ASSESSING THE CONTRIBUTION OF AQUACULTURE TO POVERTY REDUCTION IN GHANA

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DECLARATION

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ABSTRACT

This thesis assesses aquaculture's actual and potential poverty impacts and the institutions required for aquaculture development in Ghana. Data were collected using a survey of 69 small-scale fish farming households and 74 crop farming households in Ashanti Region, a survey of cage farms (19 small and medium enterprises (SMEs) and 2 large-scale farms) in Lake Volta, focus group discussions and key informant interviews. The hypotheses tested are: i) small-scale aquaculture has positive direct poverty impacts; ii) indirect impacts (e.g. economic multiplier effects) from SME development have more poverty reduction potential than direct and indirect impacts from small-scale aquaculture; and iii) aquaculture development requires complementary technical and institutional development.

The results suggest that small-scale pond aquaculture increases household income of non-poor farmers who are trained and/or use better management practices (termed fish farming type A). Fish farming type A by non-poor farmers has strong indirect poverty impact pathways and thus, for equivalent increases in scale, higher potential poverty impact than small-scale aquaculture by poor farmers (who have difficulties achieving equivalent productivity), or SME cage aquaculture (where indirect poverty impacts are weaker). However growth of fish farming type A is constrained by high transaction costs and risks. Institutional innovation is thus required to facilitate coordinated value chain development and enable farmers to access services and more lucrative markets.

The findings support the current move in aquaculture development away from focusing on poor producers towards a broader value chain perspective and emphasis on developing more commercial aquaculture. This perspective is important due to the benefits of employment generation along value chains and the need for simultaneous and complementary value chain investments for aquaculture system growth. However the findings highlight ambiguities within the emerging paradigm and the need to target aquaculture systems and farmer categories with the highest poverty impact potential in different contexts.

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ABBREVIATIONS

ABS	Average budget share
AFFA	Ashanti Fish Farmer Association
BMGF	Bill and Melinda Gates Foundation
BMPs	Better management practices
CGE	Computable general equilibrium
CH	Chilling Hub
FC	Fisheries Commission
FAO	Food and Agriculture Organisation (of the United Nations)
DfID	Department for International Development
EIA	Environmental impact assessment
FCS	Food Consumption Score
FFA	Fish Farmer Association
FGD	Focus group discussion
FTE	Full-time equivalent (jobs)
GAA	Ghana Aquaculture Association
GDP	Gross domestic product
GH¢	Ghana cedi
GLSS	Ghana Living Standards Survey
GNADP	Ghana National Aquaculture Development Plan
GR	Green Revolution
GSS	Ghana Statistical Service
Ha	Hectare
IAA	Integrated Agriculture Aquaculture
IDM	Income Determination Model
IV	Instrumental variable
m^3	Cubic meter
MBS	Marginal budget share
MoFA	Ministry of Food and Agriculture
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
NIE	New Institutional Economics

OLS	Ordinary Least Squares
OSAS	One Stop Aqua Shop
PB	Participatory budget
PPP	Purchasing Power Parity
RNFE	Rural nonfarm economy
RRA	Rapid Rural Appraisal
SAM	Social Accounting Matrix
SE	Standard error
SFC	Simple Food Count
SLF	Sustainable Livelihoods Framework
SPSS	Statistical Package for the Social Sciences
SSA	sub-Saharan Africa
SME	Small and medium enterprise
t	Tonne
TLU	Tropical Livestock Unit
USAID	United States Agency for International Development
US$	US dollar
WAF	West Africa Fish Ltd.
WFP	World Food Programme
WRI	Water Research Institute

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Aquaculture is the fastest growing animal food-producing sector worldwide, contributing 47 percent of global food fish supply in 2010. Between the early 1950s and 2010 aquaculture grew from under one million to 60 million tonnes (valued at US$119 billion). Between 1980 and 2010 per capita farmed fish consumption increased on average by 7.1 percent annually (from 1.1 kg to 8.7 kg) while the world's population grew on average 1.5 percent annually (FAO, 2012). Aquaculture's rapid expansion is often referred to as the 'blue revolution' and the sector is now poised to overtake capture fisheries as a global source of food fish. Global aquaculture is dominated by Asia which produced 89 percent of global production in 2010, the majority coming from China. Africa contributed 2.2 percent to global aquaculture production in 2010, and sub-Saharan Africa (SSA) contributed just 0.6 percent (FAO, 2012) despite its natural aquaculture production potential, estimated at 1.5 thousand million tonnes annually (Kapetsky, 1995).

World demand for fish and seafood is projected to keep rising, driven by population growth, increasing urbanisation (often associated with increased consumption of animal protein) and rising incomes. Demand is estimated to reach at least an additional 40 million tonnes by 2030 just to maintain current per capita consumption levels (FAO, 2006). Aquaculture is perceived to have the greatest potential to meet this growing demand. Globally fish provides 4.3 billion people with approximately 15 percent of their average per capita consumption of animal protein. In low-income food-deficit countries, fish contributed 24 percent of animal protein intake in 2009, perhaps more if the contribution of small-scale and subsistence fisheries and aquaculture was fully accounted for (FAO, 2012). The importance of fish to food security and nutrition is further seen in the poorest SSA countries where fish can provide over 50 percent of animal protein intake (FAO, 2006). Per capita fish consumption in SSA is however lower than all other regions and is the only region where it is falling, and projected to keep falling, due to population growth and stagnating capture fisheries (FAO, 2006).

Aquaculture's growth is an example of the 'high-value revolution' (World Bank, 2007) which is creating a second wave of employment growth after the Green Revolution (GR), and includes sectors like horticulture and livestock. Employment in fisheries and aquaculture has increased by 3.6 percent annually since 1980 which is faster than the growth in world population and employment in traditional agriculture. It is also estimated that for each person directly employed in fisheries and aquaculture production, a further three jobs are created in secondary activities (FAO, 2010).

With developing countries dominating the production of aquaculture products, aquaculture has the potential to increase incomes and create employment along with meeting the growing demand for fish. Governments and donors supporting aquaculture development view it as a means to promote rural development, livelihood enhancement, food security and poverty reduction in developing countries. However, despite this potential, it is uncertain whether aquaculture has made any significant direct impact on poverty alleviation (Stevenson and Irz, 2009).

1.2 PROBLEM STATEMENT

Aquaculture promotion for poverty alleviation has had a poor record in many developing countries, especially SSA where aquaculture's potential is yet to be realised at any significant scale (Harrison et al., 1994; Brummett et al., 2008). Brummett et al. (2008) suggest this is due to constraints including: lack of seed, feed and technical advice; poor market infrastructure and access; and weak policies favouring central planning over private sector initiative. Brummett and Williams (2000) suggest uneven growth is partly because aquaculture is not indigenous to SSA (it was introduced during the colonial period) unlike Asian countries like China, India, Indonesia and the Philippines, which have long traditions of aquaculture. Increasing globalisation of trade in aquaculture products is also tending to marginalise small-scale producers. Producers face major challenges, especially to export, such as increasingly strict food safety standards, traceability, certification and other non-tariff requirements favouring medium- to large-scale, capital intensive operations. Small-scale aquaculture farmers thus face many constraints to integrate into supply chains and benefit fully from the new market environment.

Aquaculture's potential to contribute to the livelihoods of the rural poor in SSA has been emphasised by the New Partnership for Africa's Development (NEPAD) that sees aquaculture as a priority for African development. NEPAD's 2005 Fish for All Summit in Abuja, Nigeria produced the Abuja Declaration on Sustainable Fisheries and Aquaculture calling for increased focus on aquaculture promotion and development[1]. This was followed up by the first Conference of African Ministers of Fisheries and Aquaculture organised by NEPAD in 2010, with the theme of 'African fisheries and aquaculture: contributing to agricultural development and economic growth'. Donors such as the UK Government's Department for International Development (DfID), international research and development agencies such as the WorldFish Center and the Food and Agriculture Organisation (FAO) of the United Nations, and developing country governments are also promoting aquaculture as a means for poverty alleviation, food security and stimulating rural economic growth.

However, despite the wide range of benefits expected from aquaculture promotion, the actual and potential contributions of aquaculture development to poor people's livelihoods in SSA have not been fully assessed (Edwards, 2000). There are some empirical examples, mainly from Asia and Latin America, of aquaculture's influence on poverty, however there is little documented evidence of direct poverty reducing impacts, and few studies investigate causality with reliable counterfactuals. Systematic and quantitative evaluation of aquaculture's impact on national economies,

[1] Proceedings of the NEPAD - Fish for All Summit (including the Abuja Declaration) available at: http://www.worldfishcenter.org/resource_centre/WF_2899.pdf (accessed 31 July 2013).

poverty and food security is poorly documented, especially in developing countries. Thus there is limited empirical evidence assessing the role and effectiveness of aquaculture in poverty alleviation (Charles et al., 1997; Hishamunda et al., 2009; Stevenson and Irz, 2009), or of the institutions needed for aquaculture development to realise its potential in SSA.

Research on the impacts of agricultural technology suggests there will be no single way in which aquaculture impacts on poverty alleviation as the outcome is dependent on context. Das (2002) argues in the case of the GR, technology does not have any inherent pro-poor qualities and the relation between technology and poverty is contingent on the context. The inherent effects of technology on society are those which are internal to the technology itself (e.g. increased yield for GR technology, or increased fish production for aquaculture). He suggests technology can only have '*technological/physical'* effects (p. 65), therefore its inherent effects, unlike its contingent effects, cannot be social. The poverty impact of aquaculture is thus contingent on the institutional, political, economic, social and natural context in which aquaculture development occurs and hence is an empirical question, with the answer differing between contexts (Stevenson and Irz, 2009).

Aquaculture's ability to affect poverty also depends on the type of aquaculture systems that develop within each context. For small-scale artisanal producers, successful aquaculture development has the potential to increase revenues, household food security, and can lower risk and improve resilience. Large-scale commercial fish farms have the potential to generate food, jobs and revenues in both local and export markets. However, some experts argue that a business approach focusing on commercial small and medium enterprises (SMEs) would produce more benefits for more people, through stimulating economic growth and reduced fish prices, than either non-governmental organisation (NGO) and government led development projects, focused on direct poverty alleviation of small-scale artisanal producers, or large-scale commercial operations (Moehl et al., 2005; Brummett et al., 2008 and 2011). Beveridge et al. (2010) suggest that evidence from some African countries including Cameroon, Ghana and Uganda, shows that fish production starts to have an important effect on food security where conditions support the growth of commercially oriented aquaculture SMEs. They argue that the SME sector is more likely to have the assets needed to invest in larger operations and adopt more productive technologies resulting in increased fish production and employment generation both on-farm and along the value chain.

However, the potential poverty impact of these different systems has not been subject to rigorous analysis. The type of aquaculture system(s) promoted in different contexts should be informed by an assessment of the poverty impacts arising from each system. Both direct and indirect effects of aquaculture development have the potential to impact poverty, but it is unclear which are more significant. For example, given that rural households face certain minimum resource requirements (e.g. access to land and water), to adopt aquaculture, often beyond the reach of the poor, indirect effects of SME development such as increased labour demand and fish supply, could be potentially more important than direct effects in reducing poverty in some contexts.

Estimating the potential livelihood benefits from different aquaculture systems, including an assessment of the relative benefits to the poor from engaging in aquaculture through employment, or through direct adoption, would have strong implications for policy orientation and the focus of future research and development investments. Enhanced understanding of where the strongest potential for poverty impacts lies (e.g. through livelihood enhancement or consumption effects), and exploring market-related constraints to stronger pro-poor outcomes for the areas with such potential, is needed to inform research on technology and institutional development (Gordon and Kassam, 2011). Therefore, to harness the role of aquaculture for poverty alleviation in SSA, the pathways, constraints, and conditions under which aquaculture can maximise its potential impact on poverty alleviation must be explored.

1.3 RESEARCH OBJECTIVES

This thesis therefore aims to understand: a) the actual and potential impacts of aquaculture development on poverty and livelihoods in SSA, and b) the institutions required for aquaculture development to maximise its potential poverty impact. These issues are explored using aquaculture development in Ghana as a case study. The specific research objectives of this thesis are outlined below:

Objective 1

To assess the direct poverty and livelihood impacts (positive and negative) of small-scale aquaculture systems on different categories of poor people in Ghana.

Objective 2

To analyse the significance of direct and indirect poverty impact pathways from different aquaculture systems and assess implications for pro-poor growth in different contexts.

Objective 3

To identify the institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction in different contexts.

1.4 THESIS STRUCTURE

Following this introduction to the main issues and research questions addressed in this thesis, Chapter 2 starts by reviewing the existing literature on the impact of aquaculture on poverty. The review highlights the limited nature of this literature, especially relating to SSA. It shows that few studies have analysed aquaculture's direct contribution to poverty, that evidence concerning aquaculture's indirect poverty effects is mixed, and that some of aquaculture's potential impacts have hardly been studied. In view of the limited literature and to facilitate the exploration of ways in which to examine the full range of potential impacts of aquaculture on poverty, the chapter goes on to look at literature in the related areas of sustainable livelihoods, economic growth linkages and institutional development. Exploring these different literatures helps to identify appropriate conceptual frameworks and methodologies used to address the three research objectives outlined above. Considering studies from the agriculture sector also informs the ways in which aquaculture's impact on poverty is investigated in this thesis. Chapter 2 concludes by highlighting the gaps in the literature identified by the review and expands on the thesis' research objectives by proposing hypotheses to be tested. By addressing these objectives this thesis seeks to fill some of the gaps found in the literature and contribute to furthering the current state of knowledge on the actual and potential impact of aquaculture on poverty and how to maximise this impact.

Chapter 3 briefly outlines the reasons for selecting Ghana as a case study and gives some background information on Ghana's geography, economy, income, and fisheries and aquaculture sectors and on the aquaculture production systems currently in operation. Chapter 4 describes the data and methodology used to test the hypotheses outlined in Chapter 2.

Chapters 5, 6 and 7 present the results of the research conducted in Ghana and comprise the body of the thesis. Chapter 5 addresses the first research objective by examining the direct impacts of small-scale pond aquaculture on poverty in three districts in Ghana. Chapter 6 investigates the second research objective by assessing the importance of direct and indirect poverty impacts of the three aquaculture systems under analysis (small-scale artisanal pond aquaculture, SME and large-scale cage aquaculture). Chapter 7 builds on these results to address the third research objective by undertaking an institutional analysis of the different aquaculture systems and associated value chains.

Chapter 8 summarises the key findings from these results. The chapter explores ways in which institutional innovation could help to maximise the potential poverty impact of aquaculture development in Ghana. The thesis ends by proposing some important areas for further research and some concluding remarks.

CHAPTER 2: LITERATURE REVIEW

2.1 BACKGROUND

2.1.1 The role of aquaculture in rural development

Three quarters of poor people in developing countries live in rural areas, most depending directly or indirectly on agriculture[2] for their livelihoods (World Bank, 2007). Agricultural development is widely thought to be crucial for stimulating growth in other sectors and reducing poverty (World Bank, 2007). Agriculture's contribution to growth and poverty alleviation varies across countries. For agriculture based economies, which make up the majority of SSA countries, agriculture is an important source of growth (responsible for 32% of GDP growth on average) due to its large share of GDP (29% on average) and high levels of employment generation (employing 65% of the labour force on average) (World Bank, 2007). It is estimated that GDP growth from agriculture is at least twice as effective in reducing poverty as growth from any other sector, making agricultural development an important strategy for poverty alleviation in SSA (World Bank, 2007).

Agriculture contributes to development as an economic activity, driving local and national economic growth and stimulating growth in agriculture related industries and the rural nonfarm economy[3] (RNFE). Agricultural production is important for food security, stabilising and increasing domestic food production and providing income for the majority of the rural poor. In addition, the rural poor depend on a range of livelihood options including diversification of activities in the agricultural sector and off-farm employment, with those in resource poor environments having a broader range of livelihood strategies. A global study of farming systems by Dixon et al. (2001) identified five household strategies to escape poverty: intensification; diversification; increased farm size; increased off-farm income; and exit from agriculture.

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[2] including crops, livestock, agroforestry, and aquaculture.
[3] The rural nonfarm economy includes all rural economic activity outside agriculture.

Diversification, which includes aquaculture, was considered to be a key poverty reduction strategy in all farming system categories and the most important strategy in SSA for farm poverty reduction. However, the extent to which aquaculture will lead to poverty reduction depends on a number of factors including: the level of engagement by the poor, the scale of adoption, the importance of livelihood and production effects compared to consumption effects benefiting poor consumers, and the significance of indirect effects such as increased demand for labour from larger scale enterprises and of economic growth linkages arising from different aquaculture production systems and their associated economic multiplier effects. Therefore, even though aquaculture may have the potential to contribute to agriculture and farming systems development and to rural development and poverty alleviation, the extent to which this potential will be realised is dependent on an array of contingent factors.

2.1.2 Definitions

Aquaculture is the farming of aquatic plants and animals. Different types of land and water based aquaculture production systems exist in inland and coastal areas varying in intensity and commercial orientation. Land-based systems involving ponds can be integrated with agriculture, improving farm productivity and profitability. Water-based systems use existing water bodies (e.g. lakes, reservoirs or rivers) and enclosures (e.g. cages and pens) and can provide the landless a way to enter into aquaculture (Edwards, 1999).

Aquaculture systems are commonly characterised by the intensity of feed use, dividing systems into extensive, semi-intensive or intensive (Edwards, 1999). Extensive aquaculture relies on natural food such as plankton without human intervention. Semi-intensive systems supplement natural food with organic or inorganic fertilisers and/or low-cost supplementary feed. Intensive systems depend on relatively high-cost feed such as small wild fish or formulated pelleted feed (Edwards, 1999). Although classification is based on feed, increasing intensification of feed is correlated with higher levels of other inputs such as seed, labour, capital and management[4]. Semi-intensive systems have favourable characteristics for poor households as they rely largely on natural food which can be increased by using on-farm by-products like manure and crop residues, produce is affordable for poor consumers, and intensification can be achieved using relatively cheap inorganic fertilisers (Edwards and Demaine, 1997).

Aquaculture systems are also defined by commercial orientation. Lazard et al. (1991) (cited by Edwards and Demaine, 1997) divide systems into: subsistence (family-level); artisanal (producing for the market on a small-scale); specialised (where various stages of the production cycle are undertaken by different farmers); and industrial. Ridler and Hishamunda (2001) define aquaculture as commercial when the goal is to maximise profit, undertaken by the private sector without direct financial assistance from donor or government sources. Operations aiming to minimise risk and maximise family utility are classified as 'non-commercial' (or 'rural aquaculture'[5]) even if output is sold. In practice aquaculture occurs along a continuum from subsistence to completely commercial farms.

2.2 CONCEPTUAL RELATIONSHIP BETWEEN AQUACULTURE AND POVERTY

Aquaculture's theoretical potential to impact on poverty has been clearly outlined in the literature (e.g. Edwards, 2000 and Stevenson and Irz, 2009). Figure 1 identifies the main direct and indirect impact pathways, between aquaculture development and poverty alleviation. The main impacts are summarised in Table 1 below and examined in detail in the rest of the chapter.

[4] This classification is relevant to crustaceans and fin fish, not molluscs or aquatic plants.

[5] 'Rural aquaculture' refers to two types of aquaculture (for the 'poorest of the poor' and the 'less poor') and is roughly equivalent to extensive and semi-intensive systems as defined above (Martinez-Espinosa, 1995).

Direct impacts affect the welfare of aquaculture adopting households through for example increased regular income and fish consumption. The poverty impact of these benefits depends on the socio-economic status of adopting households and will only be significant if the poor adopt aquaculture. However there are many constraints to adoption for poor households including limited access to capital and technical knowledge, and high risks. Extensive or semi-intensive systems are more pro-poor than intensive systems, as the poor are often unable to purchase the large amounts of inputs such as feed and seed used in intensive systems (Irz et al., 2007a).

Table 1: Summary of potential impacts of aquaculture

Potential impacts	**Pathway**
Direct impacts affecting adopters	
Income	Increased on-farm income from own enterprise production
Consumption	Enhanced food security and quality from increased household fish consumption and/or as a result of higher incomes from sale of fish (especially where women are producers and in control of family income)
Farm sustainability	Increased farm sustainability through Integrated Agriculture Aquaculture enabling more effective use of on-farm inputs
Indirect impacts affecting non adopters	
Consumption	Increased availability of fish for poor consumers
	Lower prices of fish for poor consumers (also referred to as cost of living linkages by Paz et al., 2006) which could also negatively affect poor fishermen
Employment	Increased employment of poor labourers on fish farms (potentially also boosting rural wage rates)
Economic growth/multiplier	Increased employment, wage and income effects in the aquaculture value chain through production linkages Increased employment, wage and income effects in other sectors through consumption linkages increasing the demand for locally produced goods and services creating an economic multiplier effect and boosting local economic growth
Environmental	Privatisation of previously common access grounds used by the poor, degradation of capture fisheries habitats etc.

Increased household food security through on-farm consumption of nutritionally rich food is an important potential direct benefit (Prein and Ahmed, 2000). Approximately 70 percent of Africans are both producers and consumers of agricultural products, generating livelihoods from small-scale, mixed enterprise farms producing food crops primarily for subsistence and secondarily for sale (World Bank, 2000). Brummett et al. (2008) suggest that although rarely captured in official statistics, small-scale integrated aquaculture systems promoted by governments and development agencies since the 1970s have had substantial impact on rural food security. Kawarazuka and Béné (2010) have developed a framework to improve understanding of the contribution of fisheries and aquaculture to fish producing households' nutritional security. They identify three distinct pathways through which this may occur, through: increased fish consumption by producing households; increased purchasing power of producing households from the sale of fish enabling them to buy other food and improve their dietary intake; and the economic enhancement of women producers who are more likely to use increased family income to improve household food security. For each of these pathways they find the data to be limited and often anecdotal and decide there is not enough evidence to conclude that there are positive nutritional impacts on fish producing households.

Systems that rely on recycled agricultural by-products and simple technology are said to have doubled small-farm fish production, albeit from a low base (Brummett and Noble, 1995; Prein et al., 1996; Lazard, 2002). Other potential direct benefits include increased farm sustainability through constructing ponds which also serve as on-farm reservoirs, and improved farm productivity (leading to potentially higher incomes and fish consumption) through Integrated Agriculture Aquaculture (IAA) technology, exploiting synergies between production systems, enabling more effective use of conventional inputs like labour, organic fertiliser and capital, along with conserving the environment (Edwards, 2000; Dey et al., 2007).

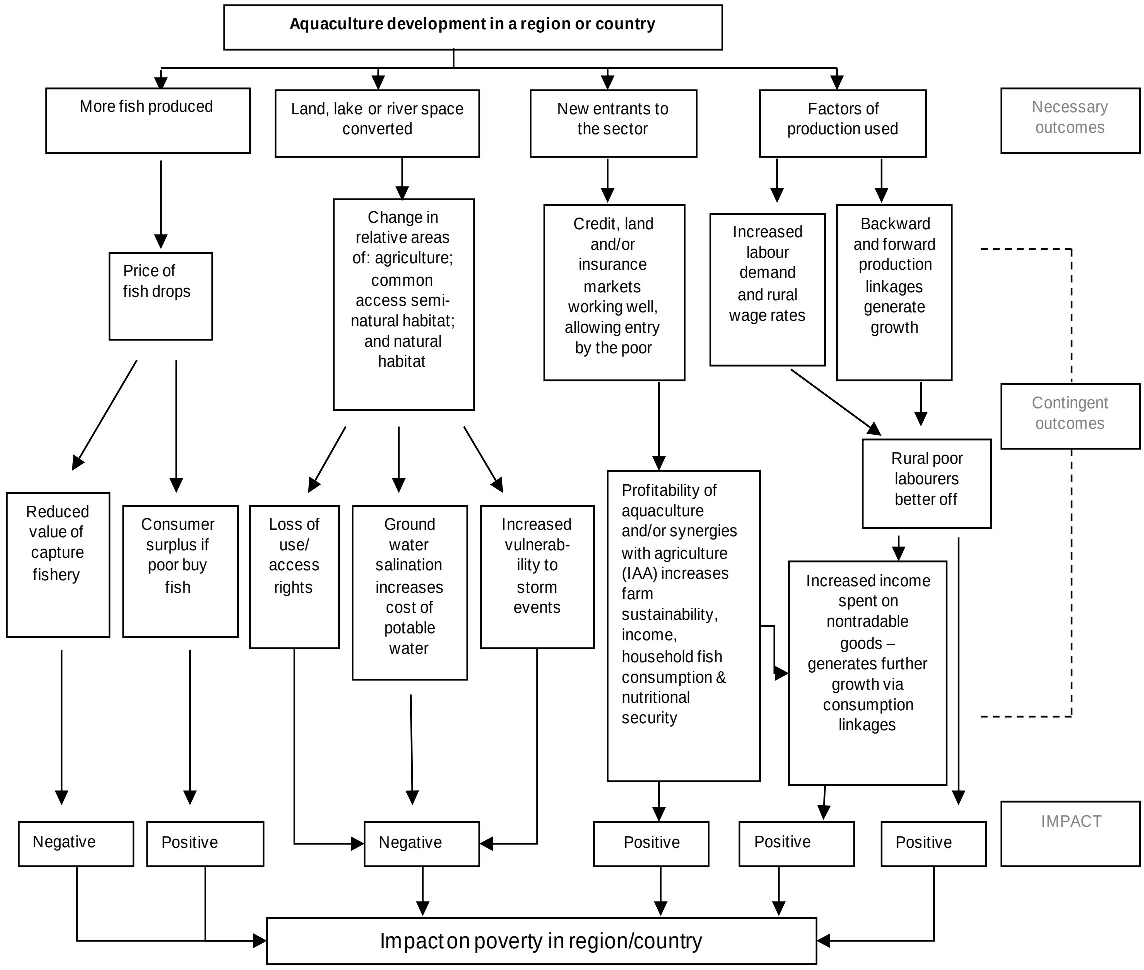
Indirect poverty impacts affect the welfare of the poor from aquaculture adoption by both poor and non-poor farmers. Aquaculture development increases fish supplies, potentially increasing the availability and lowering the price of fish in local and urban markets. This can benefit poor consumers including landless farm workers, smallholders, and the urban poor. As fish is a more nutrient efficient, and usually cheaper, protein source than livestock, it can be an important source of protein for the poor. Cost of living linkages can also occur when a significant portion of household incomes is spent on fish. Reduced fish prices will then lead to decreased household expenditure leaving more income to spend on local goods and services generating consumption linkages which can contribute to economic multiplier effects (discussed in more detail below). However, the extent of these benefits depends on the size of the market where production is sold and the type of fish produced. If output is sold locally in small and poorly integrated markets, price reductions could be large (benefiting consumers but not necessarily producers); however if production is exported, the country's poor will not benefit in terms of food security and cost of living linkages will not arise. Further, consumption benefits will only occur if the poor, either locally or nationally, consume the species produced by aquaculture. If only high-value species are farmed, it is unlikely these potential nutritional benefits will affect the poor (Irz et al., 2007a).

Aquaculture development can increase employment of the poor on farms, both full-time (e.g. farm managers or caretakers) and seasonal employment of unskilled labour (e.g. during harvesting). This could benefit the poor in countries with labour surpluses such as in Asia. Labour demand in many SSA countries is seasonal, especially in rural areas, and aquaculture enterprises can create new jobs, which may or may not be at times of peak agricultural labour demand, potentially decreasing seasonality in labour demand. Aquaculture can also potentially increase the marginal productivity of labour leading to higher wage rates, further benefiting the poor. However, large-scale operations can be capital intensive, not generating much unskilled employment. Therefore, the labour intensities of different aquaculture systems influence their relative potentials for poverty reduction (Irz et al., 2007).

Other potential indirect benefits include employment, wage and income effects on other sectors, and these could benefit the poor through production, consumption and other growth linkages (Haggblade et al., 1991). Production linkages include backward linkages from the farm in demanding inputs and services for aquaculture production, and forward linkages from the farm in demanding processing, storage, and transport of production. Consumption linkages arise when increased farm income is spent on other goods and services, often in the RNFE. These linkages enable initial increases in aquaculture production to stimulate growth in other sectors, producing an economic multiplier effect. Employment creation on aquaculture farms, related activities and other sectors in the economy could have positive impacts for a range of poor people including landless farm workers, net labour-selling smallholders and the rural non-agricultural and urban poor. Growth linkages are difficult to measure and have not been estimated for the aquaculture sector in developing countries. However there is a large theoretical and empirical literature on the effects of agricultural growth on the RNFE and most empirical studies have estimated large agricultural multipliers in SSA (Delgado et al., 1998; Irz et al., 2001, Haggblade et al., 2007a).

The conceptual relationship between aquaculture development and poverty, elaborated above, is illustrated in Figure 1 through impact pathways. A distinction is made between the necessary and contingent outcomes of aquaculture development on poverty with the latter dependent on the context (Stevenson and Irz, 2009).

Figure 1: Aquaculture poverty impact pathways



Source: Adapted from Stevenson and Irz (2009:294).

2.3 EMPIRICAL EVIDENCE

Few studies have analysed aquaculture's direct contribution to poverty and empirical evidence concerning aquaculture's indirect poverty effects is mixed. Most studies have focused on Asia and some on Latin America, and evidence from SSA is limited. There is a general view that aquaculture promotion in SSA has largely been unsuccessful (Harrison et al., 1994; Edwards and Demaine, 1997; Brummett et al., 2008), while in Asia, although small-scale commercial aquaculture has experienced significant growth, generally households with better resource bases have benefited rather than the poor (Halwart et al., 2002).

2.3.1 Income effects

Aquaculture can be a good income source for households in rural areas, although it is not usually the main source for most small farmers. In Bangladesh, Bouis (2000) found that aquaculture contributed 5 to 10 percent of household income. Also in Bangladesh, Jahan and Pemsl (2011) estimated the total income of IAA project households receiving training and extension support increased annually by approximately 8 percent over the 3 year project period compared to just less than 1 percent for non project households who did not receive support. This difference was due to increased farm and fish income. It was also found that at the end of the project aquaculture contributed just over 11 percent to total income for project farmers compared to just less than 8 percent for control farmers. In one of the few case studies from SSA which attempts to estimate a counterfactual, Dey et al. (2007) found that IAA adopting households had 1.5 times the income of non-adopters (US$254 and US$174 respectively), due mainly to differences in farm income and larger farm size of IAA farmers. IAA farmers' average farm income was US$185 (80% of total income), 1.8 times as much as non-IAA farmers' average of US$115 (66% of total income). 10 percent of IAA farmers' income was from aquaculture. Intensification of aquaculture technology can also generate higher incomes, for example Ahmed and Lorica (2002) report polyculture technology using more intensive feed and other inputs, popular in some Asian countries, provides a larger share of household income compared to traditional semi-intensive operations. Evidence from a 5 year WorldFish Center aquaculture project in Cameroon showed that average net profits of fish farms in peri-urban areas rose from US$150 to US$1500 over 5 years whereas those is rural areas rose from US$34 to US$213. One of the main reasons put forward by Brummett et al. (2011) for this difference was the positive impact of market access on the scale and intensity of fish production in peri-urban areas compared to rural areas. Combining aquaculture with other activities such as rice culture has also been found to increase incomes. The Adivasi Fisheries Project in Bangladesh helped to almost double profits within a year when fish and rice farming were integrated (WorldFish Center, 2009).

2.3.2 Employment effects

Aquaculture can reduce poverty through creating low skilled jobs that are accessible to the poor and can increase rural wage rates (Stevenson and Irz, 2009). However, compared to crop agriculture, labour use in aquaculture seems low. Ahmed and Lorica (2002) indicate most studies show aquaculture using very little labour, most of which is family labour. Ahmed et al. (1993) (cited in Ahmed and Lorica, 2002) found less than 1 percent of total hired labour employed by pond operators/owners in Bangladesh was used for aquaculture. Brummett et al. (2008) also report large-scale aquaculture production systems in SSA are not highly labour intensive requiring between 0.05 and 0.1 person-years per tonne of fish produced. However other studies suggest aquaculture requires higher amounts of labour. Ahmed and Lorica (2002) report that hired labour can be common for smallholder aquaculture; for example, in the Mekong Delta of Vietnam, hired labour cost accounted for nearly 37 percent of labour costs. Shrimp farms in Brazil are estimated to generate higher labour demand than agriculture (Costa and Sampaio, 2004) while shrimp mariculture in Honduras is estimated to generate 100-150 person days per hectare per year (Stanley, 2003). Stevenson (2006) cited by Stevenson and Irz, 2009 shows labour intensity of aquaculture production varies substantially across farm types in the Philippines, estimating mean demand for hired labour on low-input systems at 211.5 person days per hectare per year, four times the estimate for larger farms. In a related study, Irz et al. (2007) found income from aquaculture activities (mainly from employment on aquaculture farms) in the Philippines benefited the poor disproportionately and reduced inequality. Hishamunda and Ridler (2006) suggest employment generation varies with the intensity of production technology, estimating extensive aquaculture in SSA has the same labour-land ratio as rice farming while intensive aquaculture uses three times more labour per hectare. There is also some evidence suggesting labour and land productivity is higher for aquaculture resulting in higher wage rates than agriculture. For example in Malawi, productivity of family labour in IAA activities was found to be higher than in off-farm activities (Dey et al., 2007). In Mexico, Singh (1999) (cited in Stevenson and Irz, 2009) estimated that the lowest grade of shrimp farm employee earned 1.22 times the average annual income in 1996. Direct employment generation from aquaculture therefore seems to vary with technology and farm size and in some cases labour use and wage rates are higher than those generated by alternative activities and will likely vary by context. The evidence is mixed and so far, aquaculture's impact on wages and labour markets in SSA has not been studied in depth.

Aquaculture generates indirect employment through backward linkages (e.g. to hatcheries and feed suppliers) and forward linkages (e.g. to harvesting, post-harvest handling, processing and marketing activities) which could generate important employment opportunities for the poor depending on the degree to which aquaculture is integrated into the local economy. Empirical evidence is again limited and mixed. Costa and Sampaio (2004) estimated indirect employment generation from shrimp farming in Brazil at 1.86 jobs per hectare, similar to direct employment generation. However Stanley (2003) estimated 0.25 full-time equivalent jobs per hectare generated indirectly from shrimp production in Honduras. Stevenson (2006) also estimated low off-farm employment generation by aquaculture production in the Philippines, with inputs accounting for 11 percent of total labour demand (260 person days per hectare per year) and processing accounting for 10 percent.

A related aspect of aquaculture's impact on poverty through employment creation concerns the role of women. While poverty affects households as a whole, due to the gender division of labour and their responsibilities for household welfare, women often bear a disproportionate burden. Poverty is particularly acute for women living in rural households who represent up to 70 percent of the rural poor (IFAD, 1998) especially where they are household heads. Women often carry most of the responsibility for household food security. Women play an important role in processing and marketing of agricultural goods. The extent of women's participation in aquaculture production and value chains has been estimated to be relatively high. According to Weeratunge and Snyder's 2009 review of the literature on gender and fisheries/aquaculture, women's participation in aquaculture is higher than in the fisheries sector. This is especially true in Southeast Asia, where women's engagement in the aquaculture sector ranges from 42-80 percent in Indonesia and Vietnam, and in the Tonle Sap Lake in Cambodia, women's participation in fish culture is 50 percent and as high as 85 percent in buying and selling (Weeratunge and Snyder, 2009:5). However they suggest there is room for increasing the engagement of women through better extension services, innovation policies and institutional practices directed at women especially in South Asia and Africa where promotion of aquaculture as a development strategy for women has been partially based on the perception that it is an extension of women's domestic activities to be coordinated with housework and child care (Weeratunge and Snyder, 2009:5). However it may not always be appropriate or beneficial for women to increase their engagement in new activities such as aquaculture as women already have heavier time burdens than men due to their simultaneous productive, reproductive and community roles. Women's multiple roles can limit the benefits of development interventions unless specifically targeted to them and due consideration is given to their specific situations, roles and responsibilities and the context in which they operate.

2.3.3 Consumption effects

Production of low-value fish within extensive or semi-intensive systems has supplied large quantities of affordable fish for home consumption and domestic markets (Prein and Ahmed, 2000). Much of the literature reports an increase in household consumption of fish for those who invest in pond-based aquaculture or in IAA systems (Prein and Ahmed, 2000). Evidence from Asia suggests aquaculture can significantly affect direct fish consumption. Dey et al. (2000) found in countries where aquaculture constituted a large proportion of national fish production and smallholder production dominated (e.g. China, Vietnam and Bangladesh), per capita fish consumption was significantly higher for fish-producing households than non-producing households and the national average. In India, Kumar and Dey (2006) cited in Kawarazuka and Béné (2010) found the energy intake of households that own fish ponds to be nearly 11 percent higher than that of households with wage earners but no ponds, and that the undernourished population was 10 percent lower among fish pond owners than in the comparison group. Dey et al. (2007) found that following IAA introduction in Malawi, IAA households consumed fresh fish and other animal protein more frequently than non IAA households. However no significant difference was found in the nutritional status of children under five, although this is a more long-term impact. Most studies assume increased production and accessibility of fish to the poor will lead to greater consumption, with resultant benefits to nutrition and livelihoods. Direct measurements of the nutritional impact of aquaculture are rarely conducted, although a recent study in Zomba, Malawi (Aiga et al., 2009) found that the prevalence of malnutrition among children was lower in fish farming households compared to non-fish farming households. The authors suggest that fish farming may have indirectly contributed to this result by increasing household purchasing power and enabling increased consumption of fats and oils though also cautioning that the causes of malnutrition are likely to be more complex.

Not all studies show that aquaculture is associated with increased household consumption and food security. Ahmed et al. (1993) suggest that due to the low productivity and small fish ponds in some fish eating countries, total on-farm production may not be enough to meet household consumption requirements. They highlight fish farming households in Bangladesh that still purchased 68-78 percent of their per capita fish requirement. Other studies show that fish farming households do not necessarily show any increase in their fish consumption for example, Roos et al. (2003) found no difference in total fish consumption between households engaged in domestic aquaculture production and non fish producing households in Kishoreganji district, Bangladesh from 1997 to 1998. Fish bought in the local markets and wild captured fish was found to represent over 90 percent of the total fish consumed by both groups. Kawarazuka and Béné (2010) suggest that one reason aquaculture may not increase household fish consumption is that farmed fish are not usually the same species as wild caught fish and are often seen as a cash crop rather than a food crop, produced to supply higher value markets. Income from sale of farmed fish is also not necessarily used to buy smaller, cheaper fish for home consumption.

In terms of indirect consumption effects on poor consumers, in theory aquaculture development could increase the consumption of protein by poor consumers due to decreases in the price of fish and other substitute protein sources like beans and wild-caught fish. Cost of living linkages will also arise if adoption of fish farming increases fish supply in the local market so prices fall, real incomes rise and are spent on local goods and services. Fish prices and household incomes are important determinants of fish consumption and fish tend to have high income elasticities of demand (i.e. fish consumption rises rapidly with income), and high price elasticities of demand (i.e. fish consumption rises as price decreases). Dey (2000a) showed price-elastic demands for species such as carp and tilapia in India, Bangladesh, Thailand and Philippines. Evidence suggests most high-value products like shrimp have higher price elasticities of demand and low-value products have lower price elasticities (Ahmed and Lorica, 2002:132). The effect of price decreases on consumers differs between countries, areas, income groups and types of product. Dey (2000b) disaggregated fish demand by species and income groups for urban and rural areas in Bangladesh finding that price and income elasticities of demand varied across species and income groups between urban and rural areas but that overall demand for fish was price elastic. Garcia et al. (2005) found price elasticity of demand for tilapia and milk-fish in the Philippines was high for lower income groups, suggesting a price reduction would increase consumption by the poor. Studies have also estimated price and income elasticities of fish, rice (as a complementary good) and meat (as a substitute good) in Asian countries showing higher price and income elasticities of demand for fish, suggesting that as disposable income and market supply of fish increases, fish demand will increase at a higher rate than demand for staple goods and meat (Ahmed and Lorica, 2002:132). Dey (2000a) also estimated that adopting improved tilapia would reduce tilapia prices by between 5 and 16 percent in Bangladesh, Philippines, Thailand, China and Vietnam leading to increased fish consumption. Even if demand for fish is price inelastic and a price reduction does not necessarily increase demand, there would still be a positive effect on consumers in terms of increased consumer surplus and real income.

Despite these potential positive effects on poor consumers, there is also the possibility that lower fish prices could reduce income for poor fishermen. In countries where capture fisheries is an important livelihood for poor people, and where the majority of consumers are either concentrated in urban areas or are not poor, a price reduction of fish and fisheries products due to aquaculture development may have negative impacts on the poor. As noted by Stevenson and Irz (2009) however, this may not happen if wild and farmed fish are sold in separate markets. For example, Garcia et al. (2005) found cross-price elasticities of demand for farmed species and wild-caught fish in the Philippines to be very low implying lower prices for farmed fish would not lead to a large decrease in the price of wild-caught fish, limiting the impact on poor fishermen.

Despite the results of these studies showing that a decrease in fish price would increase demand for fish, there is little evidence in the literature to show that aquaculture development does actually reduce fish prices and so benefit poor consumers. As discussed by Kawarazuka and Béné (2010), the extremely limited literature on this shows that reality is more complex than the theory suggests. They conclude that many factors interact with market dynamics to either support or weaken the effect of increased farmed fish supply on the market price so the impact on poor consumers is unclear. The overall effect is complicated by the economic interactions between aquaculture and wild fisheries at the local level which have not been studied in the literature (and are beyond the scope of this thesis).

