.83	41.51	15.70	60.55	11.90	25.81	7.84
	Share*	**72.45**	**11.72**	**7.93**	**2.98**	**0.66**	**2.16**	**0.82**	**1.05**	**0.31**
PU	Mean	402.58	127.92	35.79	21.40	4.40	4.52	5.96	11.36	0.00
	SD	630.16	182.44	58.60	52.06	8.91	16.21	15.29	65.71	0.00
	Share*	**65.67**	**20.87**	**5.84**	**3.49**	**0.72**	**0.74**	**0.97**	**1.85**	**0.00**
BO	Mean	727.52	140.37	55.54	21.77	3.43	10.43	7.67	17.31	2.34
	SD	698.40	203.90	89.56	50.96	8.27	56.33	14.49	69.54	8.46
	Share*	**73.76**	**14.23**	**5.63**	**2.21**	**0.35**	**1.06**	**0.78**	**1.75**	**0.24**
WO	Mean	226.94	70.19	38.62	20.47	5.48	10.17	4.24	2.12	0.17
	SD	224.51	96.38	69.29	42.45	16.03	35.65	12.46	7.24	0.90
	Share*	**59.98**	**18.55**	**10.21**	**5.41**	**1.45**	**2.69**	**1.12**	**0.56**	**0.04**
Active	Mean	516.26	151.3	77.51	20.33	6.86	4.26	5.05	4.55	1.76
	SD	548.68	187.96	93.91	49.36	18.46	16.43	11.79	15.88	7.02
	Share*	**65.53**	**19.20**	**9.84**	**2.58**	**0.87**	**0.54**	**0.64**	**0.58**	**0.22**
Passive	Mean	521.34	126.83	32.25	26.55	3.56	16.85	6.48	12.31	1.41
	SD	704.31	148.71	72.86	52.24	8.5	68.91	15.97	39.76	6.64
	Share*	**69.74**	**16.97**	**4.31**	**3.55**	**0.48**	**2.25**	**0.87**	**1.65**	**0.19**
Non-pond	Mean	296.34	0	16.9	15.52	2.19	11.41	6.21	12.27	0
	SD	295.12	0	37.69	32.5	4.58	41.99	12.85	79.82	0
	Share*	**82.13**	**0.00**	**4.68**	**4.30**	**0.61**	**3.16**	**1.72**	**3.40**	**0.00**
Mean	Mean	458.92	102.71	46.46	21.07	4.53	10.29	5.83	9.16	1.17
	SD	560.62	159.22	79.58	46.48	13.03	46.27	13.51	48.1	5.88
	Share*	**69.52**	**15.56**	**7.04**	**3.19**	**0.69**	**1.56**	**0.88**	**1.39**	**0.18**

(* Contribution (%) to the total on farm income, CR- Criteria, RU- Rural, PU- Peri-urban, BO-Better off, WO- Worse off)

4.4.4.2 Expenses

The majority (27%) of the households' monthly expenses ranged between $ 8.5-17.0 There was no significant association [$\chi^2(2)=11.21$, P=0.06] between expenses and groups (Table 4.49). Peri-urban and better off households' expenses tended to be higher than rural and worse off households respectively. Expenses among the well-being categories varied significantly [$\chi^2(5)=41.12$, P=0.001].

Table 4.49 Expenses (US$/ household) by location, group and well-being

	$ 8.5-17	$ 18-34	$ 35-52	$ 53-69	$ 70-85	$ 86-103	Total
Rural	34 (30)	37(33)	21(19)	13(12)	5(4)	2(2)	112(100)
Peri-urban	22(24)	25(27)	26(28)	6(6)	12(13)	2(2)	93(100)
Better off	9(9)	27(28)	30(32)	11(12)	14(15)	4(4)	95(100)
Worse off	47(43)	35(32)	17(15)	8(7)	3(3)	0	110(100)
Active	22(27)	22(27)	19(23)	11(13)	8(10)	1(1)	83(100)
Passive	17(25)	24(36)	14(21)	4(6)	5(7)	3(4)	67(100)
Non-pond	17(31)	16(29)	14(25)	4(7)	4(7)	0	55(100)
Total	56(27)	62(30)	47(23)	19(9)	17(8)	4(2)	205(100)

(I US$=58 Tk, during the study period, 2002)

4.4.4.3 Food and nutrition

Fish

Participants were asked about the types of food they ate along with frequency (meals/week) and source in the last seven days prior to the survey day. On average active households consumed fish at least once a day, whereas passive (4.9 times/week) and non-pond (4.05 times/week) households' consumption frequency was significantly (P<0.05) less. Fish consumption frequency also varied significantly (P<0.05) between the well-being groups but not between locations (Table 4.50).

Table 4.50 Fish consumption frequency by location, well-being and groups

Criteria	Groups	Frequency (times/week)
Better off	Active (n=41)	11.20(2.91)
	Passive (n=30)	7.37(2.43)
	Non-pond (n=24)	5.83(1.49)
	Total(n=95)	8.63(3.37)
Worse off	Active (n=42)	6.48(2.58)
	Passive(n=37)	2.92(1.21)
	Non-pond(n=31)	2.68(1.51)
	Total(n=110)	4.21(2.61)
Rural	Active (n=48)	8.25(3.69)
	Passive(n=32)	5.13(3.03)
	Non-pond(n=32)	4.13(2.18)
	Total(n=112)	6.18(3.61)
Peri-urban	Active (n=35)	9.57(3.42)
	Passive(n=35)	4.71(2.78)
	Non-pond(n=23)	3.96(2.20)
	Total(n=93)	6.35(3.84)
Total	Active (n=83)	8.81(3.62)
	Passive(n=67)	4.91(2.89)
	Non-pond(n=55)	4.05(2.17)
	Total(n=205)	6.26(3.71)

(Figures in the parenthesis are standard deviation)

A higher proportion [$\chi^2(2)=5.47$, P=0.012] of better off households consumed fish from pond (culture) than worse off. A higher proportion (37%) of active [$\chi^2(2)=13.07$, P=0.001] households tended to consume more wild fish than passive and non-pond groups (Table 4.51). More [$\chi^2(1)=8.86$, P=0.003] peri-urban people (63%) depended on fish purchased at the market compared to rural (42%).

Table 4.51 Source of fish consumed (household wise)

Criteria	Culture	Market	Wild	Rice fish (natural)	Rice fish (culture)
Rural	59 (63)	39 (42)	19(20)	2 (2)	2 (2)
Peri-urban	60 (54)	70 (63)	31(28)	3 (3)	0
Better off	62(65)	52 (55)	22 (23)	4 (4)	1 (1)
Worse off	57 (53)	57(52)	28 (25)	1 (1)	1 (1)
Active	68 (82)	41(49)	31(37)	1 (1)	1 (1)
Passive	51(76)	29 (44)	9 (13)	1 (1)	1 (1)
Non-pond		46 (84)	10 (18)	3 (5)	0
Total	119 (58)	109 (54)	50 (24)	5 (2)	2 (1)

(Figures in the parentheses are percentage of households)

Vegetables

Vegetable were categorized into two major types; leafy and non-leafy (gourd, rooted, tuber etc) based on the type (Kennedy et al. 2005). It was found that the average consumption frequency of leafy and non-leafy vegetables per week were (3.57±2.06) and (4.19±2.37) respectively (Table 4.52). Among the better off households active households consumed leafy vegetables more frequently ($P<0.05$) than passive and non-pond groups, all of the groups of worse off households consumed similarly. On the other hand active groups consumed non-leafy vegetable more frequently than others and better off households consumed more than worse off (Table 4.52).

Among the groups, active groups harvested more leafy (29%) [$\chi^2(2)=19.89$, $P=0.001$] and non-leafy vegetables (43%) [$\chi^2(2)=36.71$, $P=0.001$] from "pond-dikes" than passive groups, while a higher proportion of passive households collected both leafy [$\chi^2(2)=10.94$, $P=0.004$] and non-leafy vegetables [$\chi^2(2)=9.86$, $P=0.007$] from plots "near the house" than others (Figure 5.4).

Table 4.52 Vegetable (leafy and non-leafy) consumption frequency (times/week)

Well-being	Group	Leafy		Non leafy (gourd, rooted, tuber etc)	
		Mean	SD	Mean	SD
Better off	Active	5.39	1.94	5.41	2.43
	Passive	2.68	1.36	4.33	2.10
	Non-pond	2.56	1.23	3.10	1.65
	Total	**3.79**	**2.10**	**4.54**	**2.35**
Worse off	Active	3.17	2.01	4.86	2.86
	Passive	3.57	2.16	3.14	1.31
	Non-pond	3.07	1.68	3.42	2.14
	Total	**3.31**	**2.00**	**3.89**	**2.36**
Total	Active	4.43	2.25	5.14	2.67
	Passive	3.15	1.87	3.66	1.80
	Non-pond	2.77	1.44	3.27	1.93
	Total	**3.57**	**2.07**	**4.19**	**2.37**

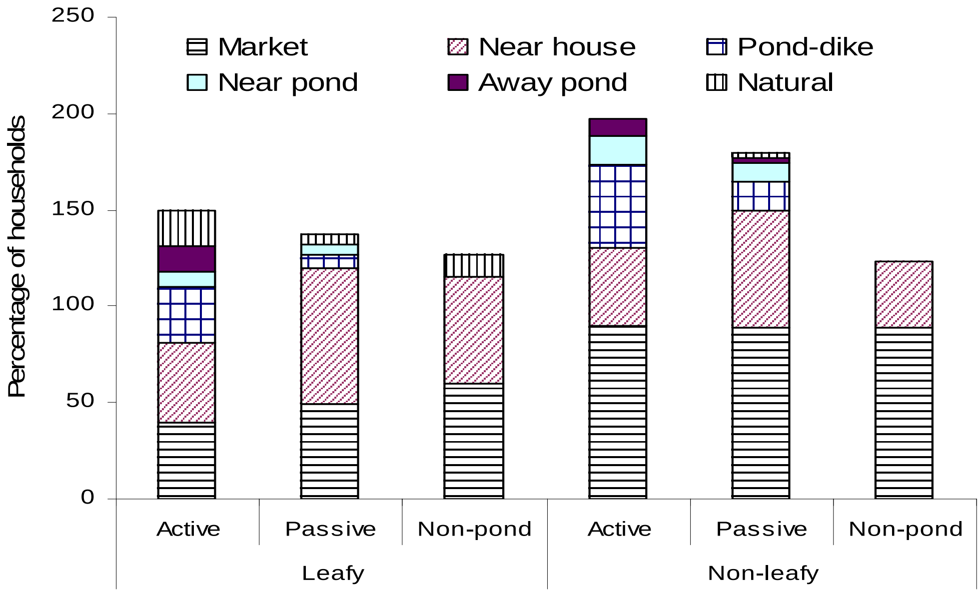

Figure 4.5: Sources of leafy and non leafy vegetables

A similar percentage of households was found to buy non-leafy vegetables from the market, whereas higher numbers (60%) of non-pond households purchased leafy vegetables from market followed by passive (49%) and active groups (40%), which was not associated significantly [$\chi^2(2)=8.81, P=0.012$] (Table 4.53).

Table 4.53 Number of households collected leafy vegetable from market

Location		Leafy vegetable purchased from the market	Total
Rural	Active	18(47)	38(100)
	Passive	14(54)	26(100)
	Non-pond	12(50)	24(100)
	Total average	44(50)	88(100)
Peri-urban	Active	7(27)	26(100)
	Passive	13(45)	29(100)
	Non-pond	13(72)	18(100)
	Total average	33(45)	73(100)

(Figures in the parentheses are percentage)

4.4.5 Discriminant analysis

The discriminant analysis suggests that active and passive households' separation can be explained based on 13 factors when a total of 54 factors used to run the test (Table 4.54). These factors are responsible for classifying the groups by 96.4% correctly. However, among the factors identified fish consumption frequency, well-being, non-leafy vegetable consumption frequency, inorganic fertilizer oil cake application to the ponds, meat consumption frequency, watering to vegetable field were the dominant among all of the factors (Table 4.55).

Table 4.54 Main factors characterizing active and passive households

Variables Entered/Removed (a,b,c,d)		Wilks' Lambda							
						Exact F			
Step	Entered	Stat	df1	df2	df3	Stat	df1	df2	Sig.P
1	Fish consumption frequency	0.743	1	1	148	51.292	1	148	<0.001
2	Wellbeing	0.623	2	1	148	44.435	2	147	<0.001
3	Non leafy vegetable consumption frequency	0.55	3	1	148	39.881	3	146	<0.001
4	Inorganic fertilizer application in pond (times/year)	0.504	4	1	148	35.735	4	145	<0.001
5	Oil cake use in pond (times/year)	0.476	5	1	148	31.695	5	144	<0.001
6	Meat consumption frequency	0.449	6	1	148	29.208	6	143	<0.001
7	Watering frequency to vegetable field	0.428	7	1	148	27.1	7	142	<0.001
8	Number of poultry	0.414	8	1	148	24.991	8	141	<0.001
9	Number of households members illness	0.4	9	1	148	23.298	9	140	<0.001
10	Easy to produce vegetable	0.387	10	1	148	21.986	10	139	<0.001
	Oil cake use in pond (times/year) (Removed)	0.392	9	1	148	24.083	9	140	<0.001
11	Meat consumption frequency	0.381	10	1	148	22.573	10	139	<0.001
12	Location	0.368	11	1	148	21.539	11	138	<0.001
13	Easy to produce fish	0.353	12	1	148	20.921	12	137	<0.001

At each step, the variable that minimizes the overall Wilks' Lambda is entered.
a Maximum number of steps is 108.
b Minimum partial F to enter is 3.84.
c Maximum partial F to remove is 2.71.
d F level, tolerance, or VIN insufficient for further computation.

Table 4.55 Classification results of active and passive households

Results		Group	Predicted Group Membership		Total
			Pond-dike (active)	Pond-dike (passive)	
Original	Count	Pond-dike (active)	80	3	83
		Pond-dike (passive)	4	63	67
	%	Pond-dike (active)	**96.4**	3.6	100
		Pond-dike (passive)	6	**94**	100
95.3% of original grouped cases correctly classified.					
90.7% of cross-validated grouped cases correctly classified.					

On the other hand, fish consumption frequency, watering the vegetable field, well-being, income from on-farm, non leafy vegetable consumption frequency , easy to produce vegetable were the important factors identified as responsible to identify active, passive and non-pond households, based on a total of 36 different factors entered to test the analysis (Table 4.56). Hence, based on these factors the result shows that 73.7 % of the households were grouped correctly (Table 4.57).

Table 4.56 Main factors characterizing active and passive and non-pond households

Variables Entered (a,b,c,d)		Wilks' Lambda							
Step	Entered	Statistic	df1	df2	df3	Exact F			
						Stat.	df1	df2	Sig.P
1	Fish consumption frequency	0.669	1	2	202	49.881	2	202	<0.001
2	Watering frequency to vegetable crops	0.534	2	2	202	36.978	4	402	<0.001
3	Well-being	0.454	3	2	202	32.296	6	400	<0.001
4	Income from on-farm (US$/households)	0.419	4	2	202	27.128	8	398	<0.001
5	Non leafy vegetable consumption frequency	0.392	5	2	202	23.654	10	396	<0.001
6	"Easy to produce" vegetables	0.37	6	2	202	21.151	12	394	<0.001
7	Vegetable production (kg/ha)	0.351	7	2	202	19.241	14	392	<0.001
8	Education (yes and no)	0.335	8	2	202	17.731	16	390	<0.001

At each step, the variable that minimizes the overall Wilks' Lambda is entered.
a Maximum number of steps is 64.
b Minimum partial F to enter is 3.84.
c Maximum partial F to remove is 2.71.
d F level, tolerance, or VIN insufficient for further computation.

Table 4.57 Classification results of active, passive and non-pond households

Results		Group	Predicted Group Membership			Total
			active	Passive	Non-pond	
Original	Count	Active	69	13	1	83
		Passive	6	41	20	67
		Non-pond	1	13	41	55
	%	Active	**83.1**	15.7	1.2	100
		Passive	9	**61.2**	29.9	100
		Non-pond	1.8	23.6	**74.5**	100

73.7% of original grouped cases correctly classified.
69.8% of cross-validated grouped cases correctly classified.

4.5 Discussion

The baseline survey helped develop an understanding the role of pond-dike systems on livelihoods, especially the existing status of integrated farming systems, vulnerability issues, and potential benefit of IAA system for enhanced income and food security.

4.5.1 Livelihood assets

Among all of the human capitals explored in this study the level of literacy, knowledge and skills were envisaged as important factors probably made greatest distinction among the independent variables (location, groups and well-being level). The average household occupancy observed in this study was a little bit higher than in the national population as a whole (5.59/hh) in 2001 (BBS, 2004). There is evidence that human capital such as family size and its composition are linked with employment, occupation and income (Ignacy, 1994; Islam, 1995), and likely to have an important influence on farming practice. For instance, large family size may make it difficult for a households to invest in fish farming because of financial constraints (Gill and Motahar, 1982) which might be one of constraining factors of the households of this study. However, the family size of the different farming households were found similar and perhaps had no effect on adopting active integrated farming households.

Although education is not an input, education is known to be an important factor in determining households' ability to understand and manage unfamiliar technology (Doss and Morris , 2001). Education and farming efficiency are closely related, and education generally has a positive effect on farm productivity (Phillips, 1994a; Phillips, 1994b; Veerina et al. 1999). A high rate of illiteracy tends to result in low farm efficiency (Ali et al. 1982; Wang et al. 1996). A higher level of education has a significant positive relationship with fish production (Hoq and Maharjan, 2000). Education and well-being were also revealed from discriminate analysis as important factors which separated the groups.

Sampled household literacy level (72%) was much higher than the national literacy level (53.74%) of 2001 (BBS, 2004), which suggests a higher literacy level in Mymensingh district perhaps linked to the relative abundance of educational institutions compared to other districts of Bangladesh. Active household heads' and their family members' higher literacy level was perhaps a significant advantage over other households which most likely influenced their ability to absorb new income earning opportunities. Similarly better off households higher literacy level compared to worse off was favourable for understanding the integrated faming technology. Eventually, better educated households were found to be aware of improved technology, while illiterate and low educated households could not avail such opportunities, which probably inhibited them from the adoption of technologies. The higher educational level of active and better off households probably enhanced their confidence as was reflected even from their motivational statement ‘easy to produce fish and vegetable’ compared to other households.

Land holdings were identified as important as land ownership in this study as pond owners had similar land holding and ownership pattern, while non-pond households were relatively deprived of this asset. However, in case of pond ownership, a higher proportion of active and better off households had their own ponds than passive and worse off households respectively, which seems to be an important factor for adopting integrated farming systems in Bangladesh (Rahman, 2003). The existing uses of ponds and their integration into farming systems are tied-up with ownership and rights, lack of which constrains intensification (Hoq and Maharjan, 2000). Ownership of a pond appears to be an important factor for their active integrated pond fish culture systems in Bangladesh. About 60% of the pond area is under multiple private household ownership and 56% jointly operated in Bangladesh (World Bank, 1991). Resource ownership was observed as an important factor determining the adoption of a technology in other studies (Savadogo et al. 1998). In contrast, around 25% of the non-pond households growing vegetables used water from their neighbours’ pond which probably reflects the potential of growing vegetable by the households without owing a pond and also demonstrate that ponds can benefit the broader community.

Location of ponds was presumably another important limiting factor for the adoption of IAA systems as the majority of the active household ponds were located close to the homestead are; perhaps homestead ponds were easier to manage compared to ponds located further away. In a recent study it was observed that *gher* location was one of the important factors for the adoption of dike cropping (Ahmed, 2001). However, the majority (more than 4 million) of the ponds in Bangladesh are located in the homestead area (Bestari et al. 2005). It was also observed that around 80% of the ponds are located in the homestead area (Rahman and Ali, 1986; Hoq and Maharjan, 2000), which facilitated integration within farming systems.

Physical capitals presented in this study included house construction design and materials, means of transportation, poultry/livestock, radio, TV and households durables. There was similarity observed among the groups in terms of household contents, though very small numbers of non-pond households had a TV. Radio was another common item, but very small number of households had access to this media which probably hindered them accessing information. Independent means of transportation was also very poor for all of the households though a relatively higher number of better off and active households owned a bicycle that helped them to access market and other facilities. A similar finding about physical capital was reported in a recent study carried out in Kishoreganj district in greater Mymensingh district (Ahmed et al. 2005).

The majority of the households had chickens which enabled them to access organic fertilizers (poultry litter) irrespective of location, well-being and group. Active and passive households were in a better position than non-pond in terms of owning scavenging poultry, while better off households had a higher number of poultry than worse off households, which probably improved access to organic fertilizer supply for growing crops and fish. Several studies of small-holder aquaculture in Bangladesh and elsewhere indicated that livestock wastes are the most commonly used input for fish production, though its use for fish culture is limited by competition as crop fertilizers or fuel (Little and Edwards, 2003).

Financial capital included ‘credit’ and ‘interest free credit’ from formal and non-formal institutions. Bangladeshi households in general require modest working capital to purchase fish seed for pondfish culture, particularly when they use inexpensive feeding methods largely depending on natural feed in fertilized ponds (ADB, 2005). Active, and rural households’ greater access (by amount) to ‘credit’ and ‘interest free credit’ probably reflected their interest and capacity to pay back, while money borrowing by the relatively larger proportion of poorer households’ probably indicated a higher need than better off households.

Participating farmers of a study carried out in Bangladesh said that they could not easily reduce their vulnerability without access to cash. Although ‘money cannot solve all problems, it can solve many of them’, they said; credit is therefore very useful (Hallman et al. 2003). They also stated that first, money is needed, then advice and information. However, the lack of many of the poor households’ financial support make it unlikely that they will be able to adopt new technology.

4.5.2 Transforming process and structure

Access to information

A greater number of active households had more access to information from formal and non-formal institutes than others which seems to be an important factor for adopting integrated farming systems. It was revealed that non-formal institutions like relatives, neighbours played significant roles in information transformation. Local networks to disseminate information have been advocated (Sen et al. 1997). The higher number of active and better off households with access to the DoF was probably an advantage for those households, rather than higher dependency on NGOs. It has been proposed that DoF can facilitate opportunities for exchanging information since NGOs do not have enough access to technical research findings. A recommendation that NGOs could identify those needs which remain unmet by government and include those to their own programs appears to be unfulfilled (Lewis, 1997).

Overall, more rural households accessed information than peri-urban while peri-urban households had more affiliations (as participants) with formal institutions than rural. It appears that households at different locations utilized different strategies. A higher proportion of active households obtained credit having an affiliation with the national organizations than others.

Sources of information might be expected to influence farmers' decision-making ability in relation to farming practices, resource management and development. Even in areas in which aquaculture has a long tradition, many small farming households culture fish far below the potential for their resources because of inadequate information (Edwards, 1999a). In Bangladesh, farmers currently under-utilize the potential for dike cropping around the *ghers*, partly because they lack knowledge of feasible options (Chapman, 1997).

Access to market

Access to markets appeared as another important aspect linked with productivity and potential livelihood benefits as higher amounts of fish and vegetables were sold by peri-urban households to larger market (auction) compared to rural households deprived from this opportunity. The location of fish and vegetable cultivation systems in the peri-urban areas has been related to easier access to market and higher food demand of the urban cities (Kombe, 2005).

4.5.3 Livelihood strategies

Engaging in agriculture has been recognized as a primary livelihood strategy (Hallman et al. 2003) of active and passive households. Usually households whose primary source of income is agriculture are more concerned about land conservation compared to others whose livelihood does not derives mainly from agriculture (Ervin and Ervin, 1982; Mehta and Kellert, 1998). More rural household heads also preferred agriculture as the primary occupation compared to peri-urban probably as a consequence of less access to non farm occupation in rural areas (Satterthwaite and Tacoli, 2002), though in the peri-urban area it was also a highly preferred occupation.

A small proportion (14%) of active integrated households in the peri-urban areas considered fish culture as a primary occupation perhaps due to better marketing access. Fish culture was perceived more likely as a secondary activity by similar numbers of better and worse off active households, reflecting similar importance to these groups (Bestari et al. 2005). However, the contribution of fish culture to the total income of the households was secondary, a finding similar to that of another study carried out in Mymensingh (Hallman et al. 2003).

Farming systems

Peri-urban and active households applied significantly more rice bran, oil cake, and organic and inorganic fertilizers than passive which probably explains increased fish production (kg/ha). On the other hand, rural households stocked fish seed more frequently, which is directly linked with their higher consumption frequency from own pond reflected their higher dependency on pond than peri-urban households. On-farm input sources and its utilization was not always found to be linked, for instance the similar rice yields (kg/hh) of active and passive households in peri-urban areas, expected to obtained similar amount of rice bran as by-product, nevertheless active households used greater quantities than passive for growing fish. On the other hand, poorer households could not afford these inputs adequately, though they applied water manually more frequently to their vegetable crops which does not cost money.

In spite of rural and peri-urban household's having similar numbers of chicken and cattle, the frequencies of organic fertilizer application in ponds was higher in rural communities, because households in peri-urban areas relied more heavily on the use of other purchased inputs. Frequency of organic fertilizer application for growing vegetable was similar between these two locations but rural households applied organic fertilizer collected from their own, rather than other sources. However, in general the use of crop and manure by-products for crops and fish is location specific (Edwards, 1999a).

Seed is a critical input of both fish and vegetable cultivation, but this input is used by people probably without understanding the quality. The majority of the households stocked fish seed purchased from itinerant traders (*Patilwala*) followed by hatcheries while very few households used their own seed. Strategies towards decentralized seed production of small carps and tilapias is advocated, which have potential to alleviate poverty as local seed production would reduce cost, improve the quality of seed, generate employment and income (Bhuiyan, 1999).

Pesticide application (by number of households and frequency) was affected by location and groups, which is difficult to explain, although active households tended to apply more frequently than passive households to protect their crops. However in general it could be pointed out that a substantial number of households applied pesticide probably to enhance their vegetable production, though lack of awareness about the effect of pesticide on human health and environment as one of the awareness issues highlighted in a recent study (Rahman, 2003). Hence, lack of awareness about the effect of pesticide has been revealed from the rational analysis of vegetable cultivation, whereas a very small number of better educated respondents supported that they grew vegetable in their own field to grow 'insecticide free' vegetables.

"No need to buy fish from market" and 'no need to spend money' for buying fish and 'selling vegetables' are the major motivational issues highlighted by the rural households that most likely reflected their financial goal of using home-produced food to reduce cash expenditure (Torlesse et al. 2004) and because of poorer access to markets that increase both the cost of purchase and marketing costs of their own products.

A higher dependency on agriculture might be viewed as the most vulnerable event for the household in general. In addition education, skill, knowledge and information are the major factors, especially for the poorer and non-pond households. Poor access to auction and large markets was a disadvantage for the rural households as they could not sale their farm product (fish and vegetable) to the auction market. In general due to inadequate consumption food items such rice, fish and vegetable often results to malnutrition and illness of the households irrespective of well-being, location and groups. However, further details of household vulnerability will be assessed in the chapter 7.

Mean fish production (2.06 t/ha) was similar to the findings of national production (2.4 t/ha) of the year 2000 (Bestari et al. 2005), while lower compared to a study (3.3 t/ha) carried out recently in greater Mymensingh district (DANIDA, 2004). Fish contributed substantially (17%) to the on-farm income of households, while DANIDA result showed that fish contributed 10% to the total income. On the other hand, the average production (kg/ha) of vegetable of all households was slightly lower compared to the recent study carried out in Bangladesh by AVRDC (Weinberger and Genova, 2005).

4.5.4 Livelihood outcomes

The income US$ 927.32/hh/year revealed from this study was a bit lower than the national income (1,168.37/hh/year) of 2000 (BBS, 2004). Households mainly relied on on-farm income sources (BBS, 2004; DANIDA, 2004; Thompson et al. 2005), though dependency on rice was similar between active and passive, while fish and vegetable contributed more to the income (US$/hh) of active households than passive. Better off households also benefited more than worse off from selling fish. Active and passive households were more dependant on on-farm income than non-pond households, and on-farm income was revealed from the discriminate analysis as one of the important factors that characterise different type of households. However, instead of active, passive and non-pond household's different income level there was no difference in expenditure of these households. A similar finding was observed where expenditures did not differ significantly between adopter and likely-adopter of agriculture technology households inspite of different income level (Hallman et al. 2003). This supports the possibilities that income and expenditure may not always be positively correlated.

The worse off households' average income from fish was US$ 70/hh/year, which is very similar (US$ 63/hh/year) to the findings of a recent study carried out with 3,69,000 poorer households by MAEP project in Mymensingh district (DANIDA, 2004). On the other hand, earning (US$ 104/hh/year) from fish sale of all of the households of this study was slightly lower than the 1.4 million pond aquaculture adopted households (US$145/hh/year) of the same project implemented in greater Mymensingh area, but higher than the 3,96,000 poorer households whose income was US$ 63/hh/year (DANIDA, 2004). Probably the adopting households earned more from fish sale due to their increased production resulting from credit and technical support received from the project.

The per capita fish consumption of this study (77/6.42 kg=11.99 kg/capita/year) was a bit lower than the findings of the study of MAEP (14.03 kg/capita/year) (DANIDA, 2004) and national household expenditure (13.86 kg/capita/year) survey (BBS, 2000a). Active households benefited more in the peri-urban area from selling more fish than passive and inspite of the dissimilarity in production (kg/ha and kg/hh), active households consumed fish at a similar level to passive from their own ponds. This confirms a previous study, suggesting that increased production does not necessarily tend to increased consumption (Torlesse et al. 2004).

Although subsistence fish consumption in terms of quantity and frequency was similar between active and passive households, the total amount of fish consumed by the active households was probably higher. Active households purchased more fish from the market and wild sources than passive households. A similar result was observed among fish pond owners that were more dependent on capture fisheries than aquaculture for meeting subsistence requirement of diets (Thompson et al. 2005). However, overall better off households' consumption (amount and frequency) was found to be higher than worse off in this study. The strategies of selling more valuable pond fish and purchasing back cheaper fish and /or catching wild fish appears to better meet their overall needs.

The per capita vegetable consumption was 16.59 kg/capita/year, which was much higher than in a recent AVRDC study (around 12 kg/capita/year). Consumption of farm vegetables in terms of frequency (times/week) was different only between well-being categories. Vegetable production (kg/ha) was higher in active households than passive and non-pond, but production (kg/hh) was similar, even though vegetable land size of active households was smaller than passive and non-pond households, reflecting the greater intensity of productivity (kg/ha) of active vegetable growers.

Fish were more likely to be purchased from the market in peri-urban households than rural, probably because higher access to peri-urban households to market than rural households. Households with ponds were less dependent on the market for fish supplies than households without ponds.

Households' individual characteristics, feelings and aspirations are known to considerably influence adoption of technology similar to pond-dike systems (Giampietro, 1997). For instance, those who are literate and have relatively better exposure to society and local institutions are more adaptive than illiterate households (Ervin and Ervin, 1982; Rauniyar, 1998; Johnson et al. 1999). Capability of educated households to seek information and get necessary support from government and non-government organizations compared to the less educated, resulted in a higher tendency to adopt technologies.

However, literacy levels, access to information and capital and contact with formal and informal institutions, pond location, and transportation means of active and better-off households was significantly higher than other groups and poorer households respectively. These are probably the important factors for adoption of active integrated farming systems.

Chapter 5: The impact of seasonality on livelihood of the households practicing active pond-dike farming system

5.1 Introduction

The PCA and baseline survey helped understanding of the communities, and household livelihoods and farming systems (Chapter 3 and 4). However, the studies were unable to provide insight concerning how seasonal change could influence the dynamics of household consumption, income and expenses. In order to better understand how active pond-dike systems impacted on these factors active households were monitored longitudinally to identify the degree of association between seasonality and livelihood in relation to location and wellbeing, and characteristics of active integrated pond-dike systems.

'Why seasons matter' - in nutrients, foods, socio-economic activities and health- has long been a concern of anthropologists' (Messer, 1989b). It has been suggested that seasonal food insecurity at the household level is a problem of poorer people in most of the developing countries (Alderman and Sahn, 1989; Messer, 1989a). The causes of food and income deficiency in different seasons are complex and no particular household structure or social organization provides a recipe for limiting seasonal risks. Seasonality is interconnected with many factors. Socio economic studies have explored the linkages between seasonality, agricultural labour demand and wages, food supply, income, health, occupations, access to market, diets etc (Marshall, 1976).

It has been explored that those societies that have access to markets to sell and buy food seem not to suffer seasonal hunger (Ogbu, 1973). A study carried out in Bangladesh noticed that a higher proportion of the overall demand for labour occurs during the period of April to May (Chaudhury, 1980) ; this seasonality eventually affects the price of labour (Alderman and Sahn, 1989). Hence, the prevalence of diseases during some specific period of the years has been identified as a major factor in limiting labour. In India it was evident that due to more seasonal variability in labour per unit area on small farms reflected greater seasonal vulnerability of poorer households (Ryan and Ghodake, 1984).