2.3.4 Multiplier effects

Aquaculture can potentially stimulate growth in other sectors via economic growth linkages producing an economic multiplier effect. When aquacultural incomes are spent on nontradable goods and services (those produced and consumed locally and not imported or exported to or from the area) consumption linkages stimulate further demand for local industry and services. Demand for local services, housing, durables and high-value agricultural products such as horticulture and livestock rise faster than demand for food grains when incomes rise, stimulating the RNFE.

Consumption linkages have been found to be the most important types of growth linkages, especially in SSA. However the marginal budget share (MBS) for non-food items (an important determinant of consumption linkages to the RNFE) in SSA is lower than in Asia with studies showing African consumers spending approximately half the percentage of Asian consumers of extra income on locally produced non-food items. African consumers spend more of their average and marginal income on rurally produced foods while Asian consumers have better access to rural towns due to better transport networks[6] (Haggblade et al., 1989).

Production linkages consist of backward and forward linkages. A sector's backward linkage is its relationship with the rest of the economy through direct and indirect purchases from other sectors. The type and size of backward linkages depend on factors such as agricultural technology, size of land holding, type of commodity and whether production is rain fed or irrigated (Haggblade et al., 1989). In SSA, backward linkages are weaker than in Asia due to lower levels of mechanical input use and construction and maintenance associated with Asian irrigated agriculture (Haggblade et al., 1989). In aquaculture in SSA, feed has been estimated to represent 60-65 percent of variable costs and 45-63 percent of total costs (Hishamunda and Manning, 2002). As aquaculture develops, feed and seed, the two major inputs that often depend on imports, are increasingly supplied by local producers, indicating the growing importance of backward linkages from aquaculture (Hishamunda et al., 2009). A sector's forward linkages represent its relationship with the rest of the economy through its direct and indirect sales to other sectors. Food processing and distribution of agricultural products seem to generate the largest forward linkages in rural economies (Haggblade et al., 1989). The availability of local resources and excess capacity (e.g. labour and capital) and a favourable investment climate facilitate a supply response from other sectors, critical for realising such links (World Bank, 2007).

[6] Haggblade et al. (1989) have cautioned that African linkages may be underestimated due to the high share of non marketed goods and services in total consumption which are thus not measured.

Factor market linkages include labour and capital flows. Seasonality of agricultural labour demand means labour availability in the RNFE increases when agricultural labour demand decreases and vice versa resulting in seasonal labour flows between the two sectors. Haggblade et al. (1989) estimate 20-40 percent of the rural labour force in SSA work in both farm and nonfarm activities. Increasing labour productivity can also lead to rising rural wage rates spreading benefits to labouring households in other sectors. Capital or investment linkages occur when increased agricultural income is saved and used to finance nonfarm investment, reducing vulnerability and increasing productivity of local activities and potential elasticity of supply responses crucial to consumption linkages. Evidence from Kenya and Sierra Leone suggests agricultural surpluses account for 15-40 percent of nonfarm investment funds (Haggblade et al., 1989)

Agricultural multiplier effects differ depending on a country's economic structure. Small economies with large tradable sectors (tradables being goods and services that are imported or exported to or from the area) have smaller multipliers than large economies with a high share of nontradable agriculture and services (Haggblade et al., 1989). Empirical evidence confirms these multipliers from agriculture, although results are mixed. No studies have estimated multipliers from aquaculture. Estimating agricultural multipliers is difficult as time-series evidence from countries with fast-growing agriculture cannot isolate the impact of agriculture from the many other changes occurring. Most attempts at quantifying multipliers rely on models based on strong behavioural assumptions (Haggblade et al., 1989).

Delgado et al. (1998) estimated average agricultural multipliers in SSA to be over 2.0[7] (i.e. $1.00 of initial growth in rural agricultural incomes leads to an additional $1.00 or more of income from production in rural nontradables) implying the overall benefit of boosting rural incomes (e.g. from additional

[7] The study found adding US$1.00 of new farm income could increase total income in the local economy beyond the initial US$1.00 by an additional US$1.88 in Burkina Faso, US$1.48 in Zambia, US$1.24 to US$1.48 in two locations in Senegal, and US$0.96 in Niger.

exports) is twice as high as the immediate return from the activity promoted in the first place. The study used a fixed-price multiplier model which assumed a perfectly elastic supply of nontradable goods and services (due to underemployed rural resources), meaning increased demand from higher agricultural incomes would not increase prices and reduce the full multiplier effect. The assumption that the supply of nontradable goods and services is perfectly elastic is a stong assumption however, thus estimates from fixed-price multiplier models are upper limits and can potentially overestimate multipliers by up to 30 percent.

In a review of multipliers in developing countries, Haggblade et al. (2007a) suggest agricultural multipliers in SSA range from 1.3 to 1.5, accounting for the wide range of multiplier estimates from different countries using different methods. They note the majority of empirical studies estimate consumption spending accounts for approximately 80 percent of agricultural demand linkages while backward and forward production linkages account for the remainder. Hishamunda and Ridler (2006) suggest the total direct and indirect impact of aquaculture in SSA is likely to approximate that of horticulture, noting the small size of the horticulture and aquaculture sectors prevent them from eliminating poverty in the continent. Diao et al. (2003) estimated multiplier effects of productivity growth in a number of agricultural and non agricultural sectors in SSA using a computable general equilibrium (CGE) model and found that horticulture had the smallest multiplier effect of all the sectors. However, drawing on McCulloch and Ota’s 2002 assessment of the poverty impact of export horticulture in Kenya, Diao et al. (2003) argue that despite its low multiplier effect on national income, horticulture still impacts poverty by generating employment on the major export farms and enabling small-scale horticulture farmers to access credit and extension services. McCulloch and Ota (2002) found households involved in export horticulture were much better off than non-horticultural smallholders in similar circumstances thus while at the national level the impact of horticulture is likely to be small, the impact on poverty and food security at the household level can still be significant in particular communities due to local multiplier effects. By highlighting the role of increased access to credit and extension services in benefiting small-holder horticulture farmers, Diao et al. (2003) show that linkages other than consumption and production linkages, namely institutional and service linkages, are also important in generating multiplier effects but are not included in economic models. The role of service and institutional linkages is examined further below.

Hishamunda and Ridler (2006) note the importance of externalities, i.e. effects that can be attributed to a sector, but are not part of the balance sheet of farms. They illustrate this with a stylised example of an aquaculture sector with a dualistic structure comprising a few advanced commercial operations and many artisanal farms, similar to the aquaculture sector in many SSA countries. The advanced farms may produce positive externalities, stimulating a 'vent for surplus' and a movement along the learning curve for the artisanal farmers (as with horticulture). The result is a dynamic cumulative impact on the sector that spreads throughout the economy. Shops opening near fish farms to sell produce to workers, or transferable skills from training of workers on farms are positive externalities. Alternatively advanced farms could be 'enclaves' with few external benefits and even some negative externalities such as environmental degradation. These externalities, shown in Table 2 below, are part of aquaculture's total impact.

Overall, growth linkages are likely to be most beneficial for the poor when direct effects of increased production are equitably distributed, as poor consumers tend to demand more local and labour-intensive goods than richer consumers. Growth linkages are also stronger when agricultural income is a high proportion of household income, initial asset distribution is relatively equitable, and economic capacity is underutilised (Hazell and Haggblade, 1993).

Table 2: Linkages and externalities arising from aquaculture

Linkages	Large positive externalities, 'vent for surplus'	Few positive externalities, 'enclave'
Production:		
Direct	High value added (local content)	Low value added
Backward	Local/national inputs (feed etc.)	Imported inputs
Forward	Processing	Exported unprocessed goods
Consumption	High spending, particularly on nontradable goods	(Expatriate) workers spend on imported goods
	High proportion of unskilled labour	High capital labour ratio
Investment	Ownership is local and reinvestment occurs	Foreign ownership and profits are repatriated
Human capital	Training is available/encouraged Skills transferable to other sectors	Labour is imported Highly specialised skills required
Secondary	Infrastructure (roads, schools, health clinics) built either by the companies or by the state	No infrastructure built Social disruption Environmental degradation

Source: Hishamunda and Ridler (2006:408).

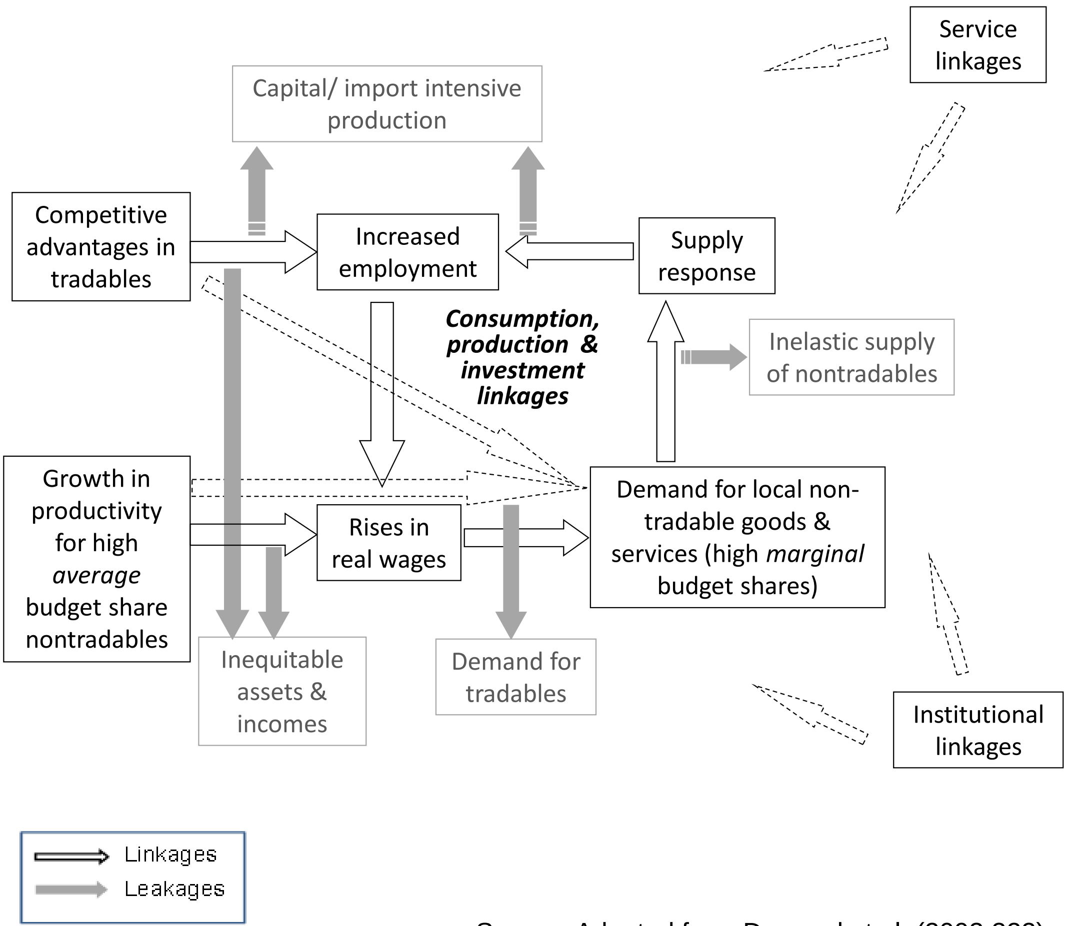
While Table 2 outlines a wide range of growth linkages arising from aquaculture, and does note secondary linkages, it does not include all service and institutional linkages which were shown by Diao et al. (2003) to be important in the effect of horticulture sector growth on overall economic growth. Service and institutional linkages are potentially very important (Paz, et al., 2006). Increasing trade flows may lead to improvements in local services particularly communications (e.g. telecommunications and transport services), increased investment in infrastructure such as roads, and reduced unit costs for service provision due to increased demand. These improvements may also increase the amount of tradables in the local economy, reducing local beneficial effects and increasing leakages. There is some evidence of beneficial service linkages from aquaculture, for example the Aqualma project in Madagascar contributed US$1.6 million in roads, utilities, communications, housing and amenities to the local economy, and Kafue Fish Farms in Zambia contributed to local road construction (Hishamunda et al., 2009).

Institutional linkages arise when increased agricultural production changes institutions, for example rules governing land ownership, water rights, or the relationship between producers and buyers. These changes can be beneficial or damaging to different groups and potentially affect the growth of different sectors and livelihoods of the poor. The effects of both service and institutional linkages are overlooked in conventional economic input-output growth linkage studies.

2.3.5 Linkages and pro-poor economic growth

Figure 2 illustrates the role of linkages and leakages in a rural economy.

Figure 2: Linkages and leakages in a local economy



Source: Adapted from Dorward et al. (2003:322)

For rural economic growth to occur, increased production of tradable commodities and increased productivity of nontradable goods with high average budget shares (ABS) is important. As tradable commodity prices are not established locally, increased supply does not reduce prices and increases producers' revenue. As nontradable commodity prices are determined locally, increased supply (when demand is constant) reduces prices, which will not necessarily increase producers' incomes. However if nontradable goods are widely consumed with high ABS (e.g. staple foods in poor areas) reduced prices will increase consumers' real incomes. Figure 2 shows how increases in real incomes of producers and consumers lead to increased demand for local nontradables via consumption, production and investment linkages, generating local employment opportunities, raising incomes further and contributing to a 'virtuous circle', multiplying the benefits of the original income gains (Dorward et al., 2003). Increased trade flows may also lead to service and institutional linkages which can further support this virtuous circle.

The local multiplier effect will be limited by 'leakages'. If extra income is spent on tradables the stimulus to local demand decreases. If local supply of nontradables cannot respond to increased demand due to lack of labour or capital, or poor market development and high transaction costs, prices will rise, off-setting consumers' increased incomes. Employment and wage gains will also be reduced if production systems are capital or import intensive or benefit only a limited number of local people (Dorward et al., 2003). Leakages may also arise if returns to local savings and investment are low, due to lack of secure investment opportunities or if effective financial markets link the local economy with other economies.

Understanding linkages and leakages helps understand markets and activities that will have wider indirect positive impacts on the livelihoods and opportunities of the poor. Dorward et al. (2003) argue that in many poorer areas, increasing productivity of farm activities has greater potential for stimulating poverty-reducing growth, whereas increased productivity of nonfarm activities and nontradable agricultural commodities with high MBS will support secondary, consumption linkage-dependent poverty-reducing growth, particularly if the activities have low barriers to entry and high labour demands. Delgado et al. (1998) also note that improved production response of nontradables is important to maximise benefits from consumption linkages. This suggests the importance of considering changes in the context of a wider livelihoods perspective, which is explored in Section 2.5 below.

2.3.6 Environmental effects

Potential negative impacts of aquaculture include detrimental environmental and ecological effects (see Hall et al., 2011 for a review and analysis of environmental impacts of different aquaculture systems). These effects can impact on capture fisheries, affecting poor artisanal fishermen due to: habitat modification e.g. mangrove loss; use of wild seed to stock aquaculture ponds; food web interactions e.g. overexploitation of small pelagics for fishmeal; introduction of non-indigenous organisms leading to hybridisation of farmed stocks with wild, causing genetic pollution through loss of adaptive traits; and effluent discharge which can cause problems in coastal areas (Naylor et al., 2000). Linking these potential ecological impacts to the livelihoods of poor fishermen has, however, not been established convincingly in the literature.

2.3.7 Direct and indirect effects

The previous sections have shown that there is a wide range of direct and indirect ways through which aquaculture can impact on poverty. However, the relative importance of these impact pathways and the type of growth strategy which will maximise indirect effects via growth linkages has not been explored in the literature on aquaculture development. In agriculture, there has been a debate amongst development economists about the relative importance of the direct and indirect effects of changes in technology on reducing poverty with implications for the target groups of research and policies. For example Alston et al. (1995) argue technology’s main benefit is increasing food supply and lowering prices. Thus they suggest research should focus on maximising output, most likely to be achieved by focusing on larger farmers in more productive areas, leaving the issue of poverty reduction of smallholders to other interventions. Others like Fan and Hazell (2002) argue that direct effects are the most important for poverty alleviation and attention should be focused on resource poor farmers in marginal areas where research has been minimal.

Empirical evidence suggests the strength of agricultural growth linkages depends on a range of conditioning factors. Due to the strength of consumption linkages, consumption preferences of the farmers receiving the initial income boost and their propensity to consume local goods as opposed to imports, are extremely important to the spatial distribution of indirect income gains (Haggblade et al., 2007a:169). Many studies have tried to identify the farmer groups that offer the strongest local consumption linkages. Mellor and Lele (1972) looked at MBS by rural expenditure deciles in India and found higher-income rural people and the dominant cultivator class generated the largest consumption linkages. Hazell and Roell (1983) analysed MBS by farm size in Malaysia and Nigeria and found larger farmers (or according to them medium-sized farmers by most standards) generated the largest consumption linkages.

In a review of the linkage literature, Tomich et al. (1995) suggest small farmers generate the strongest consumption linkages. Many others have also supported a small-farm focus in agriculture-led growth, which Mellor and Johnston (1984) referred to as a 'unimodal' growth strategy. However the term unimodal seems to cover a wide range of farm sizes and types of consumers, leading to confusion. Haggblade et al. (2007a:169) suggest this is partly due to differing farm sizes in different parts of the world and because consumption data is often collected by expenditure class rather than farm size, and these classes do not necessarily correspond. They suggest that ultimately farmers who consume locally produced goods and services and send their children to school locally produce the largest rural consumption linkages. Thus the targeting of different categories of farmers will have important implications for the size and nature of nonfarm spinoffs arising from agricultural (and aquaculture) growth (Haggblade et al., 2007a).

Moehl et al. (2006) suggest that to maximise aquaculture's impact on poverty in SSA, focus should be placed on SMEs. They argue SMEs are the most effective economic growth engines with the highest potential to maximise poverty impacts of aquaculture development, implying indirect effects are more important than direct effects. Brummett et al. (2008) also support this argument noting that although small-scale semi-intensive aquaculture systems can create important direct benefits for poor producers such as increased household food security, artisanal farmers create little or no economic growth as they generate minimal cash revenues and little liquid capital for reinvestment and expansion, unlike SMEs. They also suggest large-scale systems have relatively less economic impact and tend to concentrate wealth more than would a larger number of smaller-scale investments. Thus they argue for a stronger focus on the growth of a SME aquaculture sector that can make the most of the secondary economic opportunities created through the aquaculture value chain and maximise the impact of growth linkages and employment opportunities on the poor. These views represent an emerging paradigm in aquaculture development of shifting support from small-scale artisanal farming to larger more commercial SMEs, explored below.

2.4 THE EMERGING PARADIGM IN AQUACULTURE DEVELOPMENT

A number of authors (Moehl et al., 2006; Brummett et al., 2008; Little et al., 2012) have highlighted the failure of aid over the past few decades to develop the aquaculture sector in SSA. Moehl et al. (2006) present a detailed summary of donor support of aquaculture in SSA from the 1980s onwards. They indicate that much of this support was focused on family fishponds and in some cases larger commercial scale farms. From 1980 to the mid 1990s aid was directed to institutional support and capacity building, subsidising existing national government aquaculture activities, building infrastructure such as hatcheries and government stations, and supporting the Training and Visit system (a popular model for extension at the time but now widely regarded as ineffective, inefficient and unsustainable (Anderson and Feder, 2004)). However by the end of the 1980s many of the larger farms had folded while small-scale production continued, albeit heavily subsidised. Donors became disappointed by the apparent failure of small-scale aquaculture to meet often unrealistic expectations of increased food security and economic growth and by the mid 1990s donor support was at its lowest (Moehl et al., 2006).

Brummett et al. (2008) indicate that aquaculture support to SSA was poorly managed for example, much of the aid was invested in infrastructure which failed to perform thus did not create positive or sustainable outcomes. Beveridge et al. (2010) suggest that the relative failure of African aquaculture compared to Asia, was due to factors such as the different market conditions between the two and also the focus on smallholder aquaculture in SSA driven by external support. Like Brummett et al. (2008) they note that small-scale aquaculture may have had some positive community level impacts, but did not lead to growth in national fish production. Belton and Little (2011:476) contend that there were three main conditions that contributed to the growth of commercial aquaculture in South East Asia: high demand for aquaculture products; readily available factors of production to enable supply to meet the demand: and the development of infrastructure, networks and governance needed for export, to deliver products to market. They argue that these three conditions are in fact related to the status of general economic development and the policies that have the greatest effect on aquaculture are those which are not specific to the sector but are rather geared towards general development in the areas of trade and investment. Thus it could be suggested that the relative failure of the aquaculture sector to develop in SSA is not due simply to the misdirecting of aid to the wrong type of farmer, but due to a range of other factors, not all specific to the sector, such as unfavourable market, infrastructure and governance conditions along with mismanaged aid. It could also be hypothesised that demand for fish is unlikely to pick up until labour productivity in staple food production and hence real incomes rise and stimulate demand for fish.

By the end of the 1990s private sector investment in aquaculture in some SSA countries had again been established and, driven by increasing urban demand for aquatic products, has been growing ever since (Moehl et al., 2006). However the focus on small-scale farmers of past decades and the underlying assumption that smallholder aquaculture development has more potential to reduce poverty than the indirect poverty impacts generated by larger commercial farms through employment and economic growth is being challenged in the light of past experience. There is a drive to move beyond support to small-scale artisanal farming to more commercial forms of aquaculture. Moehl et al. (2006) argue for a shift from 'non commercial' to 'commercial' aquaculture, defining 'non commercial' aquaculture as 'farm ponds' i.e. farmers with ponds. These farmers view aquaculture as one component of a diversified farming system which serves to reduce risk, improve farm sustainability and act as a 'bank' or store of wealth like livestock, and do not run their aquaculture operations as a business. 'Commercial' farmers are those who are primarily fish farmers of any scale but who manage their fish farm as a business with profit being the primary goal. As noted above, Brummett et al. (2008) argue that due to the limited potential for economic growth from dispersed small-scale rural farmers, support should focus on developing the SME sector and associated value chains if aquaculture's potential in SSA is to be realised. Little et al. (2012) highlight the emerging consensus supporting a shift away from the 'small-farm first' paradigm based on research from the past decade which supports the hypothesis that commercially oriented 'quasi capitalist' aquaculture has more potential to impact on poverty through employment generation in the value chain compared to the potential benefits from small-scale artisanal or 'non commercial' 'quasi peasant' aquaculture (Belton et al., 2012). They note that the poor mostly do not benefit directly from rural aquaculture as generally, they are not producers, rather they benefit indirectly through employment on-farm and along the value chain. Beveridge et al. (2010) also agree that more commercial SMEs are better able to impact on food security and generate employment throughout the value chain especially where there is strong and accessible market demand. They do however still see a role for small-scale aquaculture which they suggest may not impact on national fish production, but should be supported where it provides a viable crop alternative for improving livelihoods.

Despite this emerging consensus, aquaculture SMEs do not appear to have received much attention from African governments or international donors as they are not perceived to represent the poor (Brummett et al., 2008). This could also partly be because a strong case, supported by empirical evidence and rigorous assessment of the relative importance of direct and indirect poverty impact pathways of different types of aquaculture development in SSA, has yet to be made. As noted above, empirical evidence on the direct impact of aquaculture on poverty in SSA is limited and the actual and potential contributions of aquaculture to poor people's livelihoods in SSA have not been fully assessed. There is inadequate documented evidence of direct poverty reducing impacts of aquaculture, especially studies with rigorous counterfactuals which can overcome the attribution problem and establish causality, let alone of the indirect effects and the strength of multiplier effects of SME development. Overall the existing empirical evidence is mixed, indicating the contribution of aquaculture to poverty alleviation and economic growth is highly context specific.

The range of contextual factors on which the relative importance of the various 'contingent' direct and indirect effects of aquaculture on poverty is likely to depend, include the distribution of poverty between rural and urban areas, market structure, agrarian structure, infrastructural and institutional development, geographic concentration of the poor, economic policies, and the extent to which aquaculture products are important in incomes of poor producers or expenditures of poor consumers (Byerlee, 2000). The extent to which aquaculture growth will stimulate growth in other sectors depends on a variety of structural features of the rural economy. Haggblade et al., (2007a:171) suggest the following 'conditioners' that strengthen linkages:

- entrepreneurial and technical skills to enable a supply response from the RNFE
- good rural infrastructure to facilitate communication, transport and credit flows and improve the responsiveness of the RNFE to increases in demand
- increasing population density favouring local production enabling minimum efficient scales of production to be reached more easily,

reducing transport costs and improving supply response from the RNFE

- a policy environment that supports RNFE enterprise growth
- a high marginal propensity to purchase non foods (this increases with average per capita income levels).

Conceptualising and measuring direct and indirect impacts of aquaculture development on poverty and pro-poor economic growth, and assessing how these impacts could be maximised, is necessary if aquaculture is to effectively reduce poverty. Detailed analysis is required to understand how the nature of the aquaculture system adopted, the structure of poverty, and the economic and institutional context, influence aquaculture's impact on different groups (de Janvry and Sadoulet, 2002).

The preceding review of the literature on aquaculture's impact on poverty has highlighted its limited nature, especially in the literature relating to SSA. Few studies have conducted detailed analyses of aquaculture's direct contribution to poverty and the evidence concerning aquaculture's indirect poverty effects is limited and inconclusive. Some of aquaculture's important potential impacts, such as the economic multiplier effects arising from different types of aquaculture development, have barely been studied. In order to further explore ways in which to examine the full range of potential impacts of aquaculture on poverty, the following sections of this chapter investigate some aspects of the broader literature on rural development and poverty, specifically relating to livelihood enhancement and institutional development. These distinct but related sets of literature help to inform the ways in which aquaculture's impact on poverty is conceptualised and investigated in this thesis. Consideration of findings from both the aquaculture and agriculture sectors also assists in the development of hypotheses on what the poverty impacts of aquaculture might be (presented in Section 2.7.2).

2.5 A LIVELIHOODS PERSPECTIVE

Livelihoods perspectives represent an important way in which to examine complex rural development questions, such as those related to aquaculture's actual and potential impact on poverty and the institutions required for pro-poor aquaculture development. Amongst other things livelihoods perspectives allow a holistic understanding of poverty to be used, incorporating more than the conventional income and consumption based approaches found in much of the aquaculture and poverty literature. Perceptions about poverty have changed over the past decades to more multidimensional understandings, focusing on aspects of poverty that are important to poor people themselves. Apart from low income, poverty can include food insecurity, social inferiority and exclusion, lack of assets and vulnerability (La Rovere and Dixon, 2007). Well-being is an important concept for understanding poverty and refers to quality of life which includes the full spectrum of human experience: social, mental, spiritual and material. Each individual may define well-being differently and Chambers (1997) argues that well-being for all is the objective of development. Two basic components of well-being are secure livelihoods to meet basic needs, and realising and expanding one's capabilities to achieve fulfilment (Sen, 1981, 1993; Chambers, 1997; Kerr and Kolavalli, 1999). Findings of the World Bank's participatory poverty assessments in different countries indicate that poor people consider poverty as ill-being, in terms of factors such as vulnerability, physical and social isolation, lack of security, lack of self-respect, powerlessness and lack of dignity (Kerr and Kolavalli, 1999; Narayan et al., 2000; World Bank, 2002). Vulnerability, which is related to risk, is an important concept in understanding poverty. People are vulnerable to poverty when they face risks at different levels. At the household level this could be illness, at the community or wider level risk could be related to weather, and at the national level risks could be related to policy changes affecting costs of inputs or outputs. Concepts such as vulnerability, social exclusion and empowerment are all part of this multidimensional view of poverty and should be kept in mind when assessing impacts of policies, technology change and development interventions on poverty alleviation.

This broader understanding of poverty has contributed to the emergence of ‘livelihoods’ as a way of conceptualising the multiple economic activities poor people undertake, defined as ‘the capabilities, assets (both material and social resources), and activities required for a means of living’ (DfID, 1999). A livelihood is sustainable when ‘it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base’ (DfID, 1999) (this definition is based on a paper by Chambers and Conway in 1992). The Sustainable Livelihoods Framework (SLF) (Carney, 1998) has been widely used for over a decade to analyse the causes of poverty, peoples’ access to resources and their diverse livelihoods activities, strategies and outcomes.

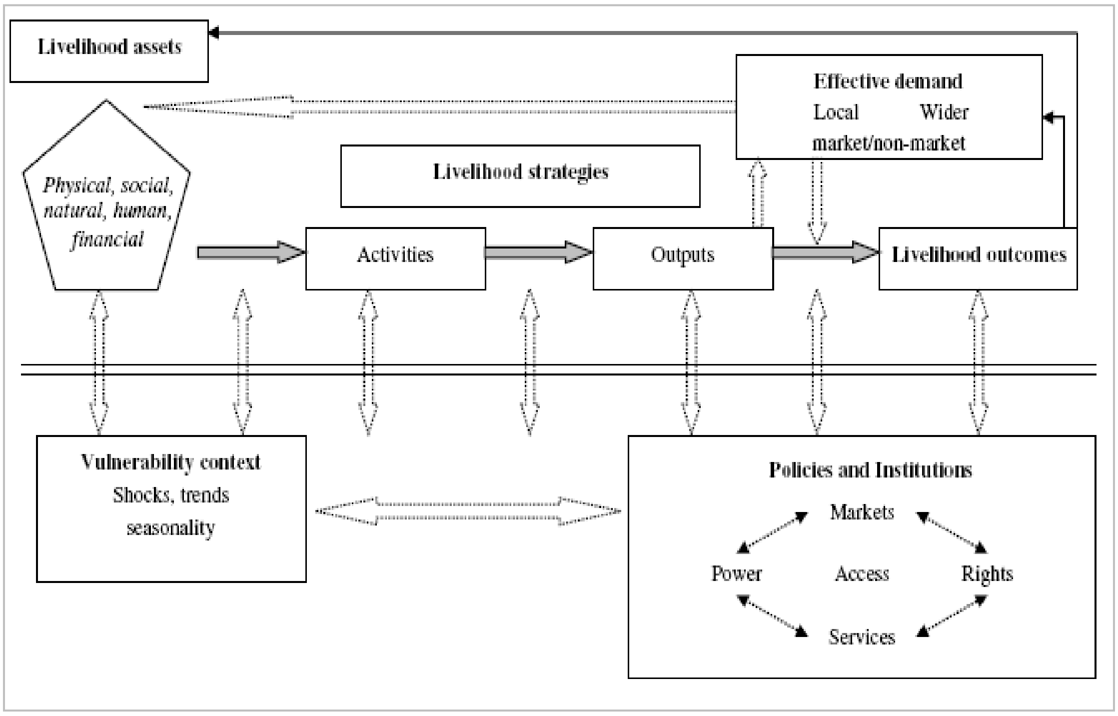
There are a number of sustainable livelihoods frameworks that take an asset/vulnerability approach to the analysis of poor people’s livelihoods. The DfID SLF identifies five types of assets or capitals (human, social, natural, physical and financial capital) which are influenced by a particular vulnerability context, including trends, shocks and seasonality. The framework also includes a set of policies, institutions and processes that influence and are influenced by people’s livelihood strategies. Based on the interactions between these elements, the framework defines a set of livelihood outcomes or poverty indicators which go beyond simple income and consumption measures as noted above (Kanji et al., 2005).

Scoones (2009) has noted that livelihoods perspectives are less prominent now than a decade ago. He suggests that failure of these perspectives to engage with more macro processes of economic globalisation, politics and governance debates, environmental sustainability and climate change, and fundamental transformatory shifts in rural economies and wider agrarian change has resulted in a refocusing of research and policy from more contextual livelihood perspectives, often back to macroeconomic analyses. In order to address these failures and be responsive to new contexts, Scoones (2009) sees the need for livelihoods perspectives to focus more explicitly on concerns of knowledge, politics, scale and dynamics. Dorward et al. (2003)

also highlight an important weakness in the original SLF arguing that it lacks emphasis on markets and their role in livelihood development. Considering the importance of markets to livelihoods, their frequent failure to serve poor people's interests, and the dependence of livelihood development on demand for livelihood outputs, this gap could lead to failure to identify and act on livelihood opportunities and constraints arising from critical market processes that are important for pro-poor market development. Their approach is informed by the linkages between processes of livelihood change and market access, and wider processes of growth whereby production, consumption and other linkages allow increased production or market opportunity to feed back into increased demand for labour and locally produced goods and services producing a multiplier effect (as discussed in Sections 2.3.4 and 2.3.5 above). These linkages are overlooked by the traditional SLF.

Their modified SLF approach is also influenced by New Institutional Economic (NIE) theory which: highlights the role of institutional development in livelihood enhancement and economic growth, viewing markets as one type of institution for economic coordination and exchange; enables analysis of the institutional causes and effects of vulnerability; emphasises development of institutional arrangements; and provides a framework for investigating the institutional requirements and context of technological change. The modified SLF of Dorward et al. (2003), shown in Figure 3, therefore enables a clearer understanding of the markets and activities that will have wider positive impacts on poor people's livelihoods and opportunities.

Figure 3: Modified Sustainable Livelihoods Framework



Source: Dorward et al. (2003:327)

As mentioned above, within the SLF people operate within a context of vulnerability to sudden shocks in the physical environment (drought, flood, or typhoons), or longer term trends in the economic environment or resources, which can reduce household assets.

The five assets which form the basis of people's livelihoods are:

- *Natural capital* e.g. land, water, forests, marine resources, air quality, erosion protection, and biodiversity
- *Physical capital* e.g. transportation, roads, buildings, shelter, water supply and sanitation, energy, technology, and communication
- *Financial capital* e.g. as savings (cash and liquid assets), credit (formal and informal), and inflows (state transfers and remittances)
- *Human capital* e.g. as education, skills, knowledge, health, nutrition, and labour power
- *Social capital* which includes any networks that increase trust, ability to work together, access to opportunities, reciprocity; informal safety nets; and membership in organisations.

The effects of policies and institutions on institutional interactions between assets, activities, outputs and outcomes are emphasised along with interactions between access, markets, power, rights and services. Policies and institutions may affect access to any livelihood component (e.g. access to demand, different assets, benefits from livelihoods and technologies). This framework can also analyse effects of power, processes and incentives for institutional and technical change; and reasons for, and effects of, current institutional arrangements. Livelihood assets interact with the vulnerability context and policies and institutions, which also interact with each other, affecting all livelihood components.

Livelihood strategies develop in response to people's asset situation, the vulnerability context, and prevailing policies and institutions. Strategies consist of activities which utilise inputs (including assets) to produce outputs, e.g. migration, off-farm or urban employment, crop diversification or intensification, often combining farm and nonfarm activities. Technology's role in changing input: output (or asset: output) relations is important. Demand for livelihood outputs is critical for livelihood development and the extent and nature of this demand is central to determining immediate and longer term impacts and sustainability of livelihood activities. Demand must be effective and can be: mediated through markets or other institutional mechanisms; embedded in the local or wider economy resulting in different linkage characteristics; and affected by livelihood outcomes.

Livelihood outcomes are the types of poverty impacts that are of interest in this thesis, both traditional indicators such as income and food security, and broader outcomes such as strengthened asset base and reduced vulnerability which all feed back into the vulnerability status and future asset base. Changes in other factors affecting livelihoods such as institutional structures or processes, the resilience or vulnerability of households and livelihood strategies are also important using a livelihoods framework to assess aquaculture's impact on poverty.

The modified SLF framework of Dorward et al. (2003), with its emphasis on markets and institutions, facilitates the linking of micro and macro processes more explicitly than the original SLF and so address some of the concerns of Scoones (2009) mentioned above. Scoones argues that one of the shortcomings of livelihoods approaches has been the failure to address wider, global processes such as globalisation and their effect on livelihoods at the local level. However with an emphasis on markets, economic linkages and broader processes of growth, the modified SLF goes some way to addressing this concern. The modified SLF's focus on markets as one type of institution, and the importance placed on other institutional arrangements between actors and the institutional and policy environment at district, national and sometimes even international levels, also speaks to this concern of scale. Another shortcoming that Scoones identifies is the lack of attention placed on power and politics. The modified SLF places the role of institutions more centrally than the original SLF. Peoples' access to assets is mediated by institutions and social relations, which are in turn mediated by power relations. The importance placed on institutional and governance arrangements in the modified SLF thus also highlights the key relationships between livelihoods, power and politics.

Finally, including effective demand (from the local or wider economy) and markets within the modified SLF reflects the importance of linkages between processes of livelihood change, market access, and wider growth processes. Analysing linkages gives important insights into the indirect impacts of growth in one sector on different elements of the rural economy and local economic growth. To understand aquaculture's indirect effects on pro-poor economic growth the nature and importance of linkages arising from different types of aquaculture development must be understood. As already noted, there is limited literature on aquaculture linkages, but the large theoretical and empirical literature assessing farm nonfarm/RNFE linkages within developing country rural economies (reviews include: Delgado et al., 1998; Haggblade et al., 2007a and 2007b) introduced above in Section 2.3.4, can be used to conceptualise the range of linkages arising from aquaculture and their potential importance for pro-poor economic growth.

2.6 THE ROLE OF INSTITUTIONS

The SLF highlights the role of institutions in mediating people's access to the assets they depend on for their livelihoods. Edwards (2000) has suggested that it is socio-economic and institutional, rather than technological factors that are constraining aquaculture's contribution to rural development. Little research has been done on the role of institutions in aquaculture development, although over the last two decades institutions have been increasingly recognised as important in influencing economic behaviour and processes of economic growth (Nabli and Nugent, 1989; Poulton et al., 1998; North, 1990; World Bank, 2002; Dorward et al., 2005a).

2.6.1 Institutions, New Institutional Economics and transaction costs

Institutions, defined as the 'rules of the game' (North, 1990), influence the incentives and actions affecting people's behaviour (e.g. land tenure arrangements, procedures for approval and release of new seed varieties or laws). Institutions are not 'organisations' which are the 'players in the game'. Institutions are formal or informal and are described at two levels (Davis and North, 1971:6-7):

> The *institutional environment* is the set of fundamental political, social and legal ground rules that establishes the basis for production, exchange and distribution. Rules governing elections, property rights, and the right of contract are examples of the type of ground rules that make up the economic environment

and:

> An *institutional arrangement* is an arrangement between economic units that governs the ways in which these units can cooperate and/or compete.

The institutional environment describes the set of institutions within which particular groups operate, determining the way markets exchange and institutions develop. Institutional arrangements describe the actual mechanisms for exchange and coordination in an economy e.g. markets. Exchange can be conducted through non-market channels involving formal or informal contracts, agreements or understandings. Coordination can also be formally or informally established through market mechanisms, within firms, or through state or collective actions.

Institutions reduce uncertainty inherent in human interaction and help overcome market failures caused by high transaction costs and risks[8] (Dorward et al., 1998b). These are influenced by imperfect information and opportunistic behaviour of trading partners. Williamson (1991) suggests transaction costs depend on the degree of asset specificity[9], uncertainty[10] and transaction frequency[11]. If transaction costs are prohibitively high, producers and traders will not engage in markets (de Janvry et al., 1991) leading to low levels of economic activity, constraining economic development, potentially resulting in a 'low equilibrium trap' (Dorward et al., 2003). The key importance of institutions in economic development therefore lies in their transaction cost minimising role (Dorward et al., 2000).

Standard neo-classical economics starts from assumptions about perfectly competitive markets and focuses on minimising transformation costs for market players to gain competitive advantage, placing no importance on transaction costs or institutions. In reality, markets are not perfect, especially in poor rural areas of developing countries where transaction risks are high, information is costly, and the institutional environment is weak. Where transaction costs are high and one or more parties are risk averse, market arrangements may not be viable and non-market arrangements may be more

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[8] The costs incurred by trading partners associated with the exchange of goods and services and exchange risks are comprised of: *ex ante* costs of arranging a contract (acquiring information, establishing relations, agreeing contract); costs of transferring ownership of transacted goods (legal costs, communication costs); and *ex post* costs of contract monitoring, adjusting and enforcement. If transaction costs and risks plus transformation (production) costs and risks exceed returns, there will be no transaction and a missing market.

[9] The more specific the asset, the higher the cost of transferring it to the next best use. Thus with a more specific asset there will be a higher cost involved in minimising the risk of transaction failure as the asset owner will spend more to ensure the transaction is successful.

[10] Which influences the costs of searching for information, screening, negotiating, bargaining and monitoring contracts

[11] For a transaction of a given size, a one off transaction will have higher transaction costs than a transaction that will be repeated. Thus increased transaction frequency spreads the fixed costs of a relationship between trading partners over more transactions.

efficient than market failure. This is overlooked in standard neo-classical analysis, NIE thus offers a more comprehensive framework in which to explore market development, economic growth and poverty alleviation in developing countries.

2.6.2 Coordination

Dorward et al. (2005a) argue that focusing only on developing competitive markets is inefficient in promoting growth and unlikely to achieve pro-poor growth as markets are just one type of institution. They suggest other institutions may be more effective at fulfilling market functions in economies with weak institutional environments (such as Ghana) where some markets may not perform at all. Dorward et al. (2005b) suggest coordination is a central challenge facing smallholder agricultural development and is vital to achieve rapid pro-poor growth. Poulton and Lyne (2009) explore vertical, horizontal and complementary coordination for market development.

2.6.3 Commodity techno-economic characteristics

Coordination incentives vary between innovations and crops. Jaffee and Morton (1995) argue that the organisation and performance of private sector marketing and processing and the institutional arrangements developed by transacting parties are influenced by ‘distinctive techno-economic characteristics of the individual commodities’. These characteristics affect transaction costs (and hence demand for institutions) by influencing asset specificity, uncertainty and frequency of transaction in production and marketing. Institutional requirements, the need for coordination mechanisms and the relevance of non-market institutional arrangements increase with demanding techno-economic characteristics. Dorward (2001) separates these characteristics into transaction characteristics (e.g. volume and frequency, uncertainty and bounded rationality, asset specificity, and scope for opportunism) and commodity characteristics (e.g. price and volume (production) uncertainty, perishability, processing and storage requirements, quality, seasonality, economies of scale, the supply chain and the commodity’s place in it and government interventions).