In Bangladesh, seasonal difference in the availability and intake of food affect the nutritional status of people are well recognized. Conclusive evidence is available from Bangladesh on the seasonal variation in the intake of food and nutritional status (INFS, 1977; Chaudhury, 1980; Brown et al. 1982; Black et al. 1984; Abdullah and Wheeler, 1985; Brown et al. 1985; Abdullah, 1989; Tetens et al. 2003). However, to understand consumption, it is crucial to understand income dynamism (Deaton, 1997). Seasonal changes in households' income have two major consequences. First, they result in changes in the quantity of food consumed in the household from one season to another season. Second, they affect households' seasonal consumption choices by altering the set of market baskets they can afford (Camara, 2004). For example, during the lean season when water and food might be scarce, people adjust by switching to less preferred and less expensive foods rested more (Marshall, 1976).

Food in Bangladesh traditionally means cereals, especially rice, the price of which in the market changes seasonally. Relative abundance and shortage of food, particularly rice, occur cyclically in relation to variable post harvest and pre harvest periods. It is noteworthy that the rice cultivation seasons may differ a little between districts, upazilas and villages due to factors such as availability of inputs such as irrigation water and fertilizers, other competing labour demand of farmers and also local variation in climate.

The availability of rice peaks after the principal rice (*boro*) harvest in June and thereafter reaches its lowest level in late January to early March. This coincides with a time of least agricultural paid labour, lowest food stocks and highest food prices. This period has been recognized as the "hungry season" (Tetens et al. 2003). The pre-harvest period (September to October) of *amon* rice was previously considered as the main hungry season (Abdullah, 1989). As *boro* rice has become more important over the past decade the high investment cost for this crop often results financial and food shortage vulnerability prior to *boro* rice harvest being most prominant (Tetens et al. 2003) .

The adoption of *boro* has had a major effect on the timing of both required expenditure and harvest. Seasonal variations in the availability of foods play an important role in adding variety to the diet. Vegetables are available throughout the year, although the availability is reduced in the rainy season (May to October) and increases in the winter season (November to April) (Weinberger and Genova, 2005). In the months from September to November the monsoon flood starts reducing and fish supply increases.

However, in general April-May are the months when people engage in intensive agricultural works, especially *boro* rice intercultural operation and subsequently harvesting (Chaudhury, 1980). June-July is a busy period for the farmers as they get involve in land preparation, transplantation of *amon* rice and in some areas harvesting of Aus rice and November-December is the month when *amon* rice is just harvested (Hossain et al. 2006), eventually farmers spend time and employ labour for *amon* harvesting and post harvesting activities.

5.2 Objectives and hypotheses

The main objective of the study was to identify the relationship between seasonality and livelihood outcomes in relation to location, well-being, gender and characteristics of integrated pond-dike systems. The main and sub-hypotheses of this study are given below –

Hypothesis; Seasonality normally affects the following aspects of the community peoples' livelihoods-

- Income and expense varies from season to season, in locations and well-being categories
- Households members' health conditions varies from season to season
- Consumption pattern and food source differs in different months, location and well-being
- Financial requirement varies at different times of the year
- Aquaculture and associated horticulture potentially smooth consumption and income

5.3 Methods

5.3.1 Sample size and the questionnaire

A total of 72 pond-dike active integrated households were monitored on a monthly basis between April 2003 to March 2004 through visits of the research team and use of a structured questionnaire (Appendix 10). i.e households were interviewed once per month for a period of 12 months resulting in a total of 864 separate interviews. The questionnaire was developed in English language first and translated into Bangladeshi language and tested with 10 households in a non-sample village carried out by the facilitators, revised and finalized for use. The same number of better off and worse off households from rural and peri-urban locations were monitored regularly.

Meeting were organized with the baseline farmers in each of the six villages to share the objectives and process of the monitoring survey. Only active integrated farmers were invited to participate based on their interest. A total of 12 households were selected from each of the six villages, 50% better off and 50% worse off households. It was planned to monitor 72 active integrated farmers out of 83 baseline farmers, however, out of 83 farmers only 60 farmers were interested and another 12 households were sampled randomly form the previous list which was developed before the baseline survey for monitoring.

Repeat interviews of the same household head and available family members were implemented at the end of each month. Monitoring took place over the last week of each calendar month in each household based on each village facilitator interviewing 12 households over a whole week. This allowed farmers to be aware of the interview date and follow flexibility around the households' schedule. The interview took place in the house of each respective household.

Data on food consumption collected from the households, included type and amount of food and source consumed by the household over the last three consecutive days prior to the interview. Household income and expenses data were collected based on the seven days; however, monthly fixed income data were converted to weekly. Information related to health and credit was collected monthly basis assuming that respondent could remember about the information on sickness and credit.

This study followed a similar method " dietary history recall method" defined by (Klaver et al. 1988). The length of time recalled has ranged from a few hours to 7 days, though 24 hours being most common (Block, 1982; Bingham et al. 1988; Rose et al. 2002; Savy et al. 2005), though 24 hours dietary intake has shown to be a poor indicator of habitual intake (Basiotis et al. 1987). Recent studies carried out in Bangladesh on consumption collected data on a five days (Roos, 2001) and seven days (Torlesse et al. 2004) basis. Respondents were asked to provide information about the food types and amount they consumed during the last 72 hours. In addition, the interviewer cross checked with a checklist of foods usually the household consume in the study area. However, dietary intake can not be estimated without error and perhaps never will be (Beaton, 1994).

Mean consumption data were converted from three days to a weekly consumption basis during analysis to allow comparison with the household income and expenditure. Attempts were taken to link consumption, income and expenditure mainly based on per capita, though consumption unit per adult equivalent is presented as well. The number of adult equivalent (AE) units of a household is determined by assigning different values to the household members (adult male=1). The weights are standard and depend on the age and sex of individuals (Ahmed, 1993) (Appendix 10). However, discussion has been made based on capita rather than AE, and emphasis has been given on the seasons, especially on rice seasons; during result presentation and discussion of this chapter.

5.3.2 Field facilitator and training

Six field facilitators were selected from the respective villages to assist the households monitoring and rest of the research. Facilitators were selected based on set criteria like good local reputations for good social relations, a minimum level of formal education, willingness, and of course a commitment to remain in the village at the time of the household survey etc.

They were interviewed and a training session was organized to introduce the process of household monitoring. Each of the facilitators was trained through carrying out interviews with two farmers in the presence of a researcher in a non-sample village. Two facilitators were discontinued and replaced after the 1st month due to their poor performance or unwillingness to continue the job.

5.4 Results

5.4.1 Consumption

Rice was the major food item accounting for 48% of the total food consumption followed by non-leafy (23%) and leafy (10%) vegetables and fish (8%) to the total food consumed irrespective of well-being categories across the locations (Figure 5.1). In Bangladesh rice constitutes as much as 60% of the rural diet, while more than 50% of animal nutrition is provided by fish (Shankar et al. 2004). Processed fish (dry fish and fermented fish) contributed only 0.26% and 0.17% to the total food respectively. There was no difference observed between location and well-being level in terms of contribution of different food items to the total food consumed per household in a year.

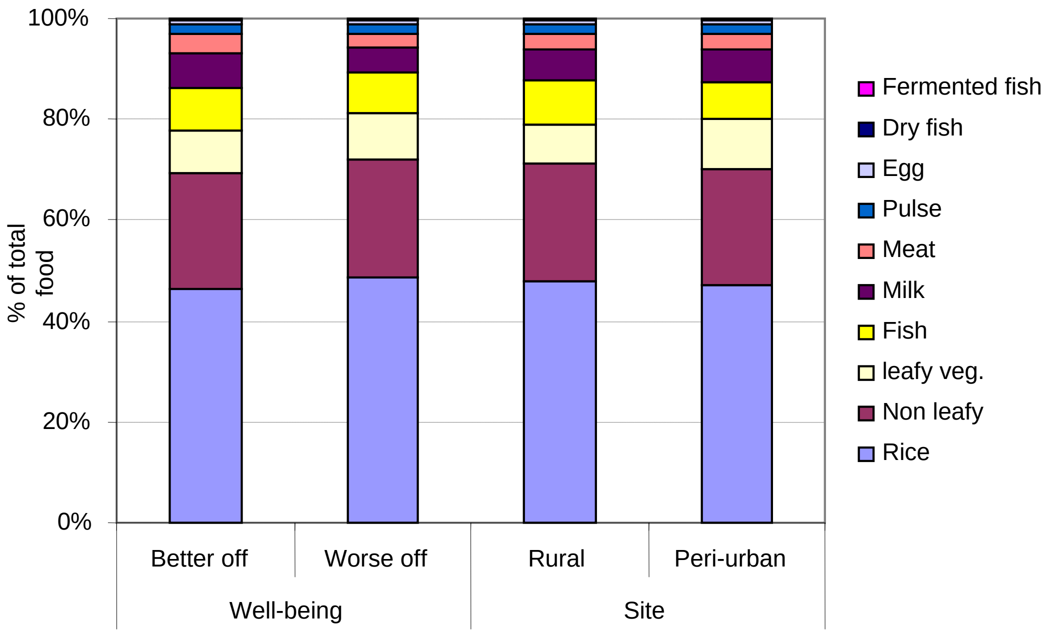

Figure 5.1 Consumption (weight in kg) of different food items to the diet (Leafy veg- Leafy vegetables; Non-leafy-Non leafy vegetables)

5.4.1.1 Fresh fish

There was no influence (P<0.05) of location and well-being category on weekly fish consumption (g/hh/week and g/AE/week) in a year. The amount (g/capita/week and g/AE/week) of fish consumption was affected by location (P<0.05) X months (P<0.05) (Figure 5.2).

The average amount of fish consumption (g/capita) tended to peak in the month of April (1,037±1,185 g/capita/week, 1,342±1,510 g/AE/week) at peri-urban locations and then decline over subsequent months. In contrast, consumption was more consistent in rural areas; consumption (g/capita/week) was highest in the months of October and November and lowest in the month of April (369±326 g/capita/week and g/AE/week). The least fish was consumed between November and April. Overall, February, March and April were the months when least fish was consumed irrespective of location and well- being.

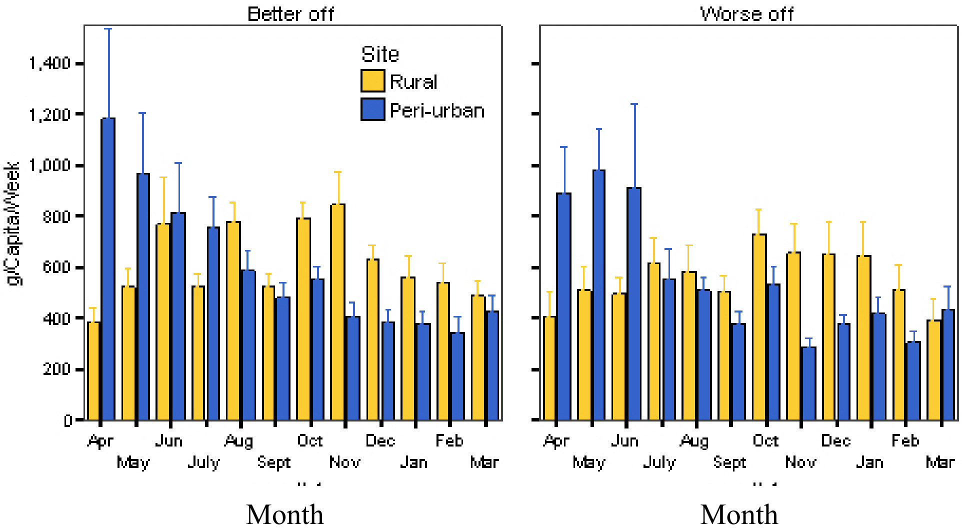

Figure 5.2 Fish consumption (g/capita/week) by location and well-being

Sources of fresh fish

62% and 52% of the total fish consumed (g/capita and g/AE) was produced on-farm by better off and worse off households respectively. The second important source was markets, followed by wild stocks and gifts received from neighbours or relatives. Worse off households depended more on wild stock (21%) than better off (16%) (Figure 5.3).

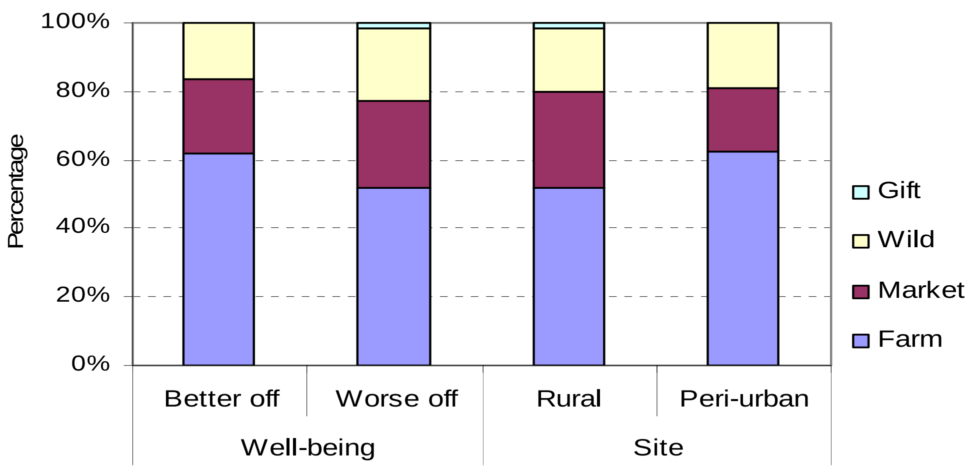

Figure 5.3 Contribution (%) of sources to the total fish by location and well-being

Better off households consumed (g/capita/week) more ($P<0.05$) fish in a year from their own farm than worse off. Better off households also tended to consume greater amounts of fish from their own farm in most of the months of the year, except May (Figure 5.4). Location and season interacted to affect ($P<0.05$) the source of fish consumed.

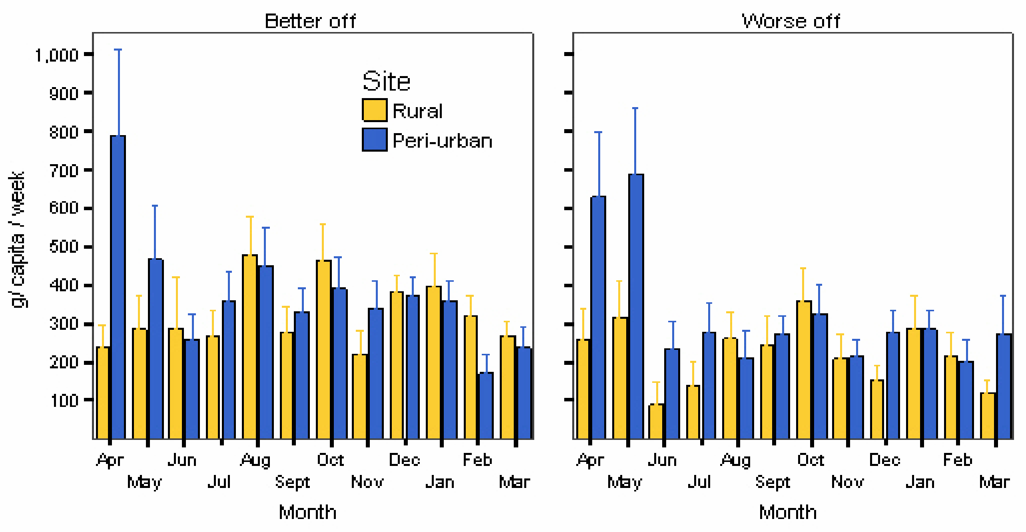

Figure 5.4 Fish consumption (g/capita/week) from farm source by well-being

August to January were the months when rural households tended to purchase relatively higher amounts (g/capita/week) of fish compared to peri-urban location, whereas peri-urban households purchased fish in April than rural. The highest amounts (g/capita/week) of wild fish were consumed between June to August, compared to other months.

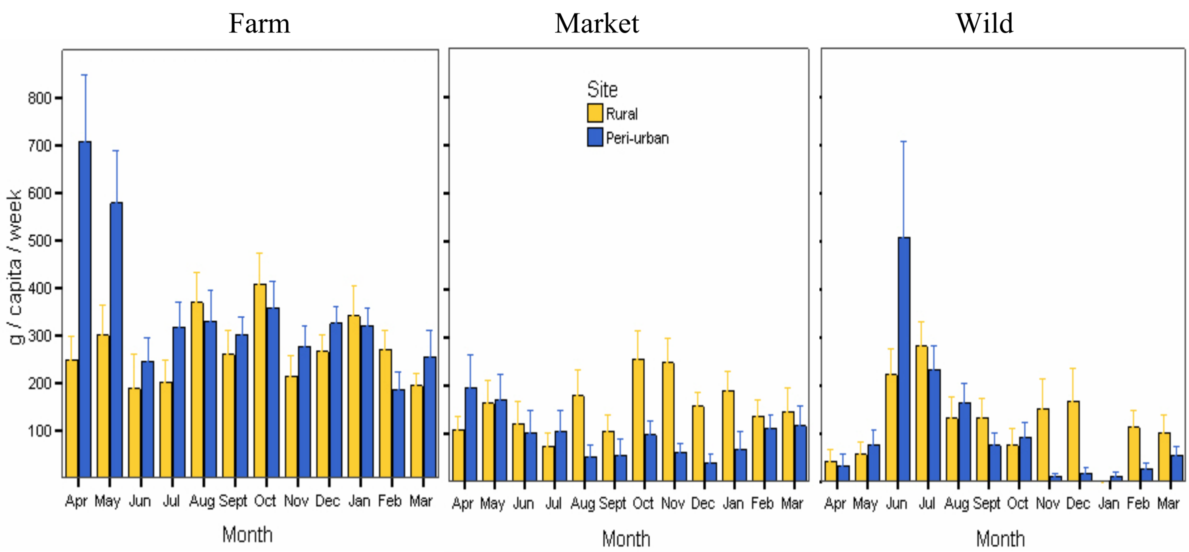

Figure 5.5 Amount (g/capita/week) and sources of fish consumed by location

5.4.1.2 Processed fish

Fermented and dry fish consumption amount (g/capita/week and g/AE/week) was significantly affected by season (P<0.05; Table 1.1). Fermented fish consumption peaked strongly in the months of April to July in contrast dried fish consumption which was bi-modal with April to May and December to February being the months of greatest consumption.

Table 5.1 Mean consumption (g/capita/week and g/AE/week) of processed fish

Month	Fermented fish		Dried fish	
	g/capita/week	g/AE/week	g/capita/week	g/AE/week
April	**16.76(17.10)**	**21.63(22.47)**	**23.37(24.66)**	**29.68(30.72)**
May	**37.08(63.95)**	**47.99(83.79)**	**24.10(56.71)**	**32.22(77.04)**
June	**45.92(71.55)**	**58.51(92.64)**	8.28(31.70)	10.08(37.51)
July	**12.06(18.59)**	**15.29(23.33)**	15.46(44.79)	21.37(62.52)
August	7.63(15.66)	9.77(20.72)	5.74(12.07)	7.37(15.28)
September	2.99(8.91)	3.85(11.71)	10.57(19.43)	13.50(25.12)
October	1.27(5.25)	1.69(7.20)	7.98(15.72)	9.88(18.60)
November	1.56(4.98)	1.83(5.82)	16.09(22.25)	21.05(29.16)
December	3.10(8.69)	4.05(11.60)	30.95(49.76)	40.71(67.57)
January	3.09(9.08)	3.98(12.21)	**28.43(29.32)**	**37.35(43.13)**
February	1.83(5.37)	2.27(6.75)	**26.15(37.93)**	**34.05(47.82)**
March	**8.79(14.13)**	**11.11(18.10)**	**12.34(23.23)**	**16.41(32.09)**
Total	11.84(32.76)	15.16(42.51)	17.46(34.27)	22.81(45.82)

(Figures in the parentheses are standard deviation)

5.4.1.3 Vegetables

Households depended more on their own production than the market for leafy vegetable consumption, while a higher proportion of non-leafy vegetables were purchased from the market compared to produced on-farm (Figure 5.6). There was no difference between location and well-being for the percentage of vegetable consumed from difference sources.

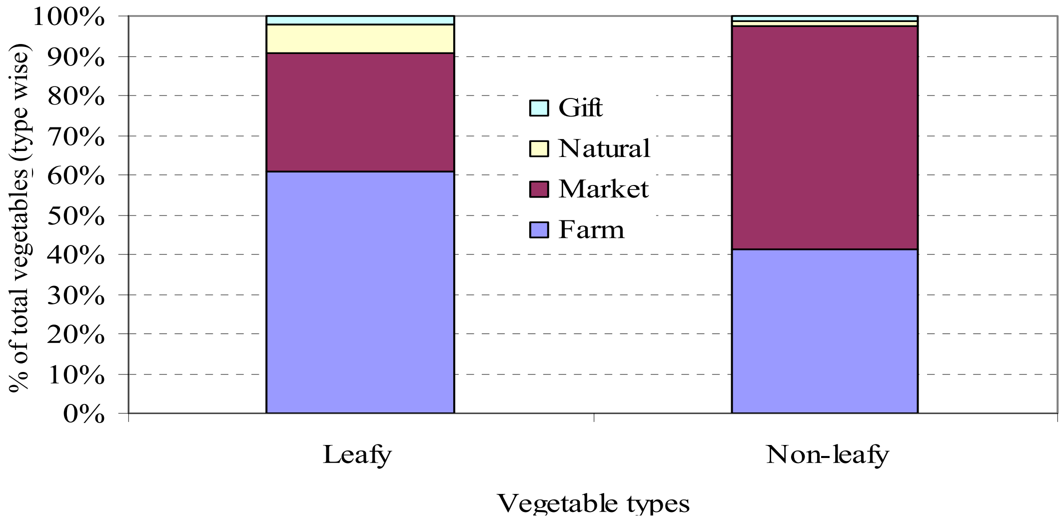

Figure 5.6 Contribution (%) sources to the total amount of vegetable

Leafy vegetables

Leafy vegetable consumption per adult equivalent (P<0.05) and per capita (P<0.05) were found to be affected by location x months (Figure 5.7). The average amount of leafy vegetable consumption tended to be lower in the months of January to March, although consumption increased in April and May. The average amount of leafy vegetable consumed per adult equivalent and per capita was similar between June and December months.

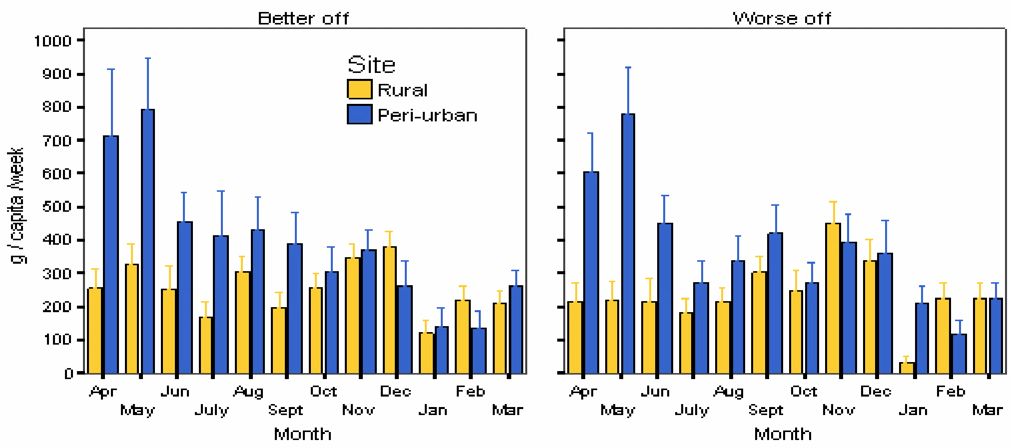

Figure 5.7 Consumption of leafy vegetables by location and well-being

Consumption of leafy vegetables produced on-farm varied significantly (P<0.05) over the year (Figure 5.8). More leafy vegetables were eaten between April and June in peri-urban areas; consumption levels were lower in rural areas. There were a significant differences (P<0.05) over time for leafy vegetable consumption (g/capita/week) from on-farm and market sources. April, May and November were the months when households' consumed (g/capita/week) more purchased leafy vegetable than other months.

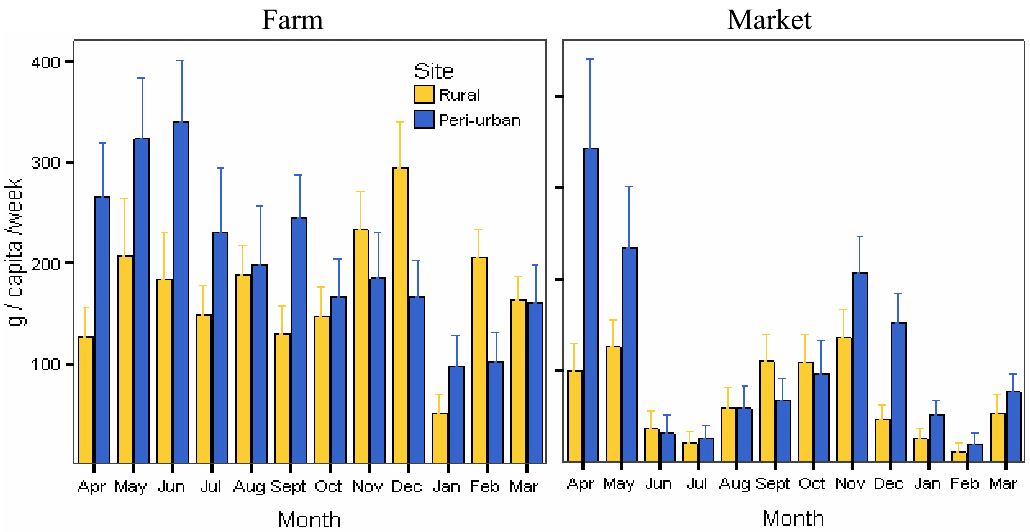

Figure 5.8 Source of leafy vegetable

Non-leafy vegetables

The non leafy vegetable consumption amount (per adult equivalent and per capita) was found to vary significantly (P<0.05) by location X months (Fig. 5.9). The lowest amount of non-leafy vegetables were consumed in the months of April, May and June and intake peaked between December to March.

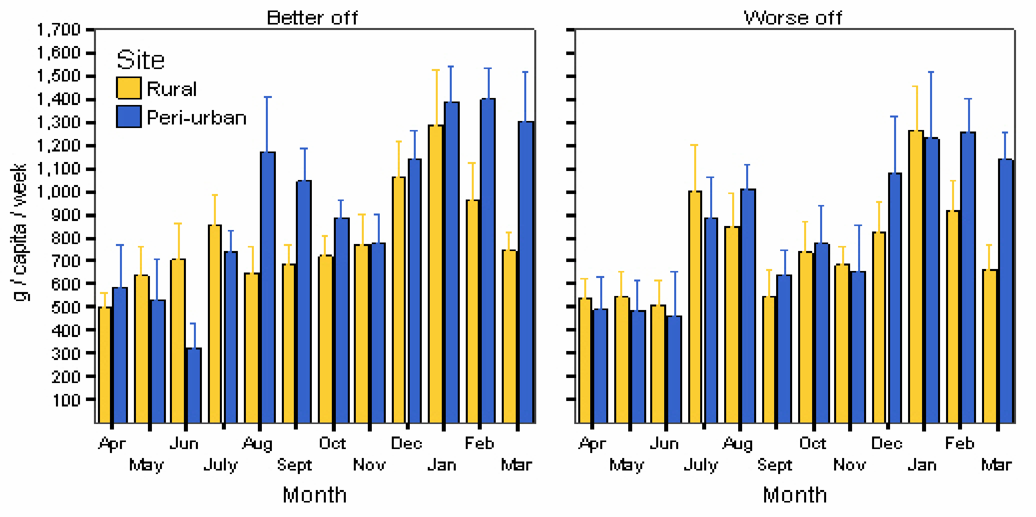

Figure 5.9 Consumption of non-leafy vegetable by location and well-being

Households consumed more farmed non-leafy vegetables produced on-farm in the months of July, August, December to March compared to other months ($P<0.05$). On the other hand, consumption from market source was affected ($P<0.05$) by location X months (Figure 5.10). On average, whereas peri-urban households purchased 34% more non-leafy vegetables from the market than rural households. The latter tended to depend more on their own production, especially in the months from May to August.

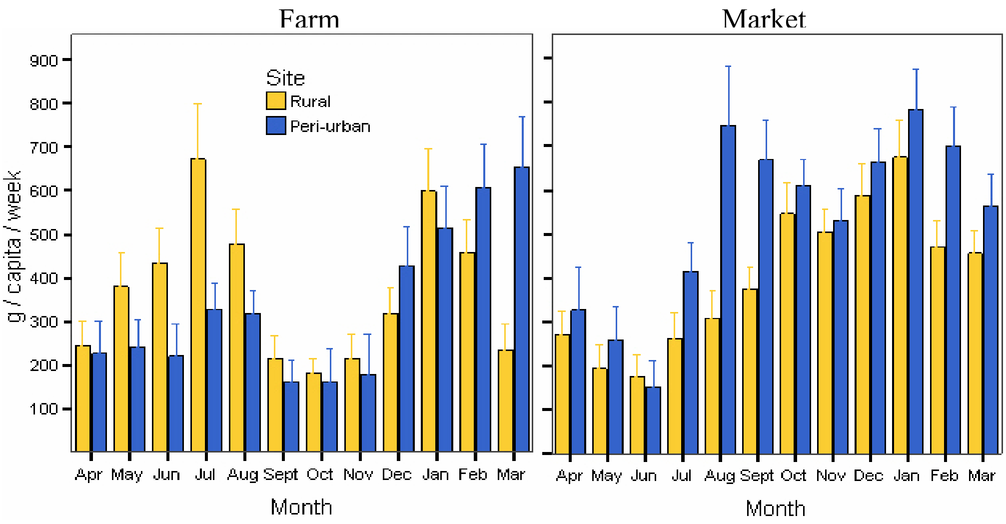

Figure 5.10 Consumption (g/capita/week) of non-leafy vegetable by sources

5.4.1.4 Rice

An average amount of rice was 3,390±1,672 g/capita/week and 4,361±2,127 g/AE/week consumed by the households. Rice consumption was found to vary significantly by location in different months ($P<0.05$) and worse off households rice consumption varied more in the months than better off households. In contrast, there was no influence of well-being on consumption level (Figure 5.11). Peri-urban households were likely to consume more rice than those in rural areas in April to November.

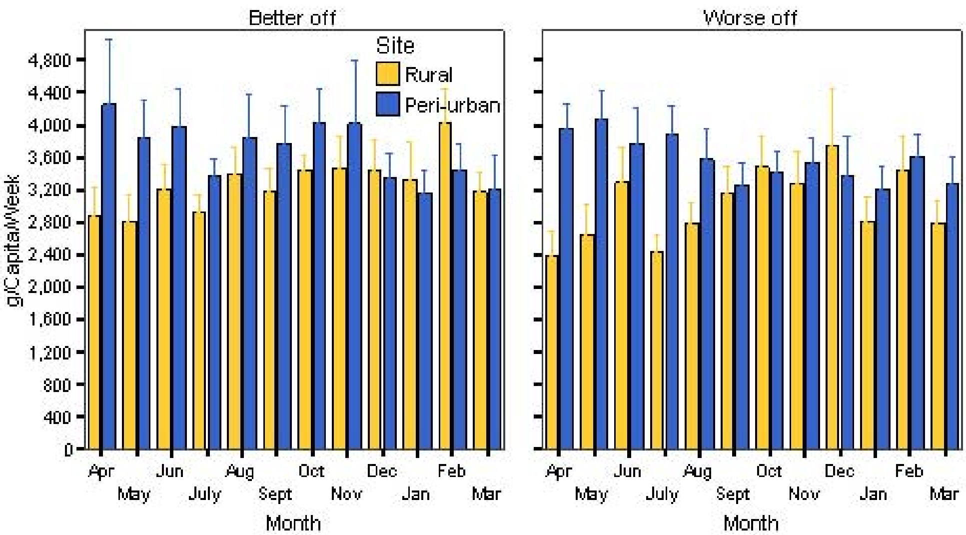

Figure 5.11 Consumption of rice (g/capita/week) by location and well-being

5.4.1.5 Other food (pulse /milk/meat)

Pulse was one of the most preferred food items of Bangladeshi diet, after rice, fish and vegetable. Better off households consumed higher amount (g/capita/week) of pulse in a year than worse off households (Table 5.2).

Better off households consumed significantly more ($P<0.05$) (g/capita/week and g/AE/week) amount of meat and milk over the year than worse off households

(Table 5.2). Meat consumption amount per adult equivalent and capita were significantly affected by months of the year (P<0.05) (Figure 5.12). Meat consumption increased strongly after June and peaked in November.