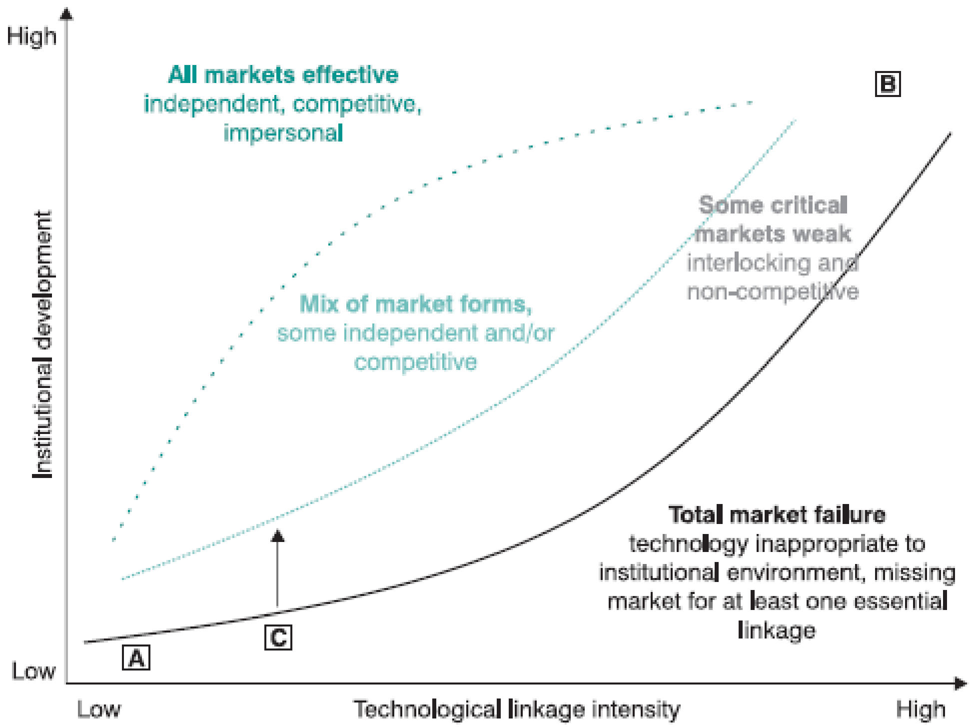
Jaffee and Morton (1995) applied a transaction cost analysis to marketing of high-value crops in SSA, hypothesising that the range of feasible institutional arrangements for commodities posing inherent problems for quality control and vertical coordination and associated with economies of scale in production and/or processing would be limited to vertically integrated or contract–based systems. For commodities with less demanding characteristics, decentralised, small-scale trading and processing operations could well be the institutional norm. This approach has been used in several studies on agricultural marketing, e.g. on potato in Egypt (Loader, 1996), cashew in southern Tanzania (Poulton, 1998a), cotton in northern Ghana (Poulton, 1998b) and cotton and wheat in Pakistan (Stockbridge et al., 1998).

2.6.4 Technology and institutions

This discussion has important implications for promoting new technologies and commodities in poor rural areas. High transaction costs may make some opportunities like aquaculture non-viable. The environment and commodity and players' characteristics affect preferences for and negotiations over institutional arrangements which affect the incentives for different players to take up new technologies or commodities (Dorward et al., 2000).

Dorward et al., (2000) explore the effects of institutional development and 'linkage intensity' of technology on uptake. Technologies with low 'linkage intensity' do not need many resources brought into the farm or sophisticated market chains to reach consumers (e.g. subsistence crops - point A in Figure 4). Technologies with high 'linkage intensity' need resources brought into farms and market chains to reach consumers (e.g. high input cotton production - point B in Figure 4). Where institutions are developed, a wide range of technologies and activities may be possible and inputs and outputs will be traded in competitive markets. Where institutions are less developed (and players face greater risks) markets may not be effective, and vertical linkages may be needed to reduce transaction costs. Alternatively, transaction costs may be too great, leading to market failure. Therefore, technologies and production systems must 'fit' the institutional environment of farmers.

Figure 4: Technological linkage intensity, markets and institutional fit



Source: Dorward et al. (2000:102).

Limited institutional development in countries such as Ghana, especially in rural areas, is likely to constrain development of commodity systems like aquaculture. Aquaculture products have institutionally demanding techno-economic characteristics (e.g. perishability, quality requirements, use of multiple inputs, need for cold chain, sale and transport of live fish etc.), especially if products are exported. Institutional innovation is needed to enable aquaculture to ‘fit’ (shown by the arrow above point C in Figure 4) the institutional context and provide incentives for aquaculture uptake. Institutional innovation must be efficient, equitable, sustainable, and compatible with existing institutions. Assessing the role of institutional innovations in developing aquaculture systems is thus central to maximising aquaculture’s potential effects on poverty in Ghana.

2.7 RESEARCH OBJECTIVES

2.7.1 Gaps in the literature

The problem statement outlined in Chapter 1 proposed that aquaculture has a significant role to play in rural development and poverty alleviation. The review of the literature related to aquaculture's impact on poverty above found that the empirical evidence of aquaculture's impact on poverty is limited, especially in SSA, and highlighted a number of gaps in the literature. It showed that even though there are some examples of aquaculture's influence on poverty, mainly from Asia and Latin America, there is little documented evidence of direct poverty reducing impacts, and few studies investigate causality with reliable counterfactuals. These studies also tend to look at narrow indicators of poverty such as income rather than taking a more holistic approach to poverty and livelihoods. Furthermore, evidence from Asia suggests that it is the better resourced farmers who are able to adopt aquaculture and from the few studies from SSA it does not seem clear whether poor farmers are also able to adopt and sustain aquaculture without outside assistance.

The literature review further revealed limited and mixed evidence on indirect employment effects, either through direct employment on SME and large-scale farms or through employment along the value chain. Again, studies have focused mainly on Asia and South America, not on SSA. Evidence on direct and indirect consumption effects was also found to be limited and inconclusive. While most studies found that household fish consumption increased in fish producing households compared to non fish producing households, other studies found this not to be the case. Kawarazuka and Béné (2010) suggest quite plausibly that aquaculture's impact on household fish consumption will depend on the type of fish that is produced compared to the locally consumed wild caught fish and the role the farmed fish plays, either as a cash crop or a food crop. The literature on indirect effects of aquaculture on poor consumers is also scarce. While quite a few theoretical studies show price elastic demands for fish, there is little evidence to show that aquaculture development reduces fish prices in reality due to the complex economic relationship between aquaculture and wild fisheries at the local level, and this has not been studied.

The literature review also discovered that there has been no study at all of a potentially significant type of indirect impact related to growth linkages arising from aquaculture and the potential economic multiplier effect. There is a large theoretical and empirical literature on agriculture growth linkages, reviewed above, confirming these multipliers from agriculture, but no studies have estimated multipliers from aquaculture. Despite the fact that multiplier effects arising from aquaculture development have not been estimated, promotion of aquaculture SMEs over small-scale artisanal farmers is increasingly being supported by some, based on an untested assumption that local economic growth effect will be stronger from the development of aquaculture SMEs rather than from small-scale artisanal fish farming.

Finally, the literature review found that even though it has been suggested that institutional rather than technological factors are constraining aquaculture's contribution to rural development, and even though the SLF, a dominant approach in rural development for at least a decade, highlights the important role of institutions in people's livelihood strategies and outcomes, little research has been done on the role of institutions in aquaculture development.

2.7.2 Research objectives

This thesis aims to understand the actual and potential impacts of different types of aquaculture development on poverty and livelihoods in SSA and the institutions required for these types of aquaculture development to maximise their potential poverty impact, using aquaculture development in Ghana as a case study. This overall objective has developed from the observation that various actors in the development sector are promoting aquaculture as a means for poverty alleviation in SSA even though there is currently a shortage of evidence of aquaculture's impact on poverty in SSA and even less on which type of aquaculture development would have the strongest potential to impact on poverty. A review of the literature has confirmed the lack of empirical evidence of aquaculture's impact on poverty in SSA and has revealed major gaps.

This section elaborates on the three main research objectives of this thesis. These objectives seek to: i) fill some of the gaps identified in the literature as highlighted in Section 2.7.1; and ii) contribute to the debate surrounding the emerging paradigm of broadening support towards more commercial aquaculture, as discussed in Section 2.4 above. Each research objective has alongside it a hypothesis that is tested by this thesis. These hypotheses have been informed by the literature on both aquaculture and agriculture, as reviewed above.

Objective 1

To assess the direct poverty and livelihood impacts (positive and negative) of small-scale aquaculture systems on different categories of poor people in Ghana.

Hypothesis 1

Small-scale aquaculture has positive direct impacts on poverty and livelihoods of poor households in Ashanti Region, Ghana. The magnitude of these impacts depends on the livelihood characteristics and production systems of small-scale farmers, and the institutional and infrastructure context.

Hypothesis testing

The hypothesis is tested using the SLF. Poor fish farming households are first identified to see whether the poor have been able to adopt aquaculture and thus have the potential to benefit directly from aquaculture. The livelihood characteristics, capital assets, activities and livelihood strategies of poor and non-poor, small-scale fish farmers and a comparison group of non-fish farmers are then investigated and compared. Fish farming as a livelihood activity is explored along with the perceived benefits for adopting households and the community. The difference in livelihood outcomes such as income and food security between fish farming and non-fish farming households is then compared to identify any significant differences between fish farming and non-fish farming households which could indicate that fish farming households are better off than non-fish farming households. However these comparisons do not account for possible differences in household characteristics, other than participation in fish farming, which may cause differences in poverty status and livelihood outcome indicators between fish farming and non-fish farming households. Thus an Income Determination Model is used to control for differences in observable characteristics between households and assess the factors that contribute to differences in income between fish farming and non-fish farming households.

Objective 2

To assess the importance of direct and indirect poverty impact pathways from different aquaculture systems and examine implications for pro-poor growth in different contexts.

Hypothesis 2

Indirect poverty impact pathways (such as employment, consumption and multiplier effects) from increased aquaculture SME activity have more potential to impact on poverty than indirect pathways from large-scale commercial operations and direct and indirect pathways from small-scale aquaculture.

Hypothesis testing

To test this hypothesis, the thesis investigates the nature and importance of the various growth linkages (production, consumption, investment, infrastructure, institutional etc.) arising from the different aquaculture systems under analysis. The economic multiplier effects arising from these aquaculture systems are estimated in order to compare the potential economic growth generated by development of each system. Labour opportunities created by different systems are also estimated, along with employment created along the different value chains related to these systems. The strength of each of the direct and indirect impact pathways and linkages, and their likely impact on poverty, are then compared between systems.

Objective 3

To identify the institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction in different contexts.

Hypothesis 3

Due to the institutionally demanding techno-economic characteristics of aquaculture products, complementary technical and institutional development is necessary for aquaculture to develop and impact poverty.

Hypothesis testing

The institutional framework developed by Dorward and Omamo (2009) is used to test this hypothesis. Some important aspects of the institutional environment in which aquaculture development in Ghana is taking place are first reviewed. The 'techno-economic' characteristics of aquaculture commodities are assessed, and the implications of these characteristics for the expected institutional arrangements in the different aquaculture systems are then considered. The key actors and institutional arrangements observed in each aquaculture system are analysed. In this analysis, actors' characteristics and economic behaviour, and the role, form and functions of institutional arrangements in reducing transaction costs and risks are highlighted. Based on this analysis, the thesis identifies key constraints to development of the different systems and identifies actors and institutions that may be missing. Based on the overall findings of these three research objectives and their associated hypothesis testing, the types of institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction are explored.

2.7.3 Significance of research

As already noted, these research objectives and their associated hypothesis testing, seek to address some of the important gaps in the literature, in the context of the emerging paradigm shift in aquaculture development. The review of the literature confirmed that despite the recognised potential of aquaculture to achieve poverty alleviation in developing countries, the actual and potential contributions of aquaculture development to the livelihoods of the poor in SSA have not been fully assessed. The poverty impact and potential for pro-poor growth of different aquaculture systems has not been rigorously explored, making this thesis particularly significant in contributing to the currently limited evidence on this. Furthermore, even though there have been some studies applying a NIE theoretical framework to commodity systems (e.g. Jaffee and Morton, 1995), the NIE literature is still lacking empirical data on the institutions needed for commodity development in SSA, and an institutional framework has not been used to analyse aquaculture development before. Finally, it should be noted that while this thesis does not address the issue of whether or not aquaculture offers the best poverty-reducing pathway, given other ways that public and private funds could be invested, it provides more specific information on the poverty impacts of aquaculture in SSA than has hitherto been available.

CHAPTER 3: GHANA CASE STUDY

The research objectives and hypotheses addressed by this thesis are explored using a case study approach in Ghana. Ghana's aquaculture sector is growing rapidly, albeit from a low base, encompassing a range of different production systems (extensive aquaculture in the north, semi-intensive pond aquaculture in the central and southern belts and intensive SME and large-scale commercial cage aquaculture in Lake Volta). Significant urban markets exist for aquaculture products, a factor driving much of the private sector led aquaculture development in SSA. Fish also plays an important role in Ghana's economy due to its significant capture fisheries sector and the high share of protein from fish in local consumption. These conditions make Ghana an especially interesting and relevant case study, with the potential to yield lessons applicable to other countries in SSA.

This chapter outlines some background information on Ghana, the economy, the agriculture sector, household expenditure and income, poverty rates and trends, the fisheries and aquaculture sectors and evidence of aquaculture's impact on poverty in Ghana. This information provides a useful context for the findings of the thesis presented in Chapters 5 to 7.

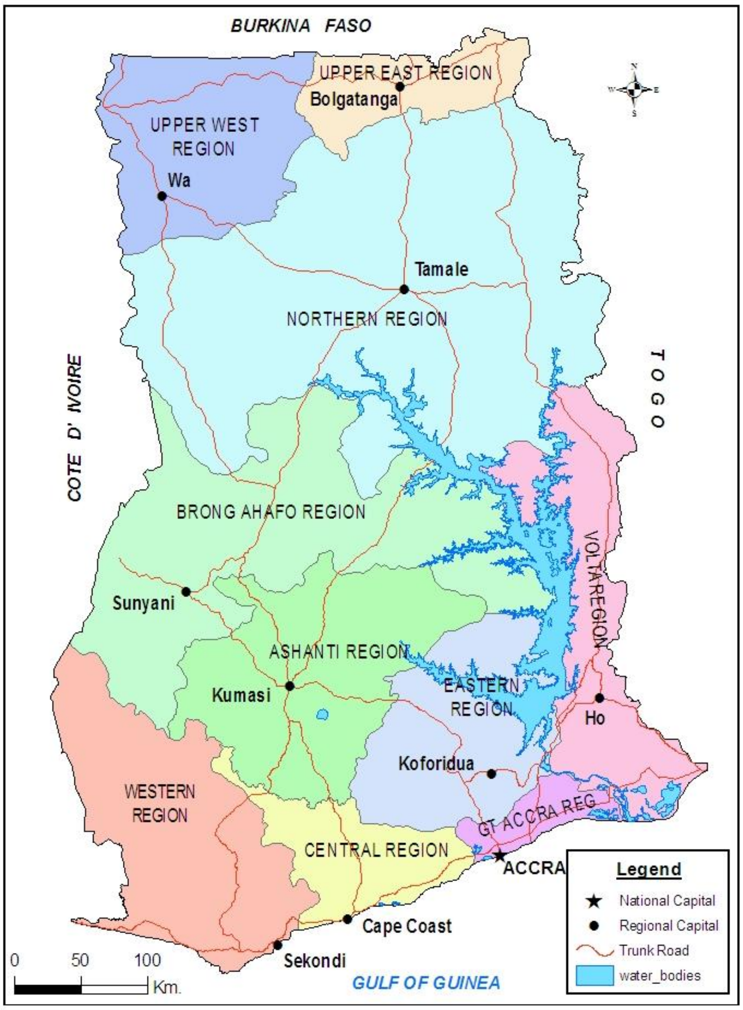
3.1 GEOGRAPHICAL CONTEXT

Ghana is located just north of the equator in West Africa and has a total land area of 238,539 km^2 and a 536 km coastline. Ghana's population was 24.97 million in 2011 (World Bank, 2013a), 48.5 percent of which is rural[12]. The country is comprised of 10 administrative regions shown in Figure 5 below: Greater Accra (where the capital Accra is located), Volta, Central and Western Regions in the south, Ashanti, Eastern and Brong-Ahafo Regions in the middle belt and Northern, Upper East and Upper West Regions in the north. The regions are further divided into 138 individual metropolitan, municipal and district assemblies. The Ghana Living Standards Survey

[12] http://www.indexmundi.com/facts/ghana/rural-population (accessed 22 May 2013).

(GLSS) divides rural areas into three ecological zones: savannah (northern belt), forest (central belt) and coastal (southern belt) with the savannah zone being the poorest and forest zone being the least poor (GSS, 2008).

Figure 5: Map of Ghana



3.2 THE ECONOMY

Ghana's economy is predominantly based on natural resources and agriculture, oriented around primary commodity production and export, particularly cocoa, timber and gold (Asmah, 2008). Ghana's GDP was estimated at US$39.2 billion in 2011 (World Bank, 2013a). The agriculture sector (crops, livestock, fisheries and forestry) contributed approximately 26 percent of GDP in 2011 (World Bank, 2013a) and is the largest industrial sector employing 41.6 percent of the economically active population aged 15 years and older (GSS, 2012). Since the mid 1980s, Ghana's economy has been growing steadily (though GDP growth almost doubled from 8% percent in 2010 to 14.4% in 2011) with GDP per capita estimated at US$1,570 in 2011 (World Bank, 2013a) making Ghana a low-middle income country with the highest per capita income in West Africa (Kolavalli et al., 2011).

3.3 AGRICULTURE SECTOR

The fifth and most recent GLSS, undertaken between September 2005 and 2006 (GLSS5), indicated that 60.5 percent of households own or operate a farm or keep livestock, 85 percent of them in rural areas (GSS, 2008). The savannah zone has the highest percentage of households in agricultural activities (92%) followed by the forest zone (86%) and coastal zone (73%). Livestock are concentrated primarily in the savannah zone, followed by the forest zone (GSS, 2008). Food crop production is mainly at subsistence level, with a small but growing proportion of commercial enterprises. Crops vary considerably by region but the most common crops grown include maize, cassava, yam, plantain, pepper, sorghum/millet/guinea corn, cocoa, groundnut/peanut, beans/peas and rice. Maize is the only staple grain which is grown extensively in all three ecological zones. The two most important crops, in terms of sales, are maize and cocoa (GSS, 2008).

Agriculture has dominated the Ghanaian economy until recently when the service sector has taken over. Crops other than cocoa make up nearly two thirds of agriculture GDP, cocoa accounts for 13 percent and export crops (including cocoa) account for 22 percent. The agriculture sector has grown over 5 percent annually for the past decade, driven by the expansion of agricultural land area (60% of which has been for cocoa) rather than productivity growth (Kolavalli et al., 2011). Ghana's agriculture is smallholder dominated with the average land holding size of rural households at 4.3 hectares (GSS, 2008), characterised by low levels of inputs and high reliance on rain-fed agriculture. The lack of productivity growth over the years has been attributed to lack of support for innovation in small-scale agriculture, along with poor transport and distribution channels (Kolavalli et al., 2011).

3.4 HOUSEHOLD EXPENDITURE

Food expenditure accounts for 40.4 percent of household expenditure, while the imputed value of own-produced food consumed by households represents a further 10.5 percent. Total food expenditure (actual and imputed) accounts for approximately half the expenditure of households in the highest wealth quintile and approximately 60 percent of expenditure in the lowest quintile. In rural areas, total food expenditure accounts for 55.4, 61.8 and 73.8 percent of total expenditure in forest, coastal and savannah zones respectively. Overall the most important foods in terms of food budget shares (based on both cash expenditure and home production) are bread and cereals (20%), fish and seafood (16%) and vegetables (14%) (GSS, 2008:127), showing the significant role that fish plays in average household food consumption.

3.5 HOUSEHOLD INCOME

Average annual household income was estimated by the GLSS5 as US$1,327 and average per capita income as US$433[13]. In the rural localities, rural coastal had the highest average annual per capita income (GH¢368) while rural savannah had the lowest (GH¢232) (GSS, 2008). Overall, the main sources of household income are agriculture (35%), wage employment (29%) and self-employment (25%). Households in the lowest four quintiles earn their primary source of income from agricultural activities and the majority of income of rural households is from agriculture (57.7%). 28.5 percent of the population were under the poverty line in 2005/2006 (GSS, 2008) and rural household heads constituted the largest proportion (87.1%) of household heads in the poorest quintile in 2000 (GSS, 2002).

3.6 POVERTY TRENDS

Ghana's poverty rate has declined substantially over the past two decades from 51.7 percent in 1991/92 and 39.5 percent in 1998/99 to 28.5 percent in

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[13] Average June 2006 exchange rate of GH¢0.92 to US$1 (GSS, 2008:viii).

2005/06 (GSS, 2007). Poverty has reduced more in rural areas, both in absolute and relative terms. Rural poverty decreased from 63.6 percent in 1991/92 to 39.2 percent in 2005/06, a decline of 24.4 percentage points. However, regional inequality considerably increased and the poverty rate remained as high as 62.7 percent in the north in 2005/06, while it reached 20 percent in the rest of Ghana (Diao, 2010). This poverty reduction is attributed to improvements in economic growth over the past decade, driven in part by high prices for cocoa and gold. Economic growth has been accompanied by policies on poverty reduction including a school feeding programme and the Livelihoods Empowerment against Poverty Program, intended to help reduce the levels of food insecurity, malnutrition and poverty[14].

While the poverty headcount ratio has not been estimated since 2006, with this sustained growth, the reduction in poverty is expected to be maintained. However, there may not have been a continued decline in poverty from 2006 due to the recent global economic crisis and the rise of food and fuel prices. Food prices have been rising in Ghana since 2007. For example, maize retail prices increased by 83 percent in real terms in 2008 between March (the beginning of the lean season) to July/August (the peak of the lean season). This was five times higher than maize prices for the same period in 2007 and 10 times higher than the five year average. With markets being the main source of food for 80 percent of households, the majority of the population is vulnerable to such market upheavals (Biederlack and Rivers, 2009). Overall inflation increased from an annual average of 10.7 percent in 2007 to 16.5 percent in 2008 and reached a peak of 19.3 percent in 2009 but was down to 8.7 percent in 2011 (World Bank, 2013a). It is in this dynamic context that aquaculture is developing in Ghana and shows the difficulty of disentangling the effect of fish farming on poverty when many other variables are also changing.

[14] http://www.cpc.unc.edu/projects/transfer/countries/ghana (accessed 22 May 2013).

3.7 FISHERIES SECTOR

The fisheries sector, which includes aquaculture, accounted for nearly 7 percent of Ghana's agricultural GDP and 1.7 percent of her national GDP in 2011 (GSS, 2012). It has been estimated that fisheries contributes directly and indirectly to the livelihoods of over 2.2 million people (Seini et al., 2004), just under 10 percent of the population.

3.7.1 Fish consumption and demand

Fish is important in Ghanaian diets and is estimated to represent approximately 60 percent of average animal protein intake (FAO, 2006:41). Average per-capita fish consumption is 29.7kg (FAO, 2004), one of the highest in the SSA. The GLSS5 estimated the food budget shares (both cash expenditure and home produced) of fish and seafood was 20.8 percent for the rural forest zone (where the study area for analysis of small-scale artisanal pond aquaculture for this thesis is located, see Chapter 4) and 22.6 percent in rural coastal zone (where the study area for analysis of cage aquaculture for this thesis is located, see Chapter 4). These shares are higher than the shares for bread and cereals (16.4% and 19.5% for rural forest and rural coastal zones respectively) and for meat (6.3% and 4.2%) (GSS, 2008:128).

3.7.2 Domestic production

Domestic fish supply in Ghana comes from marine fisheries, lagoon fisheries, Lake Volta, other inland fisheries, aquaculture, and imports. Fisheries production, mainly from capture fisheries has been following a decreasing trend over the past decade (FAO, 2004-2013). However, overall fish production was reported to have increased by over 8 percent between 2009 and 2011, from just under 410,000 tonnes to approximately 440,000 tonnes[15]. Aquaculture production increased from 950 tonnes in 2004 to 5,594 tonnes in 2008 and between 2009 to 2011 it increased by over 165 percent

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[15] http://www.ghana.gov.gh/index.php/news/features/18811-fish-production-up-by-82 (accessed 15 May 2013).

from 7,154 to 19,092 tonnes (FAO, 2004-13) (due mainly to increased production from large-scale cage farms), representing over 4 percent of overall fish production in 2011. The overall domestic fish requirement was approximately 992,000 tonnes in 2011 leaving a shortfall of 552,000 tonnes[16]. This shortfall is currently being met by importing fish valued at over US$200 million annually, highlighting the potentially important role of aquaculture in meeting domestic fish requirements.

3.8 AQUACULTURE SECTOR

Fish farming in Ghana began in 1953 when the Department of Fisheries (DoF) built ponds to produce fingerlings for culture based reservoir fishery development in northern Ghana. After independence in 1957 the government allocated 5 percent of state owned irrigation facilities to aquaculture. However fish farming did not develop much during this time (FAO, 2006-2013). Between 1982 and 1984, the government supported the establishment of several fish farms by facilitating the provision of commercial loans for pond construction. However many new fish farmers failed as they were given little technical assistance in aquaculture production or marketing (Prein and Ofori, 1996; Quagrainie et al., 2009). The government did not provide much support to the sector again until early 2000 with a number of policy changes with the objective of developing the aquaculture sector. In 2005 a Ministry of Fisheries was created[17], free extension services to fish farmers were provided by fisheries extension staff, fingerlings were produced at government hatcheries and Fish Farmer Associations (FFAs) were established (Quagranie et al., 2009).

The Fisheries Commission (FC) of the Ministry of Food and Agriculture (MoFA), has recently produced a draft Ghana National Aquaculture

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[16] http://www.ghana.gov.gh/index.php/news/features/18811-fish-production-up-by-82 (accessed 15 May 2013).

[17] However in 2009 the Ministry of Fisheries was reconstituted as the Fisheries Commission (FC) and brought back under the Ministry of Food and Agriculture. The FC advises the Minister responsible for fisheries.

Development Plan (GNADP), with support from FAO, which aims to increase production of commercially farmed fish from 10,200 tonnes in 2010 to 100,000 tonnes in 2016, boosting the market share of farmed fish to 30 percent (MoFA/FC, 2012). The strategy is based on supporting the development of commercial aquaculture through the development of high priority aquaculture zones. The GNADP also emphasises the need for support mechanisms and services for aquaculture businesses to be private sector led with government playing facilitation and monitoring roles. Although the GNADP's vision statement includes food and nutritional security, employment generation, increased incomes, economic growth and poverty reduction, the primary focus of the plan is increasing fish production through commercial aquaculture development to reduce the national fish deficit. There is a mention of the importance of the small-scale sub-sector for achieving national socio-economic goals of employment generation and poverty reduction (MoFA/FC, 2012:2) though it is unclear whether this refers to the 'commercial' or 'non commercial' small-scale sub-sector. However the GNADP does not appear to make provisions for supporting rural artisanal pond aquaculture farmers who dominate the aquaculture sector in Ghana and who are unlikely to fall into the 'commercial' category or relocate to high priority aquaculture zones where support is focused.

Ghana's aquaculture sector has also been supported by international organisations over the years. From 1996 to 2002, The World Bank funded the Fisheries Sector Capacity Building Project aimed at strengthening the DoF's capacity and supporting improved aquaculture extension services and higher quality fingerlings[18]. In 2002 FAO funded a project to strengthen the organisational capacity of FFAs, and supported the development of the National Fisheries and Aquaculture Policy in 2006. In 1999 WRI collaborated with the WorldFish Centre to undertake a project to develop improved tilapia strains for aquaculture. The project developed the 'Akosombo' strain of Nile Tilapia which is reported to grow approximately 30 percent faster than those

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[18] http://www.worldbank.org/projects/P000962/fisheries-subsector-capacity-building-project?lang=en (accessed 22 May 2013)

in the wild. From 2008 to 2010, FAO in collaboration with the WorldFish Center and the governments of six countries sharing the Volta basin implemented a project[19] to further develop and disseminate the 'Akosombo' strain[20]. The Aquaculture and Fisheries Collaborative Research Support Program (known as AquaFish CRSP), funded by USAID, has also been supporting aquaculture through research and training of fish farmers (Quagrainie et al., 2009).

In July 2011 the World Bank approved an investment of US$53.8 million (a grant of US$3.5 million from the Global Environmental Facility and a loan of US$50.3 million from the International Development Association) to implement the West Africa Regional Fisheries Program, a 5 year fisheries and aquaculture project in Ghana (World Bank, 2011). US$8 million is earmarked for aquaculture development as follows: developing aquaculture policy and legal framework; improving genetic quality of tilapia fingerlings and broodstock; catalysing aquaculture development for medium and large-scale enterprises; marketing and technical studies; and small-scale aquaculture development (to which US$5 million is dedicated, focused on encouraging development of new commercial small-scale enterprises rather than rural artisanal fish farmers) (World Bank, 2011).

These activities indicate an increasing level of interest in aquaculture development in Ghana and have contributed to the development of the aquaculture sector in recent years. Asmah (2008) found that nearly 64 percent of pond farms surveyed were established after 1995 and estimated a 16 percent annual growth rate in the number of fish farms established since 2000, showing how pond aquaculture has been developing, although from a small base. The development of the sector is also reflected in the recent rapid increase in aquaculture production mentioned above.

[19] Funded by the Agencia Espanola de Cooperacion Internacional.

[20] http://ongoing-research.cgiar.org/factsheets/aquaculture-investments-for-poverty-reduction-in-the-volta-basin-creating-opportunities-for-low-income-african-fish-farmers-through-improved-management-of-tilapia-genetic-resources/ (accessed 22 May 2013).

3.8.1 Production systems

Aquaculture is practiced in all ten regions of Ghana, most prominently in the southern and central sections. The main fish species cultivated are Nile Tilapia (*Oreochromis niloticus)* and African Catfish (*Clarias gariepinus)* (Kaunda et al., 2010). Pond aquaculture is the dominant production system in the southern and central belts, accounting for over 98 percent of farms there (Asmah, 2008). In the last 5 years the dominant culture system for tilapia production has changed and the vast majority of cultured tilapia is now being produced in cages. Cages (and pens), introduced after 2003, account for less than 2 percent of farms by number but much more by production. The cage farms are mainly located in Asuogyaman and South Dayi Districts of the Eastern and Volta regions respectively with the majority in Lake Volta (Asmah, 2008). Fish farming in the north is largely extensive and conducted in reservoirs and 'dugouts' (earthen dams) due to the relatively poor rainfall distribution pattern.

Kaunda et al. (2010) estimated that in 2010 there were two large-scale commercial cage farms (Tropo and West African Fish Ltd (WAF)), 5-10 medium-scale cage farms, 100 small-scale cage farms and 10 larger pond farms. The GNADP states there are 2,869 small-scale farms (including both artisanal pond farms and reservoirs) (MoFA/FC, 2012). Kaunda et al. (2010) categorise the main systems which are expected to meet the increasing fish demand in Ghana as follows: i) fully commercial internationally/regionally targeted operations including development of large-scale cage culture tilapia farms producing 1,000 to 10,000 tonnes per annum per farm; (ii) local commercial small to medium size operations producing tilapia, catfish, and/or polyculture with an output between 50 to 500 tonnes per annum per farm; and iii) small-scale aquaculture activities (small-scale pond or cage culture across a range of species with an output of 1 to 20 tonnes per annum per farm). While this broadly categorises the commercial aquaculture sector it does not include the majority of artisanal pond aquaculture farmers producing less than 1 tonne per annum per farm.

In order to address the objectives and test the hypotheses presented in Chapter 2, this thesis focuses on analysing the three most important aquaculture systems in Ghana categorised as follows: i) the small-scale artisanal rural pond aquaculture sector producing less than 1 tonne per annum per farm; ii) the commercial SME cage aquaculture sector producing 1 to 500 tonnes per annum per farm in Lake Volta (with small-scale cage farms producing 1 to 50 tonnes per annum farm and medium-scale commercial cage farms producing 50 to 500 tonnes per annum farm); and iii) the large-scale commercial cage aquaculture sector consisting of 2 farms producing over 500 tonnes per annum farm in Lake Volta, estimated by the FC to contribute more than half of the total aquaculture production in Ghana (i.e. more than half of the 19,092 tonnes produced in 2011). The particular study areas chosen to explore these systems and the methodology used for data collection and analysis are described in Chapter 4.

3.8.2 Evidence of aquaculture's poverty impact in Ghana

There has been limited research on aquaculture's role in poverty alleviation in Ghana. Kaliba et al. (2007b) used a CGE model to estimate the effects of aquaculture expansion in three SSA countries including Ghana. Their results suggest a 10 percent increase in aquaculture production would increase income for all household groups by 2 percent and reduce the poverty gap. However it is unclear how realistic these estimates are. By using a static CGE model the process of adjustment to the new equilibrium was not shown. The model uses a set of restrictive equilibrating conditions (e.g. no excess demand and full employment of resources (except labour)) which is unrealistic especially for a developing country like Ghana. The limited number of household groups (e.g. treating agricultural producers as a homogenous group) may also hide negative income and poverty impacts within groups.

Ruddle and Prein (1997) (cited in Prein and Ahmed (2000)) studied the potential nutritional impact of IAA and concluded that large economic and nutritional benefits were possible for farmers in inland regions if they had favourable water availability and soil quality for pond construction and operation. Lightfoot et al. (1996) compared IAA and non-IAA smallholders before and after integration. Preliminary results showed potential for transforming existing, traditional farming systems to become more sustainable. However, the small sample meant that results were only illustrative.

3.9 CONCLUSION

The background information summarised in this chapter has highlighted the important role of fisheries in Ghana's economy and of fish in national diets and household expenditure. It has given an overview of the rapidly growing aquaculture sector and its range of production systems, showing the potential for aquaculture development in Ghana. The chapter also suggested that the current limited empirical evidence is inadequate to provide in depth understanding of aquaculture's role in and impact on poverty and livelihoods in Ghana. These are some of the conditions which make the aquaculture sector in Ghana a particularly interesting and appropriate case study through which to explore the objectives and hypotheses outlined in Chapter 2.

The following chapters present the methodology (Chapter 4) and findings (Chapter 5 to 7) of this thesis, which focus on assessing the actual and potential impacts of the three main aquaculture systems (small-scale rural artisanal pond aquaculture, SME and large-scale commercial cage culture) on poverty and livelihoods in Ghana and the institutions needed to maximise their potential for poverty reduction.

CHAPTER 4: DATA AND METHODS

This chapter describes the overall research strategy, study sites, data sources and methodology used to address the thesis' three research objectives and test their related hypotheses, outlined in Chapter 2. Where appropriate, additional details of the data and methods used are given in Chapters 5, 6 and 7, where the results for hypotheses 1, 2 and 3 respectively, are presented. This chapter starts by outlining the overall research strategy used for data collection, followed by a description of the two main study sites where primary data were collected. The chapter then discusses the data and methods used to test each hypothesis in turn.

4.1 RESEARCH STRATEGY

A mixed method approach using quantitative and qualitative research methods is used. There is a growing acceptance of the integration of quantitative and qualitative methods and over the last decade, there has been a marked increase in the combined use of qualitative and quantitative (Q-Squared) methods in poverty analysis (e.g. Hulme and Toye, 2006; Kanbur and Shaffer, 2007; Q-Squared Working Paper Series[21]).The benefits of mixed method research include (Bryman, 2012):

- *Triangulation:* methods are combined to cross-check information to increase the validity of findings and help offset the weaknesses of each method.
- *Completeness:* gaps left by one method can be filled by another.
- *Instrument development*: qualitative research is used to develop survey questionnaires to ensure appropriate wording of questions and choices of closed answers.
- *Explanation*: qualitative methods are used to help interpret findings from quantitative research

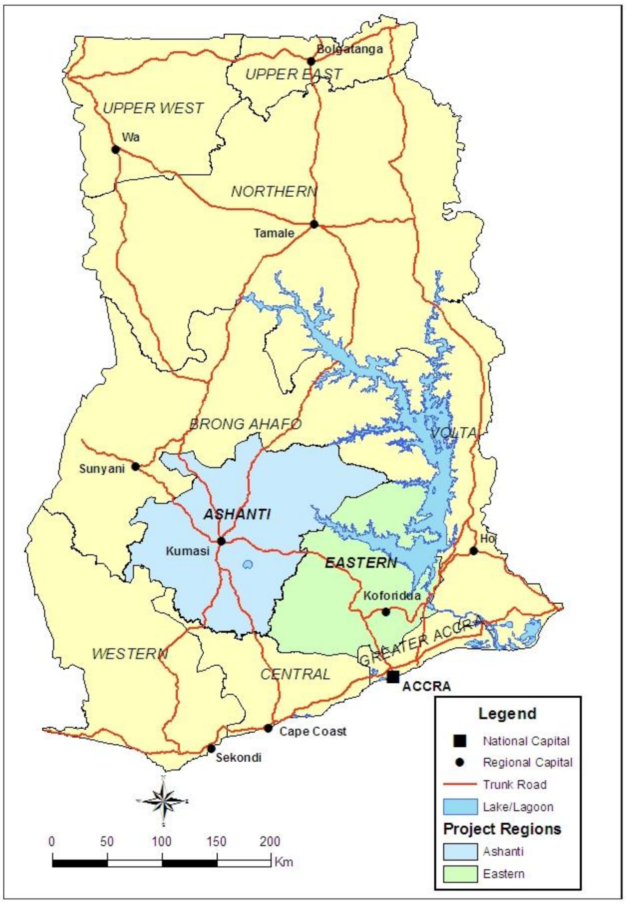
[21] http://www.trentu.ca/ids/qsquared.php (accessed 24 April 2013).

- *Process*: qualitative methods are used to explore trends and processes.

4.2 STUDY SITES

Research was conducted in two regions: Ashanti Region, where more small-scale pond aquaculture farmers are located compared to other regions (though uptake of fish farming is still very low); and Eastern Region around Lake Volta where the majority of commercial cage fish farms are situated[22]. The two study regions are shown in Figure 6 below.

Figure 6: Study regions



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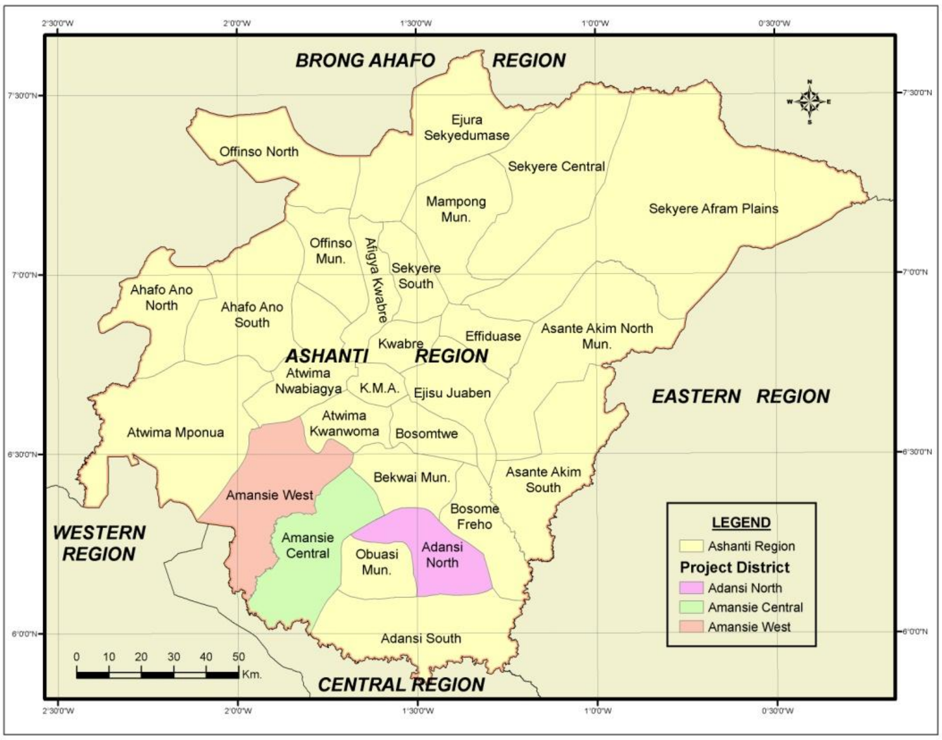
[22] The Regional FC Office in Kumasi (the regional capital), and the Water Research Institute's (WRI) field station in Akosombo (the Aquaculture Research and Development Centre) were used as bases for data collection in Ashanti and Eastern Regions respectively. WRI is one of the 13 public research institutes of the Council for Scientific and Industrial Research in Ghana.

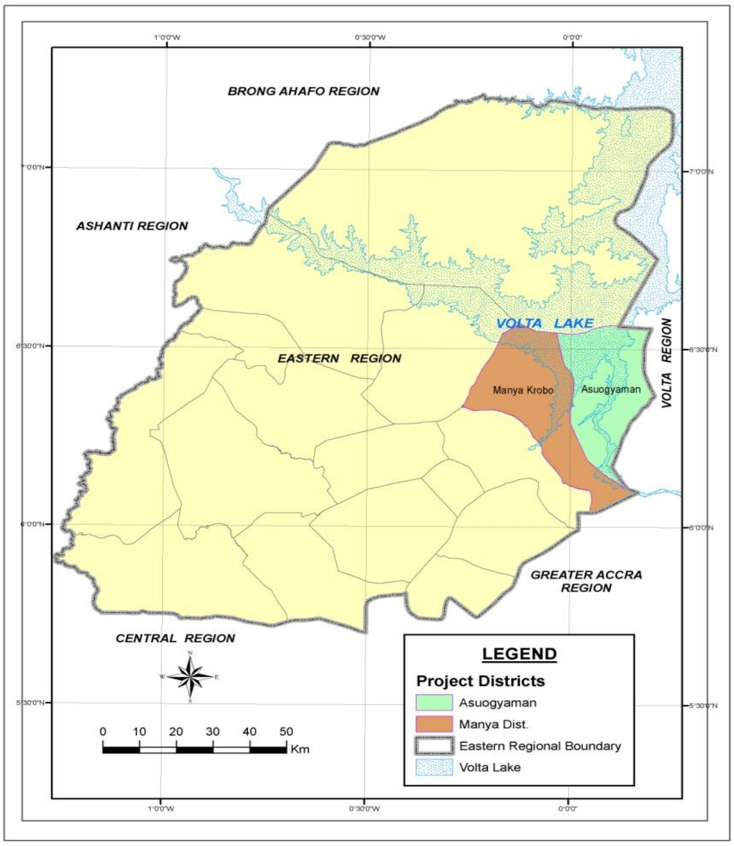
In Ashanti Region, data were collected in: Amansie West, Amansie Central and Adansi North districts, all in the forest zone (see Figure 7).

Figure 7: Study districts in Ashanti Region



In Eastern Region, data were collected in Asuogyaman and Lower Manya Krobo districts (Figure 8). These districts were chosen as they had the highest density of fish farmers in their respective regions.

Figure 8: Study districts in Eastern Region



Notes: In 2008 Manya Krobo District was split to form Lower and Upper Manya Krobo Districts. Pre 2008 district boundaries are shown here

Key characteristics of the study districts are outlined below[23].

4.2.1 Study districts in Ashanti Region

Amansie West

Amansie West is one of the largest districts in Ashanti, covering 1,364 km^2. The district capital is Manso Nkwanta, located 65km from the regional capital Kumasi. The population was estimated at 144,104 in 2010 (over 95% of which is rural). Population density is approximately 106 persons/km^2 and there are over three hundred towns, villages and hamlets. The district has potentially rich gold deposits and large areas have been leased to companies with licenses for prospecting. Agriculture employs 70 percent of the population and is the main source of household income (73%). Agriculture is

[23] Unless otherwise stated, the background information on study districts is taken from Ghana's MoFA website: http://mofa.gov.gh/site/ (accessed 22 May 2013).

mainly small-scale and average farm size is 5ha. Staple crops include cassava, cocoyam, plantain, yam and maize and cocoa is the main cash crop. Many of the communities in Amansie West (especially in the hinterland where some fish farming is practised) are quite remote due to the poor road infrastructure and high transportation costs.

Amansie Central

Amansie Central has an area of 710km^2. Jacobu is the district capital, located 35km from Kumasi. The population was estimated at 110,026 in 2010 (90.4% of which is rural). The population density is 155 persons/km^2 and there are about 220 communities or settlements. Both large- and small-scale gold mining activities are present in the district, including illegal mining operations such as “galamsey” which many youth are engaged in. Agriculture employs 80 percent of the population. Cocoa, oil palm and citrus are the main cash crops and cassava and maize are the main food crops. Average farm size is less than 1ha resulting in low production and income per farmer. Out migration is a problem especially with the youth who do not want to engage in agriculture. Fish farming is concentrated in areas around Tweapease and Kankanfrase.

Adansi North

Adansi North has an area of 1,140km^2 and the district capital, Fomena, is located 59km from Kumasi. The district population was estimated at 123,120 in 2010 (68.8% of which is rural). Population density is 108 persons/km^2 and there are 94 communities, most within 28km from Fomena. Infrastructure development is very low. Agriculture employs about 77 percent of the labour force and the average farm size is 1ha. Major food crops grown are maize, plantain, cassava, cocoyam, yam and rice. The main cash crops are cocoa and oil palm.

4.2.2 Study districts in Eastern Region

Asuogyaman

Asuogyaman has an area of 1,507km^2. The district capital is Atimpoku, 82km from Accra. The population was estimated at 87,734 in 2010[24] (35% of which is rural, the only study district with a majority urban population). Agriculture is predominantly small-scale and average farm size is 1ha with about 90 percent of farm holdings less than 1.2 ha. The major crops are maize, cassava, vegetables and yam. Cocoa and oil palm are the major cash crops grown on small plantations. There are some large farms and plantations for mango and banana. Fishing in Lake Volta is an important part of the agricultural sector and is practised in several communities along the Lake.

Lower Manya Krobo

There is limited demographic and socio-economic information available on Lower Manya Krobo as it was formed in 2008 (along with Upper Manya Krobo) out of Manya Krobo District. Lower Manya Krobo is 1,476km^2. The district capital is Odumase, located approximately 70km from Accra. The major economic activity is agriculture employing nearly 70 percent of the population. Maize is cultivated throughout the district while cassava, plantain and rice are grown in certain areas. About 15 percent of the working population farm livestock. Average farm size is estimated at approximately 1.4 ha[25]. Fishing is carried out along Lake Volta and rivers in Kpong, Akuse and around Obelemanya. Many SME cage farms are clustered around Akuse.

4.3 DATA AND METHODS

The data and methodology used to test the three research hypotheses are described in this section. Overall, country level data were gathered from secondary sources including case studies, published articles, books, government surveys and statistics, and grey literature. Primary data were

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[24] Author's own calculation based on the 2000 population census estimate of 74,124 and a growth rate of 1.7 percent.

[25] http://lowermanya.ghanadistricts.gov.gh/?arrow=atd&_=74&sa=2189 (accessed 22 May 2013).

collected from the field between September 2010 and July 2011. A number of questionnaire surveys were undertaken (described in detail below), complemented by Rapid Rural Appraisal (RRA) techniques such as semi-structured interviews, focus group discussions (FGDs), key informant interviews and direct observation (Chambers, 1981). Data collected to test Hypotheses 1 and 2 is broadly analysed within the conceptual framework of the modified SLF of Dorward et al. (2003) (presented in Chapter 2). Data collected to test Hypothesis 3 is analysed within the broad framework of NIE (presented in Chapter 2) using the institutional framework of Dorward and Omamo (2009) (outlined in Chapter 7).

4.3.1 Data and methods to test Hypothesis 1

This section starts by reviewing Objective 1 and Hypothesis 1. It then briefly discusses some challenges with impact assessment which have implications for the methodology used. The section then goes on to describe the methods used for quantitative and qualitative data collection, along with the use of some participatory methods, and data analysis.

Objective 1 and Hypothesis 1

Objective 1: To assess the direct poverty and livelihood impacts (positive and negative) of small-scale aquaculture systems on different categories of poor people in Ghana.

Hypothesis 1: Small-scale aquaculture has positive direct impacts on poverty and livelihoods of poor households in Ashanti Region, Ghana. The magnitude of these impacts depends on the household and livelihood characteristics and production systems of small-scale pond aquaculture farmers in Ashanti Region, and the institutional and infrastructure context.

Challenges of impact assessment

To test Hypothesis 1, an *ex-post* impact assessment of aquaculture on the livelihoods and poverty status of poor households is required. To measure this impact, the difference between i) impact indicators after adoption of aquaculture; and ii) what these outcomes would have been without aquaculture adoption (the counterfactual scenario), is needed to disentangle the effects of aquaculture from other intervening factors (Baker, 2000) and thus attribute any difference to aquaculture. However it is impossible to measure the impact indicators for adopting households had they not adopted, and in social science research it is extremely difficult to isolate a true 'control' group for comparison with a 'treatment' group. Thus 'experimental controls' are nearly impossible and 'quasi-experimental controls' such as the 'double difference' approach are often used. Constructing a realistic counterfactual requires both 'before' and 'after', and 'with' and 'without' scenarios to be generated for a 'difference in difference' approach (Baker, 2000). However as no baseline data exist on impact indicators and poverty levels of the small-scale artisanal fish farming households under analysis before they started fish farming, and on a comparison group of non-fish farmers at the same time, a true impact assessment using a 'double difference' approach and constructing a realistic counterfactual to test Hypothesis 1 is very difficult.

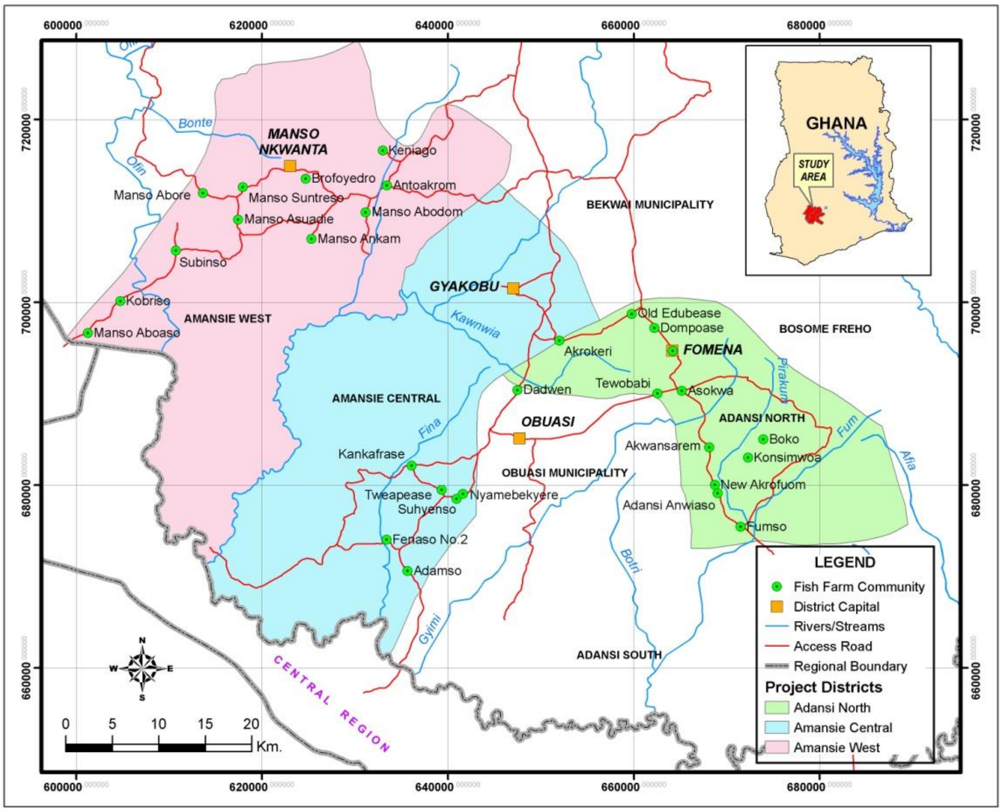
In order to overcome this, the following two groups were surveyed: i) a group of small-scale artisanal pond aquaculture farmers; and ii) a comparison group (or counterfactual) of non-fish farmers, constructed using an informal matching method, described in detail below. The limitation of this approach is that the difference in impact indicators between fish farmers and non-fish farmers can only be used to measure impact if it is assumed that both groups were on average at the same poverty level before fish farming was adopted, which may not be the case. However as each comparison non-fish farmer was chosen according to certain criteria to match them on the characteristics of their 'paired' fish farmer, it could be assumed that the adoption of fish farming, while not randomly adopted in the wider population as farmers 'self select' into adopting and non adopting groups, is randomly adopted within a core group of households with certain similar characteristics (Mendola, 2007). Thus matching non-fish farmers with fish farmers informally controls for a combination of observable variables. This enables the impact of fish farming on poverty to be measured by the difference in poverty impact indicators between these two groups (or as the coefficient of the binary variable in a linear Ordinary Least Squares (OLS) regression to determine income) (Mendola, 2007). However these issues may potentially lead to selection bias and this was therefore tested for in the analysis presented in Chapter 5.

Quantitative data collection

A household survey was undertaken in early 2011 in the three study districts in Ashanti Region. A sampling frame of 90 small-scale semi-intensive artisanal pond aquaculture farmers who had stocked fingerlings in or harvested fish from their ponds in the past two years, was constructed with the assistance of Regional FC staff in Kumasi and district level agricultural extension agents. The comparison group of non-fish farmers was constructed from the same villages as the selected fish farmers, using informal matching criteria, to represent the counterfactual scenario as described above. The criteria to select the comparison non-fish farmers were as follows: the comparison farmer had to be i) the nearest neighbour of the surveyed fish farmer; ii) within 5 years of age of the fish farmer; and iii) a crop farmer (and not a fish farmer) as all fish farmers interviewed were also crop farmers. These criteria were chosen as it was thought that farming households located close to each other with similarly aged household heads were likely to have similar household characteristics to their matched fish farmers.

As many as possible of the 90 fish farmers in the sampling frame (and their corresponding 90 non-fish farmers) were surveyed over the course of six weeks, from January to February 2011. In total 158 farmers (79 fish farmers and 79 non-fish farmers) were surveyed in the villages shown in Figure 9 below.

Figure 9: Villages surveyed in three districts in Ashanti Region



The survey questionnaire collected information on the respondent's household, the main unit of analysis, and was divided into 7 main sections as follows: i) ***Human Capital*** (household characteristics and occupations); ii) ***Natural Capital*** (access to land and ponds); iii) ***Social Capital*** (information and training on fish farming, access to extension services and association membership); iv) ***Financial Capital*** (access to credit); v) ***Physical Capital*** (ownership of household assets, access to infrastructure and facilities); vi) ***Livelihood strategies***: aquaculture (goals, production practices), crops and livestock (crop production, livestock holdings); vii) ***Livelihood outcomes (key impact indicators)***: income (sources and level of household income for 2010), food security (dietary diversity and food adequacy), vulnerability (crises and coping strategies); impacts of fish farming on households and communities. Comparison non-fish farmers were administered the same questionnaire as fish farmers without the questions relating specifically to fish farming. The full questionnaire is presented in Appendix 1[26].

On completion, each questionnaire was checked for mistakes and inconsistencies and, if necessary, corrected by asking the respondent for clarification (either in person or by phone), to minimise error. The data were then entered into a data base in Statistical Package for Social Scientists (SPSS) Version 16 and cleaned. All outliers and missing data were checked against the questionnaires and corrected. A number of cases were removed based on the presence of outliers (in household size, income level or size of land ownership) leaving a final clean data set containing 143 farmers (69 fish farmers and 74 non-fish farmers) as shown in Table 3 below.

Table 3: Number and percentage of surveyed households by district and fish farming status

District	Fish farmer households		Non-fish farmer households		Total households	
	N	%	N	%	N	%
Amansie West	19	28	20	27	39	27
Amansie Central	20	29	19	26	39	27
Adansi North*	30	44	35	47	65	46
Total households (Nos.)	**69**		**74**		**143**	

Notes: * Including 2 fish farmer and 2 non-fish farmer households from Obuasi Municipality

Qualitative data

Qualitative data were collected to supplement the household survey. FGDs and semi-structured interviews were conducted with fish farmers and FC extension officers and staff before the household survey to refine the questionnaire and ensure questions and impact indicators were relevant and meaningful and the choice of closed answers were comprehensive and

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[26] Responses were pre-coded and all questions were translated into Twi (and back again to English to ensure accurate translation). The questionnaire was tested on ten fish farmers in non survey districts prior to administering the survey and the questionnaire was revised accordingly. Six enumerators (a mixture of staff and National Service volunteers based at the Regional FC office in Kumasi) were trained in interview techniques and on administering the survey questionnaire.

appropriate for the context. Qualitative research was also undertaken after the survey was completed to help triangulate and interpret survey findings and gain a deeper understanding of the impact of aquaculture on poverty.

Participatory data collection

Participatory wealth rankings (Grandin, 1988) were undertaken in three communities to understand local perspectives on poverty and wealth, and to determine if fish farming was being adopted by those the community considered poor or only by the better off. Each wealth ranking group consisted of 8 to 12 community members of mixed ages and genders and included a community leader. The groups were asked to list all the households in their communities and then separate the households into different groups based on their wealth and/or poverty status, however they defined it. The characteristics of each group of households were then discussed to understand local conceptions of poverty and develop meaningful impact indicators to include in the household survey. Seasonal calendars were also developed in two communities using FGDs with community members (with groups made up of fish farmers, non-fish farmers, men and women) to understand: seasonal variations in activities, food consumption, labour etc.; local production systems; and how aquaculture fits into the general productive system.

Fish farm budgets were estimated with four groups of fish farmers using the method of participatory budgeting (Dorward et al., 1998a). Participatory budgets (PBs) are used to help farmers measure and analyse inputs and outputs, including non-cash resources[27]. The method is based on a traditional African board game (*oware* in Ghana) and uses local materials (stones, beans, or anything that can be used as counters in a grid) to develop a budget and does not require farmers to be numerate. The method can be

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[27] This method was chosen as most fish farmers do not keep good records so it would have been difficult and time consuming to record budget data with each farmer individually during the household survey. It was also thought that the process of developing a PB with farmers would be a learning experience both for farmers and for the FC extension staff who were trained in the method and facilitated the groups, enabling them to use the tool with other farmers in the future.

used either with individual farmers, with a group of farmers where one is used as a case-study, or an average budget can be developed for a given size of enterprise, if all the farmers in the group have similar production practices (Dorward et al., 1998a). The limitation of this approach for the present analysis is the possibility of non representative farmers being selected as case studies.

Data analysis

The household survey data were analysed using SPSS Version 16 and SAS/STAT software Version 9.3 was used for specific statistical tests. The descriptive analysis compares differences in livelihood characteristics and strategies, and livelihood outcomes (or impact indicators) between the fish farming and non-fish farming households surveyed. Chi square tests for independence are used to test the significance of differences and associations between categorical variables and independent samples t-tests are used to test the significance of differences between the means of continuous variables.

Identification of poor households is necessary to test the hypothesis that fish farming has positive direct impacts on the livelihoods of poor households. As noted in Chapter 2, poverty is a multi-dimensional concept and definitions of ‘the poor’ vary according to who is doing the defining. However, for simplicity, ‘poor’ and ‘non-poor’ households are identified in Chapter 5 by estimating per capita household income and placing households above and below a poverty line, enabling the characteristics of ‘poor’ and ‘non-poor’, fish farming and non-fish farming households to be compared. The results presented in Chapter 5 show that broader poverty measures such as access to assets, household wealth and food security, are positively associated with income measures.

Composite indexes

A number of indexes related to key poverty impact indicators of household wealth and food security are used in Chapter 5 to enable easier comparison of multiple variables between groups, described below.

Durable goods index

A durable goods index is constructed by assigning weights (to represent value) to each of the durable goods owned by each household and summing over all assets. The methodology and weights used to construct the durable goods index (and household asset index below) are adapted from BMGF (2010) which draws on the current literature on asset based approaches to measuring poverty impact. The weights are constructed as follows: radio = 2; TV = 4; electric fan = 2; refrigerator = 5; phone = 3; bicycle = 6; boat = 10; motorcycle = 48; vehicle = 160; water pump = 12[28]. The weight is halved if the asset was owned but not functioning, and weighted values on all items then summed to produce a durable goods index score.

Household asset index

The household asset index represents household wealth. It is composed of the durable goods index, household livestock holdings in Tropical Livestock Units (TLUs)[29], and additional variables related to household facilities (ownership of iron roof, latrine and flush toilet). Just as with the durable goods index, weights are assigned (to represent value) to each of the assets, facilities and number of each livestock (in TLUs) owned by each household and summed over all assets. The durable goods index weights are given above, the remaining weights used are as follows: iron roof = 6; latrine = 4; flush toilet = 8; draught animals = 10; cattle = 10; sheep = 3; goats = 3; pigs = 2; poultry = 1; rabbits = 1; and grasscutter = 1.

Food Consumption Score and Simple Food Count

Food security is a core dimension of poverty and vulnerability. The most common definition defines food security as "access by all people at all times

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[28] Flush toilet and latrine are excluded from the durable goods index but are included, along with livestock and corrugated iron roof, in a more comprehensive household asset index used as a proxy indicator for wealth described below.

[29] The concept of TLU provides a common unit to quantify different livestock types in a standardised way enabling comparison of total livestock holdings between groups. The TLU conversion factors used follow Jahnke (1982) as follows: draught animals (0.80); cattle (0.70); sheep (0.10); goats (0.10); pigs (0.20); and chickens (0.01). Jahnke (1982) does not estimate conversion factors for rabbits and grasscutters so are assumed here to be equal to chickens (0.01).

to sufficient food for an active and healthy life" (World Bank, 1986). Food security can be broken down into four components – availability, access, utilisation and vulnerability – each capturing different, but overlapping, dimensions. No single indicator can capture all of these dimensions (Migotto et al., 2006).

The most common food consumption indicator used by the World Food Programme (WFP) in their Comprehensive Food Security and Vulnerability Analyses, is the Food Consumption Score (FCS). The FCS is a proxy indicator representing the dietary diversity and energy, and macro and micro (content) value of the food people eat. It is based on dietary diversity (the number of food groups consumed by a household over a reference period), food frequency (the number of days in a week a particular food group is consumed), and the relative nutritional importance of different food groups[30] (WFP, 2009). The FCS used by the WFP is adapted[31] and constructed here using the survey data to compare food security between groups.

To construct the FCS, food items are grouped according to the food groups in Table 4 below. The consumption frequencies of all the food items surveyed in each food group are summed (with a maximum consumption frequency of 7 days per week). Each food group is assigned a weight (see Table 4, weight A), reflecting its nutrient density.

[30] The FCS has been found to have positive and statistically significant associations with per capita calorie consumption, increasing its validity as a measure of food security per capita (Wiesmann et al., 2009).

[31] In the full FCS used by the WFP a wider variety of food groups is used including staples (cereals, tubers and root crops), pulses, sugar and oil. Data on these food groups were not collected due partly to time constraints and partly due to the importance placed on understanding the impact of fish farming on the consumption of fish and protein. However it can be assumed that the households surveyed are food secure in terms of staples and pulses otherwise it is unlikely they would be able to consume fish and meat so regularly (see Chapter 5 for more details).

Table 4: A completed Food Consumption Score table

Food group	Weight (A)	Days eaten in average week in dry/rainy season (B)	Score A x B
Meat and fish (including eggs)	4	7	28
Milk	4	1	4
Vegetables	1	7	7
Composite score			**39**

For each household, the FCS is calculated by multiplying each food group frequency by each food group weight, then summing these scores into one composite score. Along with the FCS, a Simple Food Count (SFC) index is also constructed for both dry and rainy seasons. This uses the same methodology as for FCS but does not combine food items into groups, giving more variability in the scores.

Income Determination Model

The descriptive analysis described above may not account for all possible differences in household characteristics, other than participation in fish farming, which could cause differences in impact indicators such as income between fish and non-fish farming households. Therefore, a household Income Determination Model (IDM) is used to control for differences in observable characteristics between households and to assess the factors that contribute to differences in income between fish farming and non-fish farming households. The multiple log-linear regression model is estimated using OLS (see Chapter 5, Section 5.2.11 for details).

4.3.2 Data and methods to test Hypothesis 2

This section reviews Objective 2 and Hypothesis 2, and then describes the main data and methods used to test Hypothesis 2.

Objective 2 and Hypothesis 2

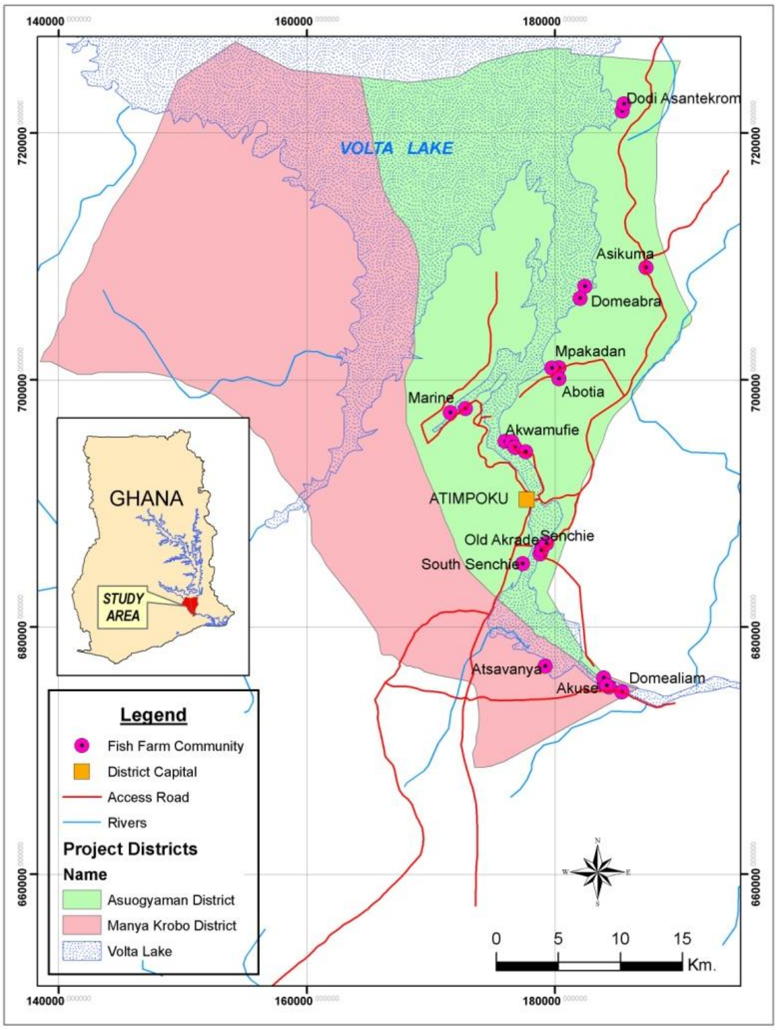
Objective 2: To assess the importance of direct and indirect poverty impact pathways from different aquaculture systems and examine implications for pro-poor growth in different contexts.

Hypothesis 2: Indirect poverty impact pathways (such as employment, consumption and multiplier effects) from increased aquaculture SME activity have more potential to impact on poverty than indirect pathways from large-scale commercial operations and direct and indirect pathways from small-scale pond aquaculture.

To test Hypothesis 2 and explore the linkages arising from different aquaculture systems, a number of data sources and methodologies are utilised as follows: i) the household survey of small-scale fish farmers in Ashanti Region described in Section 4.3.1 above: ii) an enterprise survey of SME and large-scale cage farms in Lake Volta in the two study districts in Eastern Region; and iii) FGDs conducted in seven communities on Lake Volta where cage aquaculture is present. The communities in which the surveyed cage farms are located are shown in Figure 10.

Economic multiplier effects are calculated using a semi input-output multiplier model using data from the small-scale fish farming PBs described in Section 4.3.1, budget data from the cage farm survey, and expenditure data from the GLSS5. Employment generated by different systems along with wage rates is calculated using data from the household survey and the cage farm enterprise survey. These data sources and methodologies are described in turn below (aside from the household survey and PBs). All survey data is analysed using SPSS Version 16.

Figure 10: Location of cage farms surveyed in the two study districts



Cage farm enterprise survey and community FGDs

A cage farm enterprise survey was undertaken in early 2011 in the two study districts in Eastern Region. A sampling frame of 54 functional SME and large-scale cage farms was constructed with the help of the District FC and Water Research Institute (WRI) staff in Akosombo. A large number of cage farms on record at the District FC Office were no longer functional. As many as possible of the functional cage farms were visited. In total 14 small-scale, 5 medium-scale and 2 large-scale commercial cage farms were surveyed (shown in Figure 10) and owners and/or caretakers were interviewed. The survey collected information for 2010 on: i) farmers' socioeconomic characteristics; ii) production systems and practices including number and size of cages and levels of inputs; iii) fish production and revenue; iv) farm employment and wages; v) marketing channels; vi) costs and revenues; and vii) linkages with and impacts on surrounding communities. The full questionnaire is presented in Appendix 2.

FGDs were conducted with 7 communities on Lake Volta where cage aquaculture is present. The communities were chosen to represent the range of small, medium and large-scale farms (and one community, where a private hatchery, previously a commercial cage farm, is located was also chosen) to understand the linkages arising from different systems. The FGDs were undertaken with groups of 8-12 community members of mixed ages and genders, and gathered information on: i) community characteristics and distribution of poverty; ii) main livelihood activities of community members, iii) employment linkages from cage farms (including data on groups benefiting from seasonal and regular employment, trading and processing due to cage aquaculture); iii) cost of living linkages, and price and food security impacts on consumption of fish by poor households; iv) consumption linkages; and v) institutional, service and infrastructure linkages from cage farms. Short FGDs were also conducted with fishermen in these 7 communities to understand the positive and negative impacts of cage aquaculture on fishermen's livelihoods (if any) such as changes in access rights to fishing grounds.

Multiplier estimation

A fixed-price semi input-output multiplier model is used to estimate the economic multiplier effects arising from development of small-scale pond aquaculture in Ashanti Region and commercial SME cage aquaculture in Lake Volta, Eastern Region. The model used here, like most economic multiplier models in the literature, only considers the effects of backward and forward production linkages and consumption linkages on economic growth. Investment, cost of living, environmental, service and institutional linkages (described in Chapter 2) are excluded from the calculations. However results from Chapter 6 indicate that production and consumption linkages are the strongest of all the possible linkages from aquaculture.

Many of the models used in linkage studies are variants of the original semi input-output model developed by Bell and Hazell (1980), for example Bell, Hazell and Slade (1982), Haggblade and Hazell (1989) which used a three sector variant and Delgado et al. (1998) which used a four sector variant. The model describes an economy in which gross output consists of tradable output *T*, assumed to be fixed at T, as tradable goods are assumed to be supply constrained, plus nontradable outputs, N, the supply of which is assumed to be highly elastic.

As discussed in Chapter 2, Section 2.3.4, nontradable goods are those that are produced and consumed locally, having either no outside markets or external sources of demand. Furthermore, nontradable goods must not have close tradable substitutes that are available locally, so the domestic price of the non traded good is not likely to be highly correlated with the domestic price of any tradable good that could play the same role in the consumption basket (Delgado et al., 1998:1). Nontradables are demand constrained so any increased demand through income growth must be met by new production leading to additional growth in the local economy. This thesis uses both the regional and the national definition of trading space to calculate regional (local) and national multiplier effects. Thus the classification of a commodity as tradable or nontradable depends on whether the commodity is imported or exported from the trading space (in this case Ashanti Region/Eastern Region or Ghana) or has any locally available substitutes whose prices are correlated with it. While farmed fish produced by small-scale pond farmers in Ashanti Region are generally not traded outside the region let alone the country, and while tilapia from SME cage farms are traded outside Eastern Region but are not exported, aquaculture products are still treated here as tradables as they have locally available tradable substitutes (fish from marine and inland capture fisheries in Ghana and imported fish) whose prices are correlated.

The model measures the impact on a region's income of an exogenous shock to a sector, via technological change or outside investment, enabling the region to increase its output of tradables and causing the output of nontradables to increase. Assuming the level of intermediate inputs used per unit of tradable output does not change due to the initial increase in tradable output (Haggblade et al., 1991), Bell and Hazell's (1980) multiplier (*M*) can be written (Delgado et al., 1998:10):

$$M = \frac{1 - a_{nn} + a_{nt}\left(\frac{\mathrm{v}_n}{\mathrm{v}_t}\right)}{1 - a_{nn} - \beta_n \mathrm{v}_n\,(1 - \mathrm{s})}$$

where:

a_{nn}, a_{nt} = the share of nontradable intermediate inputs in nontradable and tradable output respectively (between 0 and 1),

a_{tn}, a_{tt} = the share of tradable intermediate inputs in nontradable and tradable output respectively (between 0 and 1),

v_n = a constant with a value equal to 1 - a_{tn} - a_{nn}, the share of value added in gross output of the nontradables sector,

v_t = same as v_n but for tradables, with value equal to 1 - a_{tt} - a_{nt}

β_n = marginal propensity to consume nontradables (or MBS of nontradables)

s = leakage, a constant proportion of total income (savings and tax rate)[32].

The MBS for nontradables as a group is the most important determinant of the magnitude of estimated growth multipliers (Delgado et al., 1998). The actual multiplier is a numerical solution to a regional level model of supply and demand which incorporates household demands and intermediate demands between sectors (Delgado et al., 1998). This model is used to estimate the regional and national economic multiplier effects (i.e. the effect on regional and national income) of a one dollar increase in income from:

i) small-scale pond aquaculture in Ashanti Region and
ii) SME commercial cage aquaculture in Eastern Region, Ghana.

[32] The multiplier and parameter definitions are taken directly from Delgado et al. (1998:10).

Parameter estimation and data

The model parameters are estimated using a mixture of primary and secondary data. The share of nontradable intermediate inputs in nontradable output (a_{nn}) is estimated from the results of a previous study of agricultural multipliers in Ghana by Al-Hassan and Jatoe (2007). The share of nontradable intermediate inputs in tradable (i.e. aquaculture) output (a_{nt}) are estimated from primary budget data collected through PBs of small-scale pond farmers, and survey data of SME cage farmers supplemented by data from key informant interviews. The ratio of value added in gross output of the nontradables sector (v_n) is also estimated from the results of Al-Hassan and Jatoe (2007), and the ratio of value added in gross output of the tradable aquaculture sector (v_t) is estimated from the primary budget data described above. The savings rate (s) is estimated from Ghana National Accounts data for 2010.

The MBS of nontradables (β_n) is calculated by empirically estimating expenditure functions for nontradable goods using expenditure data from the GLSS5. Goods were classified into nationally tradable and nontradable categories according to the definition given above. As there was only one pond farmer and no cage farmers captured by the GLSS5, the expenditure of cocoa farmers in Ashanti Region is used as a proxy for expenditure of small-scale pond farmers in Ashanti and the expenditure of professionals from Greater Accra who also had agricultural income is used as a proxy for SME cage farm owners. These proxies were chosen as the majority of small-scale pond farmers surveyed in Ashanti Region were also cocoa farmers and the majority of small-scale cage farm owners surveyed were professionals living in Accra.

An Engel curve relates the household budget shares allocated to each good to total household expenditure. A number of functional forms of the Engel curve have been developed in the economics literature (Deaton and Muellbauer, 1980). A popular form is the Working-Leser model (Working, 1943, Leser, 1963) where the budget share of each good is a linear function of the logarithm of total household expenditure which can be expressed as:

$$\omega_{ij} = \alpha_j + \beta_j \ln(x_i) + \varepsilon_{ij} \quad (1)$$

where ω_{ij} is the budget share of good j in household i (so if j is the group of nontradable goods, ω_{ij} represents the ratio of expenditure on nontradable goods to total household expenditure), x_i is total household expenditure, α_j and β_j are parameters to be estimated and ε_{ij} is an error term. An expression to estimate the MBS of nontradable goods can be derived from this equation (shown in Appendix 3).

A variant of the Working-Leser model is used to estimate the MBS of nontradable goods in this thesis, using total expenditures as a proxy for income. MBS thus represents marginal propensities to consume. The basic Working-Leser model has been expanded to include other variables such as socio-economic and demographic household characteristics assumed to affect the budget shares allocated to different types of goods (see Deaton, 1997). Household characteristics are therefore included in the model used here which takes the following form:

$$\omega_{ij} = \alpha_j + \beta_j \ln(x_i) + z_i \gamma_j + v_{ij}, \qquad i = 1,2, \ldots \ldots n, \quad (2)$$

where ω_{ij} is the budget share of category j of goods (in this case the share of nontradable goods) in household i, x_i is total expenditure of household i, z_i is a vector of household characteristics (household size, sex of household head and age of household head), α_j and β_j are parameters to be estimated, γ_j is an unknown parameter vector to be estimated and relates to household characteristics contained in the z_i vector, and v_{ij} is an error term. The estimation technique used is the OLS procedure. The MBS values for nontradables were estimated with the assistance of an econometrician from the University of Ghana, Legon.

Estimation of employment generation and wages

The level of employment generated by small-scale pond aquaculture is compared to the employment generated by crop farming and also by SME and large-scale commercial cage aquaculture using data collected from the household survey and from data collected from the cage farm enterprise survey. Employment is measured in full-time equivalent (FTE) jobs based on the number of days usually worked in the farming sector so one FTE job is estimated to represent one full time job for someone working 8 hours a day, 300 days a year. Wage rates between labourers on small-scale pond farms and SME cage farms are also estimated and compared to average wage rates in the agricultural sector.

Labourer characteristics

Some demographic characteristics of labourers on SME and large-scale commercial farms are explored using data collected from a survey of labourers. 86 employees on 3 small-scale farms, 5 medium-scale farms, 2 large-scale farms and the largest hatchery (Crystal Lake) were selected at random to be interviewed. The questionnaire is presented in Appendix 4.

4.3.3 Data and methods to test Hypothesis 3

This section reviews Objective 3 and Hypothesis 3, and then describes the main data sources, methods for data collection and analysis used to test Hypothesis 3.

Objective 3 and Hypothesis 3

Objective 3: To identify the institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction in different contexts.

Hypothesis 3: Due to the institutionally demanding techno-economic characteristics of aquaculture products, complementary technical and institutional development is necessary for aquaculture to develop and impact poverty.

To test Hypothesis 3, the institutional framework of Dorward and Omamo (2009) (outlined in more detail in Chapter 7) is applied to both pond and cage aquaculture sub-sectors. Data collected to test Hypothesis 1 and 2 (described above) along with additional primary data, are utilised to analyse the following components of the conceptual framework within the pond and cage aquaculture sectors (referred to as ‘action domains’): i) activities and their attributes (including the techno-economic characteristics of farmed fish commodities); ii) actors and their attributes; iii) institutions and their attributes; and iv) outcomes. Secondary data are used to supplement the primary data to understand the operational environment (physical, socioeconomic and policy and governance environment) in which the aquaculture systems operate. Analysis of each of these components makes use of data from a range of sources to enable more comprehensive analysis (described further below).

Data used to test Hypotheses 1 and 2 were utilised, specifically data from the household survey and the cage farm enterprise survey. These data were supplemented with data gathered from 42 farmed fish traders, key informant interviews with other stakeholders in the aquaculture value chains including feed and seed suppliers and FC extension staff as well as direct observation. Information gathered from these sources is used to understand the techno-economic characteristics of farmed fish in the three systems as well as analyse the activities and attributes of actors and the types of institutional arrangements linking them. Secondary data is also utilised to understand the wider institutional environment. The sources of primary data used are described below.

Household survey

Data collected by the household survey of small-scale artisanal fish farmers on: farmers socio-economic characteristics; production practices; marketing channels for farmed fish; institutional arrangements between producers and buyers; and problems of farmers related to fish farming production and marketing, are used to analyse the components of the conceptual framework for the pond aquaculture ‘action domain’.

Cage farm enterprise survey

Similarly, data collected by the cage farm enterprise survey on: the socio-economic characteristics of cage farm owners; production practices; marketing channels for cage farmed fish; institutional arrangements between producers and both buyers and input suppliers; and problems of farmers related to production and marketing, are used to analyse the components of the conceptual framework for the cage aquaculture 'action domain'.

Trader interviews

Data from the two surveys described above were supplemented with information gathered from semi-structured interviews with 3 pond farmed fish traders and 8 wild caught tilapia traders in Kumasi (Ashanti Region), and 31 cage farmed fish traders (3 of whom were also fish wholesalers) in Eastern Region. All traders were interviewed individually while they were buying fish (from small-scale pond farms, SME cage farms and/or large-scale commercial cage farm retail/marketing outlets). One FGD with 6 members of a farmed fish trader group was also undertaken. Information was gathered from traders on: i) socio-economic characteristics of traders; ii) trading activities; iii) the marketing chain including sources of fish, retailing outlets, sources of credit, transport and other services; iv) institutional arrangements linking traders with other value chain actors as well as with other traders and wholesalers; iv) fish grading and pricing; v) profitability of fish trading; vi) problems related to sourcing fish and fish marketing, especially sources and levels of risk faced by traders.

Key informant interviews

The above data were supplemented with information gathered from key informant interviews with other key actors in the pond and cage aquaculture sectors including: feed and fingerling suppliers, credit providers, staff from the FC in Accra, Kumasi and Akosombo, and staff from WRI in Accra and Akosombo.

Direct observation

Fish harvests (for both pond and cage farms) were attended where traders, farmers and processors and their interactions could be observed. Direct observation of Regional FC staff and their activities in Kumasi and staff at WRI in Akosombo (which is also a government hatchery) was also used to verify and supplement the data collected from the sources outlined above.

Iterative process of data collection and analysis

Overall data collection for the institutional analysis required to test Hypothesis 3 was an iterative process. The institutional picture and the dynamics and relationships between actors and institutions were built up gradually over the course of the fieldwork.

CHAPTER 5: DIRECT IMPACTS OF SMALL-SCALE AQUACULTURE ON POVERTY

5.1 INTRODUCTION

This chapter focuses on assessing the direct impacts of small-scale pond aquaculture on poverty and livelihoods of households in three districts in Ashanti Region using a Sustainable Livelihoods approach. The research question and hypothesis addressed in this chapter are as follows:

Objective

To assess the direct poverty and livelihood impacts (positive and negative) of small-scale aquaculture systems on different categories of poor people in Ghana.

Hypothesis

Small-scale aquaculture has positive direct impacts on poverty and livelihoods of poor households in Ashanti Region, Ghana. The magnitude of these impacts depends on the livelihood characteristics and production systems of small-scale farmers, and the institutional and infrastructure context.