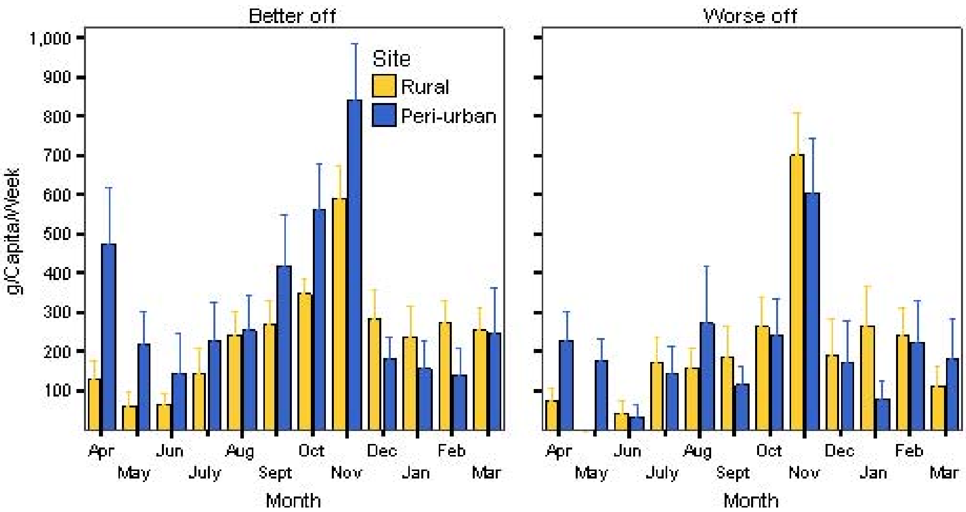

Figure 5.12 Consumption of meat (g/capita/week) by location and well-being

Table 5.2 Mean consumption (g/capita/week and g/AE/week) by well-being and location

Food		Well-being		Location		Mean
		Better off	Worse off	Rural	Peri-urban	
Fish	C	610.12 (253.71)	553.21 (291.26)	585.69 (248.78)	577.64 (298.24)	581.66 (272.71)
	A	775.67 (326.88)	724.55 (385.90)	748.74 (321.22)	751.48 (392.33)	750.11 (356.02)
Fermen. fish	C	12.53 (9.49)	11.15 (12.25)	13.81 (12.15)	9.87 (9.24)	11.84 (10.90)
	A	15.93 (12.42)	14.40 (15.90)	17.41 (15.69)	12.91 (12.31)	15.16 (14.19)
Dry fish	C	17.30 (9.85)	17.61 (11.38)	17.49 (10.35)	17.42 (10.93)	17.46 (10.57)
	A	22.25 (12.98)	23.36 (15.94)	22.71 (13.93)	22.91 (15.13)	22.81 (14.44)
Meat	C	280.64 (182.79)	202.29 (181.43)	219.97 (144.79)	262.96 (218.11)	241.47 (185.07)
	A	351.27 (225.47)	261.59 (223.58)	279.43 (187.28)	333.43 (261.51)	306.43 (227.47)
Rice	C	3,481.70 (1135.19)	3,297.30 (1092.32)	3,146.99 (1,036.73)	3,632.01 (1,141.72)	3,389.50 (1109.98)
	A	4,417.32 (1470.50)	4,304.19 (1367.29)	4,026.63 (1,293.48)	4,694.87 (1,461.40)	4,360.75 (1410.94)
Milk	C	565.08 (486.06)	351.59 (289.27)	370.66 (262.96)	546.01 (508.34)	458.34 (411.42)
	A	716.34 (605.38)	460.94 (366.53)	479.13 (341.72)	698.16 (626.85)	588.64 (513.25)
Pulse	C	175.40 (100.60)	136.40 (87.02)	131.15 (83.92)	180.65 (100.86)	155.90 (95.43)
	A	221.11 (126.97)	178.96 (115.70)	167.32 (109.45)	232.75 (127.44)	200.04 (122.46)
Egg	C	43.76 (25.77)	42.57 (27.00)	38.40 (21.47)	47.93 (29.77)	43.17 (26.21)
	A	54.89 (31.67)	55.17 (34.54)	48.69 (27.18)	61.36 (37.07)	55.03 (32.90)
Leafy	C	327.44 (249.45)	304.29 (180.81)	245.81 (85.69)	385.92 (278.84)	315.86 (216.62)
	A	418.81 (322.63)	401.85 (255.59)	317.40 (118.56)	503.26 (371.13)	410.33 (289.11)
Non-leafy	C	868.74 (358.66)	798.60 (421.67)	776.07 (333.25)	891.26 (437.14)	833.67 (390.27)
	A	1,108.18 (482.23)	1,040.19 (508.34)	1,000.82 (457.37)	1,147.56 (522.56)	1,074.19 (493.15)

(Figures in the parentheses are standard deviation. Fermen. fish – Fermented fish; C- Capita; A- Adult Equivalent)

5.4.2 Income (per household and capita)

Weekly average income (US$/ capita/week and US$/hh/week) of the study year of better off was significantly (P<0.05) higher than worse off households (Table 5.4; Table 5.5). Per capita income (US$/week) was affected by well-being X months and by location X months (P<0.05) (Figure 5.13). Peri-urban household income was likely to be higher than rural in most of the months, except April, May and February regardless well-being level.

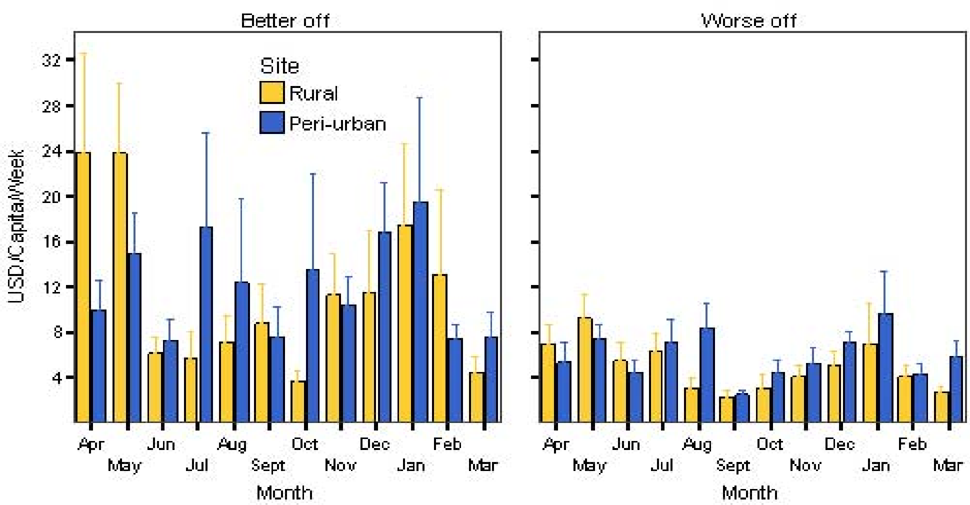

Figure 5.13 Income (US$/capita/week) by location and well-being

The contribution of rice sales to the overall farm income (US$/hh/week) was highest followed by fish, livestock, poultry and vegetable (Table 5.3). Income from salaried service (part time and fulltime employment in GOs/NGOs/ Shops/Banks etc) contributed the most to the yearly income (US$/hh/week) of the households followed by rice, fish, livestock, poultry and vegetable (Table 5.5).

5.4.2.1 Income from all sources

It was revealed that although households sold fish and vegetables throughout the year, fish sales were relatively higher in the months of July, August, October and December irrespective of well-being level, while households sold relatively less vegetables in the months of July, August and October. Households earned disproportionately from other on-farm components (rice, poultry, livestock etc) in different months of the year. Contribution trend of non-farm income sources to the total household income revealed to be similar to the respective better off and worse off households, though they earned less from non-farm (Figure 5.14).

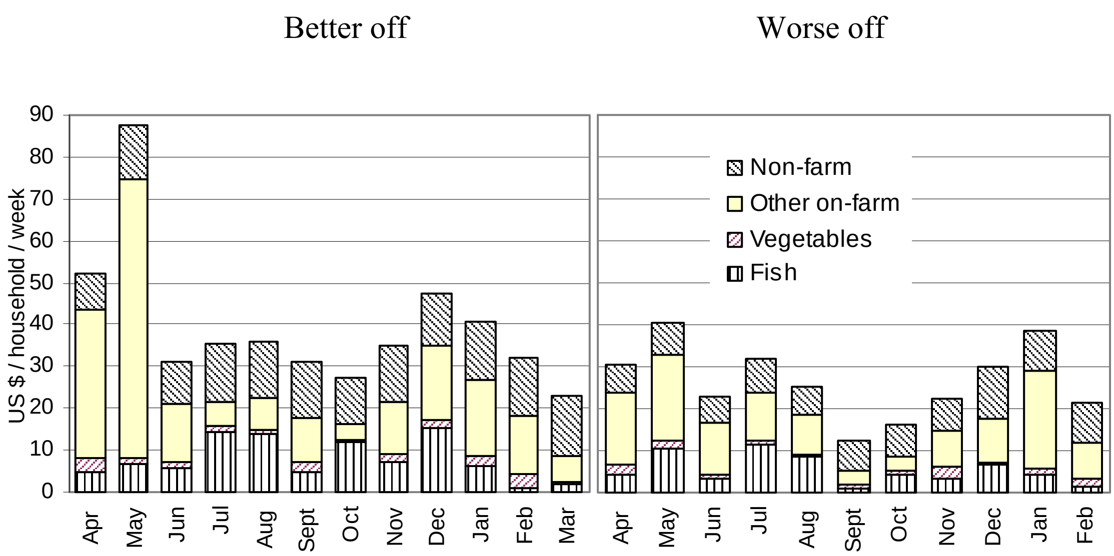

Figure 5.14 Income (US$/hh/week) by well-being

5.4.2.2 Rice sales

Weekly average income (US$/ capita/week and US$/hh/week) of the study year from selling rice of better off households was higher ($P<0.05$) compared to worse off households (Table 5.4

Table 5.4;Table 5.5). Per capita income from rice selling was different between well-being ($P<0.05$) and months ($P<0.05$) (Figure 5.15).

Rural households depend more on rice cultivation (29% of total income) as an income source than peri-urban (16% of the total income), peri-urban households mainly earned from fish culture (27% income from fish). Per capita income from rice sales was highest in the months of April and May followed by November and December irrespective of location and well-being category.

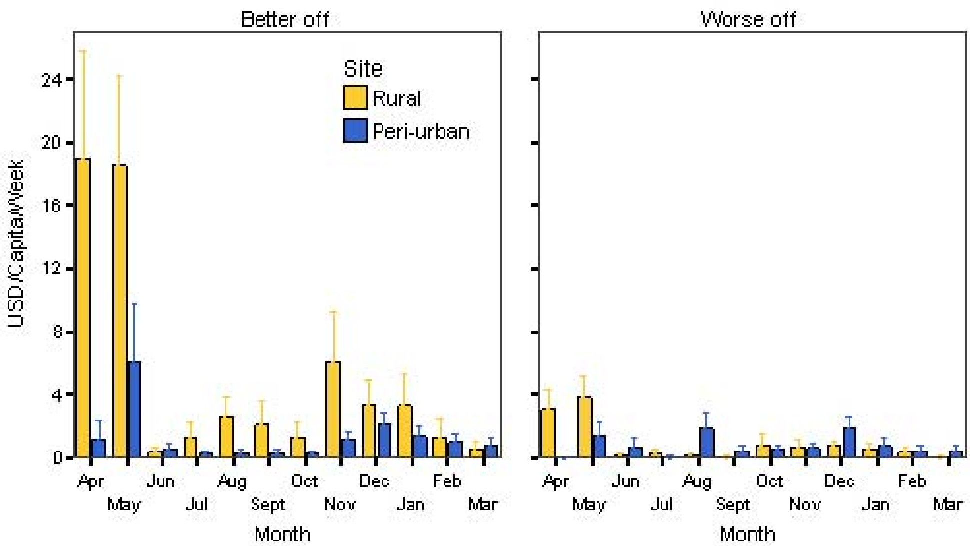

Figure 5.15 Income (US$/capita/week) from selling rice by location and well-being

5.4.2.3 Service

The major share of non-farm income earned by the households was from service. The contribution of service was 26% and 22% to the overall income of rural and peri-urban households, and 26% and 21% to the better off and worse off households' total income respectively. However, there was no difference ($P>0.05$) observed for the amount (US$/capita/week) of money earned from service between locations, well-being and months.

5.4.2.4 Fish sales

Better off households' weekly average income (US$/hh/week) in the study year from fish sales was higher than worse off (Table 5.4; Table 5.5). Income (US$/capita/week) from selling fish was affected (P<0.05) by location X season and by well-being (Figure 5.16). Peri-urban households were found to be more dependent on fish sales (27% of total income) than rural households (11% to total income).

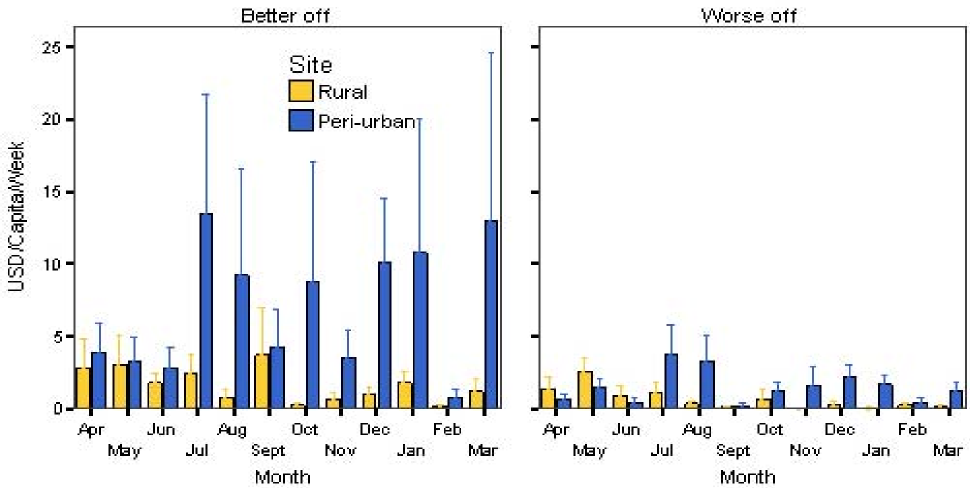

Figure 5.16 Income (US$/capita/week) from selling fish by location and well-being

5.4.2.5 Vegetable sales

Per capita and per households income from vegetable sales were also different by month X location (P<0.05). October, November and December were the peak months for vegetables sale for the better off households in peri-urban locations.

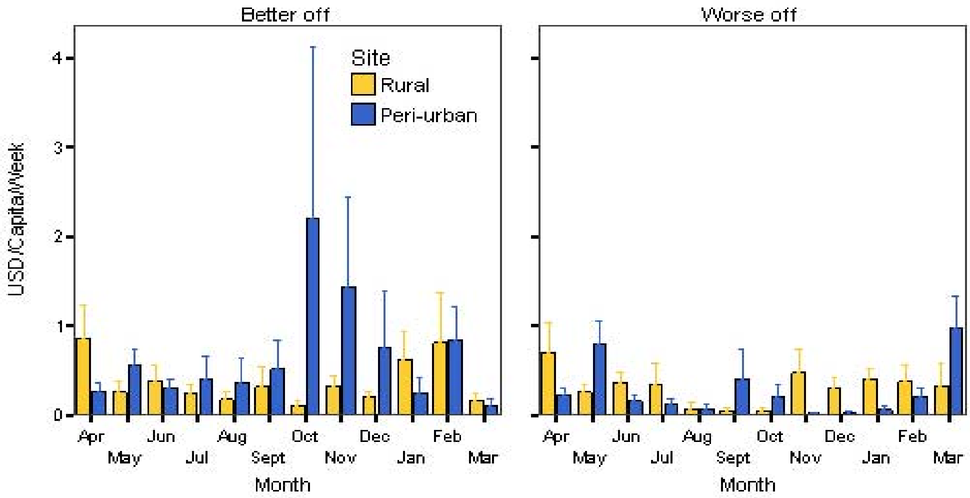

Figure 5.17 Income (US$/capita/week) from vegetable selling by location and well-being

5.4.2.6 Poultry sales

There was a significant (P<0.05) interaction observed between location X months for earning from poultry (US$/capita/week). November, December to February were the months when rural households tended to earn more (P<0.05) from poultry selling than in peri-urban locations.

Table 5.3 Average contribution (US$/hh/week) of farm components to the total on-farm income

Criteria	Rice	Fish	Livestock	Poultry	Vegetable	Fruit	Tree	Total
Better off	41.58	29.36	6.57	9.66	6.94	4.34	1.55	100
Worse off	24.30	31.01	20.64	9.54	8.52	5.10	0.90	100
Rural	44.26	17.33	11.57	8.45	8.74	7.83	1.82	100
Peri-urban	24.87	41.72	13.58	10.64	6.63	1.77	0.79	100
Mean	34.06	30.00	12.59	9.58	7.59	4.67	1.27	100

Table 5.4 Important income (US$/capita/week) by well-being and locations

Criteria		Fish	Service	Rice	Livestock	Poultry	Business	Vegetable	*Total
Better off	Mean	2.26	1.77	1.73	0.24	0.52	0.37	0.35	7.84
	SD	7.54	2.52	1.64	0.48	1.39	0.82	0.61	7.72
Worse off	Mean	1.08	1.22	0.82	0.73	0.34	0.44	0.29	5.48
	SD	1.74	2.06	1.25	1.55	0.50	0.73	0.34	3.34
Rural	Mean	0.61	1.31	1.41	0.44	0.32	0.20	0.29	5.26
	SD	0.99	1.47	1.48	1.17	0.48	0.28	0.30	2.71
Peri-urban	Mean	2.56	1.62	1.07	0.58	0.51	0.60	0.34	7.78
	SD	7.14	2.85	1.53	1.25	1.32	1.01	0.60	7.55
Mean	Mean	1.61	1.47	1.24	0.51	0.42	0.41	0.32	6.56
	SD	5.23	2.28	1.50	1.21	1.00	0.77	0.48	5.83

(* Total income is the sum of all expenses, not only the sum important expenses)

Table 5.5 Average income (US$/hh/week) from different sources by location and well-being

Item	Better off		Worse off		Rural		Peri-urban		Total mean	
	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%
Service	10.27 (12.34)	25.73	5.65 (8.62)	21.64	8.44 (9.83)	26.48	7.10 (11.47)	21.60	7.75 (10.65)	23.93
Rice sale	11.02 (11.57)	27.62	4.05 (5.90)	15.51	9.22 (10.54)	28.93	5.33 (8.17)	16.22	7.22 (9.52)	22.29
Fish sale	7.78 (16.27)	19.51	5.17 (7.87)	19.80	3.61 (5.37)	11.32	8.94 (16.13)	27.23	6.36 (12.37)	19.63
Livestock sale	1.74 (3.63)	4.37	3.44 (7.02)	13.18	2.41 (5.90)	7.57	2.91 (5.70)	8.86	2.67 (5.76)	8.24
Poultry sale	2.56 (5.59)	6.41	1.59 (1.84)	6.08	1.76 (1.75)	5.52	2.28 (5.34)	6.94	2.03 (4.00)	6.26
Business	1.94 (3.52)	4.87	2.14 (3.50)	8.21	1.30 (1.71)	4.09	2.76 (4.49)	8.39	2.05 (3.49)	6.33
Vegetable sale	1.84 (2.13)	4.62	1.42 (1.74)	5.43	1.82 (1.90)	5.70	1.42 (1.95)	4.32	1.61 (1.92)	4.98
Fruit sale	1.15 (2.00)	2.89	0.85 (1.62)	3.25	1.63 (2.23)	5.13	0.38 (0.94)	1.15	0.99 (1.79)	3.05
Power tiller driving	0.74 (3.88)	1.86	0.00	0.00	0.00	0.00	0.65 (3.64)	1.99	0.34 (2.62)	1.04
Non. agri. labour	0.07 (0.03)	0.01	0.65 (1.92)	2.50	0.25 (0.89)	0.78	0.46 (1.83)	1.40	0.36 (1.45)	1.11
Petty business	0.32 (1.00)	0.81	0.23 (0.53)	0.88	0.14 (0.37)	0.44	0.40 (1.01)	1.21	0.27 (0.77)	0.84
Tree sale	0.41 (1.22)	1.02	0.15 (0.56)	0.59	0.38 (1.12)	1.19	0.17 (0.68)	0.51	0.27 (0.92)	0.83
Agri.labour	0.06 (0.28)	0.15	0.29 (0.85)	1.12	0.32 (0.90)	1.00	0.06 (0.27)	0.18	0.19 (0.66)	0.57
Land sale	0.00	0.00	0.31 (1.85)	1.18	0.35 (1.96)	1.09	0.00	0.00	0.17 (1.37)	0.52
Remittance	0.05 (0.28)	0.13	0.09 (0.37)	0.34	0.15 (0.47)	0.46	0.00	0.00	0.07 (0.33)	0.22
Agri.by product	0.00 0.00	0.00	0.03 (0.14)	0.13	0.04 (0.15)	0.12	0.00	0.00	0.02 (0.10)	0.06
Others	0.00 0.00	0.00	0.04 (0.24)	0.17	0.05 (0.26)	0.16	0.00	0.00	0.02 (0.18)	0.07
Mean	39.89 (18.41)		26.10 (14.41)		31.86 (16.45)		32.85 (19.45)		32.37 (17.76)	

(Figures in the parentheses are standard deviation; % refers contrition to the total income)
(Agri.labour- Agricultural labour, Agri.by product- agricultural by products, Non. agri. labour- Non agricultural labour)

5.4.3 Households' expense (per household and capita)

The weekly average expense (US$/capita/week and US$/hh/week) of the study year of better off households were higher than worse off households (Table 5.6 ;Table 5.7). The worse off households spent less than 50% of the better off households. The expenses was also affected ($P<0.05$) by well-being X months (Figure 5.18).

Among all the expenses it was revealed that food accounted for 20 % of the total expenses, followed by agricultural labour (19%), rice input cost (13%), house maintenance (9%), pond input (8%), health (5%), education (3%), vegetable input (2%) etc irrespective of location and well-being level (Table 5.6). The trends of expenses (US$/capita/week) was higher in the months of January, April, May, August and November and December compared to other months.

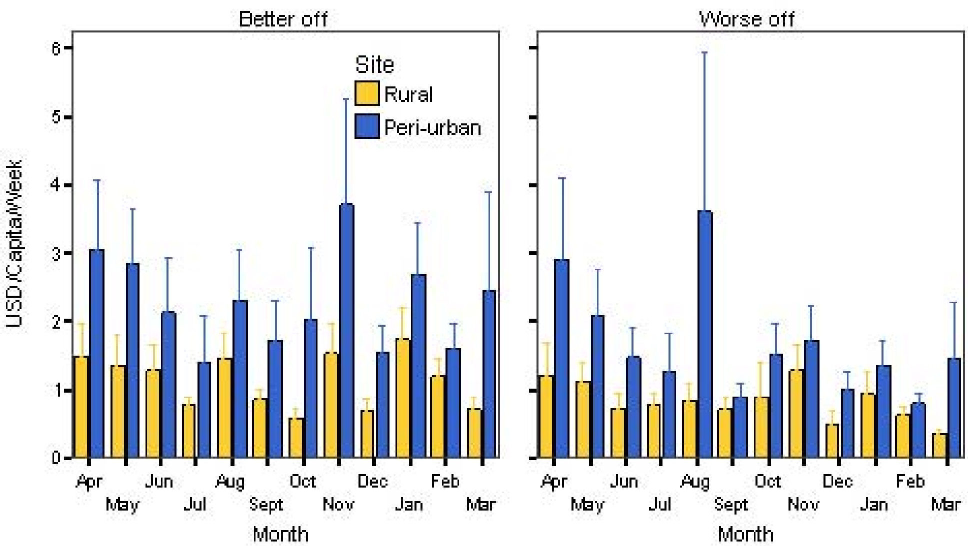

Figure 5.18 Total expenses (US$/capita/week) by location and well-being

5.4.3.1 Expense by well-being level

Both well-being levels of household paid more agricultural labour wages in April and May than other months. The expense for purchasing food was similar throughout the year though they spent more in November on food. All households invested on pond fish production mainly from March to July, and better off households spent more than worse off households. In August and November expenses for vegetable input was higher than other months for both better off and worse off households (Figure 5.19).

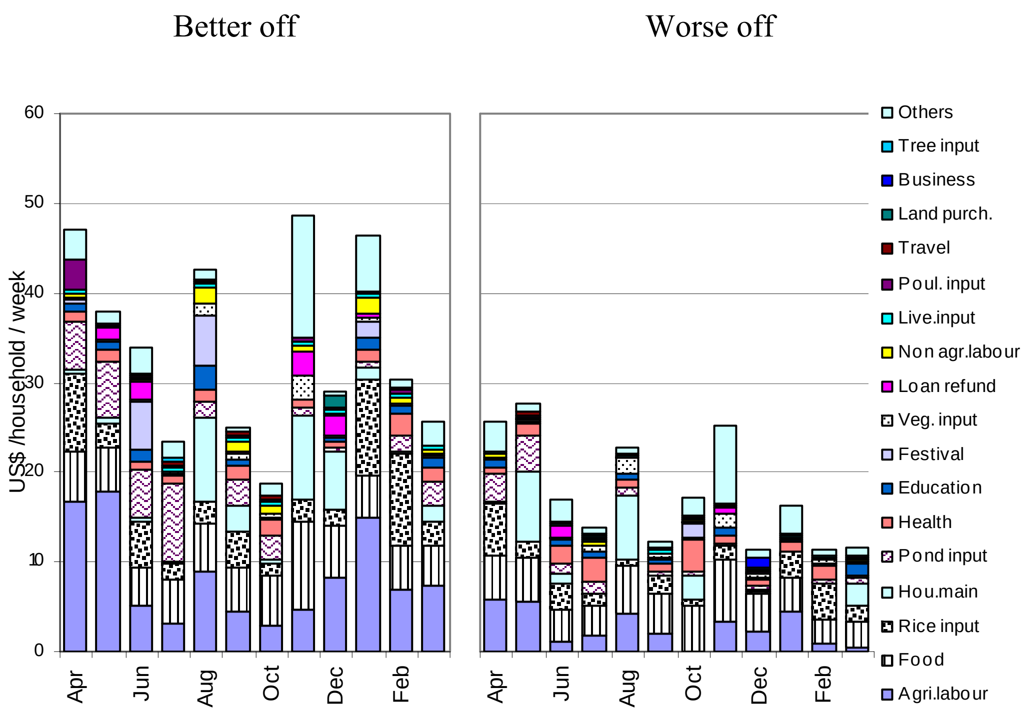

Figure 5.19 Expenses (US$/hh/week) by well-being

(Hou.main- house maintantance, veg.input- Vegetable input, Non agr. labour-Non-agricultural labour, Live.input- Livestock input, Poul.input- Poultry input, land purch.- Land purchase)

5.4.3.2 Expenses for food purchases

Food purchase expenses over the year showed variation by months, which was also different (P<0.05) in different locations (peri-urban>rural), better off households expenses were greater (P<0.05) than worse of households (Table 5.6) Expenses (per capita/week) for buying food was affected by well-being (P<0.05) and by location X months (P<0.05) (Figure 5.20).

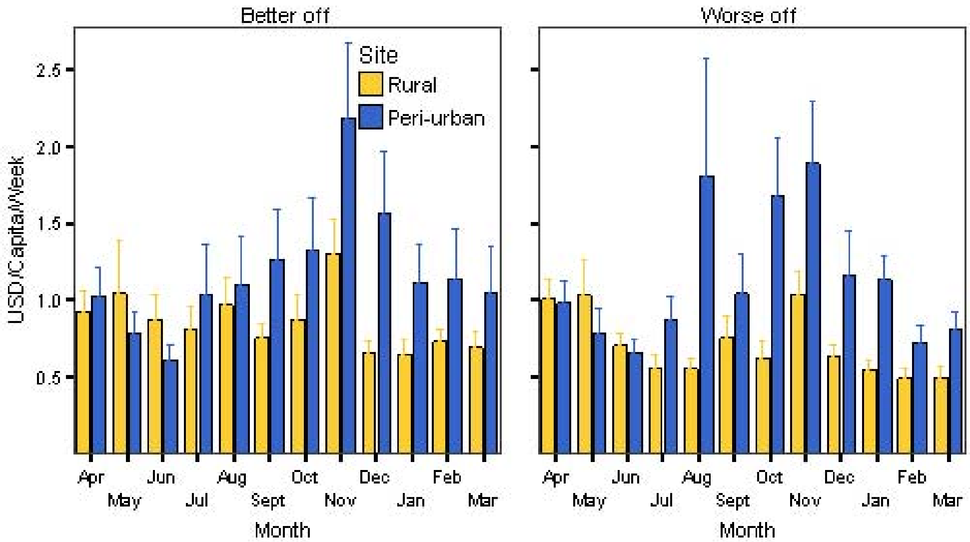

Figure 5.20 Food purchase expenses (US$/capita/week) by location and well-being

5.4.3.3 Expenses for agricultural labour

In a year better off households' paid (per households and per capita) more (P<0.05) wage for agricultural labour than worse off households (Table 5.6). Labour wage also significantly varied between different socio-economic levels (P<0.05) and months (P<0.05) (Figure 5.21).

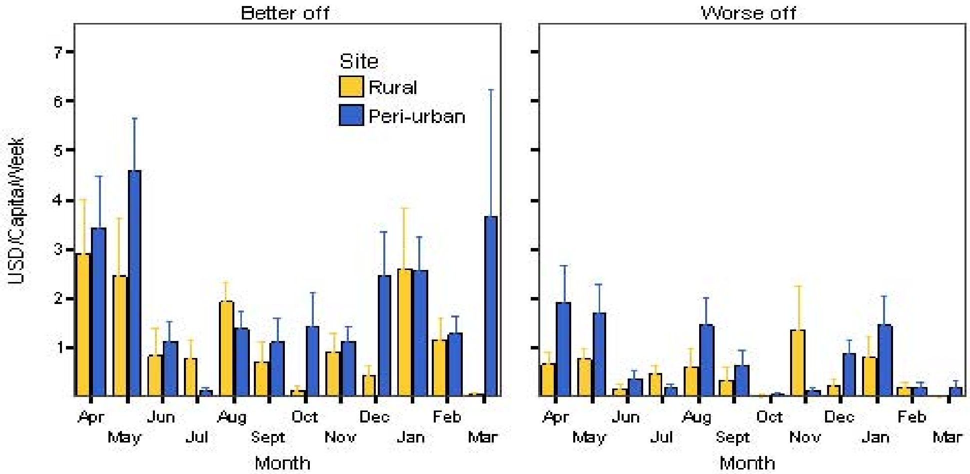

Figure 5.21 Agricultural labour wage (US$/capita/week) by location and well-being

5.4.3.4 Rice input expenses

Expenses (per household and per capita) for rice input (fertilizers, pesticide, irrigation etc) in a year were found to vary with well-being level (Table 5.6). Rice input expenses also varied ($P<0.05$) by location X months and well-being X months (Figure 5.22). The trend of input cost for rice inputs was higher in the months from January, February and April and June irrespective of location or well-being. However, the expenses of peri-urban households peaked in the month of April, while in January and February expenses for rice production were higher in rural areas.

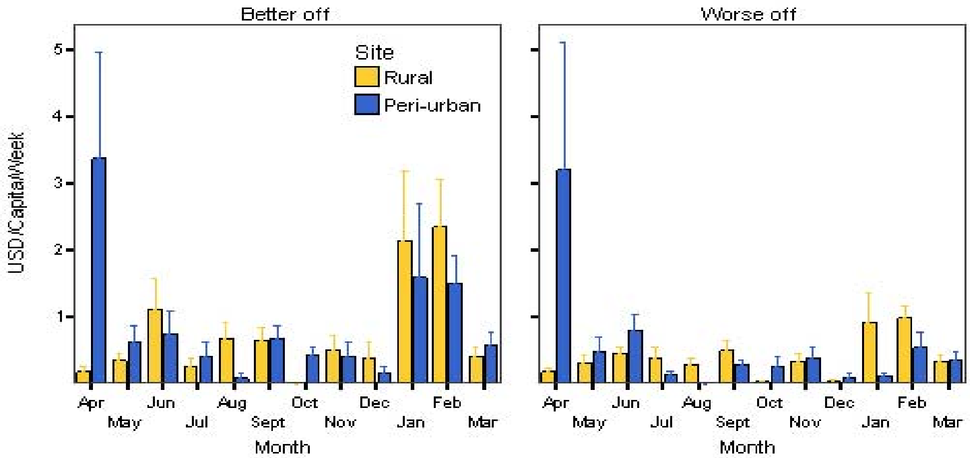

Figure 5.22 Rice input expense (US$/capita/week)

5.4.3.5 Pond input expense

Better off households' (per households and per capita) spent more (P<0.05) for pond inputs than worse off (Table 5.6). In the months of April to July pond input cost tended to be higher and declined from November to January (Figure 5.23). Expenses (US$/capita/week) for pond input was found to be different between level of well-being (P<0.05) and months (P<0.05).