To test this hypothesis, poor fish farming households are first identified to see whether poor households are able to adopt fish farming and thus potentially benefit directly from aquaculture. The chapter then investigates and compares the livelihood characteristics, capital assets, activities and livelihood strategies of poor and non-poor small-scale fish farmers and a comparison group of non-fish farmers (see Chapter 4, Section 4.3.1). Fish farming as a livelihood activity is then explored along with the perceived benefits for adopting households and the community. The differences in livelihood outcomes such as income, household assets and food security between fish farming and non-fish farming households are then compared in order to identify any significant group differences which could indicate that fish farming households are better off than non-fish farming households.

These comparisons, however, do not account for other possible differences in household characteristics which may cause differences in livelihood outcomes between fish farming and non-fish farming households. Thus an Income Determination Model is used to control for differences in observable characteristics between households and to assess the factors that contribute to differences in income between fish farming and non-fish farming households. The results presented in this chapter are based on non representative samples of fish and non-fish farming households and no compensatory weights were applied: they thus represent sample results not population estimates.

The descriptive statistics exploring group differences between fish farming and non-fish farming households have to be presented in some detail to test the hypothesis. However, readers who wish to avoid this can skip straight to Section 5.2.11 and rely on that and the summary of findings in Section 5.3 to glean the major conclusions made from the detailed examination of the descriptive statistics in Sections 5.2.1 to 5.2.10.

5.2 RESULTS

5.2.1 Defining the poor

To test the hypothesis that fish farming has positive direct impacts on the livelihoods of poor households, identification of poor households is necessary. This is done below by analysing community wealth ranking exercise results (see Chapter 4, Section 4.3.1), estimating headcount poverty rates of the fish and non-fish farming households surveyed, and analysing respondents' own subjective perception of their household poverty level.

Wealth ranking

Wealth ranking exercises were conducted in three communities to understand communities' own perception of poverty and find out which wealth categories fish farmers are in. The results are summarised in Table 5.

Table 5: Wealth ranking results: households in three wealth categories

Households from three villages	More wealthy	Medium wealth	Less wealthy	Total
Total households (Nos.)	37	107	113	257
% of households in each category	14	42	44	100
Total fish farming households	8	8	7	23
% of fish farming households in each wealth category	22	7	6	9
% within fish farmers	35	35	30	100

Of all 257 households, 44 percent were classified as less wealthy and 56 percent as medium or more wealthy. A much higher percentage of more wealthy households is involved in aquaculture compared to the less well off groups. Overall the results suggest that while less wealthy (or poor) households are able to adopt fish farming, fish farmers are more likely to be wealthier.

Table 6 below shows some of the main characteristics of households in these wealth categories, identified by the communities. Many of the household and livelihood characteristics that are compared between fish farmers and non-fish farmers, presented in the following sections of this chapter, are those which communities themselves point to as indicators of poverty.

Table 6: Wealth ranking results: characteristics of households in three wealth categories.

Category	1 (More wealthy)	2 (Medium wealth)	3 (Less wealthy)
Land ownership	25 ha and above Some rent out land for sharecropping	1-2 ha on average	Some own small sized land holdings, others do not own any land
Crop systems	Mainly cash crops (e.g. cocoa, citrus, pepper, vegetables, oil palm, coconut)	Mixture of cash crops (e.g. cocoa, oil palm) and staples (e.g. plantain, cassava).	Those with land produce mainly staples (cassava, plantain) for subsistence. Others produce cocoa through sharecropping.
Livestock ownership	Own livestock	Own livestock	Only some own livestock
Ability to invest in fish farming	Have the funds to do fish farming – e.g. income from cocoa is used to dig ponds and hire labourers	Are able to invest in fish farming	Less able to do fish farming. Those that do have small ponds
Occupation	Farming of cash crops Business owners Salaried employment e.g. teacher, banker Two incomes e.g. spouses do trading or own business	Farming of cash crops Business owners Employed in nonfarm sector as artisans Traders	Subsistence farming Petty trading Casual farm labour (GH¢ 3.5/day) Unemployed Illegal mining
House	Own one or more houses. Walls made from cement blocks, iron roofs	Own their own houses Walls made of bricks or cement blocks, iron roofs	Some own their own houses Walls made from mud, some have iron roofs, others have bamboo/ thatch roofs
Assets	Many own vehicles - car, motorbike Own assets such as pumping machine, processing machines	Some own motorbikes	No household assets No vehicle
Food security	3 good meals a day	3 good meals a day	Less than 3 good meals a day
Labour	Able to hire labour	Able to hire labour	Unable to hire labour
Savings	Able to save	Able to save	Unable to save
Children's education	Some able to send their children to private schools and on to secondary schools or training college	Government basic schools, secondary education	Government basic schools, no secondary education
Other	Strength to work, not lazy Not migrants	Strength to work, not lazy Not migrants	Not enough strength to work, always complaining, old age, invalids, lazy, drunk, Migrants

Headcount poverty rate

Surveyed households are classified here as 'poor' if their per capita income is below the poverty line[33] and 'non-poor'[34] if their per capita income is above the poverty line. Income data were collected in the household survey. However, farming, livestock and household enterprise costs were not collected due to lack of resources. Thus, the estimates are of gross (as opposed to net) income. Table 7 shows the percentage of poor and non-poor surveyed fish and non-fish farming households[35].

Table 7: Poor and non-poor surveyed households by fish farming status

Poverty status	Fish farmer households	Non-fish farmer households	Total households
	%	%	%
Poor households	44	57	50
Non-poor households	57	43	50
Total households (Nos.)	**69**	**74**	**143**

50 percent of surveyed households are classified as poor (similar to the 44% less wealthy households from the wealth ranking results above)[36]. The

[33] The international poverty line of US$1.25 a day at 2005 Purchasing Power Parity (PPP) set by the World Bank was used. Inflating this using the 2010 PPP exchange rate for Ghana (0.856) gives a poverty line of GH¢ 390.55. A US$2 per day poverty line for Ghana is GH¢ 624.88 at 2010 PPP.

[34] To avoid repetition, the terms 'poor' and 'non-poor' are used throughout the thesis to refer to sampled households with per capita income below and above the poverty line respectively unless otherwise stated.

[35] Table 1 in Appendix 5 shows the distribution of respondents in each district by fish farming and poverty status.

[36] The World Bank estimated the population under the US$1.25 international poverty line to be 30 percent in Ghana in 2006 (World Bank, 2013a). The GLSS5 of 2005/6 estimated 14.6 percent of the forest zone was below their lower poverty line of GH¢288.47. The GLSS5 poverty line is based on consumption expenditure needed to meet minimum nutritional requirements and is similar to the poverty line used here when adjusted to 2010 prices i.e. when it is increased by 37.7 percent (the increase in Consumer Price Index for food in Ashanti Region between 2006 and 2010) the GLSS5 poverty line is GH¢396.58. The difference in poverty rates between the GLSS5 and this survey may be due to a number of reasons including their use of expenditure (which was 52 percent higher than income) to measure poverty rather than income. When the income figures from the current survey are increased by 52 percent the poverty rate is 30.8 percent. Also while poverty is reported to have decreased substantially in Ghana from 1991/2 to 2005/6 (GSS, 2007), Osei (2011) argues that poverty has increased in Ghana since 2005 due to rising food prices and the global financial crisis and using a micro-simulation model for Ghana estimated 32.9 percent of households were under the poverty line in Ashanti in 2010 (Osei, 2011:11). Ultimately it is not surprising there are differences

percentage of poor fish farmer households is lower than poor non-fish farmer households ($p = .11$)[37] (see Appendix 6 for all Chi square test results).

Poverty self assessment

Respondents were also asked about their own subjective perception of their poverty level. Table 8 shows that overall 42 percent categorised their households as very poor or poor (similar to the 50 percent headcount poverty rate above). An association was found between poverty status and household's own perception of poverty ($p = .1$) suggesting that subjective and objective indicators of poverty are related.

Table 8: Household's own perception of poverty by fish farming and income poverty status

	Fish farmer households			**Non-fish farmer households**			**Total households**		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
	%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Very poor/ poor	37	31	33	57	41	50	49	35	42
Not so poor/well off	63	69	67	43	59	50	51	65	58
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

There is a significant association between fish farming status and households' own perception of poverty ($p = .04$) indicating non-fish farmers are more likely to assess themselves as being either very poor or poor than fish farmers[38].

between this survey which covers 143 households compared to the nationally representative GLSS5 covering 8,687 households and 37,128 household members.

[37] The percentage of the surveyed population (not households) under the poverty line is 55 percent, 47 percent for the population in fish farming households and 63 percent for those in non-fish farming households ($p < .001$), see Table 2, Appendix 5.

[38] 85 percent of all respondents also said that the poor practise fish farming.

5.2.2 Human capital

Household and demographic characteristics

Human capital includes the skills, knowledge, ability to labour and good health that enable people to pursue different livelihood strategies and achieve their livelihood objectives. (DfID, 1999). Data on household size and composition, education and occupation is presented for fish farmers and non-fish farmers in the following tables.

Table 9 shows that there are few major differences in demographic characteristics between fish farming and non-fish farming households (see Table 4, Appendix 5 for more data on demographic characteristics).

Table 9: Household and demographic characteristics of sample households by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Female headed households (%)	10	0	4	0	9	4	4	4	4
Married household heads (%)	93	97	96	98	88	93	96	93	94
Average age of household head	51.0 (1.95)	46.9 (1.90)	48.7 (1.38)	50.8 (1.61)	47.1 (1.91)	49.2 (1.24)	50.9 (1.23)	47.0 (1.34)	48.9 (0.92)
Average household size	9.3 (0.68)	8.1 (0.58)	8.6 (0.45)	9.3 (0.47)	7.3 (0.48)	8.4 (0.36)	9.3 (0.39)	7.7 (0.39)	8.5 (0.28)
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: % refers to column percentage i.e. percentage of total households surveyed
Standard errors (SE) in parentheses

The majority of all households are headed by males, nearly all of whom are married. While the average size of fish and non-fish farming households are very similar[39], overall poor households have more household members than

[39] The average household size of total surveyed households (8.5) is much higher than that reported by the GLSS5 which measured household size as the number of equivalent adults using a scale based on age, gender and specified calories requirements. Using this method, the GLSS5 estimated average

non-poor households (p = .005) (see Appendix 7 for all independent samples t-test results), a reflection of the way in which the 'poor' and 'non-poor' groups were constructed using per capita income which is likely to be lower when household size is larger. The average age of fish and non-fish farming household heads is very similar due to the age criteria used to match respondents described in Chapter 4. The average age of household heads is higher for poor than non-poor households (p = .03), related to older household heads having larger household sizes thus lowering their per capita income levels.

Education of household heads

Table 10 shows very little difference in the mean number of years of education of household heads between fish farming and non-fish farming households and between poor and non-poor households.

Table 10: Mean number of years of education of household head by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Mean years of education	8.5 (0.71)	9.9 (0.54)	9.3 (0.44)	9.2 (0.62)	9.2 (0.49)	9.2 (0.40)	8.9 (0.47)	9.6 (0.37)	9.2 (0.30)
Total households (Nos.)	**29**	**38**	**67**	**41**	**32**	**73**	**70**	**70**	**140**

Notes: S.E. in parentheses

On average household heads from poor fish farming household have fewer years of education than those from non-poor fish farming households (p=.12)[40].

household size in the forest zone to be 3.8 and overall rural household size to be 4.4 equivalent adults.

[40] Dey et al.'s (2007) impact assessment of IAA in Malawi used a Logit model to estimate the determinants of IAA adoption. The model showed that higher education was not associated with higher adoption, which is similar to the finding here of no difference in education levels between fish farmers and non-fish farmers. However the Malawi study found that as education increased so did the level of integration of IAA practices.

Occupation of household heads and spouses

Respondents were asked about their primary occupations (as defined by them) during the rainy season (late April to October) and the dry season (November to April). Fish farming and non-fish farming household heads are mainly engaged in agricultural activities and have similar occupations (see Tables 6 and 7, Appendix 5). The primary occupation of the majority of household heads (64%) is cocoa farming in the rainy season (reducing to 20% in the dry season) while 50 percent of household heads farm other crops (e.g. cassava and plantain) as their primary occupation in the dry season. Just over 10 percent of fish farming household heads reported fish farming to be a primary occupation in both seasons indicating that fish farming is a secondary or tertiary activity for most fish farmers, after their crop farming activities. The household heads for whom fish farming is a primary occupation are evenly distributed between poor and non-poor households in the dry season (approximately 10% in each category). This percentage increases for poor household heads in the rainy season (17%) which is higher than non-poor household heads (8%), though this difference is not significant at the 10% level[41]. Thus fish farming is not a primary occupation for the majority of both poor and non-poor households.

The primary occupation of spouses by season is shown in Tables 8 and 9 in Appendix 5. For the majority of households, household heads and spouses share the primary occupations of farming cocoa and other crops. Some spouses also have their own businesses (such as trading in food stuffs) as a primary occupation (17% in the dry season and 5% in the rainy season) with little difference between poor and non-poor households. Less than 5 percent of spouses are involved in fish farming as a primary occupation indicating it is a primarily male activity.

[41] The significance was tested using Fisher's exact test.

5.2.3 Natural capital

Natural capital refers to the natural resource stocks from which resource flows and services useful for livelihoods are derived, and is very important to those who draw all or part of their livelihoods from resource-based activities such as farming, fishing, forestry etc. (DfID, 1999). This section focuses on the access of farmers to land, which is one of the most important resources from which rural households in this survey derive their livelihoods and, along with access to water, is required for fish farming.

Land ownership

Land ownership in Ghana is either by stools[42], clans, families, individuals or the state. Table 11 shows that all the households surveyed have access to land either through owning, leasing or renting from others or through sharecropping.

Table 11: Household land ownership by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Households owning land	97	95	96	79	91	84	86	93	90
Households leasing land	10	0	4	2	3	3	6	1	4
Households renting land	3	8	6	5	16	10	4	11	8
Households sharecropping land	20	18	19	31	22	27	26	20	23
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

The proportion of fish farming households who own land is significantly higher than non-fish farming households ($p = .02$) supporting findings from

[42] A Stool represents the traditional office for chiefs in southern Ghana. Stool lands are lands which are entrusted in the appropriate Stool on behalf of and in trust for the subjects of the Stool (source: http://ghanadistricts.com/home/?_=42&sa=3638&ssa=1418 (accessed 23 May 2013))

key informant interviews that households with secure access to land are more likely to invest in fish farming[43].

Table 12 shows the average and median hectares of land owned and total farm size (the amount of land owned, leased, rented and sharecropped[44]) by all households surveyed.

Table 12: Average land size by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Size of land owned (ha)	6.0 (1.38) Median 3.5	8.2 (1.28) Median 5.1	7.2 (0.94) Median 4.1	4.4 (0.75) Median 3.7	7.2 (1.35) Median 4.9	5.7 (0.73) Median 4.1	5.1 (0.72) Median 3.5	7.8 (0.93) Median 4.9	6.4 (0.59) Median 4.1
Total farm size (ha) (1)	7.6 (1.52) Median 4.5	9.4 (1.44) Median 5.9	8.6 (1.05) Median 5.3	6.3 (1.06) Median 4.1	9.2 (1.62) Median 6.9	7.6 (0.93) Median 4.9	6.8 (0.88) Median 4.1	9.3 (1.07) Median 6.1	8.0 (0.70) Median 4.9
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

(1) Total farm size is the sum of land owned, leased, rented and sharecropped but is not necessarily the amount of land under production

Medians are included as size of land owned is skewed towards smaller land sizes. On average fish farming households own more land than non-fish farming households (p = .18) and poor households own significantly less land than non-poor households (p = .025). Poor households have a lower average total farm size than non-poor households (p = .078) and a lower median farm size. There is no significant difference at the 10 percent level between

[43] The percentage of respondents owning land seems rather high judging by the nature of the land tenure system in Ghana. For comparison Wiredu et al. (2011) reported the findings of a survey of 366 cocoa farmers in Ashanti Region in 2005 where approximately 74 percent of farmers owned land. Asmah (2008) found 67 percent of fish farmers surveyed owned land with legal title and 30.5 percent leased land from chiefs, individuals or the state. It could be possible that ownership and lease definitions between these surveys are not the same, for example the current survey did not specify ownership to mean households who have a legal title.

[44] See Table 10 in Appendix 5 for disaggregated values.

average total farm size of fish farmers and non-fish farmers and between poor and non-poor fish farming households[45].

5.2.4 Physical capital

Physical capital consists of the producer goods and basic infrastructure needed to support livelihoods (DfID, 1999). This section focuses on physical capital such as housing, ownership of household assets and access to infrastructure of the surveyed population. The majority of those surveyed own their own houses with no significant difference in home ownership between fish farming and non-fish farming households (p = .31) (see Table 11 in Appendix 5 for data on housing conditions such as roof and wall materials).

Table 13 shows the ownership of household assets of the households surveyed. Ownership of some assets (such as radio, boat, bicycle, motorcycle, flush toilet and latrine) appears to be similar across different household groups. However, ownership of other assets shows some significant differences between groups. For example, a higher percentage of fish farming households own a refrigerator compared to non-fish farming households (p = .06) and this is also the case for non-poor compared to poor households (p = .02). A higher percentage of fish farming compared to non-fish farming households own a telephone and/or mobile phone (p = .1) and a significantly higher percentage of non-poor compared to poor households own a telephone and/or mobile phone (p = .002). Significant differences are also found in vehicle and water pump ownership between fish and non-fish farmer households (p = .05 and p = .06 respectively). These differences may indicate that fish farming households are better off than non-fish farming households but could also indicate that fish farming households may have more need for assets such as water pumps to drain their ponds, and refrigerators to store their fish.

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[45] While both the average and median amounts of total farm size seems rather high compared to average district farm sizes reported by the MOFA presented in Chapter 4, other households surveys conducted in Ashanti Region have estimated similar sized average land holdings. For example a 2002-2004 survey of 441 cocoa farmers in Ashanti, Western and Brong Ahafo regions estimated the mean area under cocoa per farmer to be 7.49ha (Vigneri, 2008:35).

Table 13: Ownership of household assets by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Radio	90	87	88	95	94	95	93	90	92
Television	50	69	61	50	59	54	50	65	57
Electric fan	37	64	52	29	47	37	32	56	44
Refrigerator	27	51	41	21	31	26	24	42	33
Telephone/mobile phone	70	97	86	69	81	74	69	90	80
Bicycle	17	36	28	24	25	24	21	31	26
Boat	3	3	3	2	3	3	3	3	3
Motorcycle	3	13	9	5	6	5	4	10	7
Vehicle	7	18	13	5	3	4	6	11	8
Water pump	10	15	13	2	0	1	6	9	7
Flush toilet	7	5	6	2	9	5	4	7	6
Latrine	57	74	67	62	63	62	60	69	64
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

A durable goods index was constructed, using the methodology described in Chapter 4, Section 4.3.1 to allow easier comparison between groups, presented in Table 14 below.

Table 14: Durable goods index by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Durable goods index	22.2 (9.52)	48.0 (9.87)	36.8 (7.07)	18.9 (5.82)	18.7 (5.64)	18.8 (4.08)	20.3 (5.18)	34.8 (6.20)	27.5 (4.07)
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

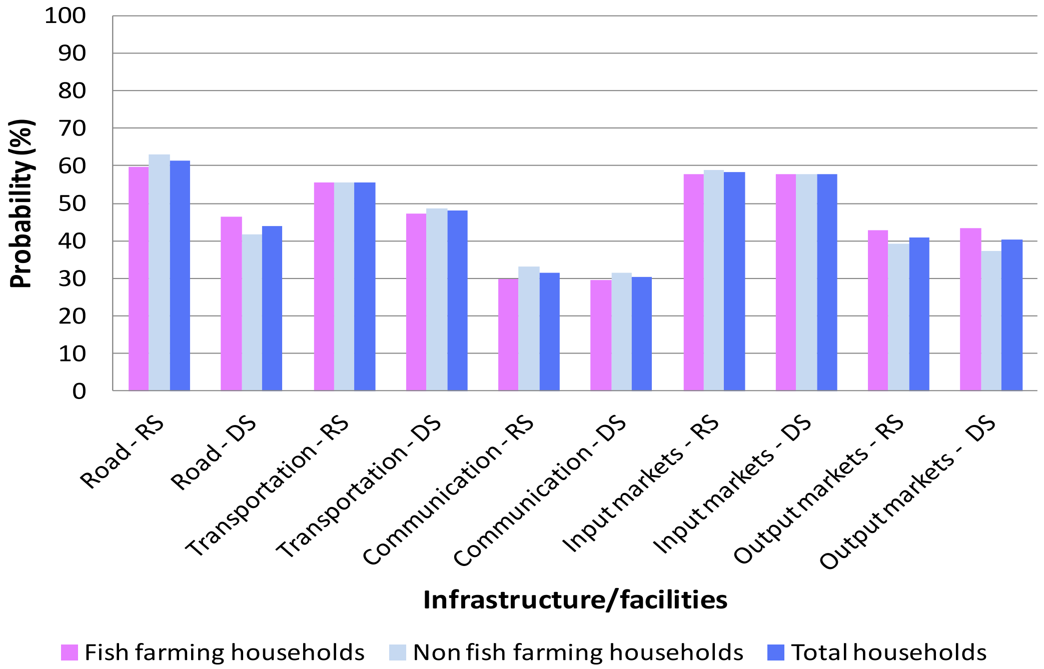
Table 14 shows large differences in the average durable goods index between groups surveyed. Fish farming households have a higher durable goods index score than non-fish farming households (p = .03). Poor households have a lower score than non-poor households (p = .08) and this difference is reflected between poor and non-poor fish farming households (p = .07). Poor and non-poor non-fish farming households have almost identical scores and non-poor fish farming households have a significantly higher score than non-poor non-fish farming households (p = .01).

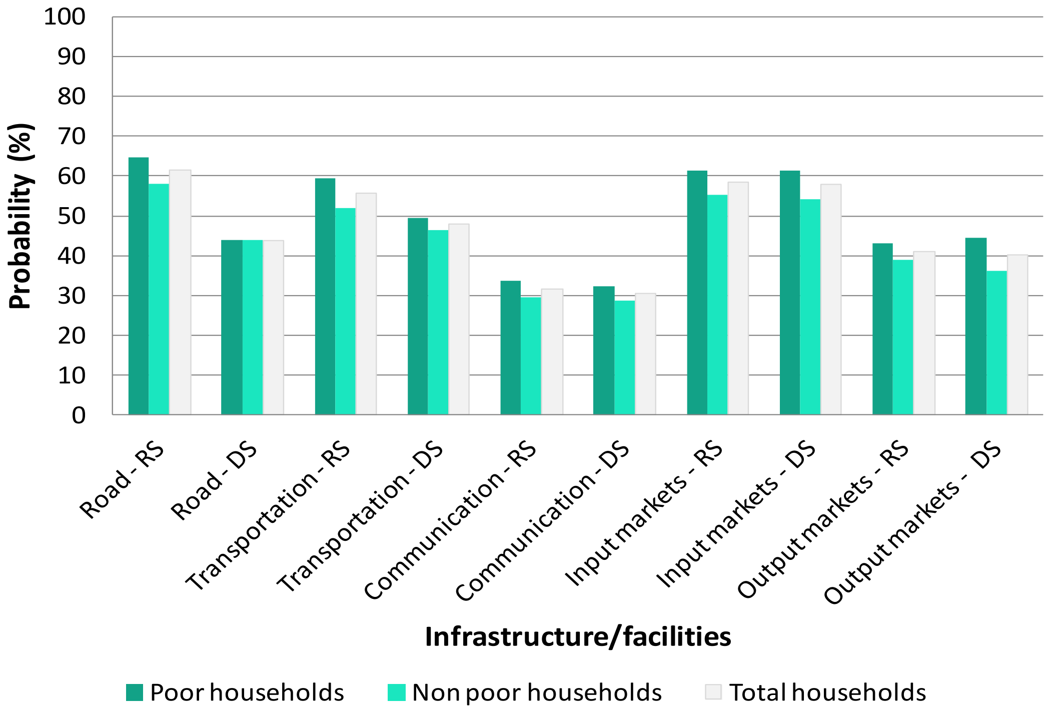
Access to infrastructure, transport and communication facilities

Figure 11 shows the average probability[46] of different groups of households facing difficulties accessing infrastructure and facilities (roads, transportation, communication facilities, input and output markets) during the dry and rainy seasons. Figure 11 shows that overall access to roads and transportation is more difficult in the rainy season than the dry season. It also shows that difficulty of accessing communication facilities is similar in both seasons, and approximately 30 percent indicated access is not difficult. The probability of facing difficulties in accessing input markets is higher than in accessing output markets, with little variation between seasons. Overall fish farming and non-fish farming households face similar levels of difficulty accessing infrastructure, facilities and markets in both seasons.

[46] Probabilities were calculated by asking respondents how difficult it was to access different types of infrastructure and facilities by season on a five step scale from very difficult to very easy. To simplify analysis answers were converted into probabilities. A response of very difficult was interpreted to mean 80 percent probability of facing difficulties, a response of difficult was interpreted to mean 60 percent probability of facing difficulties, neither easy nor difficult was interpreted to mean 40 percent probability of facing difficulties, easy was interpreted to mean 20 percent probability of facing difficulties and very easy was interpreted to mean 0 percent probability of facing difficulties.

Figure 11: Average probability (%) of facing difficulties in accessing infrastructure by season and household type

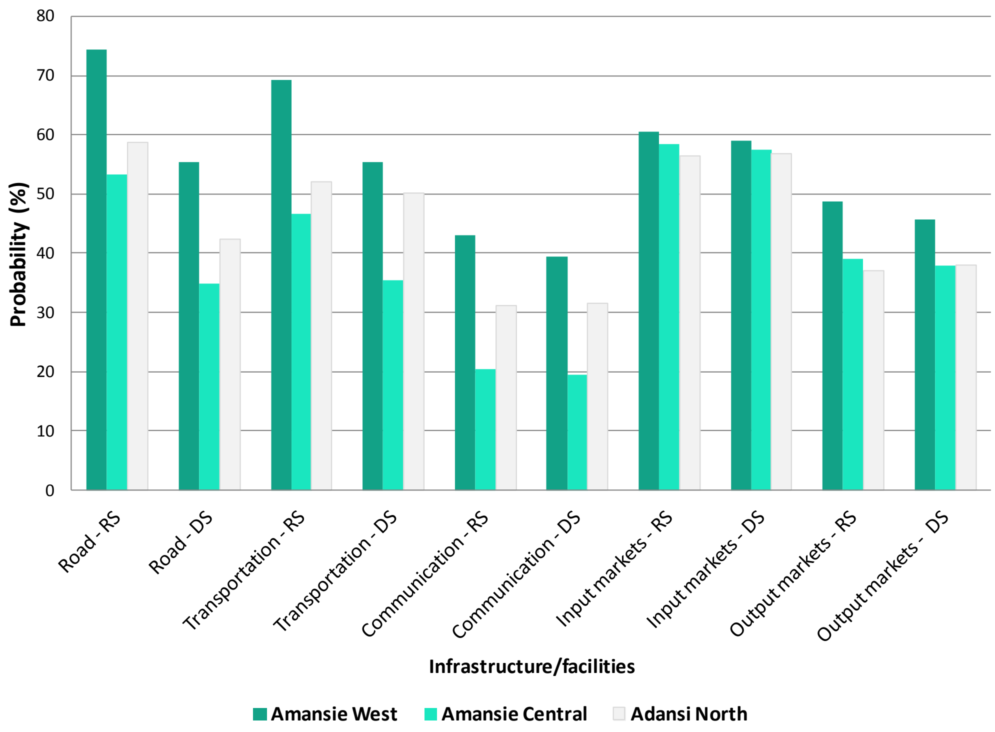




Notes: RS = rainy season, DS = dry season.

Figure 12 shows the average probability of facing difficulties accessing infrastructure and facilities in dry and rainy seasons by district. Households in Amansie West face much higher difficulties accessing all facilities and output markets in both seasons compared to the other two districts. This reflects the fact that Amansie West is the more remote district out of the three with the worst road network and villages that are more dispersed. All districts have similar difficulties accessing input markets which on average seems to be difficult in both seasons.

Figure 12: Average probability (%) of facing difficulties accessing infrastructure/facilities by season and district



Notes: RS = rainy season, DS = dry season.

5.2.5 Financial Capital

This section looks at households' access to stocks and liquid assets in the form of livestock and credit.

Livestock ownership

Livestock are the main form of savings for many poor households, and as a liquid asset can be easily sold to generate income during times of need[47]. Figure 13 shows the percentage of different household groups that own livestock (see Table 12, Appendix 5 for more details).

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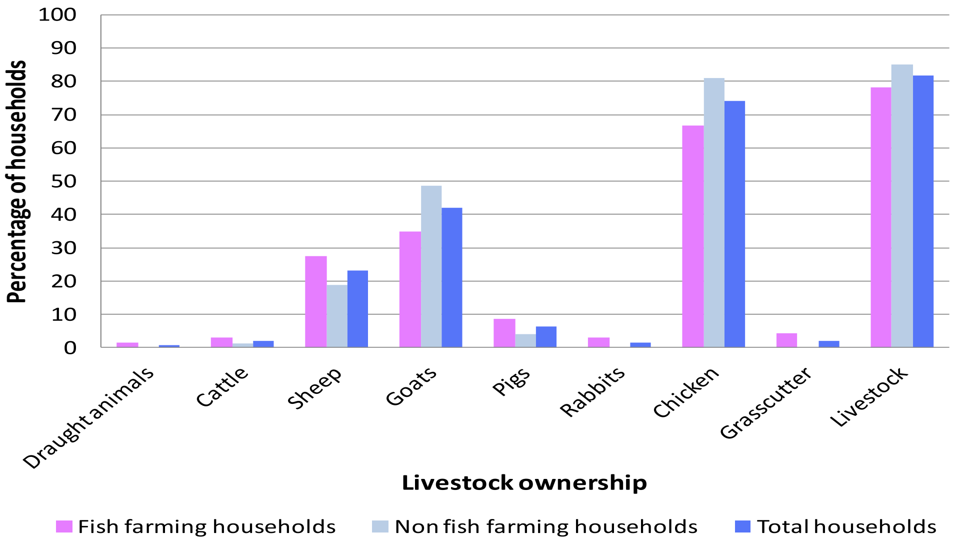
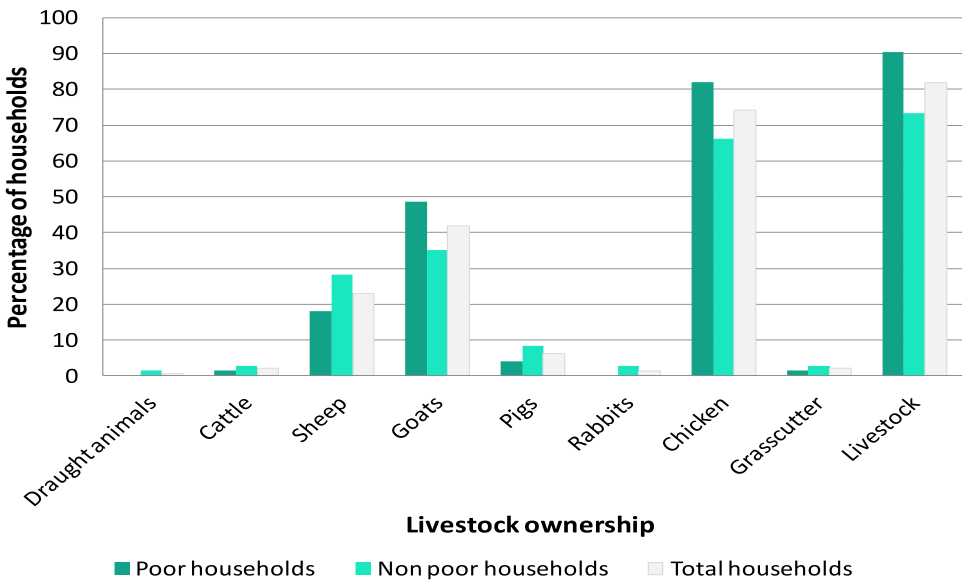
[47] Livestock is also a form of natural capital and can be a form of social capital (e.g. by increasing wealth and prestige, and strengthening networks as livestock are often given as gifts).

Figure 13: Percentage of households owning livestock





Overall the most popular types of livestock owned are chickens, goats and sheep. 90 percent of poor households own some type of livestock compared to 73 percent of non-poor households (due mainly to a higher percentage of poor households owning chickens and goats) ($p = .008$). There is no significant difference (at the 10% level) between the percentage of fish and non-fish farming households owning livestock. Analysis of livestock holdings using TLUs across different households groups, shows that the small numbers of larger animals kept by non-poor households roughly compensates for the larger number of small animals kept by poorer households so that overall portfolios measured in TLUs are roughly similar with no significant difference between fish and non-fish farming households (at the 10% level) (see Table 13, Appendix 5 for more details).

Access to credit

Only 8 percent of surveyed households had accessed credit (one or more times) in the past five years with little difference between groups. Credit was obtained 14 times by 11 households in the past 5 years. Just over half the times credit was obtained from rural banks, nearly 20 percent of the times from friends or relatives and the remainder from a mixture of private and public sources (see Table 14, Appendix 5).

5.2.6 Social Capital

The term 'social capital' is much debated. Putnam (1993:36) defined it as the 'features of social organization, such as networks, norms and trust, that facilitate coordination and cooperation for mutual benefit'. This section looks at the level of membership in livelihood associations of the surveyed households as an indicator of social capital.

Association membership

Table 15 shows the percentage of surveyed household heads who are members of livelihood associations.

Table 15: Membership of household heads of livelihood associations by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
	%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Association membership	53	49	51	17	16	16	32	34	33
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

A much higher percentage of fish farming than non-fish farming household heads are members of an association (p = .01). This reflects membership of two district level FFAs in the survey area, one in Amansie Central and one in Adansi North, established in 2007 by the then Ministry of Fisheries[48]. 14 percent of fish farmers are also members of other livelihood associations related to cocoa, citrus and other crops. Overall this suggests that fish farming households have higher levels of social capital than non-fish farming households. The poor can be at risk of being excluded from Farmer Organisations (Rondot and Collion, 2000; Stockbridge et al., 2003) however association membership is evenly distributed between poor and non-poor households here.

5.2.7 The vulnerability context

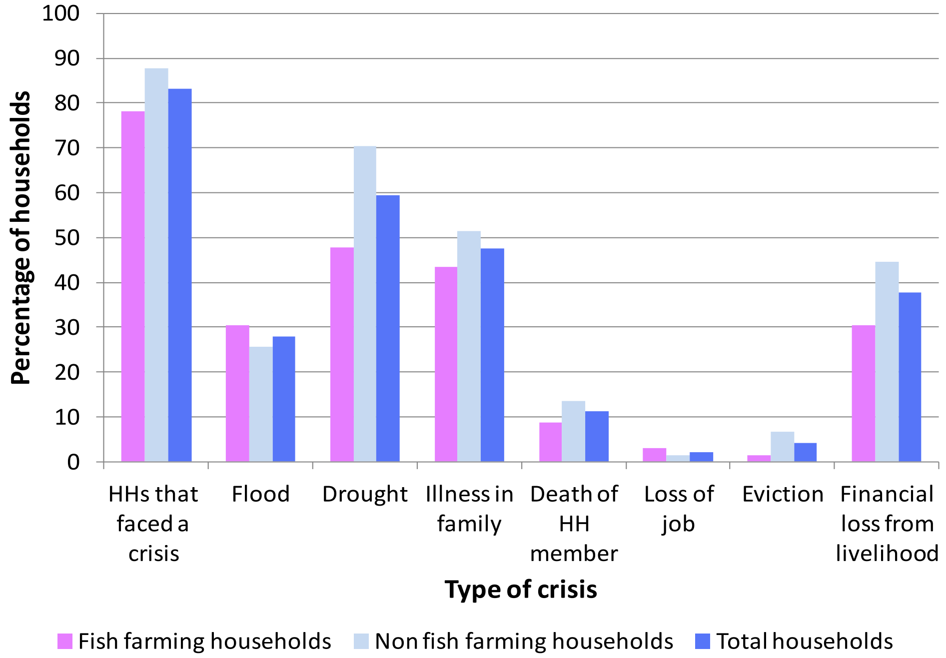
People's livelihoods and asset availability are fundamentally affected by the vulnerability context. This context is influenced by shocks (e.g. natural shocks such as floods and droughts, economic shocks such as large price changes), seasonality (e.g. of production, food security, employment) and trends (e.g. population and economic trends) which directly affect people's asset status and opportunities for livelihood strategies to improve livelihood outcomes (DfID, 1999).

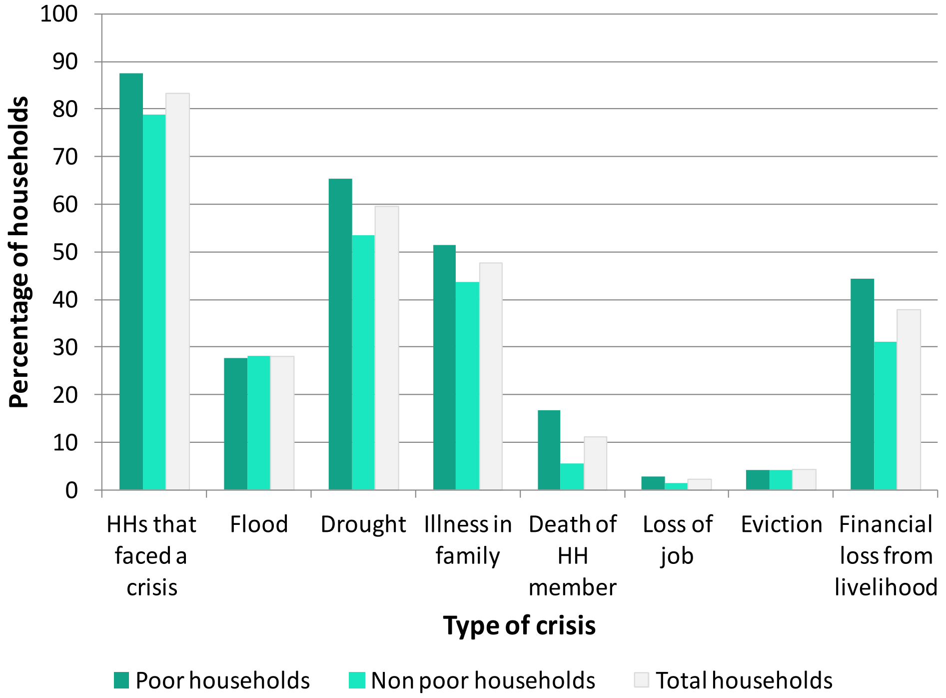
Shocks

Figure 14 shows the percentage of households who faced one or more crises in 2010 and the types of crises they faced.

[48] The sample may be slightly biased towards those in FFAs as it was through the government extension staff and the FFAs that the fish farmers in two of the three districts surveyed were found (even though non members were also found and interviewed).

Figure 14: Percentage of households facing different types of crises in 2010

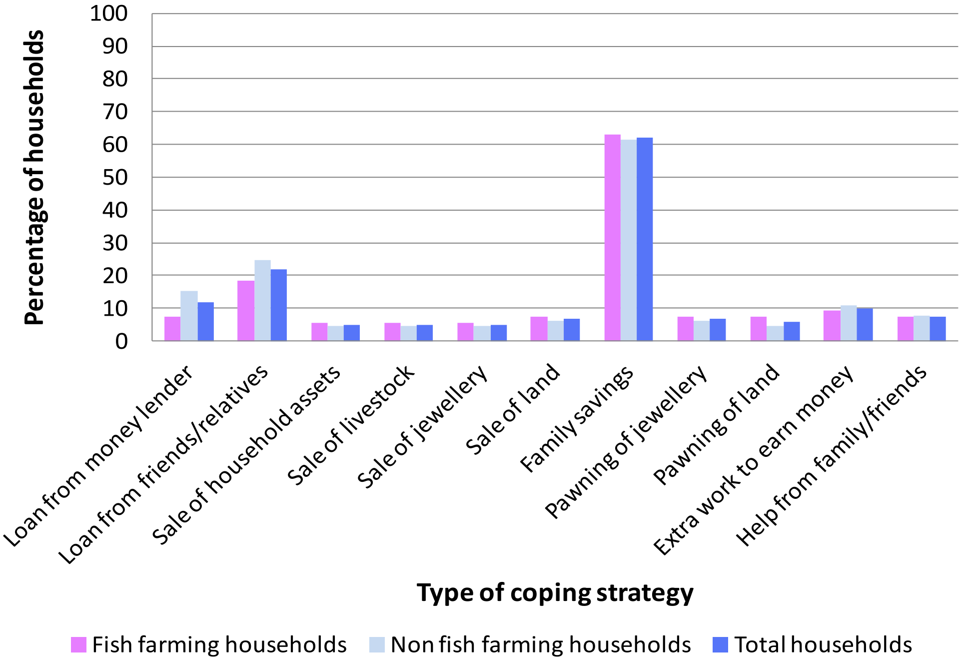


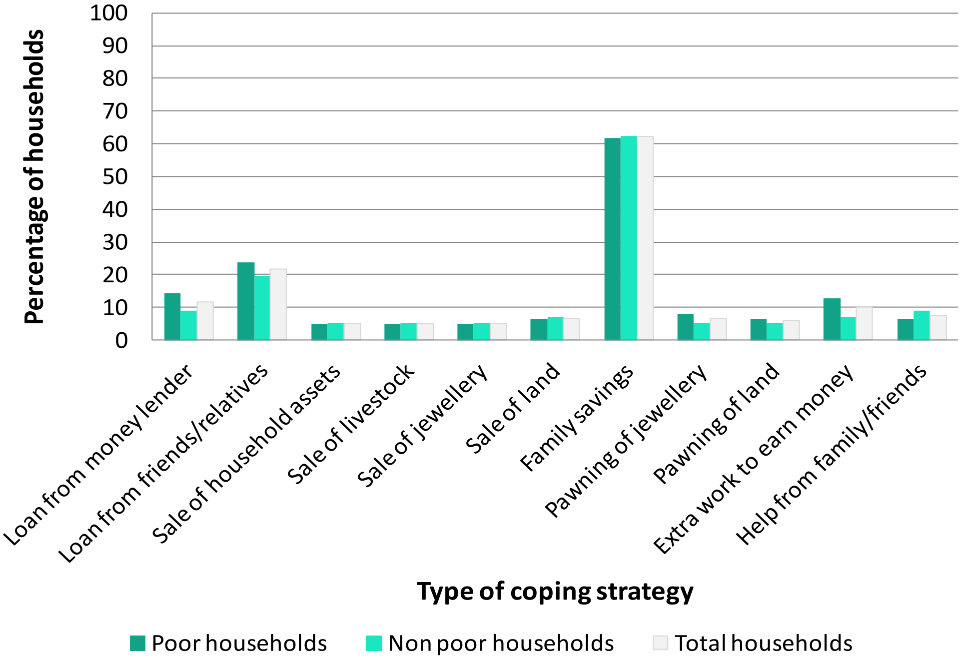


Overall 83 percent of households faced one or more crisis in 2010. There is no significant difference (at the 10% level) between the percentage of poor and non-poor households, and fish farming and non-fish farming households, who faced a crisis. Overall, drought was the most common crisis, affecting nearly 60 percent of all surveyed households. Drought affected a much lower percentage of fish farming households (48%) compared to non-fish farming households (71%) ($p = .06$). Weather related shocks, such as drought and floods, would be expected to be equally distributed across household groups. For example the percentage of surveyed households that experienced floods in 2010 is very similar across groups. Other studies have shown that households with ponds are able to cope better during drought periods. For example Brummett and Jamu (2011) note that in Malawi, farm level impacts of IAA include a 40 percent increase in farming system resilience defined by the ability to maintain positive cash flows through drought years as IAA farmers use pond water to irrigate their crops etc. (Dey et al., 2010). However here it is more likely that surveyed fish farmers have land situated in valleys suitable for fish farming and thus already have land with easy access to water sources (enabling them to farm fish in the first place) and so are less prone to be affected by drought. Illness in the family was experienced by 48 percent of all households, and 38 percent of all households experienced financial loss from their livelihoods. A higher percentage of non-fish farmer households (45%) compared to fish farmer households (30%) experienced financial loss ($p = .01$). Similarly, a higher percentage of poor households (44%) compared to non-poor households (31%) experienced financial loss ($p = .08$).

Figure 15 illustrates the range of coping strategies used by the 83 percent (119 households) that experienced one or more crises in 2010. The most common coping strategy was use of family savings (used by 62% of households) while the second most common strategy was loans from friends and relatives (used by 22% of households) with little notable difference between groups for either of these strategies.

Figure 15: Percentage of households facing crises in 2010 by type of coping strategies used





Seasonal patterns

Ghana's dry season is from November to April and the rainy season is from late April to October[49]. Seasonal changes are extremely important for rural communities that depend on rainfed agriculture for their livelihoods as the seasons affect the timing of activities such as planting and harvesting of different crops, which in turn affect food availability and demand and supply of labour. Seasonal calendars were undertaken in two districts (Amansie West and Amansie Central) to understand seasonal variations across the year, to identify vulnerable months and understand where aquaculture fits into the production system. A generalised seasonal calendar is shown below in Figure 16.

Figure 16: Generalised seasonal calendar

Month	Jan	Feb	March	Apr	May	June	July	August	Sept	Oct	Nov	Dec
Season	Dry	Dry	Dry	Dry/ Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Dry	Dry
Plantain			Harvest	Harvest/ Plant	Harvest			Sell	Sell	Sell	Sell	
Cassava		Harvest	Harvest	Harvest/ Plant	Harvest							
Maize				Plant		Harvest	Harvest	Harvest	Harvest			
Cocoa				Plant	Plant	Plant	Plant	Harvest	Harvest			
Oil palm	Harvest			Plant/ Harvest								
Fish farming	Harvest	Harvest		Stock pond								Harvest
Labour	Hire/ sell	Hire/ Sell	Hire/ sell	Hire/sell	Hire/ Sell	Hire/ sell	Hire/ sell					
Food				Lean	Lean	Lean	Lean					

In both districts planting and harvesting of most crops occurs in April/May, except for maize (harvested from June to September) and cocoa (harvested from August to September). The lean season for food consumption is from April to July during the rainy season which is the period before harvesting and when the previous year's harvest has come to an end.

[49] There is a drier month in August so there is a major and minor rainy season even though this is not reflected in the seasonal calendar below.

Fish farmers reported that their fish production cycle usually begins in April at the start of the rainy season (and the lean season) when rain fills the ponds which are then stocked. Ponds are harvested 9 to 12 months later (December to February). However, most farmers do not do complete harvesting and do not have a fixed production cycle.

5.2.8 Livelihood strategies

Livelihood strategies are diverse and dynamic and people combine a mixture of activities to meet their various needs at different times. Livelihood capital assets (as described above) are the building blocks for livelihood strategies as different activities have different asset requirements. The major livelihood strategy of the household heads surveyed is agricultural production supported by off-farm and nonfarm activities such as nonfarm enterprises and skilled and unskilled employment, the importance of which changes depending on the season. This section looks at the types and importance of crops grown by surveyed households, the sale of crops, the involvement of household members in paid employment and nonfarm enterprises and the composition of household income.

Crops

Surveyed households grew a range of staple and cash crops in 2010 (see Tables 15 and 16, Appendix 5). The two most commonly grown staple crops were plantain and cassava (grown by over 90% of all households) followed by maize (83%), cocoyam (78%) and yam (63%), with little difference between fish farming and non-fish farming, and poor and non-poor households. The three most commonly grown cash crops were maize (grown by 88% of all households), cocoa (85%) and oil palm (76%). 60 percent grew vegetables, 28 percent grew citrus and 20 percent grew coconut. There are no significant differences (at the 10% level) between poor and non-poor households and fish and non-fish farming households growing different cash crops (see Appendix 6 for all Chi square test results). Overall the majority (75%) of households ranked cocoa as the most important cash crop followed by oil palm (71%) and maize (68%).

This distinction between staple and cash crops does not necessarily reflect reality however. While plantain and cassava are both staple crops that are consumed on-farm, they were also both sold by over 50 percent of households in 2010 (see Table 17, Appendix 5). Cocoa was sold by 84 percent of households and oil palm and maize were sold by 48 percent and 43 percent of households respectively. There are few differences between the percentage of poor and non-poor households and fish farmer and non-fish farmer households selling these crops.

Over 76 percent of all households hire labour for their crop farming activities, showing the importance of agriculture as a livelihood strategy. There is little difference between poor and non-poor households hiring labour (74% and 79% respectively), nor between fish farming and non-fish farming households (78% and 74% respectively).

Off-farm activities

Nearly 20 percent of all households have one or more members engaged in paid employment with little difference between poor and non-poor households (18% and 21% respectively) and fish farmer and non-fish farmer households (17% and 22% respectively). 35 percent of households are engaged in one or more household enterprises. While there is little difference in the percentage of poor and non-poor households running household enterprises (32% and 38% respectively), a higher percentage of fish farmer households (42%) than non-fish farmer households (28%) have households enterprises ($p = .09$), suggesting fish farming households are more entrepreneurial and less risk averse than non-fish farming households. Alternatively it could indicate that fish farming households have higher and more regular income coming from nonfarm sources, enabling them to buy feed and other inputs for fish farming. Section 5.2.10 below shows that on average fish farming households have significantly higher off-farm income than non-fish farming households.

5.2.9 Fish farming as a livelihood activity

Fish farming is currently not a major activity for small farmers in Ghana, and of the fish farmers surveyed, only 10 percent classified it as their primary occupation. This section provides an overview of small-scale artisanal pond aquaculture's role in the livelihood strategies of both poor and non-poor fish farmers in Ashanti Region.

Species cultured

The primary species cultured by 97 percent of all fish farmers surveyed is tilapia (*Oreochromis niloticus*), with 86 percent producing it in a mixed culture with catfish (*Clarias gariepinus)* and mudfish (*Heterobranchus spp*.), and just under 5 percent in a mixed culture with heterotis (*Heterotis niloticus) (*an endemic species). The average number of years that farmers surveyed had been engaged in fish farming was 6.7 years (7 years for poor farmers and 6.4 years for non-poor farmers).

Fingerlings

Fish farmers obtain fingerlings from a variety of sources. 68 percent of all fish farmers obtain part or all of their fingerlings from government or private hatcheries (60% of poor farmers and 74% of non-poor farmers, though this difference is not significant at the 10% level). 38 percent obtain fingerlings from other farmers, 16 percent get fingerlings from the wild, and only 4 percent use fingerlings produced from their own ponds. Nearly all fish farmers use mixed sex tilapia fingerlings and only 7 percent use all male fingerlings either all or some of the time.

Fertiliser and manure

Organic or inorganic fertiliser is used by 46 percent of fish farmers surveyed (33% of poor farmers and 56% of non-poor farmers ($p = .057$)). 42 percent of all farmers apply organic fertiliser such as poultry droppings, (23% of poor farmers and 56% of non-poor farmers ($p = .006$)). Only 7 percent of all farmers use inorganic fertiliser (13% of poor farmers and 3% of non-poor farmers ($p = .087$)).

Feed

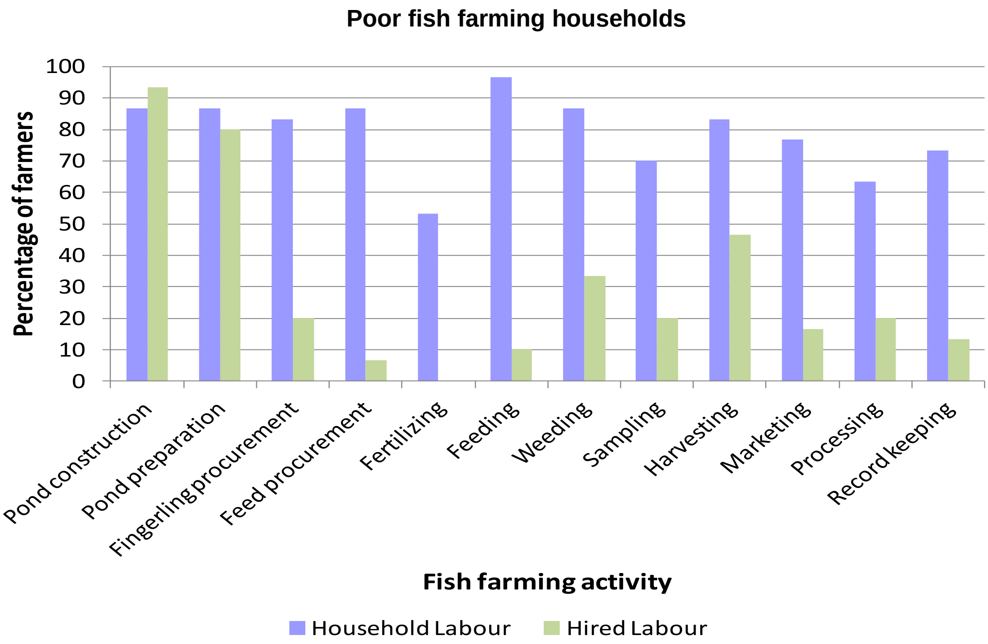
Fish farmers use a wide variety of feeds, ranging from formulated floating (pelleted) feed to cocoyam leaves and household food waste. The most common feeds used are rice bran and/or maize bran, mixed with groundnut peel, which are locally produced and readily available on the market. 91 percent of farmers use maize bran and groundnut peel. A much lower percentage of farmers use formulated floating and sinking feed (25% and 15% respectively), as these are relatively expensive compared to cereal brans and groundnut peel available locally. Formulated floating feed is not produced in Ghana and so has to be imported and is thus very expensive[50]. Other supplementary feeds used by fish farmers include kitchen wastes, agricultural wastes, and agricultural-industrial by-products. Feeding by most farmers seems to be done arbitrarily, in terms of both quantity and quality of feed, with little regard to standing crop. As feed is one of the major costs in fish farming and important for fish growth, inefficient feeding has a negative impact on fish productivity and fish farmer profit margins.

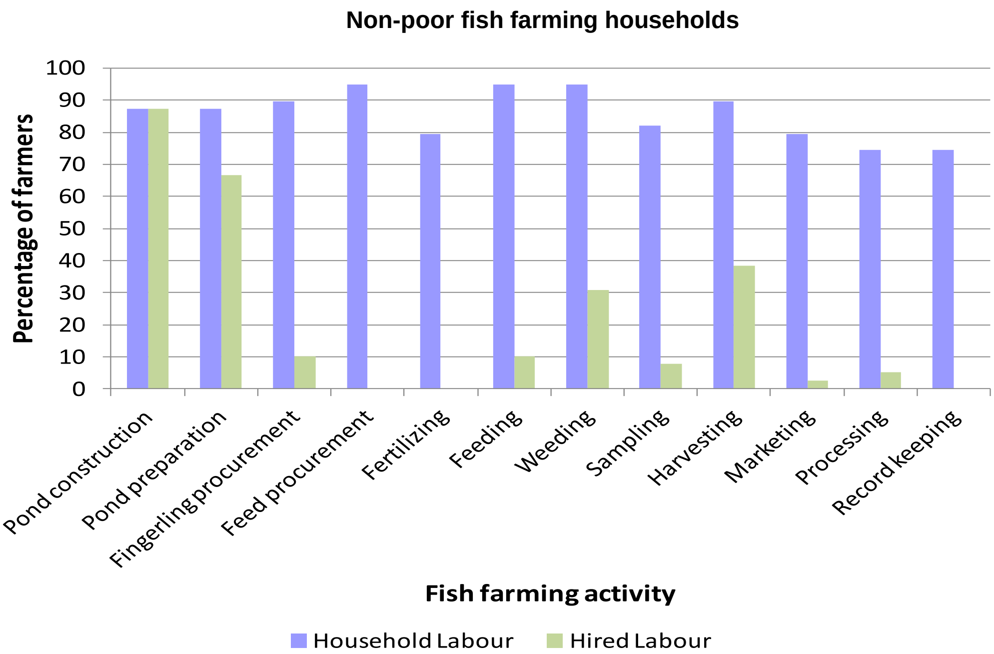
Use of labour and government extension services

Fish farming consists of a number of activities, such as pond construction and harvesting. Figure 17 shows the percentage of poor and non-poor fish farming households using household and hired labour for each activity. Several activities such as pond construction, pond preparation, and harvesting are undertaken by a mix of household and hired labour however other activities such as feed and fingerling procurement, fertilising, weeding, sampling, harvesting, and marketing are undertaken mainly by household labour. There are few differences between poor and non-poor fish farming households apart from with fertilising where a much higher percentage of non-poor households (79%) than poor households (53%) use household labour (neither groups use hired labour) which partly reflects that more non-poor households use fertiliser in their ponds than poor households.

[50] Prices of Ranaan fish feed sold in Kumasi in June 2011 were as follows: GH¢37/15kg bag of catfish feed; GH¢33, GH¢34, and GH¢38/20kg bag of tilapia feed for 6mm, 4.5mm and 2.5mm pellets respectively.

Figure 17: Percentage of poor and non-poor fish farming households using household and hired labour for fish farming activities





The majority of fish farmers do not use extension services for specific fish farming activities. Extension staff are most commonly used for harvesting (by 21% of non-poor fish farmers and 7% of poor farmers ($p = .1$), reflecting a difference in access to extension staff between poor and non-poor farmers, explored in more detail below). Extension staff are also used for fingerling procurement, sampling and pond construction, but again there is a difference between poor and non-poor fish farmers (see Table 18, Appendix 5 for details on use of labour and government extension services for fish farming activities). Analysis by gender of the type of household labour used for different fish farming activities shows that overall male household labour is used for most fish farming activities (see Table 19, Appendix 5) and is similar for poor and non-poor households.

Information, training and support for fish farming

Fish farming is relatively new for farmers in Ghana and access to good quality sources of information and training are important for fish farming to be a successful activity for small-scale farmers. Table 16 shows fish farmers obtain information from a range of sources, most commonly from government extension officers (including both fisheries and agriculture extension staff), other farmers, radio and TV. There are no significant differences between sources of information for poor and non-poor farmers (at the 10% level).

Table 16: Sources of information available to fish farmers in 2010 by poverty status

	Fish farmer households		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Other fish farmers	60	51	55
Friends/relatives	47	28	36
Government extension officers	63	64	64
NGOs	7	3	4
Hatcheries	10	13	12
Radio	47	36	41
TV	43	36	39
Feed suppliers	10	15	13
Total households (Nos.)	**30**	**39**	**69**

Aquaculture extension

Aquaculture extension services in Ghana are provided for free by MoFA through the FC. Fisheries extension officers usually have a general training in agriculture but many are not specifically trained in aquaculture representing a major challenge to the quality of their technical assistance. Due to inadequate resources, extension agents usually have limited access to transportation and are unable to visit farmers, and are often only able to go if farmers can pay for their transport. Alternatively farmers can go to the regional FC office to seek advice. However the fish farmers are scattered throughout the districts and transportation costs can be high, especially for remote farmers, meaning that it is better off and less remote farmers who are more able to visit extension staff. Farmers can also contact extension staff by phone.

Table 17 shows the average number of times in 2010 that fish farmers visited or contacted a fisheries extension agent or agriculture/fisheries extension centre to discuss fish farming and the average number of times fisheries extension agents visited fish farmers.

Table 17: Contact between fish farmers and extension agents in 2010 by poverty status

	Fish farmers			
	Poor	**Non-poor**	**P values for differences in means (1)**	**Total**
Average number of times fisheries extension agent or agriculture/ fisheries extension centre was visited or contacted	1.3 (0.47)	3.0 (0.75)	0.09	2.3 (0.48)
Average number of times fisheries extension agent visited farmer	1.28 (0.46)	3.18 (0.89)	0.07	2.37 (0.55)
Total households (Nos.)	**29**	**39**	**68**	**68**

Notes: SE in parentheses
(1) Based on independent samples t-tests

On average, fish farmers contacted or visited an extension agent, and extension agents visited fish farmers, just over 2 times each. Poor fish farmers had less contact with extension agents than non-poor fish farmers, reflecting non-poor farmers' increased ability to pay for transportation costs (both to visit extension staff and of extension staff to visit them) compared to poor farmers[51] and to gift or 'dash' money or payment in kind to extension staff in return for visiting them. The average frequency of contact between extension agents and fish farmers does not show the actual proportion of fish farmers that have been in contact with extension staff. Table 18 shows the percentage of fish farmers who had any contact with extension agents in 2010.

Table 18: Contact between fish farmers and extension agents in 2010 by poverty status

	Fish farmers			
	Poor	**Non-poor**	**P values for differences in means (1)**	**Total**
% of farmers contacting/ visiting extension agents	43	51	0.51	48
% of farmers receiving visits from extension agents	33	62	0.02	49
% of farmers who have had any contact with extension agents	47	67	0.095	58
Total households (Nos.)	**30**	**39**	**69**	**69**

Notes: (1) Based on chi square tests

Overall Table 18 shows that a higher percentage of non-poor than poor fish farmers had contact with extension staff in 2010. Overall 58 percent of fish farmers had contact with extension agents in 2010. A significantly lower percentage of poor than non-poor fish farmers were visited by extension agents, and a lower percentage of poor compared to non-poor fish farmers contacted extension agents, though this difference is not significant. The high correlation between fish farmers visiting extension staff and fish farmers being visited by extension staff (Pearson correlation coefficient = 0.62, p <

[51] The Pearson correlation coefficient between per capita income and the number of times fish farmers visited or contacted a fisheries extension agent is 0.35 (p = .004) suggesting that the higher a fish farmers' income the more times he/she visited or contacted an extension agent.

0.001), suggests that it is mainly the same farmers who contact or visit extension agents who are visited by them.

Training of fish farmers

Overall 62 percent of fish farmers had received some kind of training in fish farming from one or more sources with no significant difference (at the 10% level) between poor and non-poor fish farmers. Table 19 shows the various sources of training and indicates that 67 percent of farmers who had received training had been trained by fisheries extension staff, highlighting the important role of extension staff in disseminating information about fish farming.

Table 19: Source of training in fish farming by poverty status

	Fish farmer households		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Agricultural extension staff	33	42	39
Fisheries extension staff	80	58	67
NGO	13	4	8
Private company	0	4	3
Gold mine (1)	0	8	5
Total households (Nos.)	**15**	**24**	**39**

Notes: (1) The gold mine in Amansie West (Resolute Amansie) had supported fish farming in the mid 2000s as part of a Corporate Social Responsibility (CSR) programme but has since closed down

Motivation and goals

For small-scale pond aquaculture to have a direct impact on poverty in Ghana, poor farmers must be motivated to adopt it as a livelihood activity. Table 20 shows that the majority of farmers were influenced to start fish farming through observation of other fish farms and discussions with other fish farmers.

Table 20: Factors influencing fish farmers to adopt aquaculture by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Observation of other farms	90	64	75
Discussions with other farmers	70	72	71
Discussions with extension staff	40	49	45
TV, radio or newspaper adverts/programmes	50	39	44
Encouragement from local gold mining company CSR programme	13	18	16
Total households (Nos.)	**30**	**39**	**69**

A significantly higher percentage of poor farmers compared to non-poor farmers were motivated to adopt fish farming through observation of other farms ($p = .01$). There are no other significant differences (at the 10% level) between poor and non-poor fish farmers' motivations.

Table 21 shows the goal of almost all farmers for their fish farming operations is to make profit.

Table 21: Main goal of fish farming operations by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Increase profit	97	97	97
Increase fish for own consumption	100	82	90
Reduce seasonality of farm income	83	64	73
Spread/minimise the risk of farm activities	33	23	28
Total households (Nos.)	**30**	**39**	**69**

Overall nearly 90 percent of farmers also aim to increase fish for own consumption, with all poor farmers aiming to do this compared to 82 percent of non-poor farmers ($p = .05$). A higher percentage of poor than non-poor farmers also aim to reduce seasonality of farm income through fish farming ($p = .08$). A minority of farmers aim to minimise the risk of farm activities through fish farming with no significant difference (at the 10% level) between poor and non-poor farmers. 88 percent of farmers (87% of poor and 90% of non-poor farmers) ranked profit as their most important goal for fish farming with no significant difference (at the 10% level) between poor and non-poor farmers. 77 percent ranked fish for home consumption (87% of poor and 70% of non-poor farmers (p = .07)) as their second most important goal.

Pond ownership

Table 22 shows information on pond ownership and indicates that poor fish farmers have smaller areas of individual and total ponds than non-poor fish farmers.

Table 22: Size of ponds owned by fish farmers in 2010 by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
Average number of ponds owned	2.1 (0.26)	1.9 (0.16)	2.0 (0.14)
Average number of ponds harvested in 2010	1.2 (0.21)	1.2 (0.13)	1.2 (0.12)
Average area of individual ponds owned (m^2)	408.3 (67.75)	659.9 (139.81)	552.1 (85.91)
Average total area of ponds owned (m^2)	787.2 (175.83) (n = 27)	1187.5 (234.64) (n = 36)	1016.0 (154.76) (n = 63)
Average total area of functional ponds owned (m^2)	681.5 (117.29) (n = 27)	1165.3 (230.36) (n = 36)	957.8 (143.23) (n = 63)
Total households (Nos.)	**30**	**38**	**68**

Notes: SE in parentheses

On average fish farmers own two ponds, of approximately 550 m^2 each, and harvested one in 2010. Poor farmers have smaller ponds, total area of ponds and total area of functional ponds than non-poor farmers (p = .11, p = .18 and p = .07 respectively).

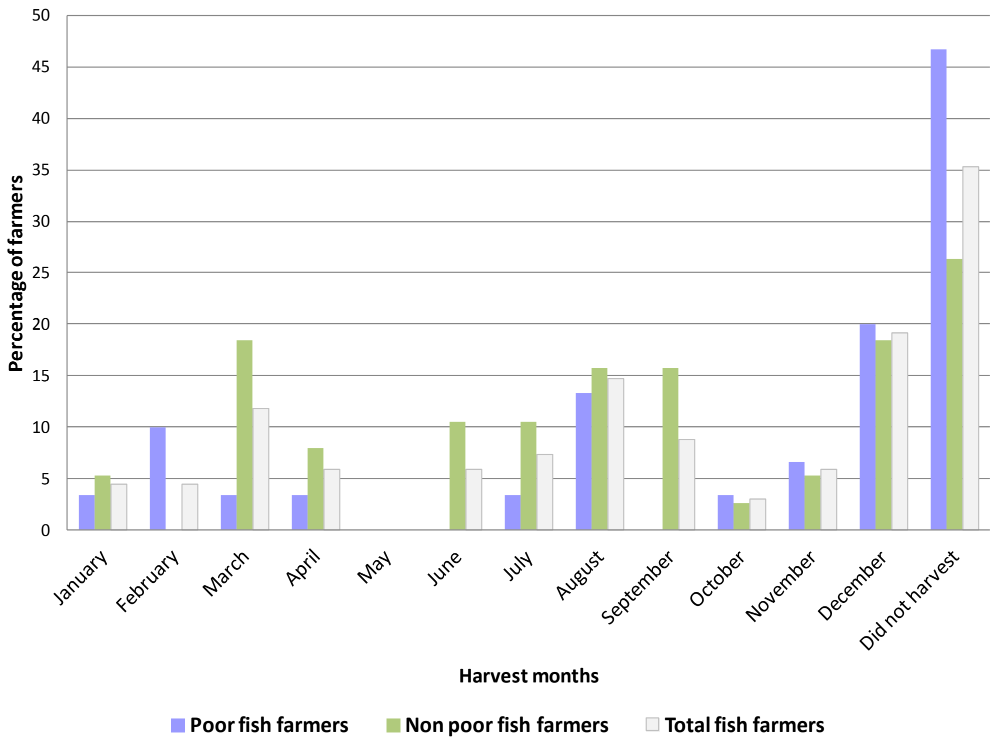
Culture period and harvesting

Just over 80 percent of fish farmers surveyed undertake selective harvesting where desired fish of certain sizes are selected for harvesting more than once in a production cycle. 8 percent of all farmers do partial harvesting where size selection does not matter and harvesting is done more than once in a cycle. Only 10 percent of fish farmers undertake complete harvesting where all the fish are harvested once at the end of the cycle. As so few farmers do complete harvesting, it is difficult to accurately estimate the average production cycle (the number of months between stocking and harvesting). However, farmers reported production cycles ranging from 6 months to 2 years. The average production cycle for all farmers is just under 10 months and poor farmers reported a longer cycle (11 months) than non-poor farmers (just under 9 months) ($p = .07$) (see Table 20, Appendix 5).

Of the fish farmers surveyed, 45 percent harvest once a year, 27 percent have no specific schedule and 19 percent harvest twice a year. 35 percent of all farmers did not do a main harvest in 2010, and a higher percentage of poor farmers (47%) than non-poor farmers (26%) ($p = .07$) did not do a main harvest. However just over half of those who did not do a main harvest (13 out of 24 farmers or 19% of all farmers) still harvested something from their fish ponds meaning that overall 16% of all farmers did not harvest anything at all from their fish ponds.

Figure 18 shows the months in which farmers undertook a main harvest in 2010.

Figure 18: Percentage of fish farmers doing a main harvest in each month in 2010 by poverty status



The most common harvest month was December where nearly 20 percent of farmers harvested. Many farmers indicated they would wait to harvest on special occasions such as Christmas and Easter when fish demand and prices were higher. August and March (close to Easter) were also relatively popular months for harvesting. The seasonal calendars showed the lean period is at its peak around May, June and July. Fish farming could make a significant contribution towards food security during these months, but no farmers harvested in May and only a few farmers (mainly non-poor farmers) harvested fish in June and July (6% and 7% respectively). This could be because ponds are stocked at the start of the rainy season in April when they are flooded and the fish would not be big enough to harvest during the lean season. Fish prices are also likely to be low during this time as consumers would be short of cash, discouraging farmers from selling.

Fish production, revenue and consumption

Table 23 shows annual production figures for 2010 for all fish (tilapia, catfish and heterotis) produced by surveyed fish farmers (see Tables 21 and 22 in

Appendix 5 for disaggregated production data on tilapia and catfish respectively).

Table 23: Production, revenue, consumption and distribution of all fish produced by fish farming households in 2010 by poverty status

	Fish farmer households			
	Poor	**Non-poor**	**P value for difference of means (1)**	**Total**
Average total fish harvested in 2010 (kg)	55.8	239.8	0.013	160.6
Average total fish yield (kg/ha/year) (2)	1303.1 (n = 26)	2487.2 (n = 31)	0.12	1947.3 (n = 57)
Average amount of fish sold (kg)	35.6	196.3	0.018	127.1
Average amount of on-farm fish consumption (kg)	15.1	33.8	0.19	25.7
Average amount of on-farm fish consumption per capita (kg)	1.9	4.7	0.098	3.5
Average amount of fish given away (kg)	8.8	15.3	0.35	12.5
Average amount received for fish sold (GH¢)[52]	129.7	654.9	0.019	428.7
Total households (Nos.)	**28**	**37**	**65**	**65**

Notes: (1) Based on independent samples t-test
(2) Outliers over 15000kg/ha omitted

Table 23 shows that compared to poor fish farmers, non-poor fish farmers: harvested over 4 times as much fish, sold over 5 times as much fish, and received over 5 times as much revenue from the sale of fish, all significant differences. While the majority of farmers harvested some fish in 2010, only 46 percent sold any fish (see Tables 23 and 24 Appendix 5). A lower percentage of poor farmers (40%) than non-poor farmers (51%) sold fish in 2010. However, this difference is not significant (at the 10% level). The average yield for all farmers was nearly 2t/ha/year with no significant

[52] As not all farmers sold fish, the average price of fish per kg based on those who sold fish (omitting outliers who sold for prices higher than GH¢15/kg) was GH¢3.24/kg (SE 0.37, n = 12) for poor farmers, GH¢3.90/kg (SE 0.75, n = 17) for non-poor farmers and GH¢3.62/kg (SE 0.49, n = 29) overall.

difference (at the 10% level) between poor and non-poor farmers. This yield falls just outside the range of 2.5 to 4t/ha/year reported from experiments by Diana and Lin (1998) for Nile tilapia in fertilised ponds and well below the range of 5 to 12 t/ha in fertilised-fed ponds (Diana et al., 1994). Green et al. (2002) found that Nile tilapia raised in fertilised ponds supplemented with feed, produced a better yield (7322.50kg/ha/year) than feeding only (4,407.50kg/ha/year) and fertiliser only (3,210kg/ha/year). These results suggest that overall productivity of surveyed fish farmers is low. However yields from controlled experiments are usually higher than those observed in the field. Also these experiments used mainly sex reversed fingerlings unlike most of the surveyed fish farmers who use mixed sex fingerlings[53], less than 50 percent of surveyed farmers use fertiliser and most have a generally low level of technical knowledge which could explain these lower results.

Table 23 shows that most of the fish harvested was sold and the remaining fish harvested was consumed by households and given away. The average on-farm fish consumption per capita was 3.5kg for all fish farming households, and higher for non-poor than poor households. Per capita fish consumption in Ghana is estimated to be 24kg. Both poor and non-poor fish farmers estimated that approximately 24 percent of fish consumed by their households came from their own farms.

Profitability of small-scale pond aquaculture

For aquaculture to have a positive direct impact on poverty through increased income for adopting households, it needs to be profitable for small-scale farmers. To assess if this is the case, participatory budgets (PBs) were undertaken with four groups of farmers across the three districts surveyed (described in Chapter 4, Section 4.3.1). Two groups (one in Amansie West and one in Amansie Central) estimated an average budget for an average sized pond as the farmers had similar production practices and resources

[53] Green et al. (2002) found little significant difference in yield between ponds stocked with mixed sex and all male fingerlings which was an unexpected result as ponds stocked with all male fingerlings are usually more productive than those stocked with mixed sex fingerlings

available to them. The remaining two groups (Adansi North and Amansie Central) used one farmer in each group as a case study. The value of fish used for own consumption was included in the budgets, along with fish sold, to make up total revenue. All budgets are for semi-intensive tilapia and catfish polyculture and the results are shown in Table 24 below.

Table 24: Summary of participatory budgets estimated for small-scale pond aquaculture enterprises

	Group 1 Adansi North		Group 2 Amansie West		Group 3 Amansie Central		Group 4 Amansie Central	
Group size	5		2		5		6	
Type of budget	Individual		Average		Individual		Average	
Pond size (m^2)	735		800		592		300	
Production cycle (months)	9		13		11		12	
	GH¢	**% of TC**	**GH¢**	**% of TC**	**GH¢**	**% of TC**	**GH¢**	**% of TC**
Hired labour	109	12	0	0	48	12	50	7
Lime	25	3	10	3	6.5	2	0	0
Fertiliser	13	1	20	6	10	2	10	1
Fingerlings	480	54	15	4	210	51	430	62
Transportation	28.7	3	45	13	79	19	70	10
Feed	228	26	260	73	58.5	14	84	12
Equipment (water pump/ nets)	0	0	5	1	0	0	55	8
Total cost (GH¢)	**883.7**		**355**		**412**		**699**	
Total revenue (GH¢)	**1031.5**		**200**		**433**		**630**	
Profit (GH¢)	**147.8**		**-155**		**21**		**-69**	
Gross profit margin (%)	**14**		**-78**		**5**		**-11**	

Notes: TC = Total cost

Of the four groups, two (groups 2 and 4) estimated a loss and 2 (groups 1 and 3) estimated a profit. Considering these budgets exclude investment costs of pond construction (which is relatively expensive[54]) and costing of family labour, these results indicate that many small-scale fish farmers are unlikely to be making a profit at present. A key cause of this was found to be the lack of technical knowledge when it came to stocking density and feeding practices[55]. However, other problems such as poor quality fingerlings (even those that have been bought from hatcheries) have a significant impact on the profitability of fish farming along with low levels of fertiliser use. None of the farmers involved in developing the PBs had done a budget for their aquaculture enterprise before and so none of them knew if their activities were profitable or not. This highlights the lack of not only technical knowledge but also business development skills, both of which are also needed for farmers to run their fish farming activities profitably.

The PBs suggest that small-scale fish farming is not profitable for many farmers even though the potential is there, shown by the two fish farmers making a profit (Groups 1 and 3). It is possible that these two farmers were chosen by their groups as case studies because they were more able than others to give accurate accounts of their costs and revenues. Thus these farmers may represent 'better farmers' rather than 'average farmers'. In any case the cost and revenue data gathered from these budgets is not detailed nor can it be generalised to the rest of the surveyed farmers and can only give an indication of how small-scale fish farmers are performing. There also appears to be large variability between estimates related to costs of fingerlings and feed. 3 of the 4 budgets estimate fingerlings to constitute 51 to 62 percent of total costs whereas Group 2 estimated fingerlings to be only 4 percent of total costs. Similarly, 3 of the 4 budgets estimate feed to be between 12 and 26 percent of total costs whereas Group 2 estimated it to be

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[54] The Ashanti regional FC office estimates the cost of constructing a pond of 500 m^2 in 2010 using manual labour was GH¢2000 (approximately US$1,400) and for a pond of 1000 m^2 using a bulldozer was GH¢4,731 (approximately US$3,300). Nearly 80 percent of farmers interviewed built their ponds with hired labour, less than 2 percent used only family labour, 16 percent used a mixture of family and hired labour and less than 4 percent used a bulldozer and hired labour.

[55] In several of the groups the rate at which farmers were stocking their ponds was found to be very low compared to the 3 fingerlings per m^2 rate recommended by the FC. Feeding practices were also found to be a problem.

over 70 percent. However Group 2 estimated a huge and unsustainable loss so cannot be viewed as representative of most fish farmers though it may give some insight into the performance of purely subsistence fish farmers who do not hire any labour or buy fingerlings from hatcheries. Discussions with extension staff confirmed that these budgets are realistic and costs are likely to be highly variable between both farmers and production cycles. Other more detailed studies on the profitability of fish farming in Ghana have been undertaken (e.g. Asmah, 2008; Kaliba et al., 2007a) which suggest fish farming can be financially viable. This is explored further in the discussion section below.

Perceived impacts of fish farming on households and communities

Fish farmers were asked open ended questions about the direct impact (both positive and negative) of fish farming on their households. Table 25 shows that fish farming has increased fish for home consumption for the majority of fish farmers, increased income for 40 percent, has helped pay school fees for 4 percent and has had no impact on 13 percent of households. A higher percentage of non-poor than poor fish farmers indicated fish farming had increased their income, and a lower percentage said fish farming had increased fish for home consumption, though these differences are not significant (at the 10% percent level).

Table 25: Fish farmers' perception of the impact of fish farming on their household by poverty status

	Fish farmer households		
	Poor	Non-poor	Total
	%	%	%
Increased fish for home consumption	70	53	60
Increased income	33	45	40
None	17	11	13
Helped to pay school fees	0	8	4
Total households (Nos.)	**30**	**38**	**68**

As noted in Chapter 4, non functional fish farmers were excluded from the survey. Thus while no fish farmers indicated any negative direct impacts of fish farming this could be because farmers who are no longer engaged in fish farming or who had abandoned their ponds were not interviewed. 25 percent of all respondents (fish and non-fish farmers) said that fish farming has negative impacts on the poor, all of whom attributed these to the high cost of fish farming. The investment cost alone can be prohibitive to poor farmers, e.g. the cost of constructing a $500m^2$ pond (approximately GH¢2000 in 2010) is about half the average total household income of surveyed farmers for 2010 and almost the same as the average total household income of poor households (see Section 5.2.10 below). Almost 100 percent of fish farmers used their own savings to fund the initial investment cost of their fish farms, with only 7 and 9 percent supplementing this with a loan from financial institutions or friends/relatives respectively. Thus it is clear that investing in fish farming is not an easy undertaking for the average poor farmer, especially with limited access to credit.

All respondents were asked about the impact of fish farming on the community. Table 26 shows that the majority said fish farming had increased fish supply, followed by employment creation, and no impact. A higher percentage of fish than non-fish farmers said fish farming had increased fish supply ($p = .02$). A lower percentage of fish than non-fish farmers said fish farming has had no impact on the community ($p = .06$) suggesting fish farmers perceive a higher benefit to the community than non-fish farmers. A lower percentage of poor than non-poor households said fish farming had increased fish supply in the community ($p = .02$), and while this difference is not significant (at the 10% percent level) within fish farmers, the difference is more significant within non-fish farmers ($p = .07$) suggesting the poor benefit less than the non-poor from increased fish supply, particularly poor non-fish farmers. A lower percentage of poor than non-poor farmers felt fish farming impacted the community through employment though this difference is not significant at the 10 percent level.

Table 26: Fish farmers' perception of the impact of fish farming on the community by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
	%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Increased fish supply	57	69	64	35	56	44	44	63	54
Employment	18	28	24	25	38	31	22	32	27
No impact	21	18	19	45	19	33	35	18	27
Total households (Nos.)	**28**	**39**	**67**	**40**	**32**	**72**	**68**	**71**	**139**

5.2.10 Livelihood outcomes

This section focuses on a number of livelihood outcomes which can also be thought of as poverty indicators, on which aquaculture has the potential to impact. These livelihood outcomes of household income, wealth and food security are compared between fish and non-fish farmer households.

Income

Table 27 shows average total and per capita household income levels of the surveyed households along with the average household income that comes from farm and off-farm sources.

Table 27: Income in 2010 by fish farming and poverty status

	Fish farmer households				Non-fish farmer households				Total households	
	Poor	**Non-poor**	**P value for difference in means (1)**	**Total**	**Poor**	**Non-poor**	**P value for difference in means (1)**	**Total**	**P value for difference in means between fish & non-fish farming HHs (1)**	**Total**
Average total HH income (GH¢)	2,173	7,453	0.000	5,124	1,951	6,457	0.000	3,899	0.09	4,486
Average per capita income (GH¢)	233	937	0.000	626	215	904	0.000	513	0.17	567
Average total farm income (GH¢) (% of HH income)	1,720 (79%)	4,980 (67%)	0.000	3,542 (69%)	1,677 (86%)	5,326 (82%)	0.000	3,255 (83%)	0.62	3,392 (76%)
Average total off-farm income (GH¢) (% of HH income)	454 (21%)	2473 (33%)	0.004	1,582 (31%)	273 (14%)	1,131 (18%)	0.02	644 (17%)	0.02	1,094 (24%)
Total households (Nos.)	**30**	**38**	**68**	**68**	**42**	**32**	**74**	**74**	**142**	**142**

Notes: The poverty line used in this thesis is GH¢390.55

(1) Based on independent samples t-tests

Household and per capita income

Overall total household income for 2010 was estimated to be GH¢4,486[56] (approximately US$3,115[57]). Fish farming households have over 30 percent higher average total household income than non-fish farming households (p = .09). Overall non-poor households have nearly three and half times higher average household income than poor households (p = .00) (see Table 25 in Appendix 5 for full details) partly due to the way in which poverty groups were

[56] The GLSS5 estimated annual household income in Ashanti as GH¢1,149, equivalent to GH¢1,884.36 in 2010 (PPP) which is under half the household income estimated in this survey, however the Comprehensive Food Security and Vulnerability Analysis: Ghana (WFP, 2009a) estimated the annual per capita income for food crop farmers as GH¢441 and for cash crop farmers as GH¢644 which is much more comparable to the household survey results.