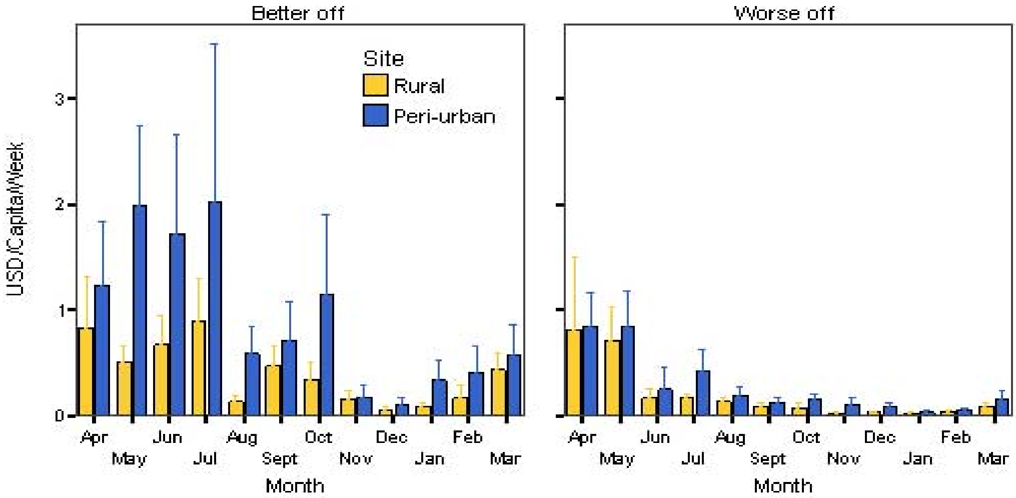

Figure 5.23 Pond input expense (US$/capita/week) by location and well-being

5.4.3.6 Vegetable input expense

There was no significant difference for vegetable input cost by location, well-being category or month (Figure 5.24).

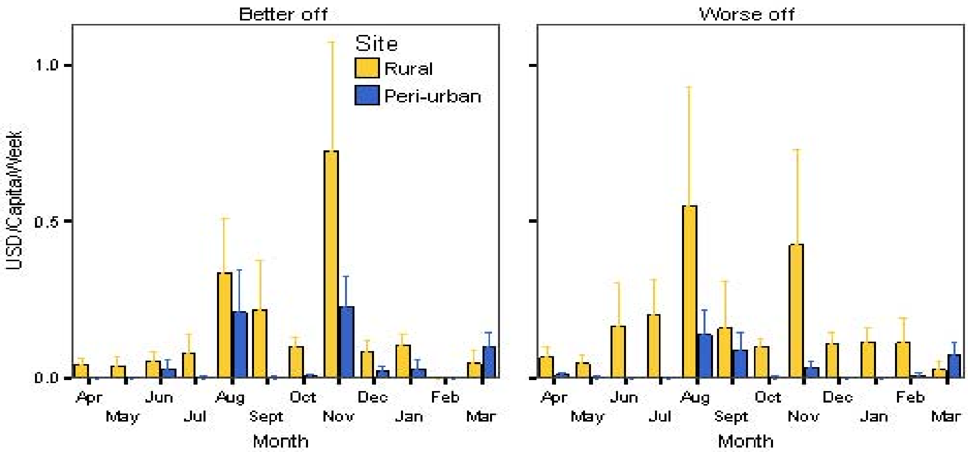

Figure 5.24 Vegetable input expense (US$/capita/week) by location and well-being

5.4.3.7 Expenses for health

Medical expenses for health was higher for worse off households than better off households. July, October and February were the most vulnerable months for the households irrespective of well-being categories (Figure 5.25). Worse off households' expenses for health was per capita and households were 64% and 28% higher respectively than better off households (Table 5.6; Table 5.7). On the other hand, rural households spent 42 % (per capita) and 77% (per household) higher than peri-urban households.

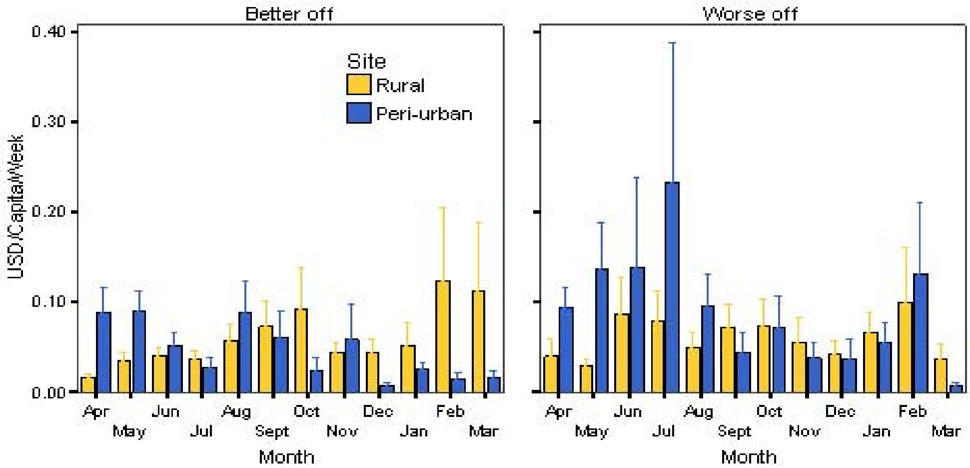

Figure 5.25 Health expenses by location and well-being

Table 5.6 Average expense (US$/hh/week) by location and well-being

Criteria	Better off		Worse off		Rural		Peri-urban		Mean	
	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%
Food purchase	5.44 (3.18)	17.64	4.31 (1.58)	24.11	4.64 (1.85)	19.66	5.00 (2.98)	21.55	4.82 (2.49)	20.30
Agri. labour	6.75 (6.45)	21.92	2.67 (2.71)	14.94	3.84 (4.82)	16.24	5.18 (5.46)	22.35	4.53 (5.17)	19.06
Rice input	4.12 (3.71)	13.36	2.16 (2.22)	12.06	3.34 (3.25)	14.16	2.77 (3.02)	11.95	3.05 (3.12)	12.83
House main.	2.38 (6.49)	7.73	1.79 (5.59)	10.00	0.88 (3.43)	3.74	3.16 (7.53)	13.65	2.06 (5.97)	8.66
Pond input	2.62 (5.12)	8.51	1.10 (1.03)	6.16	1.16 (1.31)	4.93	2.39 (4.79)	10.30	1.79 (3.58)	7.55
Health	1.00 (0.70)	3.25	1.28 (1.62)	7.16	1.49 (1.62)	6.32	0.84 (0.76)	3.61	1.15 (1.28)	4.86
Education	0.75 (1.24)	2.44	0.56 (1.48)	3.13	0.76 (1.60)	3.21	0.54 (012)	2.35	0.65 (1.37)	2.73
Festival	1.33 (4.09)	4.32	0.14 (0.77)	0.81	0.24 (0.87)	1.02	1.10 (.86)	4.75	0.68 (2.85)	2.88
Vegetable input	0.52 (0.72)	1.69	0.56 (1.37)	3.14	0.95 (1.49)	4.03	0.16 (022)	0.68	0.54 (1.12)	2.29
Loan refund	0.94 (2.77)	3.04	0.15 (0.73)	0.86	0.92 (2.68)	3.91	0.12 (071)	0.53	0.51 (1.96)	2.15
Non agri. labour	0.49 (1.73)	1.58	0.13 (0.29)	0.72	0.50 (1.67)	2.11	0.10 (026)	0.42	0.29 (1.19)	1.23
Livestock input	0.35 (0.50)	1.15	0.20 (0.31)	1.12	0.45 (0.50)	1.89	0.11 (020)	0.46	0.27 (0.41)	1.14
Poultry input	0.18 (0.18)	0.58	0.15 (0.11)	0.81	0.24 (0.15)	1.00	0.09 (.10)	0.39	0.16 (0.15)	0.68
Travel	0.16 (0.32)	0.52	0.08 (0.23)	0.47	0.14 (0.28)	0.60	0.10 (.26)	0.43	0.12 (0.27)	0.50
Land purchase	0.13 (0.71)	0.42	0.06 (0.23)	0.31	0.18 (0.72)	0.78	0.00	0.00	0.09 (0.51)	0.38
Business	0.00 (0.03)	0.02	0.10 (0.58)	0.54	0.11 (0.61)	0.48	0.00	0.00	0.05 (0.43)	0.23
Tree input	0.85 (2.40)	2.76	0.36 (0.88)	2.02	1.14 (2.37)	4.83	0.06 (.34)	0.25	0.58 (1.75)	2.46
Others	2.79 (2.04)	9.05	2.07 (1.08)	11.59	2.62 (1.41)	11.10	2.19 (078)	9.43	2.40 (1.61)	10.09
Mean	30.03 (18.00)		17.55 (8.69)		22.56 (13.06)		23.84 (16.76)		23.22 (14.98)	

(Figures in the parentheses are standard deviation). (% refers share of expenses to the total expense).(Agri.labour- Agricultural labour, Food exp.- Food expenses, House main.- house maintenance, veg.input- vegetable inputs, Non.agri.lab- Non agricultural labour) (*Cloths, gift, entertainment, utensils, repairing machineries etc)

Table 5.7 Important expenses (US$/capita/week) by well-being and locations

Criteria		Food	Agricultural labour	Rice input	Pond input	Health	Vegetable input	Mean*
Rural	Mean	0.76	0.63	0.53	0.21	0.27	0.16	3.69
	SD	0.35	0.70	0.50	0.28	0.41	0.27	2.29
Peri-urban	Mean	1.16	1.18	0.65	0.53	0.19	0.04	5.44
	SD	0.81	1.20	0.81	1.01	0.17	0.07	4.15
Better off	Mean	1.02	1.27	0.74	0.53	0.17	0.09	5.57
	SD	0.81	1.22	0.69	1.08	0.13	0.16	3.98
Worse off	Mean	0.92	0.61	0.47	0.24	0.28	0.10	3.78
	SD	0.51	0.70	0.64	0.27	0.40	0.23	2.78
Mean	Mean	0.96	0.91	0.59	0.37	0.23	0.10	4.59
	SD	0.66	1.02	0.67	0.76	0.31	0.20	3.47

(* Mean expense is the sum of all expenses, not only the sum of important expenses)

5.4.4 Incomes, consumption and expenditure

It was observed that consumption level of certain food items were positively correlated with the increased income (Table 5.8). There was no correlation observed between income and rice, fermented and dry fish consumption. Positive correlation was also observed between overall income and expenditure. Among all of the households expenses; food expense, agriculture wages and pond input cost were likely to increase with per capita income (Table 5.9).

Table 5.8 Correlation between income (US$/capita/week) and consumption (g/capita/week)

	Leafy vegetable	Non leafy vegetable	Fish	Milk	Egg	Pulse
r	0.137(**)	0.111(**)	0.117(**)	0.242(**)	0.152(**)	0.078(*)

**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 5.9 Correlation between income (US$/capita/week) and expenditure (US$/capita/week)

	Total expense (US$/Capita/week)	Food purchase	Agricultural labour wage	Pond input expenses
r	0.352(**)	0.287(**)	0.466(**)	0.264(**)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.4.5 Access to credit

There was a significant interaction ($P<0.05$) between well-being level and months to the level of access to credit. Households irrespective of well-being and locations tended to borrow more money in March, June and September compared to other months (Figure 5.26).

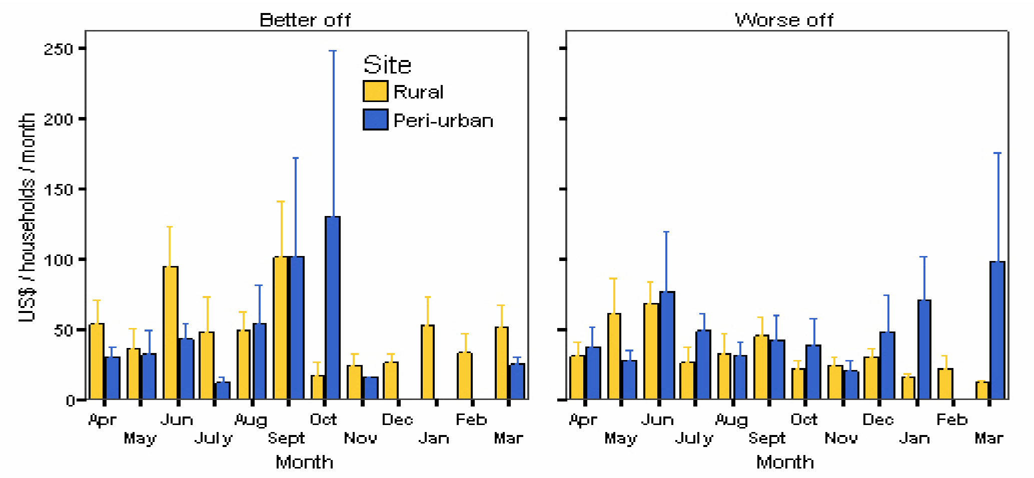

Figure 5.26 Money borrowed (sum of credit and interest free credit) by location and well-being

On average, better off households' accessed more 'credit' and 'interest free credit, compared to worse off, though a higher number of worse off households accessed to 'credit' and 'interest free credit, than better off. On the other hand, rural and peri-urban borrowed similar amount of money, and a greater proportion of rural households borrowed money than peri-urban. Pay back duration and instalment did not vary between locations and well-being levels; however, instalment frequency was double for 'credit' than 'interest free credit'(Table 5.10). It was revealed that households borrowed money mainly from neighbours, Bank and relatives. They paid higher interest rates to their relatives and money lender, while NGOs took lowest interest rate compared to others (Table 5.11).

Table 5.10 Amount of money (US$/household/month) borrowed, repay instalment and duration

Criteria	Stat.	Credit			Interest free credit		
		Amount (US$/hh)	Instalment	Duration	Amount (US$/hh)	Instalment	Duration
Rural	**Mean**	**72.32**	**2.17**	**229.80**	**29.71**	**1.10**	**50.90**
	SD	84.96	2.16	229.05	36.30	0.43	37.37
	n	77	77	77	187	187	187
Peri-urban	**Mean**	**68.55**	**2.19**	**196.37**	**29.66**	**1.07**	**65.70**
	SD	77.67	2.21	124.88	56.53	0.26	50.04
	n	52	52	52	81	81	81
Better off	**Mean**	**84.07**	**2.17**	**240.13**	**39.85**	**1.09**	**53.29**
	SD	100.03	2.30	287.10	58.76	0.32	42.64
	n	41	41	41	117	117	117
Worse off	**Mean**	**64.62**	**2.18**	**205.17**	**21.82**	**1.09**	**57.14**
	SD	71.58	2.13	130.52	22.92	0.43	41.99
	n	88	88	88	151	151	151
Mean	**Mean**	**70.80**	**2.18**	**216.27**	**29.69**	**1.09**	**55.54**
	SD	81.81	2.17	193.82	43.31	0.39	42.22
	n	129	129	129	268	268	268

('n' refers number of households had access to 'credit' and 'interest free credit' in a year)

Table 5.11 Source and interest rate (%/year) of credit

Source	n	Mean	Std. Deviation
Relative	18	67.87	107.66
Money lender	11	58.55	83.15
Neighbour	54	50.16	47.75
Village co-operative	5	26.40	11.61
Bank	33	22.77	35.01
NGO	6	22.68	18.55
Mean		44.05	60.57

5.4.6 Health

Numbers of household members were sick in a year was similar between better off and worse off households, but the number was higher in rural households than in the peri-urban location and mean sick days of the rural households was higher than peri-urban (Table 5.12). Household members suffered from various illnesses in each month. There was no difference in the number of sick days per household (Figure 5.27).

Table 5.12 Mean sick days and number of households suffered from disease

Criteria	Stat.	Mean no. of cumulative sick days (days/household/year)	Household members
Rural (n=36)	**Mean**	**92.38**	**12.47**
	Std. Deviation	76.23	4.81
Peri-urban (n=36)	**Mean**	**61.36**	**8.30**
	Std. Deviation	37.26	3.059
Better off(n=36)	**Mean**	**76.91**	**10.58**
	Std. Deviation	68.813	4.45
Worse off(n=36)	**Mean**	**76.83**	**10.19**
	Std. Deviation	54.40	4.64
Mean (n=72)	**Mean**	**76.8**	**10.38**
	Std. Deviation	61.59	4.52

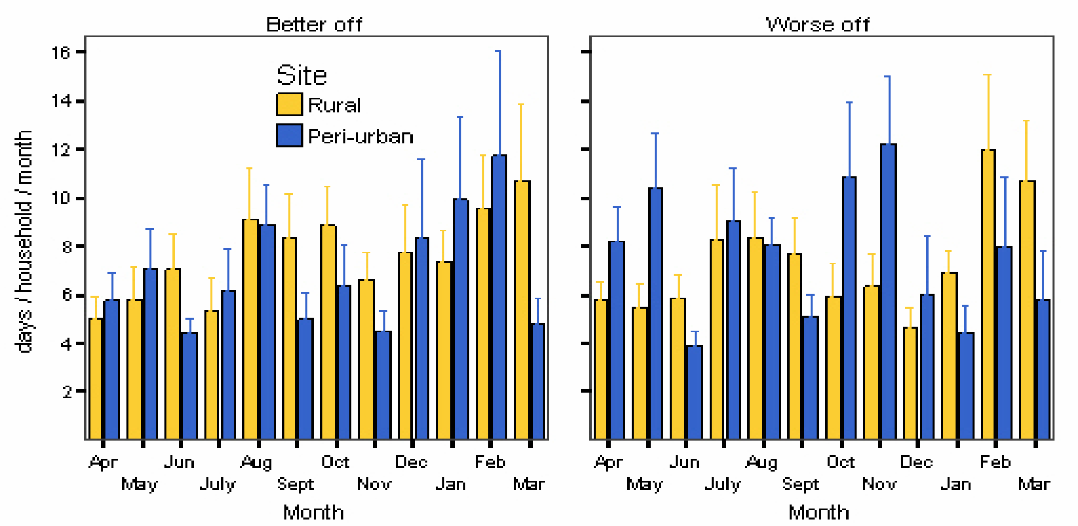

Figure 5.27 Mean sick days per household by location and well-being

5.5 Discussion

Promotion of pond-dike systems holds potential through increasing availability of fish and vegetables for improving micro-nutrient status and also improving household income (Roger and Bhuiyan, 1995). Considerable nutritional benefits are reported to result through Integrated Agriculture-Aquaculture (IAA) systems either from direct consumption or from expanded income that supports purchase of other cheaper foods, which benefit household food consumption (Ruddle and Prein, 1998; Ahmed and Lorica, 1999; Thilsted and Ross, 1999; Thompson et al. 1999; Prein and Ahmed, 2000; Sultana, 2000).

Limited information is available about the dynamics of food consumption and their links with seasonal changes, income and expenditure in Bangladesh, though these are often associated (Camara, 2004). It has been argued that consumption is generally considered to provide a better indicator of poverty than income (Rakodi, 2002).

This study was carried out through a recall 'panel' survey, which in general has several advantages (Alderman et al. 2001; Murray, 2004). Recall methods place minimal burden on the subject, compared with weighing the food items, which is especially important when non-biased survey is carried out for a long period of time (Bingham et al. 1988). Weighing and recording all food consumed constitutes too greater an effort and inconvenience (Dwyer et al. 1987; Macdiarmid and Blundell, 1997). However, there are also disadvantages of recall methods; relating to the preciseness of memory and difficulties in food description (Bingham et al. 1988). However, it was observed in this study that farmers were used to buy food from the market as they spent a large share of their overall household expenditure on purchasing food; this suggests an ability to estimate weights and volumes of food that we assumed they could apply to non-purchased food items.

As the same interviewer carried out the survey in the respective village each time, a favourable relationship with the interviewee could be developed. Interviews were arranged for a convenient time of a scheduled day improving cooperation with interviewees and reducing survey cost (Bingham et al. 1988). Another advantage of the study method was that the survey was carried out in the respondent's house; the familiarity of environment may improve a stimulate and is convenient and encouraging for respondents (Sabry and Asselbergs, 1988).

Better off and worse off households consumed similar amounts of most foods, except meat, milk and pulse, of which more were consumed by better of households. Income flows from service, rice and fish sales were higher in better off than worse off households. This reflected the higher investment in both rice and pond input and also the wages of agricultural labour compared to worse off. There was no disparity between locations in terms of yearly total and monthly consumption of all food items and income (per capita and per household), although there was significant interaction between money spent on purchasing food (capita/week) and location. Peri-urban households spent more money on food than in rural perhaps reflecting a greater dependency of peri-urban households on the market. However, there were several disparities when comparison was made on a month wise basis.

Better off and worse off households overall fish consumption was similar, although the better off consumed more from their own production than other sources. Probably worse off households sold higher value farmed fish to the market and bought cheaper wild fish for their own consumption (Thompson et al. 2006). In this study the average amount of fish consumed (83.09 g/capita/day) was almost double the national consumption figure (38.29 g/capita/day) regardless of well-being level (BBS, 2004; Bestari et al. 2005). It is noteworthy that this study was carried out only with the active integrated households, and that they are perhaps likely to produce and consume more fish than general pond owners (Chapter 4). A recent study carried out in Kapasia sub-district of Bangladesh, however, reported very similar results (88 g/capita/day; mean of fish consumption of all socio-economic level of households) (Thompson et al. 2005). The similar amount of fish purchased from the market by both groups seems surprising; however, poorer households probably bought cheaper low quality fish from the market.

Most of the studies conducted so far on fish consumption in Asia are based on national-level data collected by national organizations and compiled by FAO (Dey et al. 2005b). These lack detailed analyses of fish consumption by type of consumer (Gregory and Guttman, 2002; Dey et al. 2005b). Dey *et al.* (2005) found 61.67 g/capita/day fish consumption from their study. The per capita fish consumption was much higher than national level data as estimates of national statistics are in general based on the total availability of fish in the country, often do not include consumption of the many small and non–commercial fish species obtained from artisanal and subsistence fisheries (Gregory and Guttman, 2002; Dey et al. 2005b).

Consumption of fish was found to decline in February and March (dry season) and this possibly related to a lower availability of fish in ponds, wild stocks and/or due to lack of income to purchase fish. Households at all locations consumed less fish from their own ponds in June and July as at this time wild stocks are abundant. This demonstrated how households change their fish consumption strategy depending on the situation. Income flows are also lower in these two months (Ahmed et al. 2005). Consumption of on-farm fish was higher in April-May, around the time of *boro* rice harvest perhaps also resulted reduced trend in fish consumption (Roos, 2001). In these periods dependency on natural sources was increased (Roos, 2001; DANIDA, 2004; Thompson et al. 2005) and households' purchased cheaper food such as fermented fish rather than purchasing expensive meat and non-leafy vegetables to reduce their household expenses. In the month of November, meat consumption amount was highest, which was directly linked Muslim festival Eid, when people consume more meat in general.

Similarly, in the months of September to November (winter and pre-harvest period of *amon*) consumption of non-leafy vegetables and pulses were relatively low perhaps due to less income of during this period; the lower levels of consumption of key foods during this period point to this being a critical hungry gap (Abdullah and Wheeler, 1985; Ahmed et al. 2005). Consumption of leafy and non leafy vegetables, fish, milk, eggs and pulses were positively correlated with income which was also observed in another study carried out in Bamako, Mali (Camara, 2004) and also for fish consumption was linked with income in Bangladesh (Dey et al. 2005b).

Another study observed at this time was that households substituted expensive foods items with low price food such as dried fish. Consumption of dried fish was higher from December to February (dry season and winter) during the period when fresh fish were expensive and there was reduced availability of natural fish (DANIDA, 2004). Higher consumption levels of non-leafy vegetable was observed during this period, however as availability of winter vegetables increased and prices declined.

The study indicated that households earned more from selling rice and vegetables between April to May and also from business which ultimately increased the overall income. This supported the observations of Tetens et al. (2003), and Weinberger and Genova (2005).

On-farm supplies of fish supported households' consumption, especially during the lowest income months (September to November), and were especially important to the worse off households during these months. This study showed that the household's own fish made up a large share of fish consumed irrespective of well-being and location. This contrasts with a study (carried out in Kapasia, Bangladesh) that households with fish ponds still bought more than half of the fish they consumed from the market (Thompson et al. 2005). This disparity is probably explained by the relatively high production levels were higher and dependency on fish from pond production of the monitored active integrated household compared to the Kapasia study.

Households also depended heavily on their own leafy vegetables for meeting needs during periods of reduced availability (January to March). Non-leafy vegetable consumption tended to decline in the months of April and June (transition period of winter and summer vegetable season) due to reduced availability in the market (Weinberger and Genova, 2005), but during these critical periods the contribution of on-farm production was particularly important.

Rice consumption did not vary significantly by well-being category, though the consumption pattern was not distributed evenly for worse off households, the pattern suggests that all consumers of both well-being level gave high priority to satisfying their needs for the staple food (Torlesse et al. 2004). However, attempts to explore rice consumption pattern has been taken in Bangladesh showed that rice consumption increases with increase income (Ahmed, 2000). Rice consumption trends by better off households was distributed evenly throughout the years, but it is likely that poorer households consumed unevenly. However, rice consumption increased in October than September and continued up to November due to increased availability (*amon* rice harvest). Increased availability of non-leafy vegetables in January, February and March (winter) influenced households' consumption of non-leafy vegetables. Weinberger and Genova (2005) found that this was the period of maximum availability and lowest price especially in the per-urban locations.

The mean income and expenses of the households' monitored in this study were 32.37 and 23.22 (US$/household/week) respectively, which is very close to the mean national income 24.34 and expenses of 20.33 (US$/household/week) (BBS, 2004). Expenses for agricultural labour were higher in the months from April to

May due to increased labour engagement for *boro* harvesting and *aus* transplantation (Chaudhury, 1980). During the *boro* harvest (March to May) labour rates are high as a consequence of high demand linked to the farmers' desire to harvest and store rice as quickly as possible to avoid probable damage from heavy rainfall. Labour wage also increased in August due to high demand for *aus* rice harvest. The increase in expenses in January are related to *amon* harvest and post harvest activities, but overall expenses were lower than *boro* as the possibility of rice damage/loss is lower as the rains have finished by this time. This in turn depresses labour wages at this time, disproportionately impacting on poorer households. It was clear that poorer households spent a larger share (30%) of their income on purchasing food compared to better off (20%), which is a common scenario of most of the Asian countries (Dey et al. 2005b). This suggests that poorer households were more vulnerable than richer in terms of dependency on food purchases.

The period of lower income and higher expenditures occurred at the same time, probably forced to borrow money. Household's borrowed relatively high amounts of money in March (pre-harvesting period of *boro* rice), June (low income month) and September (pre-harvesting period of *amon* rice) compared to other months of the year. During these periods households' lower incomes probably forced them to survive by borrowing money from others. Expenditure was also relatively high in the months of March to June related to a need to invest in fish and rice inputs and higher labour expenses at the same time. In this period households spend more on fish culture (stocking, feeding and fertilizing ponds). However, this reflected households' higher dependency on 'credit' and 'interest free credit' for carrying out agricultural activities. More than double the number of rural households required ‘credit’ and ‘interest free credit’ than peri-urban households though the income and expenditure level of the households of these two locations were very similar. The reason/reasons behind borrowing more money by the rural households is/are unclear. It might be the savings of rural households are higher than peri-urban, which was not explored in this study.

Higher numbers of worse off households tended to borrow money than better off reflected their higher need and vulnerability than better off households. The interest rates when levied were uniformly very high irrespective of sources, which was probably one of the major constraints for the development of integrated farming systems and livelihood of households of all socio-economic level in rural and peri-urban locations. However, overall the households borrowed more than double amount of ‘credit’ than ‘interest free credit’, while more than double number of households accessed ‘interest free credit’ than ‘credit’. This probably explains the higher need but lower access to ‘credit’.

Another issue, health; which has appeared as a chronic problem of the households irrespective of well-being and locations throughout the year (HKI, 2002a; HKI, 2002b). Health expense share (7%) to total expenses of poorer households was higher than better off households (3%), which were 5th and 7th important expense for them respectively. The share of medical expenses to the total expense of the rural households was 4th (6%), while it was 7th (4%) in the peri-urban location. However, rural household suffered more than peri-urban in terms of average number of sick days in a year and the number of members of the households suffering from illness. This could be linked to the low per capita intake of rice, leafy and non-leafy vegetables intake as observed in this study (HKI, 2002a).

Finally, it could be concluded that pond-dike systems supported the households through smoothing income and food consumption flows throughout the year. Service has also revealed as another important source of income smoothing flows throughout the year. The contribution of both fish and vegetable (around 40% of the total food amount) to the diet overall diet was substantial irrespective of location and well-being level. Furthermore, active pond-dike integration contributed significantly to household income. Similar contribution of fish (20%) and vegetable (5%) to the income of both better off and worse off households suggest equal importance of pond-dike system to the different socio-economic level of households. A higher proportion of total income obtained from fish sale by peri-urban households (27%) compared to rural households (11%) reflected greater opportunity for commercialization through better marketing access (Chapter 4).

The empirical analysis showed that as active households' income per capita increased, per capita expenditure on food purchases, agricultural labour and pond inputs also increased. On the other hand, consumption of various food items was linked to both income and availability. On-farm products made major contributions to fish and vegetable consumption during the lower income and least productive months. However, the study suggests that policies that aim to increase household income through intensifying off-farm activities would potentially be an effective mechanism to invest more on farming and eventually improve food security of the households, especially for the worse off households.

Chapter 6: Engaging in participatory technology development with farmers to enhance benefits in pond-dike production

6.1 Introduction

It is widely accepted that agricultural technology systems can be divided into sub-systems comprised of actors carrying out specific functions. According to this schema, basic research develops new knowledge, strategic research solves problems, applied research develops new technologies based on the knowledge generated from basic and strategic research and adaptive research effect changes in the technologies to adapt them to specific regions and producers groups (Kaimowitz et al. 1990).

Agricultural research is increasingly being carried out in farmers' field, with farmers having a greater role in planning and executing it. In the late 1980s and early 1990s it has been recognized that farmers should and could play a much greater role in agricultural research (Chambers, 1994). Since 1980 Farming System Research and Extension (FSRE) has been carried out largely by research institutions within an interdisciplinary holistic framework and while Farmers Participatory Research (FPR) is implemented through a wide range of institutions. Nevertheless, FSRE and FPR share common frameworks and activities (Okali et al. 1994). However, FPR refers to the participation of farmers in a process of agricultural research (Martin and Sherington, 1997).

The term 'participatory' is usually reserved for work in which farmers are full partners. In contrast, their role might be purely logistical, such as when they carry out field operations. This is why on-farm research is sometimes described by a two-component classification scheme, e.g. 'researcher initiated, farmer managed, 'farmer initiated, farmer managed' etc. This allows more precise description than that the single term 'participatory (Thompson et al. Undated).

Participatory approaches are increasingly being recognised as more effective at achieving adoption and impact in poor farmers' fields than the technology generation and transfer approaches traditionally used by much agricultural research (Palma and Zein, 2004; Leeuwis and van den Ban, 2004). In the past, the prevailing ''technology transfer'' approaches such as the Training and Visit (T&V) system have focused on a routine, sequential transfer process through standardized recommendations. For highly diverse and location-specific agricultural systems, this is neither an efficient nor an effective approach (Fazal et al. 1996). Transfer of technology was followed by an emphasis on the modification of the research agenda by feedback (farming systems research and extension), and later by models referred to as 'farmer-back-to–farmer' (Rhoades and Booth, 1982) and 'farmer first to last' (Chambers and Ghildyal, 1985). All of these identified the continuing need to put farmers at the centre of the research process.

Participatory approaches to the development of new technologies for smallholder farmers have been widely advocated (Cramb, 2000). Participatory Technology Development (PTD) is a process by which outside facilitators and community people interact so that the target groups have greater capacity to adapt new technology to their conditions and the facilitators have a better understanding of traits and characteristics of local farming systems (Douthwaite et al. 2002). In fact, the term FPR is often used synonymously with the terms PTD (Haverkort, 1991; ETC, 1992), Agricultural Technology Development (Farrington and Bebbington,1993) and

Appropriate Technology (van der Bliek and van Veldhuizen, 1993). At the same time, these various titles are closely related to other on-farm, user focused research approaches including Farming Systems Research and Extension (Martin and Sherington, 1997).