[57] June 2010 exchange rate (US$1 = GH¢1.44). Available at: http://www.exchange-rates.org/Rate/USD/GHS/6-3-2010 (accessed 23 May 2013)

constructed based on income[58]. This difference is also reflected within both fish and non-fish farming household groups. There is no significant difference (at the 10% level) in household income between poor fish and non-fish farming households, or between non-poor fish and non-fish farming households. Table 27 shows that the differences in household income between groups are also reflected in per capita income. However while there is a significant difference in household income between fish and non-fish farming households (at the 10% level), the difference in per capita income is not significant.

Farm and off-farm income

Farm income refers to all income deriving from the household's farm (crops, livestock and livestock products including fish farming). There is no significant difference in farm income between fish and non-fish farming households. Poor households have a much lower average farm income (GH¢1695) than non-poor households (GH¢5138) (p = .00) (see Table 25, Appendix 5 for details). This difference is also reflected within fish and non-fish farming household groups. There is no significant difference (at the 10% level) in farm income between poor fish and non-fish farming households, or between non-poor fish and non-fish farming households.

Off-farm income refers to all household income that does not come from the household's farm such as salaried employment, wage labour on other farms and income from household enterprises. Fish farming households have nearly 2.5 times higher off-farm income than non-fish farming households (p = .02). Average off-farm income of poor households (GH¢349) is less than one fifth of off-farm income of non-poor households (GH¢1860) (p = .00) (see Table 25, Appendix 5 for details). This difference is also reflected within fish farmer and non-fish farmer household groups. While off-farm income of poor fish farming households is over one and a half times higher than poor non-

[58] Even so, it would be possible for poor and non-poor households to be below and above the poverty line but have incomes that were not significantly different if most of them had incomes clustered around the poverty line. However poor and non-poor households surveyed here are significantly different in terms of household income.

fish farming households, there is no significant difference (at the 10% level). Non-poor fish farming households have over twice as much average off-farm income than non-poor non-fish farming households (p = .07).

To summarise, average household income of fish farmers is significantly higher (30%) than non-fish farmer households. While farm income is similar for both groups, off-farm income is significantly higher for fish farming households, particularly for non-poor fish farmers compared to non-poor non-fish farmers.

Income from aquaculture

Household and farm income estimated above includes income from fish farming. Table 23 showed that non-poor fish farmers received over 5 times as much revenue from fish farming than poor fish farmers (p = .02) in 2010. Table 28 shows that nearly 8 percent of household income for surveyed fish farmers came from fish farming with no significant difference (at the 10% level) between poor and non-poor households.

Table 28: Percentage of household income from fish farming in 2010 by poverty status

	Fish farmer households		
	Poor	**Non-poor**	**Total**
% of HH income from fish farming	7.6 (2.69)	8.1 (2.27)	7.9 (1.72)
Total households (Nos.)	**30**	**39**	**69**

Notes: SE in parentheses

Household wealth

A household asset index was constructed to compare levels of household wealth across groups[59].

[59] The methodology and weights used to construct the household asset index were adapted from BMGF (2010), described in Chapter 4, Section 4.3.1.

Table 29 shows the average household asset index scores for household groups[60].

Table 29: Household asset index scores by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
HH asset index	33.9 (9.77)	63.3 (11.09)	50.5 (7.72)	29.9 (6.00)	29.7 (5.68)	29.8 (4.17)	31.6 (5.33)	48.2 (6.86)	**39.8 (4.38)**
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

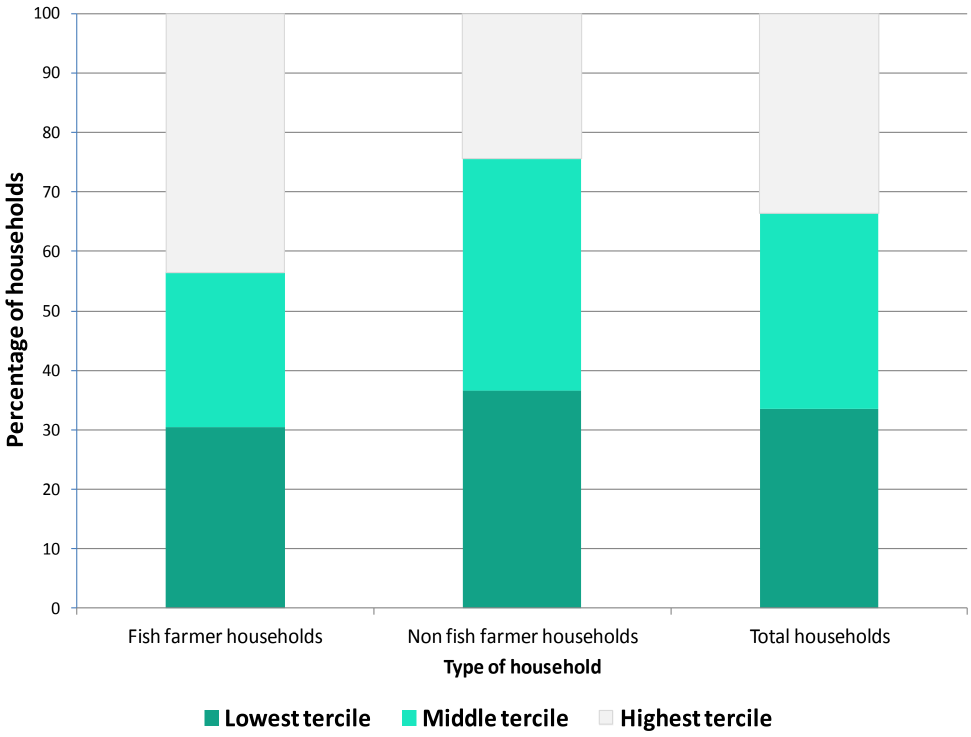
Notes: SE in parentheses

Fish farming households have a significantly higher average household asset index than non-fish farming households (p = .02) and poor households have a significantly lower average household asset index than non-poor households (p = .06). Although the index is lower for poor compared to non-poor fish farming households (p = .06), asset index estimates for poor and non-poor non-fish farming households are virtually identical. Non-poor non-fish farming households have a much lower average household asset index than non-poor fish farming households (p = .01) but smaller differences between poor fish and non-fish farming households are not significant (at the 10% level).

Figure 19 shows the distribution of fish and non-fish farming households separated between overall sample terciles of household asset index scores.

[60] The household asset index is highly correlated with income. The Pearson correlation coefficient between households asset index and total household income is .425 (p < .001) and per capita income is .378 (p < .001).

Figure 19: Percentage of fish farming, non-fish farming and total sampled households by total sample wealth tercile



A slightly higher percentage of non-fish farming households (39%) fall in to the lowest tercile compared to fish farming households (30%) and all sampled households (34%). A much higher percentage of non-fish farming households (39%) fall in to the middle tercile than fish farming households (26%) and all sampled households (33%). The largest percentage of fish farming households (44%) falls in to the highest tercile. This suggests that the household wealth distribution for fish farming households is skewed towards the highest tercile whereas the distribution for non-fish farming households is more even and concentrated mostly in the middle tercile.

Food security

Data on dietary diversity by season, and food vulnerability over the course of 2010, indicators of food security, are presented in the sections below.

Dietary diversity

Dietary diversity can be defined as the number of different foods or food groups consumed over a given reference period. Data were collected on the frequency of consumption of nutrient dense foods (fish, eggs, meat, milk and vegetables) (see Table 26, Appendix 5 for full table). Table 30 shows a summary table of the frequency of consumption of fish, meat and milk in an average week in the dry and rainy seasons, of different household groups.

Table 30: Seasonal diversity of food items consumed by fish farming and poverty status

	Fish farmer households				Non-fish farmer households				Total households	
	Poor	Non-poor	P value for difference in means (1)	Total	Poor	Non-poor	P value for difference in means (1)	Total	P value for difference in means between fish & non-fish farming HHs (1)	Total
Dry season										
Frequency of fish consumption (days/week)	6.6	5.8	0.057	6.1	6.4	6.7	0.25	6.5	0.12	6.3
Frequency of meat consumption (days/week)	2.2	3.5	0.019	3.0	2.9	3.2	0.48	3.0	0.82	3.0
Frequency of milk consumption (days/week)	0.3	1.3	0.005	0.8	0.7	0.8	0.81	0.70	0.58	0.8
Rainy season										
Frequency of fish consumption (days/week)	6.4	5.5	0.067	5.9	6.4	6.7	0.84	6.5	0.023	6.2
Frequency of meat consumption (days/week)	2.2	3.4	0.025	2.9	2.8	3.1	0.61	2.9	0.89	2.9
Frequency of milk consumption (days/week)	0.3	1.7	0.001	1.1	0.9	1.0	0.84	0.9	0.65	1.0
Total households (Nos.)	**30**	**39**	**69**	**69**	**42**	**32**	**74**	**74**	**143**	**143**

Notes: (1) Based on independent samples t-tests

Dry season

There are no significant differences in frequency of fish, meat or milk consumption between fish farming and non-fish farming households. There are some significant differences between poor and non-poor fish farming households, but none within non-fish farming households. Poor fish farming households eat fish more frequently than non-poor fish farming households (p = .06) and eat meat less frequently than non-poor fish farming households (p = .02) suggesting that non-poor fish farmers are better able to substitute meat for fish than poor fish farming households.

Rainy season

In the rainy season fish farming households have a significantly lower frequency of fish consumption than non-fish farming households (p = .02). However there are no other significant differences in frequency of eggs, meat, milk and vegetable consumption between fish farming and non-fish farming households. Similar to the dry season, in the rainy season there are significant differences in frequency of fish, meat and milk consumption between poor and non-poor fish farming households, but none within non-fish farming households.

These results indicate that fish is a more pro-poor animal protein source than meat and Table 26 in Appendix 5 shows that overall the average number of days fish is eaten by poor and non-poor households is almost the same (6.47 and 6.18 days/week). The fact that fish is eaten so regularly among surveyed households corresponds with the high estimates for Ghana of percentage of animal protein coming from fish (60%). The importance of fish in the diet of rural Ghanaian households, especially poor households, highlights the potentially important role that fish farming could play in household food security.

Food Security Index

To enable simple comparison between fish and non-fish farming households in terms of food security, average Food Consumption Scores (FCS) and

Simple Food Count (SFC) (described in Chapter 4, Section 4.3.1) by season are presented in Table 31.

Table 31: Seasonal household Food Consumption Score and Simple Food Count by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Dry season									
Food Consumption Score	35.7 (0.57)	38.2 (1.64)	37.1 (0.97)	36.8 (1.09)	38.0 (1.03)	37.3 (0.76)	36.3 (0.68)	38.1 (1.01)	37.2 (0.61)
Simple Food Count	49.8 (2.85)	57.0 (3.45)	53.9 (2.34)	53.7 (2.13)	55.8 (2.84)	54.6 (1.72)	52.1 (1.72)	56.5 (2.27)	54.3 (1.43)
Rainy season									
Food Consumption Score	35.3 (0.57)	39.3 (1.79)	37.6 (1.06)	37.6 (1.25)	38.5 (1.29)	38.0 (0.90)	36.6 (0.77)	38.9 (1.14)	37.8 (0.69)
Simple Food Count	48.9 (2.85)	57.7 (3.49)	53.9 (2.37)	54.2 (2.26)	55.6 (2.73)	54.8 (1.73)	52.0 (1.79)	56.8 (2.26)	54.4 (1.45)
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

Table 31 shows that overall the average FCS and SFC are very similar for all groups between dry and rainy season, indicating very little difference in food security and dietary diversity between seasons. There are also very few differences between fish and non-fish farming households. There are some differences between poor and non-poor households and in the rainy season, poor households have a slightly lower average FCS and SFC than non-poor households ($p = .09$ and .1 respectively). Poor fish farming households have a lower average FCS and SFC than non-poor fish farming households ($p = .04$ and .07 respectively).

While these results allow relative comparisons between groups, they do not help us to understand the absolute level of food security among surveyed households. This can be achieved by comparing the household FCS with pre-established thresholds: poor food consumption: 0 to 28; borderline food consumption: 28.5 to 42; acceptable low food consumption: 42 – 52; and acceptable high food consumption: 53+ (WFP, 2009). Although only some food groups were used, the average scores for the different groups of surveyed households in Table 31 are all in the 'borderline' food consumption group. It can be assumed that if the surveyed households are able to eat higher value foods such as fish almost every day, they will also be highly likely to be eating staple foods such as cereals and tubers every day, increasing the FCS by 14 thus increasing the average FCS for all households to over 51 in both the dry and rainy seasons. This implies that on average households are well above the threshold for acceptable low food consumption. If the remaining food groups of sugar and oil were also included, average FCS may be even higher, indicating a generally acceptable and most likely highly acceptable level of food security among surveyed households (WFP, 2009).

Food vulnerability

Vulnerability is another aspect of food security and respondents were asked to rate the difficulty of providing food for their households (from very difficult to very easy) for each month in 2010. Table 32 provides a summary of the results.

Table 32: Difficulty of providing adequate food for households in 2010 by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Number of very difficult/ difficult months	2.1 (0.49)	1.2 (0.31)	1.6 (0.28)	2.2 (0.40)	1.9 (0.30)	2.1 (0.26)	2.2 (0.31)	1.6 (0.22)	1.9 (0.19)
Number of neither difficult nor easy months	0.3 (0.14)	0.4 (0.28)	0.4 (0.17)	0.6 (0.23)	0.8 (0.40)	0.7 (0.21)	0.5 (0.14)	0.6 (0.23)	0.5 (0.14)
Number of easy/very easy months	9.6 (0.51)	10.4 (0.41)	10.0 (0.32)	9.1 (0.45)	9.3 (0.50)	9.2 (0.33)	9.3 (0.33)	9.9 (0.32)	9.6 (0.23)
Total households Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

Table 32 shows that overall the household heads surveyed found it either very easy or easy to provide adequate food over the year for their households for just under 10 months, they found it very difficult or difficult for nearly 2 months and neither easy nor difficult for a few weeks. There are no significant differences (at the 10% level) between household groups in the number of months that were very difficult or difficult to provide food. Fish farmers had a higher average number of months that were easy or very easy than non-fish farmers (p = .08). Non-poor fish farmers also had a higher number of months that were easy or very easy than non-poor non-fish farmers (p = .09). Thus it seems fish farming households were slightly better off than non-fish farming households in terms of food adequacy in 2010.

5.2.11 Income Determination Model

The descriptive statistics presented above suggest that fish farming is associated with higher income (along with increased household wealth and food adequacy) of adopting households. However, these descriptive statistics do not account for possible differences in household characteristics, other than participation in fish farming, which may be causing the disparities in income between fish and non-fish farming households. Therefore, a household per capita Income Determination Model (IDM) is used to control for differences in observable characteristics between households and to assess the factors that contribute to the differences in income between fish farming and non-fish farming households. The multiple log-linear regression model was estimated using Ordinary Least Squares (OLS).

An important issue in this analysis is the possibility of endogeneity/simultaneity between per capita income and participation in fish farming. This would imply that fish farming increases income but also that higher income induces farmers to adopt fish farming. If the causal relationship between income and participation in fish farming runs in both directions then the key assumption in the regression model, that the disturbance error is uncorrelated with the predictor variables, is violated. As a consequence the estimation by the OLS would yield biased and inconsistent estimates of the structural parameters. To test for endogeneity bias and ensure that it is fish farming that is causing increased income and not higher income that affects farmers' decision to adopt fish farming, a two stage least squares (2SLS) model with instrumental variables (IV) (Heckman, 1997) was carried out using SAS Proc Model (2SLS) procedure (SAS/STAT software). The Hausman test (Hausman, 1978) was used to compare the 2SLS with IV to the OLS estimates. The Hausman test statistic was not significant (see Appendix 8 for test results) indicating that IVs are not needed and the OLS specification is efficient. This suggests no endogeneity bias between income and participation in fish farming[61].

Another key issue is the possibility of selection bias. It is important to ensure that it is not unobservable characteristics such as ability, motivation or entrepreneurialism that leads to the self-selection of farmers into fish farming, which are also unobservable characteristics associated with increased income. Heckman (1979) suggested a simple test of the null hypothesis of no sample selection bias using a consistent two-step estimator. Heckman's approach is based on a treatment selection equation (first step) and an outcome equation (second step) to estimate the correlation between error terms in the two equations. The null hypothesis of no sample selection bias is rejected when the correlation estimate is significant at the 5 percent level. To test for selection bias and the effect of fish farming (treatment) on income (outcome), a Sample Selection Model (Heckman, 1979) was conducted using the SAS Proc QLIM procedure (qualitative and limited dependent variable model, SAS/STAT software)[62]. The correlation parameter estimate that indicates the effect of treatment selection bias on the outcome is 0.02 ($p = .95$). This result indicates that selection bias is not a problem in the estimation of (log) per capita income[63].

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[61] The same test carried out with the other variables in the model, using all fish farmers and separating out fish farming types A and B (described in more detail below), also indicated no endogeneity issues (see Appendix 8 for results).
[62] An econometrician was consulted about the possible biases in the model, and carried out the tests for endogeneity and selection bias.

Aside from assessing the factors that contribute to the differences in income between fish farming and non-fish farming households, the IDM is also used to assess the factors that are related to income within the population of fish farmers, looking in particular at how training and better management practices (BMPs) in fish farming may be associated with income. Per capita household income is treated as a function of household participation in fish farming (according to type of fish farming), along with household demographic and socio-economic characteristics. The household income equation can be written as:

$$\ln(y) = \beta_0 + \beta_i.F_i + \beta_j.X_j + \beta_z.D_z + \varepsilon$$

where y is per capita household income and ε is the error term. F_i are dummy variables representing different categories of farming households where i = 1 represents households where fish farmers have been trained and/or who use fertiliser in their ponds (a proxy for use of BMPs) and are referred to here as fish farming type A. Households where fish farmers have not been trained in fish farming and who do not use fertiliser in their ponds are represented by i = 2 and are referred to here as fish farming type B. Non-fish farming households are represented by i = 0 (and thus F_0 = 0) which is the excluded dummy variable category in the regression. The estimated coefficients of F_i reflect the impact of the two types of fish farming on per capita income and can be interpreted as the percentage change in per capita income for households involved in fish farming (types A and B) compared with non-fish farming households after controlling for other factors.

X is a vector of household demographic and socio-economic explanatory variables as follows: household size; total farm area; and a quadratic term for the number of years households have been a member of a livelihood association. D is a vector of dummy variables representing household characteristics as follows: households living in Amansie West District; households with sources of off-farm income; households who sell staple crops; households who sell cash crops; households who sell livestock and/or livestock products; households in the lowest household wealth tercile[64]; households in the highest wealth tercile; households facing difficulty in accessing input and output markets; and households who faced a crisis or shock in 2010. Different functional forms were tested and the log linear functional form was chosen based on R^2, F – ratio, number of variables significant and *a priori* expectations of the signs and magnitudes of the coefficients. The parameter estimates of factors associated with per capita household income of surveyed farmers are presented in Table 33 below.

Table 33: Parameter estimates of the Income Determination Model

Variables	Coefficients	SE	T	Sig.
(Constant)	6.404	.284	22.555	.000
Farmer category (base non-fish farmers)				
F_1 **- Fish farmers type A - trained and/or using fertiliser (proxy for BMPs)**	.543	.150	3.616	.000
F_2 **- Fish farmers type B - not trained and not using fertiliser (proxy for no BMPs)**	-.301	.211	-1.429	.155
Household size	-.118	.019	-6.062	.000
Amansie West District	.575	.149	3.857	.000
Total farm size (ha)	.026	.008	3.264	.001
Off-farm income	.334	.131	2.541	.012
Sale of staple crops (plantain and/or cassava)	.256	.135	1.898	.060
Sale of cash crops (citrus and/or oil palm)	.134	.135	.994	.322
Sale of livestock and/or livestock products	.270	.138	1.956	.053
Wealth tercile 1 (lowest)	-.276	.152	-1.813	.072
Wealth tercile 3 (highest)	.339	.151	2.240	.027
Difficulty accessing markets	-.302	.170	-1.775	.078
Households who faced a crisis or shock	-.339	.166	-2.039	.044
Number of years in an association	-.244	.076	-3.208	.002
Number of years in an association, squared	.027	.011	2.515	.013

Notes: Dependent Variable: Log of per capita income
Number of observations = 141
R^2 = .471, Adjusted R^2 = .407, F = 7.405 (p = .000)

[64] Terciles constructed using the household asset index (see Section 5.2.10, Figure 19) which includes household durable goods, productive assets and livestock.

Overall the model is highly significant ($F = 7.405$, $p = .000$) with an R^2 of .471 indicating that the explanatory variables in the model explain approximately 47 percent of the variation in per capita household income. The variables for participation in fish farming type A, household size, households located in Amansie West District, total farm size and number of years of association membership are significant at the 1 percent level. The parameter estimates of all the variables in the model carry signs which conform to *a priori* expectations and economic theory[65].

Table 33 shows that the fish farmer type A category households are much better off than non-fish farmer households. The model suggests that household participation in fish farming type A where fish farmers are trained and/or fertiliser is used in ponds is likely to increase household per capita income by 54 percent. Household participation in fish farming type B where farmers are not trained and do not use fertiliser has a negative association with income, indicating a reduction in income by 30 percent compared to non-fish farmer households. However the coefficient for fish farming type B is not significant and thus it could be that there is little difference in per capita income between non-fish farming and fish farming type B households. This suggests that adoption of fish farming is not necessarily associated with higher incomes unless fish farmers have been trained and/or use BMPs, in which case household income may be increased. Therefore the model confirms that fish farming type A has a positive effect on income and the differences in income (and most likely other outcome indicators such as household wealth) between fish farming and non-fish farming households found in the descriptive statistics presented above are not merely due to differences in household characteristics between groups. This may also explain the differences between poor and non-poor fish and non-fish farming

[65] Years of education was not found to be significantly related to income. As noted in the descriptive statistics above no difference was found between education levels of fish and non-fish farming households. Dey et al.'s (2007) impact assessment of IAA in Malawi found that while education was not related to adoption of IAA, as education increased so did the level of integration of IAA practices. Similarly here there is a significant relationship between years of education and fish farming type (Pearson correlation coefficient of .251, $p = .041$) indicating as education increases so does the likelihood of a fish farmer being trained and/or using BMPs.

households in the descriptive statistics above if BMPs are generally used by non-poor fish farmers.

In addition to highlighting the relative importance of fish farming type A for income, the model also provides useful insights into other determinants of income. As expected, larger households have lower per capita household income (an increase in household size by one person on average results in a 12% decrease in per capita household income). Households located in Amansie West District appear to be better off than those in the other two districts. Households with larger farm sizes have slightly higher incomes and the coefficient suggests that an increase in total farm size of 1ha is associated with a 2.6 percent increase in per capita household income.

Households with off-farm income sources are likely to have higher incomes (33%) than those that rely solely on farm income sources. Households that sell staple crops (cassava and/or plantain) are also likely to have higher incomes (26%). Households that sell cash crops (citrus and oil palm) are likely to be better off than those that do not even though this result is not statistically significant. Households that sell livestock and/or livestock products have higher incomes (27%) than those that do not.

The model shows that the more assets a household owns the higher its income. Compared to households in the middle wealth tercile (measured by the household asset index), households in the bottom wealth tercile have 28 percent lower income while households in the highest wealth tercile have 34 percent higher income[66]. If households find it difficult to access input and output markets, their per capita income is likely to be lower than those who have easy market access. Households who experienced a crisis or shock in 2010 are also likely to have lower incomes than those that did not.

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[66] Asset/wealth variables such as household wealth tercile are potentially endogenous (higher incomes lead to higher assets and vice versa). The model was estimated without these variables and the signs and significances of the remaining exogenous variables stayed the same, suggesting household wealth is not an endogenous variable.

Finally, the number of years spent as a member of an association has little effect on household per capita income (even though the coefficients in the model for number of years in an association are significant). The model suggests however that after approximately five years, additional years of association membership will have an increasingly positive association with household per capita income.

Although the tests for endogeneity and selection bias indicated no problems in the model, it is not possible to categorically state that fish farming type A causes income to increase. While fish farming type A is likely to increase incomes of non-poor fish farmers, it appears that fish farming may have lower impacts on income of poor fish farmers (mainly practising fish farming type B) due to resource and other constraints that make them less likely or able to use BMPs[67]. Thus the model results must be interpreted alongside the descriptive analysis presented in the previous section. The implications of this are discussed in more detail in the following section.

5.3 DISCUSSION

5.3.1 Summary and discussion of findings

The results presented above explore the differences between poverty status and livelihood activities and outcomes of surveyed fish and non-fish farming households. The key findings of the analysis above show that poor farmers (whether defined by income poverty, through communities' perception of wealth or households' own assessment of poverty status) are able to adopt small-scale pond aquaculture in Ashanti Region, suggesting that fish farming has the potential to directly impact on poverty. Few demographic differences, such as household size, or differences in human capital, such as occupation and education of household heads, were found between fish and non-fish farming households. There were no significant differences in average farm

[67] There is a significant relationship between household poverty status and fish farming type (Pearson correlation coefficient of .25, p=.043).

size between groups though a higher percentage of fish farming than non-fish farming households own land.

Fish farming households were found to have over 30 percent higher average income than non-fish farming households and while farm income between these groups is similar, fish farming households have nearly 2.5 times higher off-farm income than non-fish farming households. Non-poor fish farming households have over double the off-farm income that non-poor non-fish farming households have. The household asset index showed similar differences with fish farming households having significantly higher household wealth than non-fish farming households and non-poor fish farming households having a higher household asset score than non-poor non-fish farming households. Poor fish farming households were found to eat fish more frequently than non-poor fish farming households who ate more meat and there were significant differences between poor and non-poor fish farming households' consumption of fish, meat and milk. While there were no differences between fish and non-fish farming households in FCS and SFC, poor fish farming households have lower average FCS and SFC than non-poor fish farming households. Fish farming households and non-poor fish farming households had a higher average number of months in 2010 that were easy or very easy for food provision than non-fish farming households and non-poor non-fish farming households respectively.

Overall from the descriptive results, fish farming households appear to be better off than non-fish farming households in terms of income, household wealth and marginally better off in terms of food adequacy. The significantly higher levels of income, household assets and off-farm income of non-poor fish farming households compared to poor fish farming households, not present between poor and non-poor non-fish farming households, indicate the income poverty criteria is only telling part of the story. The results suggest there may be an asset threshold over which fish farming allows higher income and asset accumulation. It also raises questions about poor fish farmers and may indicate that while overall fish farming households are better off than non-fish farming households, fish farming may have a higher potential to increase income and assets of non-poor households (or rather those households over the asset threshold) than poor households who are below the asset threshold.

These descriptive results are further developed and supported by the IDM which controls for the effect of household characteristics other than fish farming which may be associated with increased income. The model results suggest that household participation in fish farming type A, where fish farmers are trained and/or fertiliser is used in ponds, is likely to increase household income by 54 percent. Participation in fish farming type B, where farmers are not trained and do not use fertiliser, has a negative association with income, although since the coefficient is not significant this may suggest little difference in income between non-fish farmer and fish farmer type B households. Overall therefore the model confirms that small-scale fish farming has a positive effect on income and the differences in income (and most likely other outcome indicators such as household wealth) found in the descriptive statistics are not merely due to differences in household characteristics between groups. Specifically, the model indicates that adoption of small-scale fish farming is not necessarily associated with higher incomes unless farmers have been trained and/or use BMPs, in which case household income may be increased. However as noted above, the descriptive analysis suggests an asset threshold over which fish farming allows income and capital accumulation. The descriptive results also show that while there is no significant difference in the percentage of poor and non-poor fish farmers who have been trained, a significantly higher percentage of non-poor compared to poor fish farming households use fertiliser (used here as a proxy for BMPs) and a significant relationship exists between income poverty status and fish farming type, which may indicate a threshold in the use of BMPs. The results of the IDM and the descriptive analysis together therefore suggest that while fish farming type A, practised mainly by non-poor farmers (over the BMP and asset thresholds) increases income, poor farmers (under the BMP and asset thresholds) are less likely or able to participate in fish farming type A. Therefore it can be argued that while small-scale fish farming is likely to have a strong impact on income (and other related indicators such as household wealth) of non-poor farmers practising fish farming type A, it is unlikely to have much impact on poor farmers unless their resource constraints can be overcome and they are also able to engage in and benefit from fish farming type A.

The effect of aquaculture on income indicated by these results appears to correspond in part with other studies on aquaculture in SSA. For example, as noted in Chapter 2, Dey et al. (2007) found that IAA adopting households in Malawi had 1.5 times the income of non-adopters (similar to the descriptive statistics and IDM model results). However, this was mainly due to differences in farm income (as IAA increases farm sustainability and productivity) and larger farm size of IAA farmers which is not the case here. 10 percent of IAA farmers' income was from aquaculture which is similar to the 8 percent found for the surveyed fish farmers. A WorldFish Center project in Cameroon found that average net profits of fish farms in peri-urban areas rose from US$150 to US$1,500 over 5 years whereas those is rural areas rose from US$34 to US$213. While the disparity in profit was attributed to the increased market access for peri-urban fish farmers, this shows the differential impact of fish farming on household income based on context. In the case of surveyed fish farmers in Ashanti Region, the potential impact of fish farming on income (and other livelihood outcome indicators) is related to whether farmers are trained and/or use BMPs, but is also likely to be influenced by existing asset portfolios and resource constraints of farmers and the prevalence and effects of BMPs. Belton and Little (2011) citing Mosley and Hulme (1998) related to micro credit provision suggest there may be an 'impact frontier' where lending to poorer households results in relatively low impact on households whereas lending to better off households results in higher impact. While Belton and Little indicate it is unclear if this kind of relationship holds for other types of non credit assistance, the results above suggest it may. The results show that poor fish farming households are marginally better off than poor non-fish farming households whereas non-poor fish farming households are significantly better off than non-poor non-fish farming households.

5.3.2 Financial viability of small-scale fish farming in Ghana

While the descriptive statistics and IDM above suggest that fish farming type A is associated with higher income, the results of the PBs suggest that small-scale fish farming is not profitable for many small-scale fish farmers, despite the potential, shown by the two fish farmers making a profit. However, while these PBs are realistic, they cannot be seen as representative of all fish farmers. Other more detailed studies on the profitability of fish farming in Ghana have been undertaken (e.g. Asmah, 2008; Kaliba et al., 2007a) which suggest small-scale pond aquaculture can be profitable. Asmah (2008) looked at the financial viability of pond aquaculture in Ghana, using data from 392 fish farms from 9 out of the 10 regions in Ghana. She found that average gross profit (total revenue minus total variable costs) per ha per annum was positive for different groups of 'non commercial' farms and higher than those estimated through the PBs. However only 47 percent of 'non commercial' farm types had a positive net profit (gross revenue less total production cost including interest and depreciation on capital and opportunity cost of land), although a higher proportion of farms were profitable if lower costings were used for initial capital costs in pond construction (to reflect use of household labour and lower opportunity cost of land). She also found a strong relationship between quantities of feed applied and profitability of 'non commercial' farms and notes that underfeeding could be an important reason for the low yield of the unprofitable farms. This is broadly in line with the findings reported above.

Kaliba et al. (2007a) using a dynamic model to simulate individual fish growth and estimate the profitability of Nile tilapia (*O. Niloticus*) production in Ghana found that the practise of mixed-sex tilapia culture with catfish predation using local feed of maize/rice bran and fertilising with manure (such as the fish farming type A farmers) was economically sustainable. Both these studies therefore indicate that semi-intensive small-scale pond aquaculture similar to fish farming type A can be a profitable enterprise and thus holds potential for directly impacting poverty in Ghana.

5.4 CONCLUSION

Overall therefore, the results presented in this chapter do not strongly support the hypothesis set out in Chapter 2 that small-scale aquaculture has positive direct impacts on poverty and livelihoods of *poor* households in Ashanti Region, Ghana. However the results show that small-scale aquaculture has positive direct impacts on the livelihoods of *non-poor* fish farming households, and the magnitude of these impacts depends on the household and livelihood characteristics and aquaculture production systems of farmers in Ashanti Region, and the institutional and infrastructure context. The results also suggest that while at present aquaculture does not appear to have direct poverty impacts on poor households, it does have the potential to directly benefit poor fish farming households if their resource constraints can be overcome and they are able benefit from fish farming type A and the use of BMPs. The results of this chapter and the finding that small-scale fish farming type A is associated with significantly increased household income are built upon in the following chapter which explores the potential for small-scale pond aquaculture and other aquaculture systems to impact indirectly on poverty and economic growth.

CHAPTER 6: INDIRECT IMPACTS OF AQUACULTURE ON POVERTY

6.1 INTRODUCTION

The central theme of this thesis is concerned with assessing the actual and potential, direct and indirect poverty impacts of different types of aquaculture systems in Ghana. Chapter 5 has shown that poor households in Ashanti Region have adopted small-scale pond aquaculture and that overall, fish farming households are better off than non-fish farming households, particularly in terms of household assets. An Income Determination Model controlling for differences in household characteristics showed that per capita income of fish farming households, where fish farmers have been trained and/or are using BMPs (fish farming type A), is higher than per capita income of fish farming households who have not been trained and are not using BMPs (fish farming type B) and of non-fish farming households. The ability of poor fish farmers to engage in and benefit from fish farming type A is unclear however and overall the results do not strongly support the hypothesis that small-scale pond aquaculture has a positive direct impact on poverty through increased income of poor adopters. However they do show that fish farming type A has positive direct impacts on income and assets of non-poor fish farmers. The presence of direct livelihood impacts from small-scale aquaculture (fish farming type A) suggests that indirect poverty impacts should also be present and potentially important. SME and large-scale commercial cage aquaculture on Lake Volta are also unlikely to have direct impacts on poverty through adoption by poor farmers, as the poor are unable to afford cage aquaculture due to high costs of investment and working capital. Yet like fish farming type A, SME and large-scale cage aquaculture still have the potential to impact poverty through indirect impact pathways for example via economic linkages which could create multiplier effects and generate economic growth.

This chapter focuses on the importance of indirect impacts of different types of aquaculture systems on poverty that can occur through a variety of impact pathways discussed in Chapter 2. The research question and hypothesis addressed in this chapter are as follows:

Objective

To assess the importance of direct and indirect poverty impact pathways from different aquaculture systems and examine implications for pro-poor growth in different contexts

Hypothesis

Indirect poverty impact pathways (such as employment, consumption and multiplier effects) from increased aquaculture SME activity have more potential to impact on poverty than indirect pathways from large-scale commercial operations and direct and indirect pathways from small-scale pond aquaculture (fish farming type A)

To test this hypothesis, the chapter starts by investigating the nature and importance of the various linkages (production, consumption, investment, infrastructure, institutional, cost of living and environmental) arising from each of the three aquaculture systems under analysis: small-scale pond aquaculture (fish farming type A) in Ashanti Region; SME commercial cage aquaculture; and large-scale commercial cage aquaculture in Lake Volta, Eastern Region. This is done using data from the household survey and participatory budgets (PBs) of small-scale fish farmers in Ashanti Region in Chapter 5, the survey of cage farms on Lake Volta and FGDs conducted in seven communities on Lake Volta where cage aquaculture is present (see Chapter 4, Section 4.3.2). After this descriptive analysis of linkages, the economic multiplier effects arising from these different aquaculture systems are estimated. These multiplier estimates quantify the amount of added income generated locally and nationally by an extra dollar of income from each aquaculture system to compare the economic growth created by the development of each type of aquaculture system. As one of the most important ways in which SME and large-scale commercial farms can potentially impact on poverty is through increased labour demand, labour opportunities created by different systems are then estimated, along with an approximation of the employment created along the value chains related to these systems. Some characteristics of labourers on SME and large-scale commercial farms are then explored. Having identified the main indirect impact pathways between aquaculture and poverty and assessed the relative importance of the linkages arising from each system, the results of these different analyses are synthesised in a table which scores the strength of each of the direct and indirect impact pathways and linkages arising from each of the three aquaculture systems and the likely impact of each on poverty. Finally the discussion section explores the implications of these results for aquaculture's role in generating pro-poor growth.

6.2 RESULTS

As outlined in Chapter 3, Section 3.8.1, the aquaculture industry in Ghana is clearly segmented into: i) small-scale artisanal pond aquaculture farms (explored in Chapter 5); ii) SME commercial cage farms; and iii) large-scale foreign owned commercial cage farms in Lake Volta. The SME sector, driven mainly by small local entrepreneurs, is the most dynamic category in the industry in terms of new entrants (even though production from the large farms is growing rapidly). A survey of cage farms conducted for this thesis (see Chapter 4, Section 4.3.2) showed that small-scale cage farms typically consist of 1-10 cages (125 to 12500 cubic meters (m^3) in total based on cages of 125 m^3) which produced 10 to 50 tonnes of tilapia per farm in 2010. A handful of medium sized farms are also part of the SME category and three out of five of those surveyed are owned by foreigners. The survey showed that these medium sized farms each have on average the equivalent of approximately 50 cages (62,500 m^3) in Lake Volta and produced between 50 and 70 tonnes each in 2010 with production growing steadily in 2011. The large-scale cage farms combined produced 4800 tonnes in 2010. The following sections assess the linkages arising from each of the three aquaculture systems.

6.2.1 Linkages arising from small-scale pond aquaculture (fish farming type A)

Backward linkages

A sector's backward linkages represent its relationship with the rest of the economy through direct and indirect purchases from other sectors. The type and size of backward linkages depend on factors such as agricultural technology, size of land holding and type of commodity. The larger the share of inputs into a sector that are nontradable (i.e. those not imported or exported to or from the area and that do not have tradable substitutes available locally) the stronger its backward linkages and hence multiplier effect will be. As shown in Chapter 5, the main inputs into small-scale pond aquaculture (and aquaculture generally) are fingerlings and feed. A budget was estimated for fish farmers who have been trained and/or use BMPs (fish farming type A) based on the PBs presented in Chapter 5[68] and interviews with FC staff (see Appendix 9 for estimated budget for a 600m^2 pond). The estimated budget shows that fingerlings represent approximately 30 percent of total costs (and over 40% of variable costs). Small-scale fish farmers in Ashanti Region use fingerlings produced mainly by government or private hatcheries located outside Ashanti Region, and some from other fish farmers, and these are therefore defined as nationally nontradable inputs.

The estimated budget shows that feed, the other main input into aquaculture production, represents on average nearly 24 percent of fish farming type A total costs (and just over 30% of variable cost). Small-scale fish farmers use a wide variety of feeds. However over 90 percent of farmers surveyed use rice bran and/or maize bran, mixed with groundnut peel. These are locally produced and consumed and generally not traded outside the region therefore both are defined here as regionally and nationally nontradable. A much lower percentage of small-scale farmers practicing fish farming type A (27%) supplement feeding with commercially formulated imported feed[69]

[68] All four PBs estimated in Chapter 5 include use of fertiliser and thus represent budgets for fish farming type A.

[69] As none of the small-scale fish farmers that contributed to the PBs used commercial formulated feed, it was not included in the estimated budget for fish farming type A in Appendix 9. Thus it is

which is overall a tradable input even though elements such as overhead, storage and distribution costs are nontradable. Other nontradable inputs into small-scale pond aquaculture are fertiliser, lime and transportation representing just over 10 percent of total costs for fish farming type A.

Forward linkages

A sector's forward linkages represent its relationship with the rest of the economy through its direct and indirect sales to other sectors. Food processing and distribution of agricultural products seem to generate the largest forward linkages in rural economies (Haggblade et al., 1989). Small-scale pond aquaculture (fish farming type A) in Ashanti Region currently has weak forward linkages as over 90 percent of farmers practising fish farming type A sell fish directly to consumers, which represent their most important marketing channel. 50 percent of farmers sell to consumers at the farm gate and over 40 percent sell to consumers in the village. Overall 90 percent of fish sold to all customers is unprocessed showing that distribution and processing of farmed fish is not important. However nearly 70 percent of fish farmers also sell fish to traders (63% of which is sold at the farm gate) who go on to sell to retailers and consumers but they are not as important a marketing channel as selling directly to consumers, meaning forward linkages are weak. Nevertheless there is potential for forward linkages to be stronger if adoption of small-scale pond aquaculture increases. Growth in fish supply in rural communities would require an increase in processing, trading and distribution activities, some of which is likely to be carried out by poor women.

Consumption linkages

Consumption linkages arise when additional income is spent on nontradable goods and services and this stimulates further demand for local industry and services. Section 6.2.4 below on economic multiplier effects estimates the marginal budget share (MBS) of small-scale fish farmers for regionally and

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unclear what percentage of costs commercial feed represents for the 27 percent of small-scale farmers practising fish farming type A that use it.

nationally nontradable goods in Ashanti Region. The results indicate that for every extra dollar of income earned by farmers from small-scale pond aquaculture, 44 percent will be spent on regionally nontradable goods and services and 62 percent will be spent on nationally nontradable goods and services, implying strong consumption linkages. Spending of labourers' wages on nontradable goods also contributes to consumption linkages and the MBS for nontradable goods for pond farm labourers is likely to be higher than for pond farm owners. The small-scale fish farm budget in Appendix 9 shows that labour represents nearly 80 percent of value added. Thus, consumption linkages may be even stronger for pond aquaculture if labourers' spending on nontradables is taken into consideration.

Investment linkages

Capital or investment linkages occur when increased income is saved and used to finance local investment, reducing vulnerability and increasing productivity of local activities and potential elasticity of supply responses crucial to consumption linkages. The effects of investment linkages are not included in conventional economic input-output models and data were not collected on reinvestment of aquaculture profits. However fish farmers have higher levels of household assets, nonfarm income and income from household enterprises than non-fish farming households suggesting they may be likely to invest in local businesses. Small-scale pond farms are also locally owned implying that profits are likely to stay in the local area. However gross profit margins for small-scale pond aquaculture are estimated to be modest indicating it is unlikely most fish farmers will be able to save much to reinvest into local businesses.