In Bangladesh, research and development initiatives have been taken to enhance growth and development of fisheries sector by Department of Fisheries (DoF), Bangladesh Fisheries Research Institute (BFRI), Bangladesh Fisheries Development Corporation (BFDC), Non Government Organizations (NGOs), private sector and donors mainly from European countries (United Kingdom, Denmark, Germany, Netherlands and Sweden) (Lewis, 1997; Lewis, 1998; Amin, 1998; Ahmed and Chowdhury, 1999; Edwards, 1999a; Bhuiyan, 1999; Mazid, 1999; Mazid, 2002). Bangladesh has made considerable improvement in fish culture technology, particularly in pond-based systems (ICLARM , 1998), though due to variety of reasons production of fish could not keep pace with the growth rate of population of the country (Lewis, 1998; Ahmed and Chowdhury, 1999).

Polyculture of Indian and Chinese carps along with other exotic species is the most dominant aquaculture practice in Bangladesh. Around 73% of the rural households are involved in this type of culture systems (Mazid, 1999). Intensive culture system or high input systems started with prawn and shrimp culture in ponds, which later on turned to Thai pangas (*Pangasius hypopthalmus*), and recently interest has been increasing for intensive tilapia culture in ponds in Bangladesh (Little et al. 2003; Little and Muir, 2003). Nile tilapia (*Oreochromis niloticus*) in extensive and semi-intensive culture systems is getting popular in Bangladesh (Hussain et al. 1989;

Gupta et al. 1992; Islam et al. 1992; Gupta et al. 1996; Kohinoor et al. 1996; Thompson et al. 2005).

In Bangladesh, both polyculture and tilapia monoculture are productive and cost effective; tilapia monoculture in ponds has a return of US$ 3.11 for each dollar investment in variable inputs (Dey et al. 2005a). But where tilapia–based culture has developed most sustainably in Asia such as in southern Vietnam and Thailand, monoculture is rare, rather it has developed as part of a polyculture with carps and other fish in both rural and peri-urban locations (Little, 2000). Pond fertilization increases production of natural fish food organisms, and supplementary feeding provides nutrients to further increase the growth of fish (Singh, 1984; Milstein, 1993). On the other hand, it increases the nutrient loading of pond water and sludge, which could be utilized to fertilize the pond-dike crops (Little and Muir, 1987). However, feed availability, both natural and supplementary, is likely to have major impact on the performance of both carps and tilapia (Little, 2000) and relatively more on Nile Tilapia (Hossain et al. 2003). Where nutrients are available, tilapia dominant polycultures tend to become most common (Hossain et al. 2003).

Outcomes from Participatory Community Appraisal (PCA), State of System (SOS) (Chapter 3) showed that lack of knowledge and inputs, low production, diseases of fish and vegetables were as major problems of farmer managed pond-dike systems. However, within a short span of time it was not possible to address all of the issues rather it was intended to organize pre-intervention workshops as a part of participatory technology development process with the priority for developing simple, and sustainable incremental improvements to current systems technology which would further benefit the farmers. Based on the priority, it was decided in collaboration with the farmers to assess the effect of change through modification of fish species combination by supplementary current polycultures with Nile Tilapia and input level to pond-dike systems and assess impacts on livelihoods through a participatory research.

The whole process of adoption and adaptation was monitored through sequential participatory monitoring workshops assuming that monitoring and evaluation would provide a concise and permanent flow of information. These workshops allowed the participating farmers on evaluating of theirs and others outcomes were most critical (Murray, 2004). When farmers' activity is monitored in this way, specialists can evaluate whether the farmers' situation is improving as expected and if not, they can find out the reasons. Thus, monitoring and evaluation in agricultural development enhance the possibility to adjust implementation procedures and modifies technical recommendations whenever needed (Murphy and Sprey, 1982; Merrill-Sands et al. 1991).

6.1.1 Objectives & hypotheses

The specific objectives and hypothesis of the intervention were as follows:

1. To investigate the effect of introducing tilapia into existing polycultures into pond with (1) conventional and (2) improved nutrition on economic benefit and impact on the broader pond-dike system.

Hypothesis: Overall fish yields are increased when both (1) tilapia (2) tilapia with enhanced nutrition is included in the polyculture.

2. To assess the effect of change of interventions on potential benefits to dike-based horticulture and associated livelihoods.

Hypothesis: Intensification of existing aquaculture impact positively on broder pond-dike related livelihood.

6.2 Methodology

The research was carried out with a total of 67 interested and active integrated households in the six villages between June 2004 to March 2005. The farmer selection procedure has been explained in the Chapter 2. Prior to setting up the trial it was planned to exchange views and understanding among researchers and farmers about participatory research, monitoring and evaluation through a series of workshops (Table 6.1; Appendix 12). In the economic analysis section gross margin refers value (gross return) of fish (both sale and consumption) minus total variable (all inputs) cost.

6.2.1 Farmers' workshops

There were four sequential workshops carried out in each of the six villages implementing the trial. There were different objectives of different workshops which are briefed in the Table 6.1.

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Table 6.1: Outline of pre-intervention workshops

Workshop	Timetable	Objectives
Workshop 1	April 16-25, 2004	To feedback the more detailed results and analysis of SOS and baseline
Workshop 2	April 27-02 May, 2004	To introduce participatory research process among the farmers
Workshop 3	May 05-11, 2004	To identify the critical issues that can be addressed by the project within the given timeframe
Workshop 4	May 15-25, 2004	- To review previous workshop outcomes - To share and justify the research design - To select farmers for research - To develop monitoring process

Farmers who joined in the household monitoring research along with other interested farmers of the community participated in the workshops. The outcomes of the workshops are summarized in the Table 6.2 and detailed process and outcomes are described in the Appendix 12.

At the end of the 4th workshop participants categorized themselves into three groups, group I as control, agreed not to alter their exiting practice, while group II planned to stock tilapia at a rate 10% of current stocking and group III aimed to stock an additional 10% tilapia and also increase application of feed and fertilizer. The level of tilapia inclusion in polyculture was discussed with farmers and set to encourage and reassure farmers, reduce risk of negative outcomes compared to their normal practice based on previous research (Hossain and Little, 1996). Farmers of the group III decided not to follow application of any fixed amount of fertilizer and feed regime rather they agreed to optimize feeding and fertilization regularly to maintain fertile ('green') pond water and in line with available resources. A total of 4 farmers were expected to be involve in each group of the trial in each village. Swim-up tilapia fry were imported from Nam sai farm, Thailand in May 2004 and sex reversed sex revered using standard procedures (Machintosh and Little, 1995) before distributing to the farmers.

At the end of these workshops, farmers agreed to monitor the effectiveness of modifying the pond components of their pond-dike systems. It was planed to organize a bi-monthly monitoring workshop to share the key outcomes i.e to follow Participatory Learning and Action process (PLA) (Pretty, 1994; Pretty et al. 1995; Dick, 1997; Dilworth, 1998; Dilworth, 2005). Impacts were monitored through a participatory learning and action process based on regular workshops were carried out over a period of around 10 months where farmers and researchers monitored the input and output pattern of fish and vegetable, their utility and impacts of this intervention on livelihoods (Appendix 13). Out of six study locations, species wise yield data were collected from one of the villages (Nosirpur) to assess the performance of tilapia and its effect on other fish species.

It was also discussed how the effect of this intervention would be monitored and measured. Participating farmers agreed to keep records on all inputs and outputs of pond and associated vegetable crops. They further agreed to record positive or negative impacts on their broader livelihoods and any other interesting findings. The principle of this process was that they were asked in the monitoring workshops 'why' and 'how' questions rather that just 'what' and 'how many' as PTD, as with all participatory approaches, is based on discussion (Van de Fliert, 1993). The summary of the monitoring workshops are given in Appendix 15.

Table 6.2: Brief presentation about the process and outcome of the workshops

Workshop	Process in brief	Outcomes
Workshop 1	After having the general discussions on SOS and baseline survey, researchable issues (explored from the SOS workshop) were shared with the participants. Afterwards, participants identified the most important issues needed to be addressed.	Proposed researchable issues: • Increased production of fish and vegetable • Comparison of vegetable productivity using pond-water and ground water • Access to quality seed • Distribution of vegetable and fish from the pond-dike systems in a multiple ownership context
Workshop 2	After brainstorming several issues (presented in the Appendix 12) benefits, risks and hope of participatory research were identified.	Benefits: • Within a specific period of time many types of research can be carried out • Many issues could be learned in a season, which is not possible if a single farmer do a research on a particular issue • Participants enthusiasm would be increased by working in a research team • New technology might be developed Risks : • It should not be expected that always better outcomes would result to everyone • Some of the over enthusiastic farmers might show unusual competition to prove his efficiency • Farmers may not continue the management practice whatever they decide at the beginning of the research Hope : • Risk might be minimized if a large number of farmers are involved in the research
Workshop 3	Brainstormed several issues (Appendix 12) with the participants and sharing the research ideas	The groups accepted by the participants were as follows- • Group I: Conventional carp polyculture; existing input (feed and fertilizers) (control) • Group II: Increased 10% tilapia and existing input (feed and fertilizers) • Group III: Increased 10% tilapia and increased inputs (feed and fertilizers)
Workshop 4	After reviewing previous workshops outcomes participants discussed among themselves and decided to follow any of the groups based on their resources.	A total of 12 participants from each of the villages i.e in total 72 participants willingly agreed to be involved in the participatory research process. The numbers and farmers types are given in the Table 6.3 They reached to the consensus about the trial monitoring process.

6.3 Results

6.3.1 Fish culture

6.3.1.1 Number of farmers/replication

More than 100 farmers stocked tilapia seed to their pond out of interest including the trial farmers. However, it was revealed that a total of 28 better off and 44 worse off households were interested to get involved in the trial (Table 6.3). The table shows that higher numbers of poorer farmers were interested to join in the trial both in the rural and peri-urban area than better off households.

Table 6.3: Number of group by location, village and well-being categories

		Rural				Peri-urban				
Group	Well-being	Dholia	Koirahati	Goalota	Rural total	Ainakhet	Damgao	Nosirpur	Peri- urban total	Grand toal
I	Better off	1	2		3	2	2	2	8	9
	Worse off	3	2	4	9	2		2	4	13
II	Better off	1	3	1	5				0	5
	Worse off	3	1	3	7	4	4	4	12	19
III	Better off	1	3	1	5	2		4	6	11
	Worse off	3	1	3	7	2	3		5	12
Better off total		**3**	**8**	**2**	**13**	**4**	**2**	**6**	**13**	**25**
Worse off total		**9**	**4**	**10**	**23**	**8**	**7**	**6**	**20**	**44**
Grand total		**12**	**12**	**12**	**36**	**12**	**9**	**12**	**33**	**69**

[(Group I: Conventional carp polyculture (control), Group II: Increased 10% tilapia and existing input (feed and fertilizers) use, Group III: Increased 10% tilapia and increased inputs (feed and fertilizers)]

6.3.1.2 Area of pond and inputs

There was no significant difference (P>0.05) in pond area and fish stocking density (number /ha) among the groups, locations and well-being categories (Table 6.4). All of the farmers applied rice bran, and 63% applied cowdung and 55% applied urea.

All of the group III farmers' used urea and mustard oil cake (MOC) (Table 6.5). Cooked rice was applied by 42% group III farmers followed by 25% group I and 13% group II farmers. A small percentage (5%) of farmers applied broken rice, grass (2%) and duck weed (1%). Compost was used by 20% farmers (20% group I, 17% group II and 20% group III).

Table 6.4 Stocking density (number/ha) by locations, wellbeing and groups

Criteria	Pond area (ha)	Stocking density (number/ha)
Rural	0.047(0.035)	52,297 (25,121)
Peri-urban	0.081(0.046)	25,789(11,157)
Better off	0.076(0.054)	37,571(24,555)
Worse off	0.056(0.036)	40,783(23,394)
Group I (n=22)	0.065 (0.054)	42,745 (19,720)
Group III (n=24)	0.064 (0.044)	35,476 (25,799)
Group III (n=23)	0.061 (0.035)	40,954 (25,250)
Mean (n=69)	0.063 (0.044)	39,620 (23,692)

(Figures in the parentheses are standard deviation)

Table 6.5: Number of households used different pond inputs

Criteria	Rice bran	Cowdung	Urea	MOC	Lime	TSP
Rural (n=36)	36(100)	36(100)	28(78)	26(72)	31(86)	14(39)
Peri-urban(n=33)	33(100)	27(82)	27(82)	25(76)	5(15)	17(52)
Better off Mean (n=25)	25(100)	22(88)	21(84)	20(80)	13(52)	15(60)
Worse off Mean (n=44)	44(100)	41(93)	34(77)	31(70)	23(52)	16(36)
Group I (n=22)	22(92)	19(79)	14(58)	12(50)	11(46)	6(25)
Group II (n=24)	24(100)	23(96)	18(75)	16(67)	12(50)	6(25)
Group III (n=23)	23(100)	21(91)	23(100)	23(100)	13(57)	1(83)9
Mean (n=69)	69(100)	63(91)	55(80)	51(74)	36(52)	31(45)

(Figures in the parentheses are percentage)(MOC- Mustard Oil Cake; TSP- Triple Super Phosphate)

There was significant interaction (P<0.05) observed between location and groups for poultry litter use (kg/ha). More (P<0.05) rice bran, urea, TSP and mustard oil cake were used by the group III households than the other two group households (Table 6.6). Better off households applied more (P<0.05) poultry litter than worse off. Peri-urban households applied more (P<0.05) poultry litter and wheat bran compared to rural (Table 6.6). Rural households applied (P<0.05) cowdung and lime at levels more than three and seven times higher than peri-urban situations respectively.

Table 6.6: Amount (mean±SD) of input (kg/ha/10 months) applied to the pond by location and groups

		CD	Lime	MOC	PL	RB	TSP	Urea	WB
Rural	GI	10,970.27 (6,914.93)	102.51 (104.27)	120.72 (208.32)	143.71 (484.58)	5,994.14 (2,325.86)	33.64 (53.20)	215.66 (235.78)	372.92 (1,291.84)
	GII	8,886.58 (5,971.96)	158.93 (131.73)	804.57 (1,500.20)	777.34 (1,316.27)	7,523.20 (6,098.57)	26.61 (64.85)	260.00 (226.66)	0.00
	GIII	10,159.22 (6,933.24)	231.87 (142.26)	3,971.62 (2,286.98)	649.72 (1,352.63)	10,418.51 (6,181.66)	250.89 (339.19)	727.70 (352.96)	54.65 (189.32)
Rural mean		10,005.35 (6,488.52)	164.44 (134.59)	1,632.30 (2,293.32)	523.59 (1,127.09)	7,978.62 (5,372.28)	103.72 (222.53)	401.12 (357.71)	142.52 (750.71)
Peri-urban	GI	2,899.77 (5,095.97)	17.50 (36.96)	949.17 (909.78)	0.00 (0.00)	5,417.82 (3,593.27)	33.87 (91.10)	344.85 (296.94)	88.00 (190.24)
	GII	4,222.96 (5,115.59)	7.92 (27.42)	1,184.30 (1,327.16)	508.06 (1,126.56)	6,043.79 (4,783.86)	59.40 (107.99)	349.16 (311.75)	240.21 (507.67)
	GIII	2,241.31 (2,525.29)	46.48 (120.43)	2,434.68 (726.25)	1,922.87 (3,037.03)	8,215.47 (4,085.43)	285.59 (106.44)	493.09 (173.66)	567.29 (990.01)
Peri-urban mean		3,161.44 (4,362.03)	23.67 (73.88)	1,529.84 (1,197.77)	825.70 (1,995.82)	6,578.00 (4,261.85)	127.06 (151.50)	395.83 (269.28)	303.11 (667.08)
Better off	GI	6,841.39 (7,627.28)	54.35 (89.88)	760.05 (946.59)	0.00	5,792.22 (2,961.33)	54.86 (94.76)	375.42 (294.20)	595.01 (1,468.12)
	GII	7,659.36 (6,292.89)	195.73 (183.29)	1,310.45 (2,083.17)	103.81 (232.12)	5,216.09 (5,451.39)	23.25 (51.98)	248.03 (176.38)	0.00
	GIII	4,115.33 (5,201.18)	181.92 (192.19)	2,836.65 (2,053.35)	201.07 (666.86)	7,756.41 (5,649.80)	268.99 (279.46)	588.14 (358.35)	79.99 (202.47)
Better off mean		5,805.52 (6,300.11)	138.76 (166.99)	1,783.83 (1,930.41)	109.23 (450.13)	6,541.24 (4,735.95)	142.76 (221.72)	443.54 (326.85)	249.40 (898.02)
Worse off	GI	7,620.65 (7,339.03)	70.46 (93.68)	315.38 (536.23)	132.66 (465.66)	5,690.61 (2,990.42)	19.13 (47.61)	204.44 (232.41)	0.00
	GII	6,264.09 (5,984.04)	53.87 (82.30)	911.27 (1,224.91)	784.51 (1,320.86)	7,195.97 (5,475.20)	48.21 (96.53)	319.46 (292.24)	151.71 (414.33)
	GIII	8,441.36 (7,226.31)	107.72 (122.08)	3,603.14 (1,674.14)	2,228.04 (2,917.61)	10,839.31 (4,684.15)	266.11 (234.47)	640.57 (250.07)	501.34 (966.48)
Worse off mean		7,258.69 (6,651.79)	73.46 (97.96)	1,469.36 (1,798.93)	985.61 (1,907.10)	7,744.84 (4,973.79)	99.04 (171.63)	373.05 (310.90)	202.24 (590.99)
Mean	GI	7,301.86 (7,286.55)	63.87 (90.32)	497.29 (745.47)	78.39 (358.28)	5,732.18 (2,907.48)	33.75 (70.99)	274.39 (266.91)	243.41 (954.33)
	GII	6,554.77 (5,936.86)	83.42 (120.86)	994.43 (1,398.71)	642.70 (1,206.03)	6,783.50 (5,413.30)	43.01 (88.71)	304.58 (270.42)	120.11 (371.90)
	GIII	6,372.39 (6,579.39)	143.21 (160.24)	3,236.56 (1,863.09)	1,258.62 (2,351.63)	9,364.88 (5,287.65)	267.49 (250.98)	615.50 (300.59)	299.82 (729.37)
Mean		6,732.18 (6,517.91)	97.12 (130.04)	1,583.30 (1,839.78)	668.08 (1,597.33)	7,308.76 (4,888.69)	114.88 (190.86)	398.59 (316.21)	219.33 (711.34

(Figures in the parentheses are standard deviation) (CD-Cowdung; PL-Poultry litter; RB-Rice bran; MOC- Mustard oil cake; TSP- Triple Super Phosphate; WB- Wheat bran)

6.3.1.3 Fish production

Fish production (kg/ha and kg/hh) was higher in the group III compared to group II and group I. There was no difference (P<0.05) between group I and II, well-being level and locations for fish production (kg/ha and kg/hh) (Table 6.7).

Table 6.7 Fish production (kg/ha and kg/hh) by location, well-being and groups

Criteria	kg/ha	kg/hh
Rural (n=36)	3,805.31(1,674.50)	145.98(75.66)
Peri-urban(n=33)	3,565.17(2,114.37)	285.68(230.60)
Better off Mean (n=25)	3,653.96(1,658.96)	243.95(168.00)
Worse off Mean (n=44)	3,711.19(2,023.61)	195.09(188.17)
Group I (n=22)	2,896.16(1,061.11)	174.31(160.14)
Group III (n=24)	2,891.56(1,475.47)	160.97(110.28)
Group III (n=23)	5,283.86(1,917.38)	303.68(226.90)
Mean (n=69)	3,690.46(1,887.22)	212.79(181.41)

(Figures in the parentheses are standard deviation)

It was observed from the species wise yield performance in the sample village (Nosirpur) that significantly higher yield of tilapia was obtained in group III (225.76 kg ha^{-1}) than that in group II (84.31 kg ha^{-1}), although the same number of fish were stocked under both groups. The combined yield in group III (5,312 kg ha^{-1}) was significantly higher than group II (1,848 kg ha^{-1}) and groups I (2,083 kg ha^{-1}) (P<0.05, Figure 6.1). The yield of different species obtained in group I and II were not significantly different (P>0.05). Silver barb was the only species that performed similarly (P>0.05) in all of the groups.

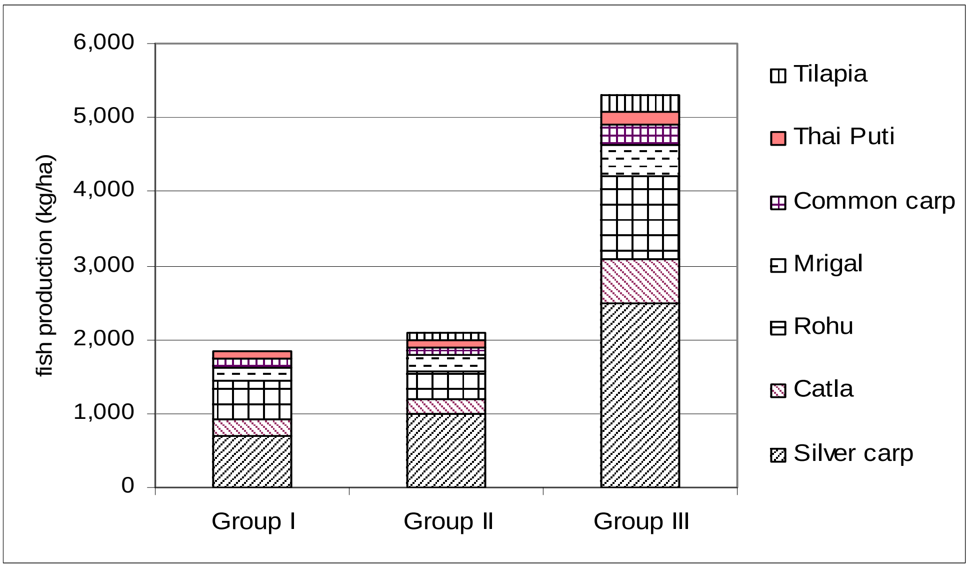

Figure 6.1 Species wise mean production (kg/ha) of different groups

6.3.1.4 Usage of fish

There was no significant difference (P>0.05) in fish consumption levels of households (kg/hh) among groups, but group III households sold (kg/hh) more fish than others (Group I=II, P>0.05). Rural households consumed significantly (P<0.05) more fish than peri-urban, while per-urban households sold (kg/hh) more than rural. There was no difference between better off and worse off households in terms of consumption (kg/hh) and sale (kg/hh). No disparity (P>0.05) was observed among the households for the amount of fish they gifted (kg/hh) among their neighbours or relatives (Table 6.8).

Table 6.8 Usage (kg/hh) of fish per households

	Consumption	Sale	Gift
Rural (n = 36)	60.08(25.29)	80.99(67.29)	4.88(4.15)
Peri-urban (n = 33)	25.17(18.54)	256.06(222.64)	3.94(7.64)
Better off (n = 25)	45.09(30.49)	194.33(169.60)	3.61(5.34)
Worse off (n = 44)	42.41(27.26)	147.89(189.72)	4.90(6.42)
G I (n = 22)	43.77(27.59)	125.30(163.37)	4.19(4.92)
G II (n = 24)	38.59(27.86)	119.17(102.80)	3.33(5.45)
G III (n = 23)	48.01(29.77)	249.95(235.28)	5.80(7.44)
Mean (n = 69)	43.38(28.28)	164.72(182.81)	4.43(6.04)

(Figures in the parentheses are standard deviation)

6.3.1.5 Correlation and regression analysis for fish production

All inputs were used for correlation analysis. Fish production (kg/ha) was positively correlated with the amount (kg/ha) of the inputs used, while pond area was negatively correlated with production (Table 6.9).

Table 6.9 Correlation matrix between fish production (kg/ha) and input use (kg/ha) and pond area

	Pond area	Fish seed	Rice bran	Wheat bran	MOC	Urea	Cowdung	Poultry litter	TSP
r	-0.248 (*)	0.296 (*)	0.646 (**)	0.313 (**)	0.602 (**)	0.507 (**)	0.354 (**)	0.554 (**)	0.525 (**)

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

All positively correlated independent variables were used for the stepwise regression analysis. The predicted R square value of 0.75, R square of 0.56 and adjusted R square of 0.54 indicate moderate explanatory power of the model as a whole (Table 6.10). Both multiple R and R square values have increased with the addition of independent variables from X1 to X3 and have moderate high level of explanatory power, as the adjusted R square demonstrates 54% variation in the fish production.

Table 6.10 Summary of the model (fish production)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.646(a)	0.417	0.408	1452.03
2	0.704(b)	0.496	0.480	1360.54
3	0.750(c)	0.563	0.543	1276.15

a Predictors: (Constant), Rice bran (kg/ha)
b Predictors: (Constant), Rice bran (kg/ha), Poultry litter (kg/ha)
c Predictors: (Constant), Rice bran (kg/ha), Poultry litter (kg/ha), Mustard oil cake (kg/ha)
d Dependent Variable: Fish production (kg/ha)

The F ration of explanatory variables in the final model is statistically significant at 0.001 confidence level. This indicates that the variables included in the model are correct (Table 6.11).

Table 6.11 ANOVA of the regression models (fish production)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.01E+08	1	1.01E+08	47.86849	2.12E-09
	Residual	1.41E+08	67	2108403		
	Total	2.42E+08	68			
2	Regression	1.2E+08	2	60008540	32.41793	1.56E-10
	Residual	1.22E+08	66	1851091		
	Total	2.42E+08	68			
3	Regression	1.36E+08	3	45444100	27.90436	1.03E-11
	Residual	1.06E+08	65	1628566		
	Total	2.42E+08	68			

a Predictors: (Constant), Rice bran (kg/ha)
b Predictors: (Constant), Rice bran (kg/ha), Poultry litter (kg/ha)
c Predictors: (Constant), Rice bran (kg/ha), Poultry litter (kg/ha), MOC (kg/ha)
d Dependent Variable: Fish production (kg/ha)

Results of the regression analysis revealed that fish production was significantly influenced by 3 independent variables: rice bran (X1), poultry litter (X2) and mustard oil cake (X3). Of these, rice bran application (kg/ha) appeared as the most influential variable explaining 74% of the variation explained. This combined with poultry litter explained 88% of the total variation, which is an indication of the importance of theses independent variables in influencing fish production (Table 6.10). However, it was revealed that the independent variables have a positive influence on the dependent variable, i.e there was a tendency to increase production with increasing application of rice bran, poultry litter and mustard oil cake (Table 6.12).

Table 6.12 Coefficients of independent variables include in the regression model (fish production)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1869.09	316.004		5.915	0
	Rice bran (kg/ha)	0.249	0.036	0.646	6.919	0
2	(Constant)	2044.495	301.09		6.79	0
	Rice bran (kg/ha)	0.191	0.038	0.494	4.975	0
	Poultry litter (kg/ha)	0.377	0.117	0.319	3.211	0.002
3	(Constant)	2148.678	284.325		7.557	0
	Rice bran (kg/ha)	0.096	0.047	0.248	2.046	0.045
	Poultry litter (kg/ha),	0.41	0.111	0.347	3.711	0
	MOC (kg/ha)	0.358	0.113	0.349	3.165	0.002
a	Dependent Variable: Fish production (kg/ha)					

6.3.1.6 Economics

Variable cost

In general, fish seed was the most important variable cost (US$/hh; all input cost) of fish culture; G I households invested relatively more (54%) purchasing fish seed followed by G II (45%) and G III (27%) respectively. On the contrary, G III households spent relatively more (26%) on purchasing mustard oil cake than other groups. G III household also spent more than double proportion of money on TSP, while rice bran shared similarly to the total cost of fish production of all group households (Table 6.14). It is noteworthy to mention that opportunity cost such as labour and land cost were not included in the analysis.

Variable cost (US$/hh and US$/ha) of fish culture of group III household was significantly higher ($P<0.05$), while group I and II households expenses were similar ($P>0.05$). Better off households variable cost (US$/hh) was higher than worse off ($P<0.05$). Cost (US$/hh and US$/ha) of mustard oil cake and urea (US$/ha) was affected ($P<0.05$) by location X group. There was no difference

(P>0.05) in the cost of cowdung (US$/ha and US$/hh) between location, well-being category and group.

Fish sales

Group III households earned (US$/ha and US$/hh) more (P<0.05) than other groups (G I and GII, P>0.05), while group I and II earned similarly from selling fish. Peri-urban households income from selling fish (US$/hh) was higher than rural households (Table 6.13). There was no difference (P>0.05) between better off and worse off households in terms of income (US$/ha and US$/hh).

Table 6.13 Sale (US$/ha and US$/hh) by groups and locations

	US$/ha	US$/hh
Rural	1,539.53(879.97)	65.33(49.78)
Peri-urban	2,582.58(1,552.18)	205.45(158.46)
Better off	2,216.60(1,340.83)	158.84(129.85)
Worse off	1,937.11(1,351.46)	117.30(136.06)
Group 1 (n=22)	1,371.82(819.26)	104.36(125.47)
Group 2 (n=24)	1,587.33(811.47)	91.79(63.97)
Group 3 (n=23)	3,146.61(1,519.33)	201.43(170.17)
Mean (n=69)	2,038.38(1,344.54)	132.35(134.40)

(Figures in the parentheses are standard deviation)

Gross margin

Gross margin (US$/hh and US$/ha) was found to be higher (P<0.05) in the group III followed by group I and group II, respectively. There was no difference between group I and II for gross margin either by households or by area. Gross margins of better off and worse off households were similar (P>0.05) (Table 6.15).

Table 6.14 Share (%) of variable cost by location, well-being and groups

CR	Group	Fish Seed	Supplementary feed			Organic fertilizers			Inorganic fertilizers		
			RB	WB	MOC	CD	PL	Com.	Urea	TSP	Lime
Rural	I	61.50	21.85	3.45	1.32	6.78	0.19	0.43	2.02	0.69	1.23
	(n=12)	(18.31)	(8.07)	(11.97)	(1.74)	(2.95)	(0.61)	(1.50)	(2.34)	(1.04)	(1.39)
	II	49.58	24.33	0.00	8.26	7.56	2.39	1.28	2.80	0.64	2.33
	(n=12)	(20.06)	(11.55)	(0.00)	(11.43)	(5.46)	(4.74)	(3.07)	(2.74)	(1.55)	(2.89)
	III	29.97	30.3	0.40	26.17	4.36	0.51	0.01	3.16	2.20	1.54
	(n=12)	(16.66)	(11.23)0	(1.37)	(8.23)	(3.46)	(1.04)	(0.04)	(1.62)	(2.23)	(1.47)
	Mean	47.02	25.50	1.28	11.92	6.23	1.03	0.57	2.66	1.18	1.70
	(n=36)	(22.20)	(10.72)	(6.93)	(13.27)	(4.22)	(2.91)	(1.99)	(2.27)	(1.79)	(2.03)
Peri-urban	I	45.92	27.35	3.35	13.94	1.93	0.40	1.77	3.33	1.71	0.14
	(n=10)	(28.86)	(15.21)	(5.40)	(11.03)	(3.37)	(1.38)	(2.92)	(2.72)	(2.90)	(0.33)
	II	40.83	29.52	3.49	15.72	3.28	0.56	1.32	3.09	2.12	0.07
	(n=12)	(33.32)	(17.60)	(6.39)	(13.16)	(3.60)	(1.25)	(3.40)	(2.58)	(3.35)	(0.26)
	III	23.60	28.61	6.59	26.20	0.92	1.42	0.63	2.92	4.41	0.52
	(n=11)	(16.59)	(8.36)	(9.47)	(6.29)	(1.10)	(1.83)	(1.12)	(1.17)	(2.73)	(1.03)
	Mean	36.78	28.50	4.48	18.62	2.04	0.79	1.24	3.11	2.75	0.24
	(n=33)	(28.12)	(13.89)	(7.25)	(11.63)	(3.00)	(1.53)	(2.63)	(2.21)	(3.16)	(0.66)
Better off	I	44.20	23.88	7.42	12.07	3.60	0.44	1.93	3.43	2.19	0.49
	(n=9)	(26.94)	(11.47)	(12.52)	(11.57)	(3.99)	(1.44)	(3.00)	(2.69)	(2.86)	(1.05)
	II	53.43	15.62	0.00	15.30	5.47	0.25	1.88	3.64	0.96	3.13
	(n=5)	(27.22)	(7.99)	(0.00)	(14.45)	(2.93)	(0.56)	(4.19)	(3.68)	(2.14)	(3.79)
	III	30.35	28.59	1.93	24.32	1.67	0.37	0.31	3.10	3.70	1.52
	(n=11)	(18.35)	(10.73)	(4.69)	(.93)	(2.33)	(0.89)	(1.04)	(1.58)	(3.15)	(1.60)
	Mean	39.91	24.42	3.74	17.90	3.11	0.38	1.23	3.32	2.62	1.40
	(n=25)	(24.45)	(11.28)	(8.75)	(11.81)	(3.39)	(1.07)	(2.65)	(2.40)	(2.97)	(2.12)
Worse off	I	61.77	25.22	0.00	3.87	4.99	0.17	0.40	2.03	0.36	0.84
	(n=13)	(20.83)	(13.28)	(0.00)	(7.01)	(3.99)	(0.59)	(1.44)	(2.39)	(0.87)	(1.22)
	II	43.04	29.90	2.21	11.12	5.40	1.80	1.15	2.76	1.49	0.70
	(n=19)	(27.60)	(14.86)	(5.29)	(12.41)	(5.50)	(3.90)	(2.97)	(2.35)	(2.82)	(1.53)
	III	23.22	30.33	5.06	28.06	3.62	1.56	0.33	2.98	2.91	0.54
	(n=12)	(14.50)	(9.00)	(9.23)	(6.07)	(3.49)	(1.82)	(0.62)	(1.23)	(2.20)	(0.83)
	Mean	43.17	28.63	2.33	13.60	4.79	1.25	0.70	2.61	1.54	0.69
	(n=44)	(26.63)	(12.94)	(6.10)	(13.31)	(4.56)	(2.80)	(2.13)	(2.11)	(2.40)	(1.26)
Mean	I	53.71	24.60	3.40	7.63	4.35	0.29	1.10	2.67	1.20	0.68
	(n=22)	(24.94)	(12.23)	(9.08)	(10.06)	(3.97)	(1.05)	(2.37)	(2.57)	(2.20)	(1.13)
	II	45.20	26.93	1.75	11.99	5.42	1.48	1.3	2.94	1.38	1.20
	(n=24)	(27.27)	(14.80)	(4.77)	(12.64)	(5.02)	(3.52)	(3.17)	(2.61)	(2.66)	(2.31)
	III	26.78	29.46	3.49	26.19	2.64	0.97	0.32	3.04	3.31	1.03
	(n=23)	(16.58)	(9.72)	(7.34)	(7.17)	(3.07)	(1.52)	(0.84)	(1.39)	(2.69)	(1.35)
	Mean	41.90	27.00	2.88	15.27	4.14	0.91	0.91	2.88	1.96	0.97
	(n=69)	(25.68)	(12.41)	(7.22)	(12.84)	(4.20)	(2.31)	(2.34)	(2.24)	(2.67)	(1.67)

(Figures in the parentheses are standard deviation) (CR.- Criteria; F. Seed- Fish seed; CD-Cowdung; PL-Poultry litter; RB-Rice bran; MOC- Mustard oil cake; TSP- Triple Super Phosphate; WB- Wheat bran; Com.-Compost)

Table 6.15 Economics of fish culture by groups, locations and well-being categories

Criteria	Group	Household level: Gross return (US$/hh)	Household level: Mean variable cost (US$/hh)	Household level: Gross margin (US$/hh)	Unit area (ha) level: Gross return (US$/ha)	Unit area (ha) level: Mean variable cost (US$/ha)	Unit area (ha) level: Gross margin (US$/ha)
Rural	I	93.12	42.67	50.45	2,660.82	1,236.29	1,424.53
	(n=12)	(41.49)	(22.73)	(40.02)	(772.58)	(410.18)	(882.08)
	II	103.33	49.83	53.50	2,348.90	1,263.68	1,085.22
	(n=12)	(63.07)	(26.81)	(57.09)	(1,019.45)	(908.97)	(613.77)
	III	171.51	99.34	72.18	4,516.86	2,682.29	1,834.57
	(n=12)	(69.68)	(54.65)	(53.18)	(1,573.26)	(1,258.46)	(1076.80)
	Mean	122.65	63.94	58.71	3,175.53	1,727.42	1,448.11
	(n=36)	(67.55)	(44.49)	(50.11)	(1,494.69)	(1,131.07)	(907.69)
Peri-urban	I	207.58	107.51	100.08	2,101.84	1,129.08	9,72.77
	(n=10)	(160.09)	(63.73)	(117.10)	(821.08)	(392.86)	(710.80)
	II	145.52	75.30	70.23	2,143.22	1,181.17	962.06
	(n=12)	(89.83)	(46.94)	(68.31)	(997.20)	(598.01)	(712.75)
	III	346.49	139.85	206.64	4,514.79	1,825.00	2,689.79
	(n=11)	(174.48)	(78.98)	(134.95)	(1,274.64)	(520.10)	(1,358.52)
	Mean	231.32	106.58	124.74	2,921.21	1,379.99	1,541.21
	(n=33)	(164.29)	(67.80)	(121.50)	(1,532.61)	(594.51)	(1,254.48)
Better off	I	209.94	106.62	103.32	2,270.95	1,177.05	1,093.91
	(n=9)	(170.27)	(67.17)	(124.54)	(876.83)	(396.28)	(833.91)
	II	129.50	55.50	74.00	2,247.36	1,239.25	1,008.11
	(n=5)	(94.30)	(28.34)	(88.41)	(960.49)	(1,112.31)	(562.27)
	III	234.54	121.47	113.08	4,212.59	2,053.90	2,158.69
	(n=11)	(96.87)	(87.09)	(71.11)	(1,482.20)	(968.88)	(1,369.82)
	Mean	204.68	102.93	101.75	3,120.56	1,575.30	1,545.25
	(n=25)	(129.04)	(73.68)	(93.81)	(1,517.08)	(915.25)	(1,172.73)
Worse off	I	100.30	48.27	52.03	2,500.74	1,194.83	1,305.91
	(n=13)	(45.82)	(30.22)	(36.93)	(811.69)	(412.76)	(837.49)
	II	123.09	64.42	58.67	2,245.72	1,218.00	1,027.72
	(n=19)	(77.27)	(42.49)	(56.11)	(1,025.62)	(671.33)	(689.48)
	III	274.13	116.19	157.94	4,793.87	2,472.46	2,321.41
	(n=12)	(197.88)	(51.04)	(152.22)	(1,333.66)	(1,126.18)	(1,224.44)
	Mean	157.55	73.77	83.78	3,016.02	1,553.28	1,462.74
	(n=44)	(135.68)	(49.14)	(98.71)	(1,517.80)	(940.72)	(1,036.86)
Mean	I	145.15	72.14	73.01	2,406.74	1,187.56	1,219.18
	(n=22)	(123.65)	(55.70)	(85.76)	(826.28)	(396.56)	(822.86)
	II	124.43	62.56	61.86	2,246.06	1,222.42	1,023.64
	(n=24)	(78.91)	(39.58)	(62.16)	(991.80)	(753.63)	(653.52)
	III	255.20	118.71	136.48	4,515.87	2,272.28	2,243.59
	(n=23)	(155.73)	(68.97)	(120.04)	(1,405.73)	(1,051.92)	(1,268.64)
	Mean	174.62	84.33	90.29	3,053.89	1,561.26	1,492.64
	(n=69)	(134.31)	(60.35)	(96.66)	(1,507.19)	(924.86)	(1,080.20)

(Figures in the parentheses are standard deviation)

6.3.2 Vegetable cultivation

6.3.2.1 Input used, production and usage

There was no difference (P>0.05) among the groups and locations for the amount (kg/hh) of different inputs used. The average amount of vegetable produced by the households was 650±549 kg/hh and there was no group effect. However, peri-urban households produced and sold more vegetable than rural households, while rural households consumed greater amounts (kg/hh) thereby. There was no effect of well-being category on the amount of vegetable sold and consumed (Table 6.6).

Table 6.16 Vegetable production and usage

Group	Production (kg/hh)	Sale (kg/hh)	Consumption (kg/hh)
Group I (n=19)	645.44 (555.49)	513.29 566.12)	68.50 (45.58)
Group II (n=20)	669.58 (565.58)	534.85 (530.77)	93.93 (83.60)
Group III (n=20)	633.34 (553.61)	480.90 (554.22)	92.94 (53.25)
Rural (n=36)	574.02 (422.63)	376.18 (374.11)	113.01 (66.15)
Peri-urban (n=23)	767.70 (697.10)	718.48 (689.00)	42.20 (19.74)
Better off (n=22)	636.00 (642.05)	509.34 (649.41)	90.57 (64.89)
Worse off (n=37)	657.56 (494.57)	509.78 (475.24)	82.33 (62.96)
Mean (n=59)	649.52 (548.81)	509.62 (541.18)	85.40 (63.26)

(Figures in the parentheses are standard deviation)

6.3.2.2 Correlation and regression analysis for vegetable production

Among all of the inputs used for growing vegetables, inputs that were positively correlated with the vegetable production in terms of yield (US$/household) and value (US$/household) are given in Table 6.17.

Table 6.17 Correlation between inputs (US$/household) and value of vegetables (US$/ household)

	Cowdung	MP	Pesticide	DAP	SSP	TSP	Urea
r	0.519(**)	0.767(**)	0.686(**)	0.763(**)	0.587(**)	0.814(**)	0.510(**)

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

However, only positively correlated variable were used for regression analysis, the predicted R square value of 0.903, R square of 0.815 and adjusted R square of 0.801 indicate high explanatory power of the model as a whole. Both multiple R and R square values have increased with the addition of independent variables from X_1 to X_4 and they have high level of explanatory power, as the adjusted R square demonstrates 80% variation in the vegetable value.

Table 6.18 Summary of the model (vegetable value)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.814(a)	0.662	0.656	63.58405
2	.862(b)	0.744	0.735	55.86724
3	.888(c)	0.789	0.777	51.18181
4	.903(d)	0.815	0.801	48.39273

a Predictors: (Constant), TSP
b Predictors: (Constant), TSP, DAP
c Predictors: (Constant), TSP, DAP, Urea
d Predictors: (Constant), TSP, DAP, Urea, Cowdung
e Dependent Variable: Value of vegetable (US$/household)

The F ration of explanatory variables in the final model is statistically significant at 0.001 confidence level. This indicates that the variables included in the model are correct (Table 6.19).

Table 6.19 ANOVA of the regression models (vegetable value)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	451715.8	1	451715.8	111.73	0.000(a)
	Residual	230447.1	57	4042.931		
	Total	682162.9	58			
2	Regression	507378.6	2	253689.3	81.281	0.000(b)
	Residual	174784.3	56	3121.14		
	Total	682162.9	58			
3	Regression	538086.1	3	179362	68.47	0.000(c)
	Residual	144076.8	55	2619.57		
	Total	682162.9	58			
4	Regression	555702.7	4	138925.7	59.323	0.000(d)
	Residual	126460.2	54	2341.85		
	Total	682162.9	58			
a	Predictors: (Constant), TSP					
b	Predictors: (Constant), TSP, DAP					
c	Predictors: (Constant), TSP, DAP, Urea					
d	Predictors: (Constant), TSP, DAP, Urea, Cowdung					
e	Dependent Variable: Value of vegetable (US$/household)					

Results of the regression analysis revealed that value of vegetables (US$/households) is significantly influenced by four independent variables which are levels of TSP (X_1), Di-Amonium-Phosphate (DAP) (X_2), urea (X_3) and cowdung (X_4) used. Of these, TSP (kg/hh) appeared as the most influential variable explaining above 81% of the variation explained. This combined with TSP and urea explained around 91% of the total variation, which is an indication of the importance of theses independent variables in influencing vegetable value (Table 6.18). However, it was revealed that the independent variables have a positive influence on the dependent variable, i.e there was a tendency to increase value (US$/household) with increasing application of TSP, DAP, urea and cowdung (Table 6.20).

Table 6.20 Coefficients of independent variables include in the regression model (vegetable production)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	39.11	10.525		3.716	0
	TSP	0.271	0.026	0.814	10.57	0
2	(Constant)	42.756	9.288		4.603	0
	TSP	0.183	0.031	0.549	5.946	0
	DAP	0.316	0.075	0.39	4.223	0
3	(Constant)	18.383	11.094		1.657	0.103
	TSP	0.147	0.03	0.442	4.904	0
	DAP	0.33	0.069	0.407	4.805	0
	Urea	0.255	0.074	0.233	3.424	0.001
4	(Constant)	13.652	10.63		1.284	0.205
	TSP	0.093	0.034	0.28	2.705	0.009
	DAP	0.374	0.067	0.46	5.586	0
	Urea	0.279	0.071	0.255	3.937	0
	Cowdung	0.129	0.047	0.203	2.743	0.008

a Dependent Variable: Value of vegetable (US$/household)

6.3.2.3 Economics

The proportion of input costs (US$/hh) to the total expenses for vegetable cultivation was similar among the households irrespective of well-being and location (Table 6.21). There was no significant difference (P>0.05) observed for vegetable cultivation between households of different location, well-being and groups in terms of expenses, income from selling vegetable, gross return and gross margin (Table 6.22).

Table 6.21 Share (%) of input expenses of vegetable production by groups

Inputs	Group I	Group II	Group III	Mean
Seed/seedling	43.73 (32.40)	43.04 (34.78)	40.43 (28.76)	42.38 (31.55)
TSP	16.72 (17.05)	16.26 (16.17)	16.67 (16.54)	16.55 (16.30)
Pesticide	12.90 (13.67)	15.13 (17.36)	15.29 (5.57)	14.46 (15.41)
Urea	11.76 (10.70)	11.05 (7.33)	12.54 (8.75)	11.78 (8.87)
Cowdung	6.54 (8.28)	6.07 (8.87)	3.85 (5.38)	5.47 (7.61)
Water	3.53 (8.81)	2.45 (6.60)	6.52 (6.55)	4.18 (11.45)
Murate of Potash	3.69 (4.31)	3.92 (5.47)	3.94 (4.66)	3.85 (4.77)
Mustard oil cake	0.68 (1.52)	1.23 (2.89)	0.44 (1.46)	0.78 (2.07)
Other nutrients*	0.45 (1.24)	0.85 (2.44)	0.32 (1.23)	0.54 (1.73)

(Figures in the parentheses are standard deviation) (* Boric powder, ash etc)

Table 6.22: Sale, gross return, expense and gross margin (US$/hh) of vegetable production

Criteria	Sale (US$/hh)	Gross return (US$/hh)	Variable cost (US$/hh)	Gross margin (US$/hh)
Rural (n=36)	53.80 (63.49)	82.33 (69.63)	20.57 (17.44)	61.75 (59.10)
Peri-urban (n=23)	135.78 (141.49)	147.72 (143.41)	23.20 (19.19)	124.51 (125.59)
Better off (n=22)	84.69 (124.14)	108.79 (126.15)	19.88 (18.24)	88.91 (111.03)
Worse off (n=37)	86.39 (98.91)	107.24 (98.31)	22.62 (18.07)	84.62 (85.87)
Group I (n=19)	81.07 (114.12)	111.67 (118.16)	23.39 (18.70)	88.28 (102.94)
Group II (n=20)	87.99 (100.10)	103.75 (100.32)	20.90 (18.39)	82.86 (85.94)
Group III (n=20)	87.97 (114.81)	108.22 (112.17)	20.61 (17.82)	87.62 (100.82)
Mean (n=59)	85.76 (107.95)	107.82 (108.45)	21.60 (18.03)	86.22 (95.10)

(Figures in the parentheses are standard deviation)

6.4 Discussion

This study followed a process towards the development of technology with the participation of different level of stakeholders in an interactive way. The farmer participatory research was undertaken with a view to assess the effect of changes through intervention in pond management, associated crop production and livelihoods, though it is a challenge to assess the effectiveness of participatory methods as they are context sensitive (Martin and Sherington, 1997).

Effects on fish production and economic benefit

The productivity of tilapia in group III was higher than tilapia stocked of group II which has been revealed from the results of sample village pond yield and also from the discussion of the trial monitoring workshops. The result of the study showed that mono-sex male tilapia can be cultured compatibly with carps provided that inputs are supplied at a higher level. The findings of the study had conformity with the statement 'proper application of scientific practice has the potential to triple the present day production' (Mazid, 2002). However, success of semi-intensive tropical fish culture is based on the supply of nutrients through fertilization and supplementary feeding regime (Hossain et al. 2003; Li and Yakupitiyage, 2003), which has been reflected in the present study.

There was no significant increase of yield between G I and II; suggests addition of 10% tilapia alone does not enhance the yield. Tilapia is an omnivorous fish (Hussain et al. 2004), adding 10% tilapia with carp without increasing feed and fertilization levels (G-II) over control levels (G-I) merely resulted in additional competition for amount of natural food available (Milstein et al. 2001). The slightly lower yields of catla (*Catla catla*), rohu (*Labeo rohita*) and common (*Cyprinus carpio*) carp in group II suggests that tilapia competed most directly with these species, it also suggests that current polyculture ratios and stocking densities optimize yields at the current level of nutrient input.

Addition of tilapia without increasing nutritional inputs did not increase overall fish production of group II, gross margins of that group were slightly lower than group I, suggests higher level of inorganic fertilizers is the most practical and profitable method to overcome this problem (Hossain, 1995). However, fertilization did not provide enough natural food for most of the species to reach their optimum growth potential if cultured at this relatively high density, which was a constraint of this study as farmers' stock fish at a very high density. Perhaps farmers' stocked fish seed at these high densities to optimise yield and ensure cash flow by regular harvest. The balance between complementarity and competition is the essential feature for polyculture. Therefore, it is very important to maintain appropriate stocking densities and ratios of culture animals to obtain the optimum production. In polyculture, synergies arise from two interrelated process; the increase in available food sources and improvements in environmental conditions (Milstein, 1992).

Further, in culture systems fish will grow until food and other environmental conditions become limiting. This point is known as Critical Standing Crop (CSC), which is the biomass of fish in any aquaculture system that results in growth reduction for each individual. Even though growth is reduced at CSC, biomass continuous to increase once fish exceed CSC until population reaches carrying capacity. At the carrying capacity, density effects of the population are so strong that growth reaches zero, and biomass remains stable (Hepher, 1978). There are three options has been suggested at this point; 1) cull some fish 2) leave the systems as it is and accept the reduction in fish grow and 3) provide a supplemental feed (De Silva and Anderson, 1995).

However, it was observed during the study period that farmers stock and sell fish year round and they eat small fish and sell large fish (Appendix 12). Despite the availability of inputs their use may limited by investment cost and knowledge of how to optimise production.

The production of different groups of the present study were within the range mentioned below and silver carp yield was also the largest proportion of the yield. Small-scale pond polyculture with Indian and Chinese carps yielded 2,575 kg /ha in Bangladesh (Muir, 2003). Hassan S et al. (1997) reported 3,600 kg/ha yield in carp polyculture. Fish production obtained from ponds were reported to range from 2,555 to 13,140 kg/ha/year (Buck et al. 1979; Wohlfarth and Schroeder, 1979; Barasch et al. 1982; Wohlfarth and Hulata, 1987). Almost all the high production mentioned above were based on polyculture with tilapia and Chinese carps where both common and silver carps accounted for a large proportion of total yield. Average fish production was also similar with the study results of ICLARM (3,262 kg/ha) (Table 6.23). However, mean production of the group III households was very high compared to production level of any of the projects/national production indicating the effectiveness of the modification of the existing carp polyculture system. Similarly overall gross margin/ha was also higher than the result (1,117 US$/ha) of the national level study carried out by Dey et al. (2005a) in Bangladesh.

Table 6.23 Comparison of fish production, gross margin and usage of fish

Project/ National	Sample	Production (kg/ha)	Gross margin (US$/ha)	Gross margin (US$/hh)	% consumed (kg/hh)
National	Aquaculture	2,440			
	Carp polyculture	3,262	1,117		
Kapasia	Credit	2,280		118	41
	Contact	1,630		64	56
	Neighbour	1,340		58	41
MAEP	Participant	2,220		180	39
	Neighbour	1,890		185	54
	Control	2,130		106	47
NFEP	Model village	2,360		139	37
	Fry trader customer	2,090		170	27
	Control	1,630		101	53
PondLive	G – I (control)	2,896	1,219	73	38
	G –II	2,891	1,023	61	28
	G – III	5,283	2,243	136	25

Source; (ICLARM, 2001; Dey et al. 2005a; Bestari et al. 2005; Thompson et al. 2005)[(Conversion rate was 1 US$=48 Tk (1998-99; referred study year); and 1 US$= 62 Tk (2004: current study year)]

There were some similarities between fish culture practices between participants of this study and others. Fish stocking densities used by farmers in this study was similar to the density of ICLARM participants (41,200 no/ha) of Kapasia but a little higher than MAEP non-participants (31,100 no/ha) (Thompson et al. 2006). Production (kg/hh) was higher in the MAEP (participants and neighbours) and NFEP (fry trader customer) project than group III and nearly same as the NFEP model village households, while higher than other households of different project.

The results of the study indicated that fish yields were most affected by the amount of input (feed and fertilizers) used. Higher application rates of rice bran, urea, TSP and mustard oil cake were the main reasons for increased enhanced fish production of the group III households. Similar amounts of cowdung were applied by all of the groups reflecting similar access, though the higher levels used by rural households suggest their higher dependence on cowdung or poorer availability of other nutrients. The availability of nutrients in rural areas is a major constraint identified to the productivity of both terrestrial and aquatic systems (Little and Edwards, 2003). On the other hand, peri-urban households used more poultry manure as feedlot poultry production tends to be located in more urban areas (Little and Edwards, 2003).

Poultry manure has been characterised as a complete fertilizer in terms of both organic as well as inorganic fertilizer among all nutrients (Banerjee et al. 1979), which contains 2.8% nitrogen and 1.2% phosphorous (Knud-Hansen, 1998). However, it has also been confirmed that because of the concentrated nature of urea and TSP, I kg of urea and 1 kg of TSP together contains an amount of available N and P equivalent to about 100 kg of chicken manure (Knud-Hansen and Pautong,

1993) and is a more cost effective source of nutrients in many context (Little, pers.comm., 2006).

It is well established that the ratio of nitrogen and phosphorus is critical to maintain a high level of natural food and water quality (Knud-Hansen, 1998; Little, 2000). The relationship between total nitrogen and net yields is well established for Nile tilapia (Knud-Hansen et al. 1991).

The quality of cowdung related to other nutrient source is very low and manure produced by ruminants (cows and buffaloes) are poor pond fertilizers although they release dissolved organic compounds which can degrade the pond environment (Knud-Hansen, 1998). Their nutrient density is low and they are better used as terrestrial inputs in most contexts for their soil conditioning value. Furthermore, it has been reported that staining of water through the tannins contained in ruminant manure and decreasing dissolved oxygen occur with increasing rates of ruminant manure application (Shevgoor et al. 1994).

For adequate phytoplankton production as natural food to support desirable fish yield requires fertilization by adding nutrients in either organic or inorganic forms (Lin et al. 1997) and supplemental feeding may be used as a technique to enhance carrying capacity of the pond or to grow fish to a larger size than is possible with natural food (Diana, 1997). But increases in input level do not necessarily increase production, but rather after a certain level the production starts to decline with additional inputs (Dey et al. 2005a).

Worse off households applied low cost inputs such as rice bran more than better off, that tended to access and use more expensive inputs. Due to easier access and availability of rice bran, worse off households probably preferred to apply this inputs more than better off households. After rice bran, cowdung and urea were preferred as the 2nd and 3rd suitable inputs by the participants irrespective of location and well-being level. However, the result obtained from the regression analysis indicated that improving the quality of rice bran alone might play an important role towards increased fish production, which might be eventually be favourable for the worse off households. The physical and chemical characteristics of rice bran depend on many factors, the most important of which are the rice itself and the milling process (Xin, 1989). The gross chemical composition of rice bran varies greatly, mainly due to the milling process based on the rice bran quality; contains crude protein (9.8-17.2%), crude fat (7.7-22.4), crude fibre (5.7-20.9%) and ash (7.1-20.6%). Rice bran also contains valuable levels of vitamins and essential minerals (Juliano, 1985). Rice bran is a good supplementary feed i.e. its high calorific value spares protein available in the natural feed (Xin, 1989). Fish fed with rice bran result in a high fat content in the fish carcass which may be desirable from a human nutrition perspective as rural, rice-based diets in Asia are typically low in fat (Xin, 1989).

Economics of fish culture

Fish seed accounted for the largest share (42%) of the total fish culture expenditure, which could be minimized if farmers could develop strategies to ensure good quality seed from their own farm through nursing of hatchlings and stocking of their ponds with their own nursed seed. It is evident from the baseline survey (Chapter 4) that farmers largely depend on fish seed traders rarely consider source and quality in their stocking decisions. More importantly fish seed are usually small and arrive stressed at the farm gate causes higher mortality rates (Little et al. 2002).

A larger proportion of all input costs was spent on the purchase of fingerlings by all groups, but seed purchase cost for group III households were proportionally lower than other groups. The proportion of expenses for inorganic (5.8%) and organic fertilizers (5.9%) to the total expense were similar irrespective of groups, but group III spent a relatively higher proportion of inputs for purchasing TSP.

Group III spent the most of the costliest type of feed i.e. oil cake. The gross margins could be increased if such expensive oil cake could be replaced or reduced using more optimal fertilisation and feeding strategies using other on-farm feed stuffs for pond fish such as rice bran, wheat bran, vegetable waste, kitchen waste etc as oil cake is comparatively expensive (Yi and Lin , 2002).

Effects on vegetable production and benefit

The similar level of production of vegetables among each type of management group, well-being and location suggested that increased investment in fish production is complementary rather than competitive with associated vegetable production. It was observed from the regression that variability in vegetable yield could be attributed mainly due to the amount of inorganic fertilizers used. On the other hand, pesticide cost accounted for a large share of the total expenses of vegetable cost.

Effects on consumption

It could also be noticed from the Table 6.23 that in general major propotion of the production was sold, which suggest households' economic intention rather than consumption benefit. However, the average consumption of fish was similar with another study (35 kg/hh/year) carried out in Bangladesh (Islam, 2002). Rural households benefited more than peri-urban through direct consumption of both fish and vegetables; in contrast peri-urban households benefited more through cash sales of both fish and vegetables than rural households. It was observed in a previous study that higher production did not lead to increased consumption rather households availed financial advantage through selling fish (Bouis, 2004).

Participatory workshops and implications

Increased numbers of worse off households' participation in the trial indicates their eagerness and need compared to better off households. Farmers' participation in research assisted researchers in conducting experiments on a wider range of conditions, and it raised interest and curiosity among other farmers in the locality. It also facilitates farmer-to-farmer technology transfer (Poudel et al. 2000). Participatory research provided a great opportunity for mutual learning between the farmers and the researchers (Chambers and Ghildyal, 1985; Farrington and Martin, 1988; Chambers et al. 1989).

However, the participatory research was very time-consuming, demanded lot of commitment and hard work both from the researchers and farmer co-operators. Research results without scientific validity cannot be replicated in other areas.

Therefore, it is imperative to balance between the scientific validity and the complexity of a participatory research (Poudel et al. 1998), which was considered in this study. However, this study was carried out with the farmers mainly in response of the farmers' demand, hence, the limited number of agreed treatments that would answer the farmers most pressing concerns.

Pre-intervention and trial monitoring workshops were part of a dynamic process and were directly linked with planning and decision making and corrective action. It led to decisions about investments, choice of technology and returns. Farmers were able to understand linkages between inputs and outputs. The trial monitoring process enabled the participants to understand how to generate technologies, adaptation according to their local situation and evaluate technologies through participating during the workshops (Shah et al. 1991; Lightfoot et al. 1993b).

The impact of the preparatory and on-going trial monitoring workshops on the community was enormous. Usually they rarely met together except for major social occasions. Community members claimed that this meeting process had improved their social relationship as they could share their general and common issues of interest during the workshops. Some conflicts were observed in two of the villages after distributing the tilapia seed among the participating farmers that required careful resolution by the researchers. However, the overall outcomes of the on-farm research were felt to be positive.

On farm studies all over the world have typical result in huge differences in yields and economic performance between farms despite very similar resource endowments (Gatenby and Humphries, 2000), which is also observed in this study as yield and economic performance of farms varied largely. Differences in education, knowledge, and past experiences among farmers are largely responsible for this disparity. However, collaboration between farmer organizations and extension services should enhance interaction among farmers and develop understanding amount the technological benefit (Stoop et al. 2002). Such approaches could enable small farmers to rise progressively and develop confidence.

Chapter 7: Discussion

7.1 Introduction

Small-scale rural aquaculture has diverse roles towards the improvement of livelihoods; potentially it can contribute to improving household food security and supplementing family income of the poor (Little, 2000; Edwards, 2002; Muir, 2003; New, 2003). Even if practiced at a subsistence level, aquaculture could provide the much needed animal protein and other elements of diets (i.e. fats and lipid-associated vitamins, calcium and other micro-nutrients) the lack of which are typical causes of malnutrition. Aquaculture in family ponds is also developing as a gender-sensitive family farming practice (Shelly, 1998). Potentially farming fish has a less strenuous and shorter daily labour requirement, occurs close to the homestead, and has a good return on investment. All these factors potentially make aquaculture acceptable as a novel enterprise and could empower and improve households' livelihood outcomes.

Year-round cropping reduces seasonal-induced vulnerability partly through smoothing of cash income, and makes it a highly acceptable food production system. These roles may be strengthened if aquaculture is promoted as part of homestead food production programs that increase the production and consumption of animal (poultry, eggs, milk, fish, etc.) and plant foods. Such programmes aim to provide income for the household and should be included in strategies to improve household food security, nutrition and livelihoods (HKI, 2004).

The study attempted to assess the impact of pond-dike systems on the livelihoods of better off and worse off producer households of rural and peri-urban people in Mymensingh district, Bangladesh. The research applied a livelihood framework to assess the role of pond-dike systems on poverty alleviation (Frankenberger et al. 2000). The research explored technical and social aspects of IAA systems through adopting a participatory approach which included qualitative and quantitative data methods at a household, community and policy level (Farrington and Martin, 1988; Cassell and Symon, 1994; Cornwall and Jewkes, 1995; Martin and Sherington, 1997; Robinson-Pant, 2001; Lindenberg, 2002; Sahn, 2003).

There were several phases of the research which aimed to use a step-wise approach to developing key research questions with those involved. A participatory community appraisal followed by a baseline household survey and longitudinal household monitoring led to identification of outstanding research issues of interest to pond-dike operators.

This chapter aims to bring together the major outcomes of the different parts of the study revisiting the original objectives and developing some integrated conclusions. The overall roles of pond within livelihoods and the nature of the benefits to households of different types will be summarised. The livelihoods framework was used to assess the impact of ponds associated within horticulture on vulnerability especially from a seasonal perspective. Further, an on-farm participatory research trial was carried out principally to evaluate the effect of alteration of existing pond-dike systems on pond-dikes and associated livelihoods. The methodologies adopted in the research are also critiqued as a process before finally discussing the potential of pond-dike systems to contribute towards sustainable livelihoods/development.

Some recommendations regarding potential policy change towards supporting pond-dike development are also given.

7.2 Impact of pond-dike systems

An extension of the concept of sustainability it that of sustainable livelihoods, in which specific focus is given to people, particularly poorer households. It is clear from the study that pond-dike systems contributed to the livelihoods in many ways providing food, irrigation for crops and livestock, income and help in maintaining other domestic requirements (bathing, washing clothes etc). However, an issue is who the beneficiaries are and do these vary between rural and peri-urban locations .

Clearly, although the multi-purpose functions of the pond has been retained, there has been a significant shift between the intended range of uses of ponds at the time of construction and their uses nowe. The results from the community appraisals showed that the key objectives regarding pond use are now dominated by fish culture for all types of households managing ponds..

The role of these systems are many fold and enhance livelihoods in many ways especially through directly providing food (fish and vegetables) for the household and indirectly by ensuring improved financial security, especially critical at certain times of the year, ultimately reducing the vulnerability of adopting households. Ownership of a pond and passive production of perennial crops, such as fruit and timber trees on the dike delivered sub-optimal outcomes compared to using the pond water for irrigation of shorter term and/or seasonal crops more actively. Active households' benefited more from selling fish and vegetables than others in peri-urban locations, and consumed fish and vegetables more frequently than others in both locations.

It is clear from the community level appraisals that rice, fish and vegetables dominated the diets of all groups of households. Baseline results showed that fish and vegetables contributed about 20 % and 10 % of the on-farm incomes of active households. Pond fish culture by the better off active integrated farming households produced significant income flows [per capita (US$2 caput/week) and household income (US$ 7.8/week)] from fish sales was relatively high compared to worse off active households (1US$1/capita and US$5.2 /households; weekly). But the share of income derived from fish culture to the total income at around 20% and on-farm income (around 30%), was similar for both socio-economic groups. The contribution of vegetable sales to total (5%) and on-farm income (7% and 8% for better and worse off respectively) was much lower than from fish culture but was similar between well-being groups.

A relatively higher impact of fish culture on poorer than better off households, as opposed to absolute benefits, has been hypothesised e.g. Little, Golder, et al. (1999) and supported by some recent field work in Bangladesh (Barman and Little, 2006; Haque et al. 2006).

Data derived from longitudinal monitoring broadly supported the trends indicated by the participatory exercise and one-off household survey although the percentage contributions to income were higher with fish and vegetable production contributing 30 % and 8 % respectively to on-farm income. The precision of results obtained by the longitudinal study is comparatively greater than from a single observation obtained from a single baseline interview. The ability to recall yearly information relating to year round during one round of any baseline survey is clearly problematic, especially if seasonal variation is great (Murray, 2004). However, the monitoring process supported the observation from the baseline that the importance of fish as a source of income was higher (42%) in peri-urban households than rural (17%), where direct impacts on subsistence were relatively more important.

Some direct indicators, particularly “benefits of pond-dike systems” identified during the community appraisals and “source of food” in the household survey were used as indicators to understand the contribution of pond-dike systems to food security. PCA results showed that fish consumption was the second highest benefit after financial gain irrespective of system and location. We learnt from the baseline that active households consumed fish and vegetables more frequently than other groups though the longitudinal household monitoring later identified that this consumption was particularly valued during food deficit/vulnerable months.

In addition to the financial and consumption advantages pond-dike systems perhaps supported strengthening social capital through distributing produce of the systems among neighbours (Langworthy et al. 2001), though the amount they distributed was negligible, it probably supported good interdependency and interrelationships between households. Similarly use of pond water from shared ponds and also water use by non-pond owners from their neighbours’ pond suggests that owners use ponds and pond water towards enhancing relationships with local people.

The sharing of knowledge and skills relevant to pond-dike systems among people residing in a village also reflects strong linkages within the community. But lack of knowledge has been identified as one of the major constraints (Chapter 3) impeding potential growth of integrated aquaculture. Shared local experience and knowledge, although valuable, may not be sufficient to completely satisfy expected needs (Blaikie et al. 1997). Sharing information can be expected to enhance social capital which in turn can help reduce vulnerability (Islam, 2002). Improving social capital benefits the welfare of poorer people both in terms of poverty alleviation and empowerment (Bebbington, 1999; DFID, 2000).

7.3 Household level vulnerability

The vulnerability context varied between well-being categories and also in rural and peri-urban locations, which will be discussed relative to seasonality, shocks and trends.

7.3.1 Seasonality

7.3.1.1 Vulnerability under the seasonal climate changes

Links between seasonality (especially critical rice pre-harvesting periods) and vulnerability were observed during the seasonal calendar exercises of the community appraisals and then in more detail through the households' longitudinal monitoring study. Other seasonal changes in natural conditions included water scarcity or drought during the dry season which has been reported during the PCA. In contrast, an outcome of the FPR monitoring workshops was the impact of flood destruction of some fishponds in the research locations during the trial period.

Devastating floods occur frequently in Bangladesh, A major flood in 1998 covered two-thirds of the country and caused a shortfall of 2.2 million tonnes in rice production and threatened the food security of tens of millions of households (Just, 2003; Del Ninno et al. 2003).

But it is anticipated that raised dikes for growing vegetables better safeguarded the pond and vegetable crops against flood compared to ponds without raised dikes. Bangladesh has many ponds, perhaps 1.3 million according to (World Bank, 1996). Most were created when households excavated earth to raise their homesteads above normal flood levels (Lightfoot et al. 1993a) and function as refuges for people and their livestock during periods of severe flood (Chatterjee, 2001).

Due to the harsh changes of the climate conditions, especially drought in dry season, agricultural diversification depends heavily on the availability of irrigation water in both rural and peri-urban areas. It was noted that, in three of the communes (one rural, two peri-urban) off-farm irrigation was not available or available in insufficient quantity (Chapter 3), exposing them to greater vulnerability with regards to water than the other study locations (Pearce, 2006).

7.3.1.2 Accessibility to resources during different period of the year

Limited financial capital to invest in productive activities during some periods of the year was seen as a chronic constraint, which has been found to constrain poorer households in general (Sen and Hulme, 2004; ADB, 2005), poorer fish farmers (Ahmed, 2001; Muir, 2003; Ahmed et al. 2005) and vegetable growers (Hallman et al. 2003; Weinberger and Genova, 2005) especially in Bangladesh.

Shortage of money to invest in agricultural production occurs frequently in the first half (January to March) of the year especially for rice and fish culture. At this time, households spend money to cover the various input costs such as seed, irrigation and fertilizers for crops (especially for *boro* rice). Pond culture of fish imposes extra demands for purchase of the major items of expenditure such as seed and fertilizers. However expenditure related to pond aquaculture was lower than rice cultivation and better spread throughout the year. The investment required for vegetable production was lower still and even better distributed throughout the year. Cash income was particularly limited in the early of year because most harvests and consequent income flows occurred in the second half of the year. Income from these sources is spent almost entirely on food purchases, medical costs, schooling and other household costs. Income flows from both fish and vegetable production, although not dominant if considered for the year as a whole, were very important during low income months earlier in the year. In addition to the lower and better distributed expenditure related to pond-dike production, fish are clearly considered as a liquid asset, similar to other types of livestock, supporting a level of consumption smoothing (Dercon and Krishnan, 1996). Liquid assets allowed households, especially those with significant harvests, to have access to funds through the sale of fish when other income sources area limited or unavailable (Sheriff, 2004).

7.3.2 Shocks

A shock is a relatively short acting stress, such as a death/sickness in the family or fall in output prices, unpredicted financial deficiency etc (Valdivia & Quiroz, 2001).

7.3.2.1 Financial shocks

Financial vulnerability increases when a family member suffer from illnesses, during low income months and during the pre-harvesting period of rice crops, particularly *boro* and a*mon* rice (Chapter 5). During these periods households sought to borrow more money to support consumption expenditure. Households with a diversified, pond-based farming system (active) were able to access credit more easily than non-diversified, non-pond households. This is probably explained by the greater level of various assets characteristic of active integrated pond-owning households.

Interestingly, if loans were interest bearing, they paid higher rates of interest to their relatives and neighbours compared to formal sources suggesting the complexity of social interactions. A higher percentage of both rural and worse off households accessed credit compared to peri-urban and better off households, possibly reflecting their greater need and lower asset inventories..

Household monitoring results showed that March (pre-harvesting period of *boro* rice; hungry gap), June and September (pre-harvesting period of *amon* rice; hungry gap) were the months when households borrowed the most money compared to other months, due to their relatively low income in June and higher expenses (March to June) required for carrying our agricultural inputs (labour, rice and pond inputs). So, it might be concluded that finance is one of the critical issues for the success of active integrated farming households but that the current mix of institutions providing credit are, at least to some extent, delivering credit where required. Greater investment in pond-dike systems, however, might require new mechanisms.

In a recent study carried out in Bangladesh, it was found that farmers valued credit/access to money more than access to information (Hallman et al. 2003). Our study supports the findings of Lewis (1997) who reported that a lack of knowledge rather than credit constrained poor households managing small ponds and ditches profitably for aquaculture in Bangladesh. The issue is often contradictory, however, both money and information has been valued similarly by the participants of this study.

7.3.2.2 Poor health and illness

Households irrespective of location and well-being level suffered from different health problems mainly during periods of seasonal change (onset of rains, summer and winter) which was similar to another studys findings (Lindenberg, 2002). It is evident through variation in health expenses and sickness levels that the impact health status of people varied by group (Chapter 5). Rural and worse off households spent disproportionately more on health care (6% and 7% respectively) and appear more vulnerable to poor health in comparison to peri-urban and better off households (4% and 3% respectively). Such poorer health might be related to inferior access to clean water, less sanitary conditions, poorer nutrition and lack of basic equipment such as mosquito nets and warm clothes (HKI, 2002a; HKI, 2002b). Poorer health status of household members may seriously affect their livelihoods, through reduced income earning potentially increasing the likelihood and degree of indebtedness.

Malnutrition contributes to poverty as it weakens the development of children, and health and work productivity of all. In fact, Bangladesh has the highest prevalence of underweight children of any country in the world except North Korea (HKI, 2002a). Almost one-half of children (47%) and one third of non-pregnant mothers (33%) are anaemic, which is largely due to iron deficiency. Polices and programs to improve nutritional status are therefore key to alleviating poverty in countries such as Bangladesh, where malnutrition is widespread. Foods that are rich in the most limiting nutrients include freshwater fish and vegetables and this explains the interest in promoting their production for subsistence consumption.

7.3.3 Trends

7.3.3.1 Lack of access to land and water resources

Land is very clearly the most important natural asset of farming households (Muir, 2003). But poor access to water, especially perennial water, reduces options for agricultural-based livelihoods. Active pond farmers perceived that poor water retention in ponds during the dry season was a constraint of similar magnitude as lack of money (PCA exercise; Chapter 3). This is related to an increasing importance of ponds as a source of irrigation water. Although both active and passive household valued ponds as a very important source of water (Chapter 3), it became clear that active (worse off) households were relatively more dependent on pond-water than active (better off) for irrigating crops. The smaller areas of ponds of worse of households' suggests their increased vulnerability and importance of pond water compared to better off households with larger ponds. Poorer peoples' ponds tend to be more seasonal, with lower water holding capacity and higher dependency on the pond water for family use and watering the vegetable crops

(Little and Muir, 1987; Pant et al. 2005). This greater reliance on the pond for multipurpose use may also contribute to an understandable reluctance to use various nutrient inputs, especially during periods of greatest water scarcity.

7.3.3.2 Transportation and communication

Low quality earthen roads that link one of the rural study locations are a major constraint to market and information access, especially during the wet season. Among the sampled households, even bicycles were not typically owned by individual households. However, relatively more better off and active households owned a bicycle than the other groups, probably enhancing their access to market. It is reported that one third of poor households have a bicycle in North West region of Bangladesh (CARE, 2002). It is evident from a study carried out in Africa that through bicycle promotion schemes, men, women and children gained better access to education, jobs, markets and health care, improved quality of life and reduced travel time (Schwartz and Boyd, 1994a).

It was noticed from the baseline that a higher percentage of peri-urban households sold fish and vegetable through auction markets while rural households mainly sold their product at the farm gate or in local markets. Lack of transportation and poor communication, especially in the wet season probably hindered access to larger markets for rural households compared to those in peri-urban areas (Muir, 2005). Ogunsanya (1987) summed up the situation by saying that poor rural road accessibility results in poor human resource mobilization for development.

7.4 Opportunities for further benefits from pond-dike systems

Strong evidence of potential for further improvement of pond-dike systems emerged through the results of the on-farm participatory trial. Simple modification of current aquaculture practices based on the enhanced use of locally available inputs could improve both production and income attained from both fish and vegetable production.. Increasing overall nutrient inputs increased fish yields to an average of around 5,000 kg/ha but there appears to be a great deal of potential for PTD to refine fertilization and feeding strategies further. A greater reliance on tilapia might be desirable given experience from neighbouring countries but this would require greater input use than farmers felt confident or able to use in the current trial, and ready access to quality seed.

The fact that vegetable production was maintained by farmers increasing their pond inputs suggests the activities are highly complementary and evidence from an associated study suggested even greater synergism. Production of vegetable (red amaranth) showed that application of pond sediment of group III (10% tilapia and increased input) pond resulted in more than 200% increased vegetable yield than other groups (no use of sediment) (Kabir et al. 2005). Application of feed and fertilizer in ponds allows the accumulation of organic matter and nutrients in the bottom sediments. The nutrients added to pond water from fertilizer, uneaten feed, fish feces and fish metabolites account for the build up in nutrient-rich organic material (Rahman et al. 2004). An associated series of trials showed that 49.6-76.2% of nitrogen used in fishponds accumulated in the bottom sediment (Rahman, 2006).

Use of pond sediments could potentially reduce vegetable production costs by sparing valuable nutrients. For instance, cow manure which is in high demand for fertiliser and fuel in rural areas contains 0.72% TN (Knud-Hansen, 1998), which is comparable to the nitrogen content of pond sediments from higher input systems. A major unresolved issue is the high labour costs associated with removal and reuse of pond sediments.

It was observed from the results of the on-farm trial that there was a positive correlation between households (groups and well-being level) fish and vegetable sales (kg/hh), and production (kg/hh), whereas consumption of both fish and vegetables did not increase with increased production once subsistence needs were met. In rural areas both sale and consumption (kg/hh) was positively correlated with fish and vegetable production (kg/hh).

The differences between rural and peri-urban systems livelihood outcomes were also observed from the trial; rural households mainly consumed the fish produced, while peri-urban households tended to sell a greater proportion of their fish production (kg/hh and kg/ha) was similar. This suggests peri-urban households had better access to markets and their interest focused on selling rather than consuming their own production.

The production levels observed during the trial of active farmers exceeded that assessed during the baseline survey suggesting an underestimation of yields using this approach.

The impact of the on-farm trial was significant (Table 7.1) as active households' fish and vegetable production and sale income increased through adopting the FPR process, which ultimately enhanced their total income. The reasons behind the increase in production of fish of the group III was due mainly to use of more nutrient inputs.

Table 7.1 Comparison between results of baseline and Farmer Participatory Research (FPR)

Study		Fish		Vegetable	
		Production (kg/hh)	Sale (kg/hh)	Production (kg/hh)	Sale (kg/hh)
Baseline (active)		175	105	468	461
FPR	Group I	174	125	645	513
	Group II	160	119	669	534
	Group IIII	303	249	633	480
FPR mean		213	222	650	510

From the above discussion it is clear that aquaculture contributed considerably to household food security and income (Muir, 1999; Langworthy et al. 2001) and the contribution of vegetables was also remarkable. There was evidence that subsistence needs for fish were met before additional income (Sen et al. 1997; Langworthy et al. 2001).

7.5 Major factors affecting adoption of pond-dike systems

A variety of underlying factors appear to support or hinder the adoption of active integrated farming systems. The baseline result showed that the level of education of household members was not affected by location which contrasted with the accepted wisdom that general education opportunities are greater in more urban areas (BBS, 2004). However, the literacy levels of active and better off integrated farming household heads and members' was significantly higher than passive, non-pond and worse off households respectively. This was probably a key advantage for these households to adopt and improve their farming systems.

Access to information appeared as another important factor as a higher percentage of active (92%) and passive (92%) households had access to formal and non-formal institutions than non-pond (72%) households. A larger proportion of better off (93%) and peri-urban (89%) households' accessed information than worse off (78%) and rural (72%) households respectively. But a higher percentage of active households enjoyed access to multiple sources of information suggesting that their better access to a range of information probably enhanced their adoption level. Active groups also accessed information from their relatives more suggesting a higher level of social capital.

Active and better off households had a relatively higher literacy level than others; this probably enhanced their capacity to become aware about new information and encouraged them to seek relevant knowledge, often from several sources. Limited access to new information emerged as a significant underlying cause of poverty particularly in rural areas and among worse off households, but was also linked to constraining production and the level of integration between pond and dike. In both the locations, lack of formal education contributes to the high level of illiteracy and inability to read and write.

A considerable number of people with compulsory education, after a long time out of school without reading and writing, are tending to fall back into functional illiteracy (Chapter 4). This situation is further exacerbated by the lack of knowledge and information attained from different channels, such as mass media, extension services.

Much has been written about the potential role of technologies to bring about sustainable livelihoods, and to reduce poverty (ITDG, 2002), but to be effective farming households have to be informed about such technologies. Neighbours and relatives roles in transferring information on agricultural technology appeared stronger than formal information providers, while participants perceived Department of Agriculture Extension (DAE) to be a comparable source of information as ‘relatives’. DOF managed to support households, particularly in rural and active households mainly through informal contacts rather than through formal training and extension. In contrast NGOs targeted poorer households, especially those in peri-urban households, but neither NGOs nor DoF provided relevant information directly to the majority of households. In Chapter 4 it has been presented that only 14% and 10% of households had access to NGOs and DoF respectively, in contrast a third of households received information from the Department of Agricultural Extension (DAE) who appeared to play a more important role as an information provider .. The DAE is the largest extension service provider in Bangladesh under the Ministry of Agriculture having a wide network of field offices across the country. DAE’s Block Supervisors cover each and every nook and corner of the country, however remote it is, to provide extension services at the farm level. They are also responsible for field application of the research output for better cultivation and better diffusion of produce (UNCTAD, 2004).

This study suggested that Government agencies can play important roles, especially in rural areas, despite a widespread perception that only NGOS are effective service providers in rural areas. “Bangladesh has one of the largest and most sophisticated NGO sectors in the developing world, over 90% of villages in the country had at least one NGO in 2000” (Fruttero and Gauri, 2005). A recent paper reported results of the role of NGOs in Bangladesh which is one of the first large, nationally representative surveys of non-governmental organizations (NGOs) in a developing country (Gauri and Galef, 2005). This paper showed that the large majority of NGOs (big and small) in Bangladesh focus on micro-finance rather than information or agriculture. An estimated 92% of NGOs overall counted credit provision as one of their services (90% of small NGOs and 96% of big NGOs). Although this study confirmed that credit is a crucial issue for pond-dike households, NGOs clearly do not dominate credit supplies to them. However, NGOs, alongside GOs could play a significant role for transforming communication about improved technologies to the farmers, as “ one important advantage that NGOs may have over public sector is the freedom of from fixed civil service rules standard operating procedures’’(Muir, 2003; World Bank, 2003).

Nowadays the privatization of agricultural extension services has been promoted as an alternative approach to public extension services (Peterson, 1998; Rivera, 2004). Funding and delivering extension services by private individuals or informal groups might lower the costs of information delivery to rural and peri-urban households (Yaghoubi and Yazdanpanah, Undated).

However, it was clear from the PCA that knowledge about pond-dike systems was perceived to be a crucial factor by most households. But, fish and vegetable production was also perceived, especially by active and better off households, as "easy" and an important rationale for their practice of IAA. This suggests the greater confidence and knowledge of these farmers compared to passive and non-pond, and worse off households. This increased confidence is self evidently linked to their current practice which in turn, it might be speculated, is related to better education and information access than non pond owners.

The relative importance of seed costs for both vegetable and fish production (>40% production costs) is noteworthy as are the implications for reducing these costs given the seasonal nature of credit needs. It might allow farmers to increase expenditure on nutrients without the need for additional credit, greatly boosting productivity and benefits. The delivery of fish seed however at current prices does result in important seasonal benefits for the usually land poor people to gain benefit as traders (Bhuiyan, 1999). Thus inefficiency at the pond-vegetable enterprise level becomes a mechanism for greater equity in the wider rural community.

Access to markets is envisaged as two major issues for the adoption of integrated farming systems. The baseline and on-farm trial studies indicated that peri-urban locations allowed households to access and sell their products at auction markets while rural households were reliant on sales at the farm gate or in local markets. The major advantage of auction markets is that they are more competitive and transactions are quick and efficient. On the contrary if the farmers' sell their products directly to the local market it is often time consuming, less transparent and more dependant on relationships, all of which incur real costs. This advantage probably encouraged peri-urban farmers to produce greater amounts of fish and vegetables than those in rural locations. This disadvantage for rural households relates to a level of infrastructure, which is outside their capability to directly control (Ellis, 2000b).

The perceived differences for the importance of fish and vegetables between men and women's may be due to gender inequality in economic activities and is a result of uneven access to resources and engagement in income earning activity (Masika and Joekes, 1996). The reasons behind the difference in importance of these activities between men and women at the different locations may be due to the increased awareness/access to resources of women in the peri-urban area (Salway et al. 2005) and also reflect better market access in peri-urban than rural areas.

Participation of men and women in agricultural activities is often linked with commercialization. Some studies indicated that women's individual productivity and access to resources decline as households increase commercial crop production (von Braun and Webb, 1989), while others indicate that commercialization is not necessarily associated with increased workloads for women (Bellin, 1994). In Asia and Latin America, men do most of the paid work and women the unpaid, household-based work; whereas in Africa, women spend more hours than men in both agricultural and non-agricultural activities (Ilahi, 2000).

Access to credit is another important factor probably affecting the level of integration of farming systems, which has been discussed and linked with poverty in the following section.

7.5.1 Credit and poverty

Over the decades of the 1980s and 90s many poverty alleviation programmes have been implemented in developing countries including Bangladesh. The analysis of one study leads to the overall conclusion that micro-credit has had minimal impact on the reduction of poverty in Bangladesh (Hoque, 2004) which is strategically embedded within the global economy (Weber, 2004). However, evaluation of such programmes have traditionally looked at their success in increasing the income levels of participants but less at the wider goals of human well-being (Chowdhury and Abbas, 2004).

There are numerous examples of success of micro-credit, often launched by NGOs, having positive impacts on income, production, employment (Khandaker et al. 1998), improved access to safe water and empowering women (Ullah and Routray, 2003). However, the contribution of informal credit continues to be important. A study carried out in northern Bangladesh established that increased access to credit from micro-finance institutions has been unable to substitute for the informal credit sources probably due to the treadmill of continuously increasing loan sizes and fixed repayment schedule (Sinha and Matin, 1998).

A substantial number of households' borrow money from formal and non-formal money lenders reflecting the demand for credit, although high interest rates of credit is revealed as one of the major constraints. The importance of credit was confirmed during the village level triangulation of the PCA when a common discussion issue was if the researchers would provide any credit support. The relative importance of informal credit, even at high interest rates that was observed in this study indicates the social aspects of informal credit.

Inputs for integrated aquaculture and agriculture emerged as another key issue for the success of integrated pond-dike system. At the beginning of the study the high price and lack of inputs was a major perceived problem of pond-dike systems. The disparity in fish yields reported by active and passive groups in the peri-urban locations was related to application of different levels of inputs. But the monitoring results suggest that actual input expenses for vegetable and fish production for active households were a very small proportion of overall expenses (2-8% of the total expenses respectively), and probably well within households capacity to sustain.

7.5.2 Input versus production and productivity

The unavailability and high price of agricultural inputs such as manure, fertilizers and seeds (Chapter 3) were identified as a significant problem constraining integrated farming. Among the inputs required for producing vegetable and fish, seed has been identified as a critical input in terms of cost of production (Chapter 4 and 5). Households largely depended on *patilwala* and hatcheries for fish seed, and vegetable seed were purchased from market and used this input without having a clear understanding about the quality and true source (Chapter 3). But the on-farm trial results showed that with the same fish and vegetable seed farmers were able to increase fish and vegetable production substantially. So, it could be concluded that the paucity of nutrients used (especially nitrogen and phosphorus) was a more important constraint to enhancing productivity and livelihood outcomes than using improved seed (Edwards et al. 1991).

Among all the inputs used a clear dependency on rice bran for pond fish production was observed and the same situation has been reported for Northeast Thailand (Demaine et al. 1999). Active households fish production and productivity was observed to be significantly higher in the peri-urban area probably resulting from enhanced access to markets for purchase of inputs and sale of products compared to rural locations. Active households also depended more on inorganic fertilization, oil cake and rice bran for fish production than passive households in the peri-urban area.

It was revealed that around half of the baseline surveyed households used pesticide to safeguard their vegetable crops, often in the vicinity of the pond. Active and rural households tended to apply most pesticide. Rural households also applied other inputs (organic and inorganic fertilizers) more frequently, even though production and productivity of vegetables between rural and peri-urban location was similar. This probably demonstrated that rural households used resources less efficiently than peri-urban households; in contrast active households used resources more efficiently as shown by higher production of vegetables per unit area than other groups. Characteristics of active households systems included higher cropping intensity, and more frequent sowing of seed and application of inorganic fertilizers. Active households' higher fish stocking frequency (Chapter 4) and greater dependency on inorganic fertilizers was also noticed from the on-farm trial (Chapter 6).

Increased pesticide use in vegetable crops can possibly lead to deterioration in the environment and also affect human health. Pesticide use in Bangladesh, negligible until the 1970s, has recorded a dramatic rise in recent years (Rahman et al. 1995; Rahman, 2003). Many farmers are competing to supply vegetables through middlemen to markets to meet urban and peri-urban demand (Chapter 4). Combined with consumer desires for unblemished and 'healthy' looking food the crops with less visible damage will fetch higher prices, being easier to sell. A similar situation has been observed by Milwain (2006) in Thailand. However in rural areas consumers may react differently as they are more in touch with agriculture and experience some of the side effects of pesticide use (Alterra, Undated). Also, as a higher proportion of production is consumed in the household and they have less available cash, appearance of vegetables is less of an issue. However the opinions on the dangers of pesticides may vary between farmers. This is understandable as there is not a wide knowledge on the impacts after application, and commercially orientated farmers are bound by economic reasons, to the use of pesticide.

There is widespread acceptance that expansion of modern agricultural technologies leads to a sharp increase in pesticide use (Roger and Bhuiyan, 1995). There is evidence that increased access to agricultural credit significantly influenced pesticides use as it opens up opportunities for diversifying crop production and/or for increased cropping intensity (Rahman, 2003). There might be a link between pesticide use frequency and amount of money borrowed (interest free) by the pond-dike households.

Integrated Pest Management (IPM), as a pest management method promoted largely through Farmer Field Schools (FFS) has been advocated in several studies throughout the world. Time series data however concludes that there was no significant difference in yields or pesticide use when comparing FFS participants with non participants in Indonesia (Feder et al. 2004b). Similarly another study carried out by (Feder et al. 2004a) reported that although FFS trained farmers had a greater knowledge of IPM than non FFS farmers, that knowledge did not spread to other farmers. Recently an ethnographic study in Bangladesh showed that farmers trained in IPM practices in FFSs subsequently used the same amounts of insecticides as untrained farmers and were not doing anything differently from them (Hamid and Shepherd, 2005). They raised question of the validity of extending the intervention until greater consideration is given to understanding how Integrated Pest Management can fit the needs and local conditions of smallholder farmers. These examples of poor uptake of a technical approach contrasts with the current study in which most pond-dike households developed their system based on knowledge obtained from other farmers.

Pond water use for growing vegetable crop on and around the pond-dike was a core characteristic of pond-dike systems. Dependency on the pond as a source of water was higher (in terms of watering frequency) for the active and worse off households than others, and a higher percentage of active households used pond water for their vegetable crops which reflects the active and worse off household dependency on pond water as a no-cost/low cost input. It was also noticed that a similar percentage of rural and peri-urban (PCA and Baseline) households used pond water for irrigating vegetable crops. But, pond sediments, an important potential source of nutrients is rarely used by the vegetable growers.

7.6 Sustainability of pond-dike systems

A major question is how to assess sustainability of pond-dike based livelihoods as there are no specific methods to measure sustainability (Blaikie et al. 1997). Any precise measure of sustainability is problematic as it is location-specific and a dynamic concept (Ikerd, 1993), though it could be measured if specific criteria or parameters are selected (Pretty, 1995). However, for sustainable agriculture/aquaculture sustainable management of land and water is crucial (Blaikie et al. 1997). Economic drivers make pond-dike systems vulnerable to changes in prices and opportunities costs and thus broader development influences their sustainability of such a specific use of land and water.

In Bangladesh, the majority of farmers are smallholders and their immediate concerns are to increase yield, income, and food security and reduce risk of crop failure (Blaikie et al. 1997). Considering these factors, the integration of aquaculture within agricultural appears to have broad potential towards improving sustainability (Asche et al. 1999). IAA is now widespread and socially accepted, though differences in specific design and management practice are observed between villages due to many factors (location, access to market, information etc) discussed in the section 7.5 of this chapter.

Food production invariably has environmental effects which occupy and fragment natural habitats and reduce abundance and diversity of wildlife; it also changes soil, water and landscape quality (Pullin, 2001). However, most IAA systems do not necessarily use low levels of inputs or are less dependent on feed and fertilizer inputs. In general, it might be expected that inputs are lower than those typical of intensive systems and therefore less likely to cause serious pollution and disease risks (Little, pers.comm, 2006). Rather, if there is any fast turnover of organic waste loading, their effluents and excavated muds can enhance the productivity of adjacent lands and avoid over-enrichment, which is being observed in one of the villages studied (Damgao). In this village farmers have explored the value of pond sediment as a substitute for fertilizers and are using it for growing vegetables on pond dikes or in the vicinity of ponds. The practice was initiated by one farmer in the village who, having repaired the pond-dike using bottom mud and planted cucumber, observed a significant increase in cucumber production compared to the other dikes where pond mud was not used. This insight influenced the other cucumber growers in the village and currently most of the cucumbers growers have adopted this practice in spite of its labour intensity (Karim and Little, 2006).

In this study, no specific risk factors other than pesticide application to vegetable crops were observed which could be considered harmful for the environment. Reduction in the use of inorganic chemicals especially fertilisers may mean that productivity levels decline below those that are economically sustainable (Hodge, 1993). Sustainability of any technology needs to be perceived in terms of social acceptability, environmental and economic viability (Asche et al. 1999).

7.7 Critique of the methods

The study was designed in the light of livelihoods framework in order to understand the complexity of the households of diverse farming systems from varied socio-economic level in the different locality. The approaches followed in this study highlighted the usefulness of combining both qualitative and quantitative research methodologies (Neuman, 1994; White and Carvalho, 1997; Marsland et al. 2001; Murray, 2004; Sheriff, 2004). Quantitative surveys have been emphasised along with qualitative assessment for measuring impacts of the agricultural systems (Bourguignon, 2003). Both qualitative and quantitative methods were used in during the initial, meso (community) and macro (policy) level phase of the study, and informed the later use of quantitative methods for the micro (household) level part of the study.

However, selection of multiple process/methodologies in this research was advantageous in understanding the complex and dynamic livelihood pattern of adopting and non-adopting households irrespective of well-being across the locations (rural/peri-urban). However, both methods have some drawbacks and advantages; quantitative methods are often criticised for being time consuming, having less opportunity for the participants to influence the discussion and also this process is more expensive than qualitative methods but provided valuable results. On the other hand, qualitative methods are in general quicker and participants enjoy more freedom to contribute to the discussion and comment of the outcomes (Davis, 1997; White and Carvalho, 1997; Marsland et al. 2001). But, the advantages of qualitative methods depend on the situation and combination of participating of mixed social backgrounds might not result in effective participation than more homogenous groups. Dominance by a small number of influential people, can greatly affect the 'quality' of participation and the outcomes (Cooke, 2001).

However, bringing together the outcomes and some of the participants of the participatory community level appraisal during the SOS workshop with a broader audience which included researchers, farmers and policy makers allowed an important level of validation and triangulation. It also permitted a contribution to be made, at an early stage in the process, to policy and practice. Moreover the inputs of a range of stakeholders at this stage allowed a focusing and sharpening of the forward research agenda, contributing in a very practical way to the design of the household level enquiry. The SOS workshop also permitted to a better understanding of the trends, existing problems and research needs in relation to integrated farming systems in the research area as well as Bangladesh as a whole. The facilitators of the workshop ensured the active participation of all level of stockholders by disaggregating them into separate groups with different tasks. Rarely a small number of participants dominated the session; dominance of individuals being a common barrier to participation in a group setting (Cooke, 2001).

Participation of people is assumed to contribute to enhanced efficiency and effectiveness to promote process of empowerment (Cooke, 2001). There are claims that participation constitutes a new' paradigm' of development (Chambers, 1997). Despite such significant claims, long term effectiveness of participation in improving the conditions of the most vulnerable people or a strategy for social change is a challenge (Cooke, 2001). The response of the on-farm trial in which a high proportion of poorer households were keen to participate after being involved since the beginning of the research process, did suggest that confidence had grown over the duration of the project.

Among many constraints designing the household baseline and monitoring studies required reducing highly complex concepts into simple, complete and self-administered formats and this has been identified as a challenge (Gill and Johnson, 1991). However, the open, participatory approach of the PCA probably improved the quality of the more structured enquiry that followed. Questionnaire survey research remains a popular social research method, which is useful to accumulate quantitative information (Theis and Grady, 1991; Neuman, 1994).

The research did not set out to be entirely farmer-focused because understanding complex phenomena requires understanding the perspectives of a broader range of stakeholders (Biggs, 1989). However the major parts of the research were farmer-focused and participatory.

The PCA helped to categorize the level of well-being of the households which was a strong base for selecting participants for the follow on research. Statistical analysis of PCA data was possible based on the exercises managed with multiple focus groups. The method followed for categorizing the households into different well-being level appeared appropriate as reflected from the results of the study. During the well-being exercise participants were allowed to use any types of indicators to groups the households into different well-being level, which helped develop understanding the broader context of peoples understanding about socio-economic level of the society.

Among all of the methods used in this study longitudinal household monitoring and PTD were critical parts of the whole research in terms of time and resource use. These two processes were complex and challenging compared to the other two studies (baseline and PCA) and particularly required the development of good rapport among participants, field facilitators and researcher which was initiated during the first phase (Biggs, 1989).

Longitudinal household 'panel' surveys have considerable advantages over more widely used cross-sectional data for social science analysis (Alderman et al. 2001; HKI, 2001; Murray, 2004). Data collected through regular, iterative visits improved understanding of key issues including: dynamics of households' adaptation to the seasons and relating these to the causes of such adaptation. The collection of longitudinal data, however, was difficult and expensive and some question whether the gains from collecting such data in developing countries are likely to be worth the costs (Alderman et al. 2001). It is noteworthy to mention that most of the results derived from the different phases of the study were in agreement although consumption levels of vegetable (g/capita/day) determined through thelongitudinal monitoring activity were much higher than estimates given during the baseline and participatory trial. These differences suggest that the precision of outcomes from one-off surveys often reflect current realities and rather than an annual perspective (Murray, 2004).

The open nature of the FPR process employed sought to ensure ownership of the process with the participants and to ensure a process of action learning occurred (Pretty et al. 1995; Dick, 1997; Smith, 1997; Dilworth, 1998). The participatory research emphasised the process rather than outcome in terms of increased productivity or gaining awareness of certain technology in a given circumstance (Okali et al. 1994; Sumberg et al. 2003). This PTD process probably contributed to building confidence in the communities given the strength of participatory research noticed during the trial monitoring workshops; on the other hand researchers also explored the complexity of field conditions in addition to getting the answers of the research questions. The design of the PTD process used raised some ethical considerations as the researcher did not seek to offer advice or knowledge during the trial at the monitoring workshops to avoid bias in farmer behaviour or encourage deviation from the agreed practice.

7.8 Follow on research

It might be worthy to follow up the impact of the entire research especially the FPR in the research villages. In addition, the context of other locations in Bangladesh might not be similar. So, it might be interesting to carry out similar research in other parts of Bangladesh, which will help developed broader understanding about integrated farming systems as literature on aquaculture and horticulture integration are limited in Bangladesh.

7.9 Summary of key findings

Fish culture is equally valued as an important enterprise by both better off and worse off households although men and women's priorities differ, womens involvement in fish culture was limited. Women currently have relatively little input to fish culture in the study areas but changing realities offer opportunities for change in this respect. Vegetable cultivation was also more important to men than women and relatively more important to poorer men in rural areaa and poorer women in the peri-urban area. This suggests that peri-urban located pond-dike systems are evolving to better utilise household resources.

Among the constraints identified to adoption of active integration between fish culture and horticulture lack of knowledge, literacy level, access to information and market, and agricultural inputs were crucial. It is noticed that for poverty alleviation factors and capabilities like education, skills, and networks were important rather than other factors, for example land. The rice (*boro/amon*) pre-harvesting periods were identified as the most common food and income vulnerable periods and the time when food and income from pond-dike systems was most critical, especially among worse off households. Rural households were also more vulnerable than peri-urban during the pre-*amon* harvest vulnerability period.

Inputs, especially fish seed and rice bran were the most essential and crucial inputs for aquaculture. Introducing homestead-based nursing would reduce input costs substantially at a critical time of the year. Vegetable cultivation, especially if commercially orientated, was increasingly dependent on inorganic fertilizers and pesticide, limiting inpus that are linked with both production levels and productivity.

It was revealed from the study that the size of land holdings did not affect adoption of active farming systems. However, active households' pond size tended to be bigger than passive, though size of pond had no effect on fish production. Vegetable land area was similar for all of the groups. Non-pond households' total and own land holdings were significantly lower than that of pond owners. It suggests that active integrated farming households utilized their land and water resources more intensively and efficiently than other farming households allowing them to increase fish and vegetable production, especially in the peri-urban area.

Farmer participatory research showed that production of fish could be increased by a substantial level through increasing pond nutrient inputs rather than stocking an additional species (tilapia), although this may be related to the 'improved' nutrition used by farmers still being well below the level required for optimal tilapia performance. Rural households benefited more than peri-urban through direct consumption of both fish and vegetable; in contrast peri-urban households benefited more through cash sales of both fish and vegetables than rural households. Higher production did not lead to increased consumption rather households availed financial advantage through selling fish. Similar production of vegetables suggests that increased investment in fish production is complementary rather than competitive with associated vegetable production. Increased productivity also helped building social capital through sharing produce among the neighbours although this was limited.

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Appendices

Appendix 1: Map of Mymensingh district, Bangladesh

Appendix 2 Example of the model used during GLM (General Linear Model) analysis (PCA, Baseline and On-farm trial data analysis)

UNIANOVA

Dependent variable BY village group well-being site

/RANDOM = village
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/SAVE = PRED RESID
/CRITERIA = ALPHA(.05)
/DESIGN = village (site) group well-being site group*well-being group*site site*well-being group*site*well-being.

Appendix 3 Example of the model used during GLM (General Linear Model) analysis (Longitudinal household monitoring data analysis)

UNIANOVA

```
Dependent variable BY wellbeing site month id village
  /RANDOM = id village
  /METHOD = SSTYPE(3)
  /INTERCEPT = INCLUDE
  /SAVE = PRED RESID
  /CRITERIA = ALPHA(.05)
  /DESIGN = well-being site month id(site*village*well-being) village(site)
site*well-being month*well-being month
 *site month*site*well-being.
```

Appendix 4: Participatory community Appraisal

Appendix 5 : Map of Koirahati village

Appendix 6 Baseline questionnaire

General information

Date		Interviewer		Checked by	

Family head		Father/Husband	

Other persons present during the interview				

Group (put ✓)	pond		Pond-dike		Non pond	

Pond close to house	yes		no	

Wellbeing (put ✓)	1		2	

Village		Unio n		Sub-district (upazila)		District	

Household profile

	Name	Age	Education	Gender	Occupation								
					1st			2nd			Others (--------------------)		
					Place of work	What you do	Income	Place of work	What you do	Income	Place of work	What you do	Income
joint													
separa													

(Income/ (last month/year/ month(average) ?

Agricultural crops

Farming system

Plots	Area (dec)	Ownership	Use	Pesticide use	Water Source	Cultivation period	Total production		Marketing				
							Qty (kg)	Value (tk)	Qty(kg)	Value(tk)	Where sell	Who bought	When sell

How you decide where to sell?

Assets

Asset (livestock & poultry)

Category	Total Number	number						Current value(tk)	Sell (tk) (last 12 months)	Own consumption
		adult		young		offspring				
Cow										
Goat										
Chicken										
Duck										

Asset (orchard)

Name of tree	age	Where located					Current value (taka)	Sell (tk) (last 12 months)
		Pond dike	Next to the pond	Away from the pond	Close to house	Total number		

Asset (equipment)

Housing		House equipment		Transportation		Farm equipment	
House status	Number	equipment	Number	Transport	Number	equipment	Number

Organizational support received by different farmers

Institutional context; Do you know what are the agencies/anybody (formal/non formal) working in your village?

(Collect information as far back as the farmer can remember)

Name of the agency	Activities carrying out by the organisation	When they started working	Do you have any affiliation	What are the benefits you are getting

Any member of the family involves in any of the above agencies*

(Collect information as far back as the farmer can remember)

Who	Agency	What do the farmers do	Position	Benefits

*Agency includes – organisations/institutes/ club/ GOs /NGOs/ any body

Information flow

From where/whom you get information about farming?	Type of information	Method used by the organisation	Who get the information?

Have you ever had to pay? (put ✔ as appropriate)

	Training	Advise		
Yes				
No				

Do you further share your knowledge with any body? (put ✔ as appropriate)

Yes		No	

Nutrient dynamics in the farm level (last 12 months)

*Input	Source	Frequency (times/month)	When (month)
Urea		Rice	
		Vegetable	
		Pond	
TSP		Rice	
		Vegetable	
		Pond	
MP		Rice	
		Vegetable	
		Pond	
Cowdung		Rice	
		Vegetable	
		Pond	
Poultry litter		Rice	
		Vegetable	
		Pond	
Water		Rice	
		Vegetable	
		Pond	
Insecticide		Rice	
		Vegetable	
		Pond	
Seed		Rice	
		Vegetable	
		Pond	
Fingerling/fry		Rice	
		Vegetable	
		Pond	
Ash		Rice	
		Vegetable	
		Pond	
Kitchen waste		Rice	
		Vegetable	
		Pond	
Pond bottom soil		Rice	
		Vegetable	
		Pond	
Oil cake		Pond	
Rice bran		Pond	
Lime		Pond	

*Input includes all seed, fertilisers (organic/inorganic), feed, residue, water, soil, rice-bran etc.

Farmers' perception about pond-dike systems

If the farmer have no pond; Why you didn't prepare a pond? Reasons for no pond-

----

Do you think that pond (question for all three systems farmer) is an important source of income?

Yes		No	

a. From which year you have started watering vegetable fields by pond water----------
b.From which year you have started watering tree garden by pond water-----------------

Do you have any idea about integration? if yes and not practised, why ?

Farmers' perception
a. In what way pond & pond dike crops is important?

----

b. What social benefits do pond/pond dike cropping bring in the community?

A. What are the problems of integrated farming system?

B. Have you heard any social problems associated with pond culture or dike cropping in the community?
Health & nutrition

Did any of the your family members get sick (last 12 months) Yes ☐ No ☐

Name of the member	Frequency	Duration (days)

Consumption pattern of nutrient dense food(last week) (write number of meal per weak)

Food	Numbers of meal	Sources				
		Culture	Open water	Market	Rice-field (cultured)	Rice-field (connected with rice field)
Fish						
Meat						
Egg						
Milk						

Consumption pattern of vegetable (last week) (write number of meal per weak)

Name of the vegetable	Numbers of meal	Source					
		Pond dike	Next to the pond	Away from the pond	Close to house	Natural source	Market

Farmers' perception about pond-dike systems

Why do you grow vegetable/fruit by yourself in your own farm? , if yes why? (put ✔ as appropriate)

	Easy to grow
	Pesticide free
	Good for health
	To avoid going to market
	Can be sold
	Own consumption
	No money required

Why do you grow fish by yourself in your own farm? If yes, why?(put ✔ as appropriate)

	Easy to grow
	Pesticide free
	Good for health
	To avoid going to market
	Own consumption
	Can be sold
	No money required

Access to financial support

Average range of expenditure per month (considering the whole year)

500-1000
1000-2000
2000-3000
3000-4000
4000-5000

Do you/any of the family members borrowed money (last 12 months)?

Loan without interest

Who	From whom	When	Amount	Refund process	
				Duration	% interest

Loan with interest

Who	From whom	When	Amount	Refund process	
				Duration	% interest

Appendix 7 General Linear model used to test households size

Between-Subjects Factors

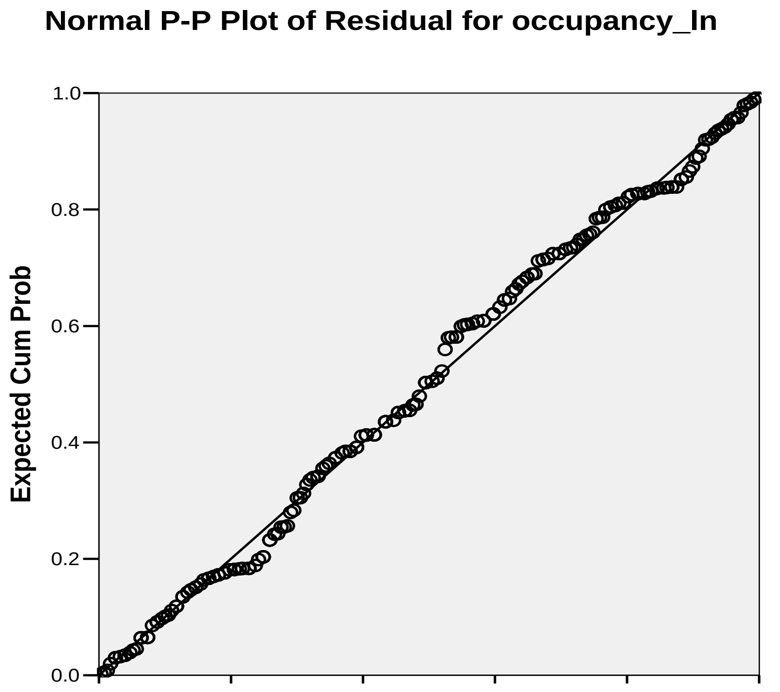
		Value Label	N
Group	1	Pond-dike(active)	83
	2	Pond-dike(passive)	67
	3	Non-pond	55
Well-being	1	Richer	95
	2	Poorer	110
Site	1	Rural	112
	2	Peri-urban	93
Village	Ainakhet		31
	Damgao		31
	Dholia		31
	Gotla		41
	Koirahati		40
	Nosirpur		31

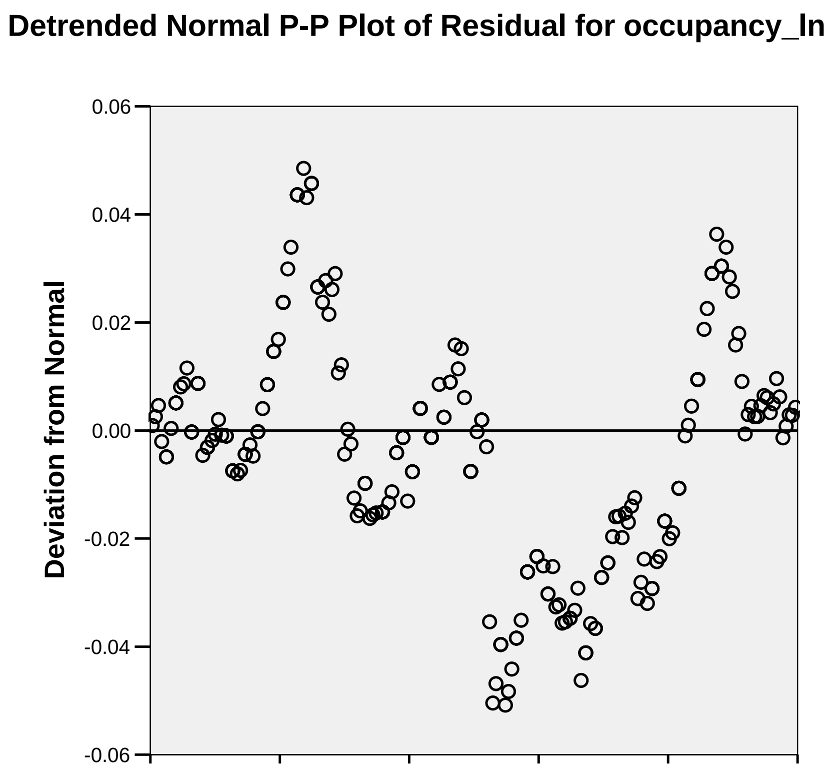
Tests of Between-Subjects Effects

Dependent Variable: Occupancy_ln

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	112.800	1	112.800	4728.428	.000
	Error	.099	4.165	.024(a)		
group	Hypothesis	.014	2	.007	.250	.779
	Error	5.167	189	.027(b)		
Wellb-eing	Hypothesis	.039	1	.039	1.432	.233
	Error	5.167	189	.027(b)		
Site	Hypothesis	.132	1	.132	5.519	.076
	Error	.099	4.165	.024(a)		
village(site)	Hypothesis	.095	4	.024	.870	.483
	Error	5.167	189	.027(b)		
Group * well-being	Hypothesis	.067	2	.033	1.220	.298
	Error	5.167	189	.027(b)		
Group * site	Hypothesis	.038	2	.019	.691	.502
	Error	5.167	189	.027(b)		
Well-being * site	Hypothesis	.002	1	.002	.064	.801
	Error	5.167	189	.027(b)		
group * well-being * site	Hypothesis	.018	2	.009	.320	.726
	Error	5.167	189	.027(b)		

a .982 MS(village(site)) + .018 MS(Error)
b MS(Error)


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


Detrended Normal P-P Plot of Residual for occupancy_ln
Deviation from Normal
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06

Appendix 8 Chi square test to compare farming household heads' literacy level (farming system wise)

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
edu_yn * group	205	100.0%	0	.0%	205	100.0%

edu_yn * group Crosstabulation

			group			Total
			Pond-dike(active)	Pond-dike (passive)	Non-pond	
edu_yn	Literate	Count	63	39	24	126
		% within group	75.9%	58.2%	43.6%	61.5%
	Illeterate	Count	20	28	31	79
		% within group	24.1%	41.8%	56.4%	38.5%
Total		Count	83	67	55	205
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.986(a)	2	.001
Likelihood Ratio	15.235	2	.000
Linear-by-Linear Association	14.867	1	.000
N of Valid Cases	205		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 21.20.

Appendix 9 Chi square test to compare farming household heads' literacy level (well-being wise)

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
edu_yn * welbe	205	100.0%	0	.0%	205	100.0%

edu_yn * welbe Crosstabulation

			welbe		Total
			Richer	Poorer	
edu_yn	Literate	Count	76	50	126
		% within welbe	80.0%	45.5%	61.5%
	Illeterate	Count	19	60	79
		% within welbe	20.0%	54.5%	38.5%
Total		Count	95	110	205
		% within welbe	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	25.684(b)	1	.000		
Continuity Correction(a)	24.246	1	.000		
Likelihood Ratio	26.660	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	25.558	1	.000		
N of Valid Cases	205				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 36.61.

Appendix 10 Monitoring questionnaire

Interview date		Village:		Farmer		Farmers code:	

Category	Better off		Worse off		Interviewer:		Editing date:	

Agricultural activities in own farm IN THE LAST SEVEN DAYS

Activities (agriculture, fisheries, poultry, dairy etc)	Field code	Who involved		Frequency (times/week)	Time spent (total hrs)	labor cost		Problems for doing activities	How did you solve the problems?	Remarks (women involvement in decision making and others)
		Household member	Labour			unpaid	paid			
Major other agricultural activities during 3 preceding weeks:										

Agricultural output (income) from own farm (rice, vegetable, fruits, cattle, goat, baffelo, duck, chicken, fish (culture & capture) IN THE LAST SEVEN DAYS

Crop	From where	Who collected	Freque-ncy and time spent	Total amount (kg)	What do you do with the products and why										In case of sell				Remarks
					Processed		Sell		Consumption		Payment	Gift	Retain for sell	Kept for seed	Where sold	Who sold	Who buys	Price sold	
					Kg	Tk	kg	Tk	kg	Tk	Kg	Kg	kg	kg					
Other major output from farm during 3 preceding weeks:																			

Agricultural non/off/others' farm activities IN THE LAST SEVEN DAYS

Activities	Name of household members	Frequency	Where	Time spent	Income	Remarks
Other major Agricultural non farm activities during 3 preceding weeks:						

Non agricultural on farm activities IN THE LAST SEVEN DAYS

Activities	Household member	Frequency	Where	Time spent	Labour cost		Remarks
					Unpaid	Paid	
Other major non -agricultural on farm activities during 3 preceding weeks:							

Non agricultural non/off farm activities IN THE LAST SEVEN DAYS

Activities	Household member	Frequency	Where	Time spent	Income	Remarks
Other major Non agricultural non farm activities during 3 preceding weeks:						

Input in all agricultural field IN THE LAST SEVEN DAY

Name of inputs (agriculture, fisheries, poultry, dairy)	Where used	Who used	Source code (own=1, own + market=2) market=3)	Price		Source of money for inputs	Problems for inputs	How did you solve the problems
				credit	cost			
Other major inputs used during 3 preceding weeks:								

Livestock inputs and outputs in last seven days

Type	numbers					Changes in number					Marketing			
	male	female	young	eaten	sold	died	born	other	Who sold	Where sold	Who buys	price	Number sold	Money received

Food consumption IN THE LAST three DAYS

How many times in a day you had food during last 3 days? ____________ Times/day

If the number is less or more than three, then: Why**?** ____________________________

Consumption of nutrient dense food

Food	Frequency (total times/3day)	Amount	Source				How		
			Raised	From rice field	Wild	Purchased	Received free	Produced On farm	Caught/collected from wild
Rice									
Fish									
Dry fish									
Fermented fish									
Bred									

Consumption of Vegetable and fruits

Food (vegetable & fruits)	Frequency (total times/3day)	Amount	Source				How			
			Pond-dike	Near to pond dike	Plots not receiving pond water	Near house	Purchased	Received free	Produced on-farm	From wild

Income *IN THE LAST SEVEN DAYS*

Name	Who	Where	Frequency	Amount (kg)	Value (Tk)
Off-farm					
Rickshaw/van pulling					
Service					
Business					
Wages (if employee take one month salary)					
Remittance					
Major income during 3 preceding weeks					

Expenditure *IN THE LAST SEVEN DAYS*

Expense items	Who buys	Frequency	Amount (tk)	Nos	Remark
Daily expenses					
Health/Medicine					
Education					
Housing					
Recreation /Cloths					
Festival					
Other major investment during last 3 preceding weeks					

Visitors/helpers/extension people <u>in the last month</u> Y/N: ____

Relationship	Purpose of visit	Frequency	Time spent	Remarks

Other questions regarding the last month

a. Did any of your family members sick in the last month? Y/N___

who	Total days sick	Types of illness	Taken support from whom

b. Were there any festival in the last month? (Festivals), Y/N?____

If yes, precise:________

Type of event	Where	Who participated	Time spent

c. Did you/any family members borrow money from any body in the last month? Y/N___

Who	From whom	When	Amount	Refund process (duration)

d. Did you/any family members credit money from any body in the last month? Y/N___

Who	From whom	When	Amount	Refund process	
				duration	% interest

e. Description of social activities during this month, Y/N _____

Activity	Who	Frequency	Time spent

b. Were any natural disasters happen in the last month? (Festivals), Y/N?____

If yes, precise:________

Questions regarding the next month

a. Will there be any harvests in the next month (e.g. from your rice/vegetable/ponds/nature?…) Y/N?: _________

If yes, please precise where and when: _______________________________________

b. Will any special occasions happen in the next month? Y/N? : _______

If yes, precise: ____

Appendix 10: Adult equivalent

Here is a table of adult equivalent consumption units differentiated by age and sex computed by the International Food Policy Research Institute in Washington D.C. Research Report 120. 2001

Age	**Male**	**Female**
0-0.99	0.25	0.25
1-1.99	0.37	0.36
2-2.99	0.42	0.40
3-3.99	0.46	0.43
4-4.99	0.49	0.46
5-5.99	0.53	0.48
6-6.99	0.56	0.49
7-9.99	0.58	0.49
10-10.99	0.70	0.64
11-11.99	0.71	0.64
12-12.99	0.73	0.66
13-13.99	0.77	0.68
14-14.99	0.81	0.70
15-15.99	0.85	0.70
16-16.99	0.89	0.72
17-17.99	0.92	0.75
18-59.99	**1**	**0.81**
60+	0.68	0.61
Adult	1	0.81

Appendix 11 Pre-intervention workshop in Damgao village

Appendix 12: Details description and outcome of the pre-intervention of the workshops:

In the first workshop the author presented the key findings of the SOS workshop emphasising on the researchable issues and validated the findings.

In the second workshop researchers started with a comparative discussion about agricultural and aquaculture research. The author asked the participants if they have previous idea about research. They were also asked if there are any differences between agricultural and aquaculture research. Some farmers shared their views and it was shared with the participants that it is very difficult to execute more than one type of research in one pond in a year, whereas in a small piece of land several types of agricultural researches could be carried out. The author then added that it is also difficult to substantially replicate aquaculture research if considerable numbers of farmers did not participate in the research process. However, the author conveyed the message that if large number of farmers were involved in aquacultural research at the same time and shared regularly the outcomes, could be worked out the limitation of groups and replications.

At this point the participants were requested to draw a sample layout of a research and make clearer understanding about research lay-out/design. Then the author asked them "how you can get benefit from comparing any research experience? And what types of information need to be documented during a research and what are the benefits of documentation?".

The author again discussed about group, replication, benefits, risks and shock of a participatory research. Finally the author requested them if any of the participants want to share what he learned from this workshop.

In the third workshop participants were requested to divide themselves into two groups and the author asked to them the following questions –

How input costs to produce value added vegetable/field crops using pond water be reduced, especially fertilizer costs?

Do you have any idea about the amounts of nutrients tied up in sediments of fishponds? Can you assess how much nutrients tied up in sediments? How this amount of nutrients can be transferred to dike-crops to reduce nutrient costs?

Do you think these unused trapped nutrients of soil and water can reduce production costs of dike crops?

Is there any potential benefits might be derived from this process?

What might be happened if more nutrients used in the fish culture system, will it benefit associated crop production and if yes then how?

How can fish yields be raised by changing species to a species more tolerant to and high yielding with more fertile pond water?

Secondary data of tilapia performance were shared with the participants have the discussion to provide a better impression on this species. It was discussed that adding fish species like tilapia can amplify fish production. Farmers' expressed mixed reaction about introducing tilapia in their existing systems. Some thought it might be disappeared during winter season while other told that tilapia could propagate quickly and overpopulate the stock. Then the author told that monosex could perform better than mix sex to over come this possible risk. There was confusion about the performance of monosex and mixed sex. Some commented that monosex tilapia might be better, while other preferred mixed sex to continuous supply of seed for the future. There was also some debate about monoculture and poly culture of tilapia.

It was discussed that sex reversed male tilapia would be better as it grows faster than females, mentioning some example, for instance, a considerable amount of energy is used by female tilapia in generating new population which inhibits their growth. However, finally most of the farmers agreed to stock monosex tilapia. They also decided to test performance of tilapia in the polyculture systems. The author asked the participants how could compare the performance of the new system, through introducing groups which were;

Group 1: Conventional carp polyculture (control) (feed and fertilizers)

Group 2: Increased 10% tilapia and existing input (feed and fertilizers) use

Group 3: Increased 10% tilapia and increased inputs (feed and fertilizers)

In the 4th workshop discussion was initiated mentioning that improving water nutrient would ultimately increase production of both fish and dike- crops. On the other hand, they were asked if they have any idea about nutrient accumulation in the pond bottom, and the amount of the nutrient trapped in the bottom. In two villages use bottom soil to the surrounding crops practiced by some of the cucumber growers. These farmers used to collect pond bottom soil manually, raise the dike a little bit and grow cucumber on the raised dike. They also keep some amount of soil near the dike, dry it and broadcast to the base of cucumber plant as fertilizer during culture period and they noticed better yield. It was discussed that if they could use bottom soil through pumping out soil mixing water, then farmers commented that it might be convenient during the period when water level goes down. Two farmers from a rural area noticed less insect infestation while used bottom soil to the sweet gourd grown on pond-dikes.

Farmers asked if they could name some fish species, which depend mostly on natural food (plankton), they told name of some species like silver carp, catla, tilapia, silver barb etc. It was then discussed that tilapia can be a good species to introduce in the system as this fish is easy to domesticate, culture, can tolerate a wide range of environmental variations and resist to many common diseases. The tilapia is able to utilize natural foods in the pond systems. The tilapia can be cultured both in extensive and intensive systems using only organic or inorganic fertilizers, and high-protein feed, aeration and water exchange respectively. Most of the farmers showed their interest in the 3rd workshops about this species, however still some of them were reluctant and confused about the performance of this species. They experienced less growth, over crowding and disappearance during winter season.

The author provided the opinion that in addition to introducing tilapia increased amount of fertilizer in the existing system might increase nutrient quality of pond water, which would help to increase fish growth. On the other hand nutrient rich water will also benefit the crops around the dikes. This process will ultimately reduce production cost of fish and dike-crops. However, at the end of this workshop the author collected the names of the interested farmers who wanted to join in this study.

Appendix 13 Trial monitoring workshop in Ainakhet village

Appendix 14 : Trial monitoring workshop summary

Introduction

It was planned to organize trial monitoring workshops with the participating and interested non-participating farmers to share the findings of the on-farm participatory research bi-monthly during the trial period; however, out of 10 months trial there were 3 workshops. Data on input-output and usage of the output were collected by the respective field level staff in each village weekly, which was recorded by participants daily. In these workshops findings especially input and out put from the trial were presented in graphical form to compare the results and generate discussion. Input-output of the pond-dike systems (fish and vegetable) information by group and farmers were presented on two different sheets. They were absolutely unfamiliar with the graphical presentation though they understood the process gradually.

1st workshop

In the 1st workshops, which was held at the beginning of August, most of the farmers in each of the villages were a bit reluctant, as it was hardly possible to realize the effect of either increased input or addition of tilapia on production of fish due the ceaseless rainfall occurred during that period which inhibited growth of phytoplankton and ultimately slower down fish growth. They also informed that increased availability of natural fish in this year due to flooding, reduced pressure on cultured fish, which resulted less output from the pond during the 1st workshop. However, they were happy with the performance of tilapia and other carps, though no significant difference observed in terms of size gained between the group 2 and 3. They were expecting that fish growth would be faster after rainy season, especially in the group 3. However, all of them ate tilapia during these two months; they informed that the test was better compared to the locally available tilapia. They did not sale bulk amount of fish during this period, rather continued consumption. They informed that from July availability of natural fish would be decreased soon and they depended largely on pond fish. On the other hand, investment for vegetable cultivation was less during the 1st months (June to July), whereas output was higher as it was the time of harvesting of previously planted vegetable crops.

August was the crucial month for the cucumber growers especially in Damgao village, as most of the farmers sowed the seed and germination was started. They informed that it is a 3.5 month duration crop. Usually farmers irrigate cucumber crops by pond water during the last 45 days; if the draught is severe they usually irrigate water pond more frequently (at least twice a day) than normal weather. They informed that cucumber cultivation is 35 times more profitable than fish culture. One farmer informed that he learned cucumber cultivation methods from a neighbouring villages in 1992, located 5-6 kilometer away from the Damgao. He brought seed from that village and distributed among other 3 interested farmers and planted in 1993. After having tremendous result in 1993 majority of the farmers started adopting cucumber cultivation. One of the farmers of Goatola village have relative to Damgao village, he also learned from his relative and introduced cucumber cultivation in that village .

2nd workshop

In the 2nd workshop, farmers were more enthusiastic than the 1st workshop as they could observe the fish growth difference and shared with the participants. It was clear during that period that inclusion of tilapia and of input enhanced fish growth compared to other groups. Observing the performance of better growth of tilapia and fish some of the non-participating farmers applied increased amount of input.

Four farmers of group 3 from 2 different villages who harvested fish earlier than others and experienced better performance of boro rice cultivated on the bottom of the pond. They discussed that pond bottom was enriched with unused food and fertilizers which effected rice yield. They also informed that compared to other farmers they applied less amount of input for growing rice, eventually their rice production cost was reduced.

3rd workshop

Some of the farmers informed during the 3rd meeting that though the fish were reached to the marketable size but due to decreasing the market price they wanted to stay until the price is rise up to the expected level. In general they cultivated vegetable crops like tomato, ladies finger, cucumber, country bean, chili, bottle gourd etc. They informed that they were able to produce cucumber satisfactorily in the last season, which is an important crop as their income earning source. Interestingly some of the participants showed their interest to follow this type of technology development process for cucumber and rice cultivation.

It was revealed from the discussion that production of cucumber was better on the dikes where newly excavated pond sludge was used. They thought that newly excavated pond sludge is better as contains quality nutrients and do not contain harmful crop disease causative agents. Some of the farmers got better yield of cucumber due to starting cultivation of cucumber earlier than the normal time. These farmers got benefits in two ways, firstly they were able to sale earlier and got good price and secondly germination occurred before rainy season eventually germination rate was also good. However, farmers though commented that there is no assurance of rain so not necessarily this would benefit always.

Evaluation workshop

It seemed that presenting their own results in such a forum created enthusiasm among the community people about the trial. However, after having an idea about the graphs and comparison between input and output their interest for this type of workshop increased substantially.

A total of three farmers observed some fry of tilapia in the pond; they informed that not all of the tilapia was monosexed. The author informed that probably small percentage was not sex reversed, which is not very unusual. They were happy with the overall performance of tilapia and effect of increased input. Around 4 farmers (2 from group and another 2 from group 3) noticed less survival. It was observed that before winter the survibility was good in all ponds, during winter they have lost around 20-40% tilapia. They informed that pond sludge quality and quantity might be linked with tilapia mortality. i.e tilapia was more susceptible to mortality in pond with more sludge than pond with less sludge.

They informed tilapia can be grown well with carps. Some of them showed their eagerness to test the performance of tilapia monoculture. Farmers liked to eat this fish due to its good taste; especially it was preferred by the children due to having less bony flesh. In general farmers consumed less number of tilapia, rather after observing better performance they were more interested to sale the fish. However, the group three farmers informed that price of pond input was a common problem.

They informed that vegetable is profitable in terms of quicker monetary return, while profitability of fish culture is higher but it takes longer duration. And on the other hand vegetable cultivation is more complicated and risky than fish culture.

Majority of the participating farmers were enthusiastic to stock tilapia in the next year if good quality seed is available. They also wanted to test the relative performance of tilapia mono culture and mixed culture. They commented tilapia is a promising species as it has a very good market demand.

Constraints

A total of 5 ponds (one group III, one group II and three controls) were flooded in three villages after one month of the trail inception and which were excluded from the trial. Another new ponds were included replacing the flooded ponds. Farmers of koirahati village suffered a lot due to devastating flood, which damaged mainly their field crop and around 20% ponds of this flooded. The scarcity of *amon* rice seedling was very high and price gone up (14 times as compared to previous season). Vegetable crops of this village were also damaged due to heavy rain fall and flood a total of three trial farmers plot was damaged which were excluded from the analysis. Around 16 houses damaged totally due to storm, there are lack of fodder for livestock, around 15% child affected by diarrhoea.