Service, infrastructure and institutional linkages

Service and infrastructure linkages are generated when increasing trade flows lead to improvements in local services particularly communications (e.g. telecommunications and transport services), increased investment in infrastructure such as roads, and reduced unit costs for service provision due to increased demand. Institutional linkages arise when increased production and market activity changes institutions, for example rights and terms of access to land and water, or the relationship between producers and buyers and access to markets and market exchange. The effects of service, infrastructure and institutional linkages are overlooked in conventional economic growth linkage studies. Small-scale pond aquaculture does not seem to have had any effects on service provision, infrastructure or local institutions in the study area. However these linkages are stronger for large-scale cage aquaculture explored below.

Cost of living linkages

Cost of living linkages can occur when increased fish supply due to aquaculture adoption leads to a reduction in fish prices and a rise in people's real incomes which is then spent on local goods and services generating consumption linkages. As noted in Chapter 2, Sections 2.2 and 2.3.5, cost of living linkages are strongest for products with high average budget shares, and local production and consumption and where markets are not well integrated so that local supply and demand are major determinants of prices. While fish markets in southern and central Ghana are generally well integrated with fish reaching many of the inland rural communities where small-scale pond farms are located, the majority of fish available in these communities is processed (smoked and dried) and comes from the coast or from inland fisheries. Supply of fresh fish is not regular and does not meet demand at prevailing prices. These communities benefit greatly from cheaper and increased supply of fresh fish when fish ponds are harvested. At present, due to the small number of pond farms in villages and the long periods between harvests, harvesting is infrequent and cost of living linkages are very weak. However, as households spend a sizeable proportion of their cash income on fish[70] (especially when compared to expenditure on other food groups) the potential for increased adoption of small-scale pond

[70] According to the GLSS5, on average 9.5 percent of household expenditure in Ghana is spent on fish and seafood which is nearly equal to the expenditure on bread and cereals (9.8%) (GSS, 2007:124). In the rural forest zone, expenditure on fish and seafood represent on average 20.8 percent of total expenditure (compared to 16% nationally) and is greater than expenditure on bread and cereals (16.4%) (GSS, 2007:129). In the rural forest zone actual and imputed expenditure on food represents 41.2 and 14.3 percent of total household expenditure respectively (GSS, 2007:121).

aquaculture in rural communities to generate cost of living linkages is strong, and potentially higher than for SME and large-scale cage aquaculture where increased production may not lead to price reductions (discussed further below).

6.2.2 Linkages arising from SME cage aquaculture

Backward linkages

Fingerlings and feed comprise the main backward linkages for SME cage aquaculture. While many cage farmers surveyed were not willing or able to give detailed cost and revenue data for their fish farming activities, some were more forthcoming. Budgets were therefore estimated using incomplete survey data supplemented with data gathered from key informant interviews at the WRI aquaculture field station in Akosombo (which is also a public hatchery). The budget estimated for a small-scale commercial cage farm with 4 cages is presented in Appendix 9. While the absolute figures for each item depend on the number of cages in the farm, the percentage of total cost of each input can be assumed as an approximation for both small and medium-scale cage farms regardless of the number of cages.

Fingerlings, defined here as nationally nontradable inputs, are estimated to represent nearly 12 percent of total costs for SME cage farms. Nearly 80 percent of small-scale cage farmers interviewed obtain their fingerlings from one or more private hatcheries and just over 35 percent from WRI. Three of the five medium-scale farmers interviewed produce all of their own fingerlings. One farmer produces some of his own and supplements them with fingerlings from a private hatchery in Eastern Region and one farmer stocks solely from fingerlings obtained from WRI.

Feed represents just over 85 percent of total costs and unlike pond aquaculture, almost all cage farmers use imported commercial formulated floating feed which as a tradable input does not contribute much to the SME sector's backward linkage. However the majority of small-scale cage farmers buy feed from local feed distributers in Eastern Region that import feed so there is some level of employment and income creation from feed distribution. 50 percent of farmers also buy feed from an Israeli feed company in Ghana called Ranaan. Three of the five medium-scale cage farmers interviewed import feed directly from abroad and two buy from Ranaan. Ranaan established a feed mill in Ghana in 2012 and is currently producing feed locally. While data on this was not collected, anecdotal evidence suggests that while Ranaan's feed prices have barely reduced since they started local production, the reliability of supply has improved (which was a serious problem before) though the number of fish farmers now purchasing feed from Ranaan is unknown. However even if feed is produced locally, while tradable substitutes are available locally and the prices of local and imported feed are related, locally produced feed is still classed as a tradable input (Delgado et al., 1998:1) and would not contribute much to the sector's backward linkage aside from employment created at the local feed mill.

Other inputs into SME cage aquaculture include the cages themselves (which only represent 1 percent of costs when cage costs are amortised over 5 years). Cages are all locally produced for small-scale farmers and most of the medium-scale farmers except one who imported his cages from Scotland.

Forward linkages

SME cage aquaculture in Lake Volta has stronger forward linkages than small-scale pond aquaculture in Ashanti Region as more cage farmed fish is used as inputs into other sectors. Over 40 percent of small-scale cage farms and 60 percent of medium-scale cage farms surveyed sell directly to retailers including cold stores, hotels, restaurants and tilapia joints. The majority of cage farmed fish is distributed to markets in Accra and other urban centres by a network of primarily female fish traders, some of whom also trade in wild caught fish from Lake Volta. Very few of these traders are from communities located around the cage farms and community FGDs indicate this is due to the relatively high level of capital needed to start trading farmed fish. While many women in local communities trade in wild caught fish (often they are the wives of local fishermen), cage farmed fish is more expensive, often sold in 25kg crates and is not sold to traders on credit unlike wild caught fish.

Over 80 percent of SME cage farms surveyed sell to traders (defined here as those who buy less than 50kg at a time). Over 60 percent of small-scale cage farms and all medium-scale cage farms sell to wholesalers (defined here as those who buy over 500kg at a time). Over 60 percent of SME cage farms also sell to consumers.

The same network of traders and wholesalers buy fish from all the SME and large-scale cage farms on Lake Volta. Information gathered from the survey, key informant interviews with fish traders and direct observation indicate there are approximately 20 wholesalers and over 200 traders within this network (and an additional 400 traders who buy only from one large-scale fish farm that has outlets in Accra and who do not buy at the farm gate, discussed further in Section 6.2.3 below). SME cage farmers surveyed ranked traders and wholesalers as their most important customers followed by retailers then consumers. Almost 100 percent of SME farms sell fish at the farm gate and some medium-scale farms also sell to consumers, traders and retailers in other towns.

While all the fish is sold fresh and unprocessed, the cleaning, descaling and degutting is undertaken by women from local communities on harvest days at the farm and they are paid by customers, mainly traders, for this service. This creates casual employment for over 160 women from 6 different SME fish farming communities, one to four times every 2 months. Local women also process fish oil from the fish guts on harvest days at the medium sized farms providing casual employment for over 35 women. A further forward linkage arises from transportation of fish from farm gate to market and groups of traders often rent a ‘trotro’ (a van used for public transportation) to transport fish.

Consumption linkages

The MBS for regionally and nationally nontradable goods for small-scale cage farmers estimated in Section 6.2.4 below suggest that 37 and 49 percent of each extra dollar of income earned by small-scale cage farmers would be spent on regionally and nationally nontradable goods respectively.

Small-scale cage farm owners are mainly professionals from Accra. Therefore, these MBS estimates are lower than for small-scale pond farmers, as wealthier people tend to spend higher shares of their income on imported or tradable goods[71]. Spending of labourers' wages on nontradable goods also contributes to consumption linkages and the MBS for nontradable goods for cage farm labourers is likely to be much higher than for cage farm owners. However the estimated cage farm budget in Appendix 9 shows that labour represents a small proportion of total costs and value added while the gross profit margin accruing to farm owners is estimated to be nearly 23 percent (much higher than for small-scale pond aquaculture). Thus consumption linkages are more likely to arise from the additional income of fish farm owners (rather than labourers' wages) being spent on nontradables.

The strength of consumption linkages from fish farming as perceived by local communities is mixed. Some community FGDs indicated that fish farming creates limited employment with little impact on local economic activity. However other, more remote, communities reported increased commercial activity from labourers spending money on foodstuffs from local traders, in drinking spots and food stalls, renting rooms and marrying local women.

Investment linkages

No data were collected on investment linkages. However all small-scale cage farms surveyed are owned by Ghanaian nationals making it likely for profits to be reinvested in Ghana. Three out of the five medium-scale cage farms surveyed however are foreign owned and the remaining two are owned by Ghanaians with strong international links suggesting some proportion of profits may be invested abroad. However, the lack of data on investment linkages means this is unknown.

[71] The MBS for nontradables for medium-scale cage farmers was not able to be estimated. As the majority of medium-scale farmers are expatriates a reliable proxy group was not found in the GLSS5 expenditure data.

Service, infrastructure and institutional linkages

Like small-scale pond aquaculture, SME commercial cage aquaculture does not appear to have had any effects on service provision, infrastructure or local institutions.

Cost of living linkages

Communities near small-scale cage farms could potentially benefit from cheaper and increased fish supply during harvests, especially as FGDs indicate that wild caught fish supplies from Lake Volta have been decreasing over the years. However, due to the small number of cage farms at present and production cycles of approximately 6 months, harvests are infrequent. One of the three communities close to small-scale farms that were interviewed indicated local fish consumption had increased since fish farming started and community members are able to buy small sized farmed tilapia on harvest days. Farmed fish prices depend on individual fish sizes so 1kg of smaller sized fish is cheaper than 1kg of larger fish. The cage farm survey indicates that traders and wholesalers prefer to buy larger sized fish, ideally 400g and above. Community members are able to buy smaller size fish usually below 330g (known as Size 1, regular, economy and schoolboys in order of decreasing size). Local communities surrounding medium-scale farms do not seem to benefit from increased supply of fish as these farms usually harvest larger fish than small farms (as they have the working capital to pay for continuous feed for a whole cycle whereas small-scale farmers often harvest early due to lack of funds to buy feed) and therefore sell fish at a higher price. The cage farm survey shows the average price of fish from small-scale farms in 2010 was 3.2GH¢/kg and 4GH¢/kg from medium-scale farms. This price difference could also reflect the weaker bargaining position of small-scale farms with their customers, compared to medium-scale farms, due to lack of cold storage facilities and hence willingness to sell fish at a lower price just to clear their harvest, thus benefiting the community.

The FGDs revealed that households spend a high proportion of cash income on fish (one community indicated on average 70 percent of household cash income is spent on fish while the rest averaged around 30 percent, indicating a high average budget share for fish) suggesting that reduced fish prices could lead to cost of living linkages. Generally though tilapia is a high value fish demanded by better off consumers whereas poorer consumers eat cheaper fish such as ‘one man thousand’ and catfish from inland fisheries and salmon from the sea.

Environmental linkages

The community between two of the medium sized farms use water from the lake for drinking, bathing and general household use due to lack of access to piped water. Since establishment of the fish farms the communities report finding that the water makes them itchy when they bathe and gives rashes to children who swim in the lake. A 2011 study by WRI found there were no clearly detectable negative impacts of cage aquaculture on water quality. They attributed this to the large volume of the lake relative to the number of fish cages (Asmah et al., 2011). However water samples for the study were taken in June 2010, approximately a year before community FGDs were conducted for this thesis. Cage aquaculture is growing rapidly in Lake Volta and as noted in the WRI study, farm clusters could have cumulative negative environmental and ecosystem effects. Therefore even if there are limited effects at present, judging by the experience of the communities around the fish farms who use the water every day, it likely that as cage aquaculture grows, decreasing water quality will become a problem, particularly around farm clusters.

Fishermen in 6 of the 7 communities interviewed reported their fish catch had reduced since fish farming started. However it is unclear whether this is due to a wider trend of overfishing and declining fish catch (attributed to a decrease in total rainfall, increasing fishermen population, use of illegal fishing methods and development of farming along the lake destroying fish habitats) (Béné, 2007) or directly related to fish farming. The majority of fishermen interviewed in the FGDs blame their decreased catch on reduced fishing grounds due to fish farming and increased difficulty in catching fish as they are attracted to the feed waste around the cages where they are prohibited from fishing. Conversely fish farmers claim that cages protect fish spawning grounds and wild fish are benefiting from feed waste. Thus, cage farms are in fact increasing the number and size of fish in the lake. Fishermen from one community said their fish catch had increased as fish were attracted to the feed from the cages. However the true impact of fish farming on fish in Lake Volta and fishermen's livelihoods is unclear and requires further research. Many of the fishermen from local communities are hired to work on the cage farms due to their familiarity with the water. They are thus benefiting in some way at the same time as their employment decreases the number of fishermen on the lake, potentially reducing pressure on the lake.

6.2.3 Linkages arising from large-scale cage aquaculture

At present there are only two large-scale farms operating on Lake Volta. The largest and longest established is Tropo farm owned by an expatriate who started pond aquaculture in Ghana in 1999 and began cage aquaculture in Lake Volta in 2006. At the time of interview (April 2011) Tropo had 200 functional cages with a combined volume of 43,200 m^3. Tropo produced 3000 tonnes of tilapia in 2010 and was planning to produce 4300 tonnes in 2011. West African Fish ltd. (WAF) was established in 2008 as a joint venture between a local company called Palm Acres Ltd. and Royal Danish Fish Group from Denmark. WAF had 32,000 m^3 of functional cages for grow out (i.e. not for fingerling production) in 2010, 41,720 m^3 at the time of interview, and produced 1800 tonnes of tilapia in 2010. In addition to these two farms, Crystal Lake Farm Ltd. is one of the oldest cage farms on Lake Volta, established in 2000 by a female Ghanaian entrepreneur. However at the time of interview Crystal Lake was no longer functioning as a fish farm but as the largest hatchery in Ghana, producing tilapia fingerlings and selling approximately 2 million in 2010.

Backward linkages

Backward linkages from large-scale farms are limited and smaller than those from SME cage farms. Both Tropo and WAF import feed directly from Denmark, Holland, Israel and Brazil and do not use local feed distributers unless there are shipping delays. Tropo produces all its own fingerlings at its hatchery at their original pond farm site. At the time of interview WAF was buying fingerlings from WRI and private hatcheries. However a hatchery facility imported from Holland had just been installed on site for WAF to start producing its own fingerlings. One nationally nontradable input used by Tropo are its cages which are locally made whereas WAF imported its cages, which therefore do not contribute to its backward linkage.

Forward linkages

Large-scale cage aquaculture in Lake Volta has stronger forward linkages than other types of aquaculture discussed above. Similar to fish from SMEs, fish from large-scale farms are used as inputs for other sectors and sold to retailers including cold stores, supermarkets, hotels, restaurants and tilapia joints and distributed to markets in Accra and other urban centres by fish traders. While WAF sells fish at the marketplace it created locally, Tropo does not sell any fish locally and sends it all directly to its 3 urban outlets in Accra, Tema and Kasoa where fish is sold, both retail and wholesale, nearly every day. A large number of traders only buy fish from Tropo's outlets and not from SME cage farms or WAF due to transportation cost. Aside from the 20 wholesalers and 200 traders estimated to buy from SME cage farms and WAF, an additional 400 traders buy tilapia from Tropo's outlets to sell in a number of markets in and around Accra, Tema and Kasoa, to retailers, and to consumers either on the roadside or house to house. As all Tropo's fish is sold from its outlets, no women from the local communities trade in farmed fish. However three times per week on harvest days at Tropo two groups of 20 women from the local community Mpakadan make fish oil from the fish guts.

WAF established a market in the local community, Asikuma, to sell its fish. As a result approximately 10 women from Asikuma are trading in farmed fish. However community FGDs revealed that most local women cannot get into the business due to lack of credit. Also WAF mainly sells in bulk to approximately four wholesalers with whom it has established relationships. These then sell the fish to their own groups of traders. On market days, twice per week, there are approximately 30 women who clean and gut the fish, over half of whom are from the local community. 8 other women from surrounding communities sell ice in the market.

Consumption linkages

Large-scale farms employ large numbers of local workers, who are likely to spend a high proportion of their wages on locally nontradable goods. While it was not possible to collect budget data for large-scale farms, it is likely that large-scale farms have a similar if not lower proportion of total costs going to labour as SME farms, where this is already very small. However due to the sheer scale of the farms, the consumption linkages arising from spending by labourers is noticeable in local communities. For example Tropo estimates that every month between GH¢25,000 to GH¢50,000 (approximately US$16,500 to US$33,000[72]) is spent by their workers in local communities. FGDs in the communities surrounding Tropo and WAF indicated they have benefited from consumption linkages from labourers spending on renting rooms, buying farm produce and food, frequenting drinking spots (which have increased from 1 to 4 in the community near Tropo since it started) and marrying local women. There are 2 expatriate staff at Tropo and 1 at WAF who are housed on the farm and who are much less likely than local staff to spend their salaries on nontradable goods. The other source of consumption linkages is the spending of additional income of farm owners. However as Tropo is owned by an expatriate and WAF is primarily owned by a Danish company, it is unlikely that a high share of additional income would be spent on locally nontradable goods.

Investment linkages

Data on investment linkages were not collected. However as the large-scale farms are owned by foreigners it is more likely profits will be repatriated than reinvested in local businesses. At present most of Tropo's profits are reinvested back into the fish farm and it is likely this is the case with WAF as well. However for WAF it is possible that much of the profits would be spent

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[72] April 2011 exchange rate of US$1 to GH¢1.51. Available at: http://www.exchange-rates.org/Rate/USD/GHS/4-4-2011 (accessed 24 May 2013).

on imported equipment such as cages and hatchery equipment from Holland. Tropo does not appear to use as much imported equipment and uses locally produced cages.

Service and infrastructure linkages

While there are no service or infrastructure linkages from small-scale pond aquaculture and SME cage aquaculture, large-scale cage aquaculture is more likely to generate these types of linkages. The two large-scale farms were established in remote rural areas on Lake Volta without basic infrastructure such as motorable roads and thus had to build or renovate access roads to their farms. Tropo renovated 7km of road and has graded it three times since 2007, costing approximately GH¢60,000 (approximately US$40,000[73]). Trotros and taxis have been using the road and it seems likely it has had a positive impact on the surrounding communities, but the extent of this impact is unclear from the community FGD. WAF built a 7.5km road in 2008 for US$200,000 and both WAF and the local community agree this has greatly benefited the community as it has enabled local farmers to reach their farm lands much more easily whereas previously they had to walk through the bush for 4 to 6 hours. Farmers can also transport their farm produce to the village using a vehicle rather than carrying it. The community FGD estimated approximately 100-150 farms have been established along the road as a direct result. The road has also benefited local fishermen who now have easier access to the lake and those who wish to cross the lake now can also do so. Many vehicles use the road daily indicating it has improved transportation for community members and increased business for taxis and public vehicles.

Since many communities that live around Lake Volta use the lake for drinking, bathing and household use, large-scale fish farming can have a detrimental effect on their water supply due to feed waste and effluent from the fish contaminating the water. To compensate Tropo has dug a number of

[73] June 2007 exchange rate of US$1 to GH¢1.51. Available at: http://www.exchange-rates.org/Rate/USD/GHS/6-14-2011 (accessed 24 May 2013).

boreholes in local communities. One was dug in Mpakandan in 2010 costing GH¢13,000 (approximately US$9,000[74]). At the time of interview however, the community were still awaiting the pump to enable the borehole to be used. Tropo also dug a borehole in the health clinic in another local community, Anyansu, in 2011 costing GH¢9,000 (approximately US$6,000[75]). Similarly WAF was in the process of digging a bore hole in Asikuma at the time of interview.

Institutional linkages

While no institutional linkages from small-scale pond aquaculture and SME cage aquaculture were observed, large-scale cage aquaculture seems to have had some effect on the institutions governing the buying and selling of fish between fish farms, fish mammies, and fish traders. Ghana's marine and inland fisheries have a well developed production, processing and marketing system, described in detail by Ames and Bennett (1995). Fish mammies play an important role, in both processing and marketing, and in fishing itself as they own many of the fishing boats and/or prefinance fishing operations to ensure continuity of fish supply (Ames and Bennett, 1995). In artisanal fishing communities such as those around Lake Volta, fishermen often sell their catch to their wives or other local women. Fishermen can also sell their whole catch to a single fish mammy who is entitled to shares of the catch if she is an owner or part owner of the boat, or is entitled to buy at low prices if she has loaned money to the fisherman for nets, outboard motors and fuel. Fish mammies then sell the fish, either processed or fresh, to fish traders often at a considerable mark up (Ames and Bennett, 1995). Many wholesalers, who buy from fish farms, are fish mammies who sell fish on to traders at marked up prices. However Tropo has established a number of outlets in Accra, Tema and Kasoa where, unlike in capture fisheries, anyone can go and buy fish, not just fish mammies, and as they are located in urban centres and not in remote areas on Lake Volta, they are easily accessible to individual fish

[74] June 2010 exchange rate of US$1 to GH¢1.44. Available at: http://www.exchange-rates.org/Rate/USD/GHS/6-14-2010 (accessed 24 May 2013).
[75] June 2011 exchange rate.

traders. Tropo's outlets have allowed traders to bypass fish mammies and buy fish directly from Tropo without a mark-up. Before Tropo had opened its own outlets and was selling at the farm gate, the harvest was sold primarily to fish mammies who would buy in bulk. Some of these fish mammies from Kasoa (on the outskirts of Accra where much of the catch from Weija Lagoon is sold) would sell their fish to traders in Kasoa, at Galilee market, at a 30 to 40 percent mark up and pretend it was wild fish to ensure the status quo was maintained and traders did not buy directly from Tropo. Much of the power of these particular fish mammies came from the fact that they controlled all of the wild tilapia caught in Weija Lagoon that supplies much of Accra with tilapia. The network and institutional arrangements between buyers and sellers were already well established. When Tropo opened an outlet opposite Galilee market selling the exact same fish that traders had been buying from fish mammies at a much higher price, traders realised they could buy the fish directly from Tropo without relying on the fish mammies. The outlet at Kasoa has thus destroyed some of the business of these fish mammies while enabling traders to buy fish at a lower price. It has also allowed a large number of new entrants, mainly women, into the farmed fish trading business. Some of the fish mammies that used to buy from Tropo now buy from WAF (as WAF sells in bulk (1-2 tonnes at a time) to a small number of wholesalers/fish mammies) and also at other wild caught fish landing sites on Lake Volta such as Jemeni.

WAF has also generated institutional linkages through its US$10,000 regeneration of the Asikuma local market which had stopped functioning. WAF rebuilt the marketplace and placed their outlet for fresh tilapia there, encouraging others from the surrounding communities to also sell their products there. WAF sells its fish harvest at the market twice a week and a small market has developed there on those days. The FGD with Asikuma community indicated that employment generation from the establishment of the market has increased local living standards. Aside from the 17 local women that go twice a week to clean and gut the fish, WAF pays the chief to employ 4 people to clean the market, several local people sell ice, a lady who started off selling polystyrene boxes to pack the fish there has now been able to open a small bar, several people sell vegetables, shoes, household items, water, food, nets and sacks to pack the fish etc. Customers from Accra coming to buy fish from WAF create demand for these products. WAF has also constructed a 30 meter deep well at the marketplace to provide clean water for the Asikuma community.

Another important institutional linkage arising from cage aquaculture is the privatisation of previously open access fishing grounds. The FGD in the community nearby Tropo indicated many fishermen had stopped fishing or migrated due to the reduction in access to fishing grounds as a result of Tropo's cages. Fishermen reported having to travel much further to catch fish, increasing not only their effort but the level of risk they face when fishing. However Tropo argue that this cannot be the case as the farm is taking up a relatively small part of the fishing grounds. Nevertheless the FGD estimated 60 out of 100 fishermen had migrated and of the remaining 40, only 30 are still actively fishing, due to the reduction in fishing grounds and decrease in fish catch (which as mentioned earlier is part of a wider trend in Lake Volta so cannot be due entirely to Tropo). Similarly, Asikuma community indicated that fishermen are restricted from fishing around WAF's cages and the reduced fishing grounds, caused not only by WAF but other fish farms as well, means they must travel much further (estimated to be 15 to 20 miles away) to fish. They have had to find alternative livelihood activities such as subsistence farming and burning charcoal whereas before they relied solely on fishing for their livelihoods. This has resulted in a decrease in their quality of life. Fishermen from both communities suggested that their reduced catch was also due to the fish being attracted to the cages so they are unable to catch them. However as with SME farmers, Tropo argues that the area around the cages acts as a conservation area, protecting fish spawning grounds and thus helping to repopulate the lake. The reduction in fishing grounds has led to a strained relationship between Tropo and the local community, showing how large fish farms have the potential to increase social conflict with local communities.

Cost of living linkages

While local communities around small-scale pond and cage farms benefit from increased fish supply and reduced prices during harvests, this is not the case for communities located around large-scale farms. All of Tropo's fish is transported directly from the farm to its urban outlets and is not sold locally. Even though WAF sells its fish in the local marketplace, the fish is sold in 25kg crates and bought by wholesalers and fish mammies (who have a relationship with and are prioritised by WAF). These then sell the fish on to their own groups of traders who do not sell the fish in the local community. The FGD in Asikuma indicated that the community does not benefit at all from increased supplies of fish. On a national level there does not seem to be much potential at present to decrease the price of fish through increased production of tilapia from cage aquaculture. In 2011 aquaculture production was estimated to be just over 19,000 tonnes (FAO, 2004-13). Kaunda et al. (2010) estimate tilapia demand to be between 60,000 and 120,000 tonnes per year and they argue the market can absorb a substantial increase in tilapia supplies without leading to major price reductions. They also note that tilapia is priced alongside the better demersal species sold in Accra, differentiated from small pelagics that retail for less than half the price per kg for tilapia. This shows that tilapia is a high value product whose price is related to other high value fish products so increased supply will not necessarily decrease its price or benefit poor consumers who are unlikely to demand high value fish such as tilapia.

Environmental linkages

Similar to the communities surrounding SME cage farms, the FGDs in the Tropo community also indicated a decrease in water quality around the farm: fishermen reported that they can no longer bathe in the water as it makes their skin itchy. The lake water is no longer drinkable and water provision in the communities remains inadequate while they wait for the borehole Tropo installed in 2010 to start working. A new large-scale fish farm called Triton is currently being established on Lake Volta and is planning to produce 10,000 tonnes of fish every year and is sited close to a water intake point, meaning their operations will pollute surrounding communities' water supply. Many of the communities around the lake do not have piped water and rely on the lake as their main source of potable water and the growth of fish farming is likely to negatively impact them.

According to an FGD in the community close to Triton, it has also been destroying farms as it puts up electricity poles. At least 5 community members had lodged complaints with the Assembly man, who was planning to issue them with a verbal warning. The Queen Mother and Assembly man reported that Triton had not informed or asked permission from the community or the chief to put up electricity poles.

6.2.4 Economic multiplier effects of increased production from different aquaculture systems

This section estimates the economic multiplier effects of small-scale pond aquaculture (fish farming type A) in Ashanti Region and SME commercial cage aquaculture on Lake Volta in Eastern Region. These multipliers estimate the amount of added income generated locally and nationally by an extra dollar of income from each aquaculture system in order to compare the potential economic growth created by the development of each type of aquaculture system.

Multipliers from small-scale pond aquaculture

Parameter estimates for the semi input-output model outlined in Chapter 4 Section 4.3.2 used to estimate multipliers from small-scale pond aquaculture are shown in Table 34 below.

Table 34: Parameter estimates for small-scale pond aquaculture (fish farming type A)

	a_{nn}	a_{nt}	v_n	v_t	β_n	S
Regional multiplier	0.27	0.27	0.57	0.31	0.44	0.185
National multiplier	0.27	0.63	0.57	0.31	0.62	0.185

In Table 34, a_{nn} is a weighted average of the shares of nontradable intermediate inputs into the farm and nonfarm nontradable sectors (0.12 and 0.34 respectively) estimated by Al-Hassan and Jatoe (2007). The average is weighted according to the ratio of agricultural to non agricultural output (which are proxies for the farm and nonfarm sectors) in Ghana: this is approximately 3:7 (GSS, 2011). Al-Hassan and Jatoe estimated these parameters from a Social Accounting Matrix (SAM) developed for Ghana in 2000 and budget data on individual crops. a_{nt} and v_t are estimated from the small-scale pond aquaculture (fish farming type A) budget, estimated using data from PBs and key informant interviews, shown in Appendix 9. v_n is a weighted average of the shares of value added in farm nontradables and nonfarm nontradables (0.9 and 0.43 respectively) estimated by Al-Hassan and Jatoe (2007) from GLSS4 data and some commodity budgets. The average is again weighted according to the ratio of agricultural to non agricultural output in Ghana (approximately 3:7). β_n is the MBS of nontradable goods (regionally and nationally) of those whose income would increase with the development of small-scale pond aquaculture which would include both fish farmers/owners and hired labourers. However β_n in Table 34 above is estimated only for fish farmer households: if the MBS of farm labourers was included it is likely the multiplier estimate would increase as labourers, being poorer than fish farmers, are likely to have higher MBS for nontradable goods[76]. s is estimated at 0.185 from Ghana National Accounts data (GSS 2011), where gross saving as a share of GDP is estimated at 18.5 percent. However this is likely to be an overestimation as the GLSS5 data shows that household and per capita expenditure is higher than income implying there is dis-saving. Thus to estimate likely ranges the multipliers in Table 35 calculated with the parameters in Table 34 are also estimated with a savings rate of zero.

Table 35: Estimates of growth multipliers from small-scale pond aquaculture (fish farming type A)

Type of multiplier	Total multiplier (M) (where s = 0.185)	Production multiplier (M_p)	% of multiplier attributable to consumption linkages (1)	Total multiplier (M) (where s = 0)
Regional	2.3	1.7	49.2	2.6
National	4.3	2.6	51.4	5.0

Notes: (1) Calculated by $(M-M_p)/(M-1) \times 100$ (Haggblade et al., 1991).

Table 35 shows that the regional multiplier within Ashanti Region generated by growth of small-scale pond aquaculture is estimated to be between 2.3 and 2.6. This can be interpreted to mean that an extra dollar of income from small-scale pond aquaculture in Ashanti Region will generate between US$1.3 and US$1.6 of further income within the region. Nearly 50 percent of this multiplier effect is from consumption linkages. Table 35 also shows that the multiplier effect of small-scale pond aquaculture within Ghana is estimated to be between 4.3 and 5.0 meaning an extra dollar of income from small-scale pond aquaculture in Ashanti Region will generate a further US$3.3 to US$4.0 of income nationally with just over 50 percent of this multiplier effect arising from consumption linkages.

[76] For example if labourers have a MBS of 0.8, the weighted MBS of β_n would be 0.76 nationally, increasing the multiplier shown in Table 35 from to 4.3 to 5.0, an increase of just over 17 percent.

Multipliers from commercial SME cage aquaculture (Eastern Region)

Drawing on parameter estimates discussed above and SME cage farm budgets shown in Appendix 9, parameter estimates for commercial SME cage aquaculture are shown in Table 36 below.

Table 36: Parameter estimates for commercial SME cage aquaculture

	a_{nn}	a_{nt} (2)	v_n	v_t (2)	β_n (1)	S
Regional multiplier	0.27	0.05	0.57	0.29	0.37	0.185
National multiplier	0.27	0.16	0.57	0.29	0.49	0.185

Notes:

(1) β_n is an estimate of the MBS for SME cage farmer households and would not increase if the MBS for labourers was included as, unlike with pond aquaculture, almost all of the value added in SME cage aquaculture is profit for the fish farmers.

(2) a_{nt} and v_t are estimated from an average SME cage aquaculture budget estimated using cage farm survey data and information from key informants, shown in Appendix 9.

The parameters in Table 36 are used to estimate growth multipliers arising from commercial SME cage aquaculture and the results are shown in Table 37 below.

Table 37: Estimates of growth multipliers from commercial SME cage aquaculture

Type of multiplier	Total multiplier (M) (where s = 0.185)	Production multiplier (M_p)	% of multiplier attributable to consumption linkages (1)	Total multiplier (M) (where s = 0)
Regional	1.5	1.1	71.8	1.6
National	2.1	1.4	60.7	2.3

Notes: (1) Calculated by $(M-M_p)/(M-1) \times 100$ (Haggblade et al., 1991).

Table 37 shows that the regional multiplier within Eastern Region generated by growth in SME cage aquaculture in Lake Volta is estimated to be between 1.5 and 1.6, while the national multiplier is estimated to be between 2.1 and 2.3. These estimates can be interpreted as for the small-scale pond aquaculture multiplier estimates above.

These results show that regional economic growth multipliers generated by small-scale pond aquaculture in Ashanti Region are larger than from SME cage aquaculture in Eastern Region, while national multipliers from small-scale pond aquaculture are over twice as large as those from SME cage aquaculture.

The multiplier effect of large-scale cage aquaculture has not been estimated due to lack of budget and expenditure data. However as the large-scale farms in Ghana are primarily foreign owned and employ some expatriate labour, even if the nontradable input to total output ratio and value added to total output ratios are similar to the SME cage farmers, the MBS for nontradable goods is likely to be lower than for SME cage farms resulting in lower multiplier effects. At present though, the scale of operation of the large-scale farms compared to small-scale pond and SME cage farms means this system is creating important multiplier effects (including from infrastructure and institutional linkages which are not generated by small-scale pond and SME cage aquaculture and are not included in the semi input-output model).

Limitations of the model and parameter estimates

The model used to estimate the multipliers above makes some assumptions which may affect the size of the multiplier estimates. The model assumes an elastic supply of nontradables and thus no price increases when demand for nontradables increases due to increased income from a shock to the tradables sector. This is unrealistic however and it seems likely that in Africa there is less than perfectly elastic supply of nontradables and part of the increased local spending on nontradables will be accounted for by higher prices rather than increased output. This suggests these multiplier estimates are an upper bound and an overestimate of up to 30 percent compared to price endogenous models with upward sloping supply curves for nontradables (Haggblade et al., 1991; Delgado et al., 1998)**.** Therefore the regional and national multiplier estimates from small-scale pond and SME cage aquaculture may be revised downwards by 30 percent to account for inelastic supply of nontradables as follows:

- regional and national multipliers from small-scale pond aquaculture (fish farming type A) estimated at between 2.3 and 2.6, and between 4.3 and 5.0 respectively are reduced to between **1.6** and **1.8**, and between **3.0** and **3.5**
- regional and national multipliers from SME cage aquaculture estimated at between 1.5 and 1.6, and between 2.1 and 2.3 respectively are reduced to **1.1,** and between **1.5** and **1.6**.

The model assumes that regional economic growth is driven primarily by increased production of tradables ignoring the effect of a growth in nontradables and also the dynamic effects of saving and investment. Delgado et al., (1998) do not see this as an unrealistic assumption and argue that if a technological breakthrough occurs for nontradables either the nontradable will become so cheap it will become tradable, or resources will flow out of the nontradable to the tradable sector. In both cases the model is able to capture the effects through an exogenous increase in tradables and its multiplier effects, so this linkage model is still appropriate when the source of the exogenous growth in tradables is explained. Similarly Haggblade et al. (2005) point out that growth based on nontradables would soon peter out in the absence of increased demand. However the argument that growth must be driven by tradables is questionable and does not apply at the global scale. Increased production of nontradable goods which are consumed widely and have high average budget shares in household expenditure also has the potential to generate economic growth (Dorward et al., 2003). Increased production of a particular nontradable good would lead to a price reduction increasing consumers' real income or consumer surplus (the cost of living linkage described earlier and not accounted for in the semi input-output model estimates presented here). When this 'extra' income that would have been spent on the nontradable good before the price decrease is instead spent on other nontradable goods and services, consumption linkages generate economic multiplier effects as described above. Whether or not the price of the nontradable good will decrease so much it will either become tradable or will no longer be profitable to produce in these quantities and so some resources are switched to producing other goods and services is unclear and dependent on the individual context.

The model's assumption that growth is driven by tradables is not a problem for the current analysis. As discussed earlier, fish prices are unlikely to fall nationally and in most areas as a result of aquaculture growth in Ghana. While there are certain pockets e.g. remote rural communities where markets are not integrated and where increased aquaculture production could potentially decrease fish prices, behaving like a nontradable good, aquaculture products are best treated here as tradable goods.

The model also does not consider the effects of saving and investment as it uses a static equilibrium approach. Delgado et al. (1998) suggest that the relative absence of a large-scale landowning class in most African countries means investment linkages are unlikely to be strong and so this is not as limiting an assumption as it might be elsewhere. However it is possible that excluding investment linkages from the model results in an underestimation of the multiplier effect of SME cage farms. The model also does not consider the effects of other potential linkages such as service and institutional linkages. However as these linkages are nonexistent for small-scale pond and SME cage aquaculture, this does not affect the multiplier estimates (see Sections 6.2.1 and 6.2.2. The model also makes a restricting assumption that production can be adequately modelled as Leontief fixed coefficients technology, which price endogenous models do not.

There are also some limitations related to the estimation of parameters which may have an effect on the multiplier estimates. Firstly due to the lack of expenditure data for small-scale pond farmers and SME cage farmers, MBS were estimated using expenditure data for non-fish farmers from the GLSS5. As noted above, small-scale cocoa farmers in Ashanti Region were used as a proxy group for small-scale pond farmers and professionals from Greater Accra who also had agricultural income sources were used as a proxy for SME cage farmers. While it is difficult to know the effect of using these proxy groups to estimate MBS for the different types of fish farmers, the parameters still reflect the higher MBS for nontradable goods for small-scale cocoa farmers compared to professionals from Accra which is what would be expected for small-scale pond farmers and SME cage farmers. It is the relative sizes of the MBS which are more important for this analysis as the primary objective is to compare the multipliers between small-scale and SME fish farming.

Secondly, some of the model parameters were estimated from Al-Hassan and Jatoe's (2007) study estimating farm multipliers in Ghana. Their parameter estimates for nontradable intermediate inputs into the farm and nonfarm nontradable sectors were estimated from a 2000 Ghana SAM which did not disaggregate between tradable and nontradable sectors, which is a weakness in their multiplier estimates and thus in the estimates presented here. However as the primary purpose of this analysis is to compare the multiplier effects between aquaculture systems, these parameters were the same for the multiplier estimates of each system therefore the overall conclusions of the relative strength of these multiplier effects are not affected.

Thirdly, the parameters for the ratios of value added and nontradable inputs to output from the two aquaculture systems are based on estimated budgets for financially viable fish farms. For small-scale pond aquaculture the multiplier is calculated for fish farming type A farmers (those who have been trained and/or use BMPs) identified in Chapter 5 as those for whom fish farming is associated with significantly higher incomes than non-fish farmers and fish farmers who have not been trained and do not use BMPs (fish farming type B). The parameters were estimated from an estimated budget based on the PBs of fish farming type A farmers in Chapter 5 and key informant interviews with FC extension staff. The budget (shown in Appendix 9) estimates a profit margin of 6 percent. However, it is clear from the range of profit margins from the PBs estimated in Chapter 5, Section 5.2.9 and findings from other studies (such as Asmah, 2008) that many small-scale artisanal pond farmers in Ghana are not financially viable at present. Thus the multiplier estimate for small-scale pond aquaculture should be viewed as the potential multiplier effect of financially viable small-scale pond farmers (who have been trained and/or are using BMPs) and not the actual multiplier effect of the whole small-scale artisanal aquaculture sector at present. Similarly the SME cage farm budget from which the parameters for the SME multipliers were estimated is an estimated budget based on incomplete survey data and key informant interviews. At the time of data collection many SME cage farms were going out of business and new ones were being established, reflecting the fact that not all SME farmers were able to make a profit (and also did not have the substantial working capital needed to sustain their farms over the 6 months production cycles). Therefore again these multiplier estimates reflect the potential multiplier effects of relatively well managed and financially viable small-scale pond and SME cage farms in Ghana rather than the actual multiplier effects of the sectors at present.

Finally, it is important to bear in mind the limitations of these budget estimates. As noted above, the budget used to estimate some of the parameters for the small-scale pond aquaculture multipliers is based on findings from 4 PBs (2 case study farmers and 2 average group budgets in Chapter 5) and key informant interviews and thus while realistic cannot be considered representative of all fish farming type A farmers (see discussion in Chapter 5, Section 5.3.2). Similarly, the cage farm budget used to estimate some of the parameters for the SME cage aquaculture multipliers (estimated from survey data and data from key informant interviews) again while realistic, cannot be considered representative of all financially viable SME cage farms. However, the differences between multiplier estimates for small-scale pond aquaculture and SME cage aquaculture are sufficiently large to reduce the impact of the potential weaknesses of using these budget estimates. The precise multiplier estimates do not matter as much as the *difference* in multiplier estimates for these two aquaculture systems.

6.2.5 Employment in small-scale pond aquaculture and commercial cage aquaculture

Fish farming can potentially impact on poverty through increased demand for labour. The labour opportunities created by different aquaculture systems are estimated in this section, along with employment generated along the value chains related to these systems. The level of employment generated by small-scale pond aquaculture (fish farming type A) is compared to the employment generated by crop farming and also by SME and large-scale commercial cage aquaculture. Employment is measured in full-time equivalent (FTE) jobs based on the number of days usually worked in the farming sector: one FTE job is estimated to represent one full time job for someone working 8 hours a day, 300 days a year. Wage rates between labourers on small-scale pond farms and SME cage farms are also estimated and compared to average wage rates in the agricultural sector to see if fish farming has the potential to increase rural wage rates. Some characteristics of labourers on SME and large-scale commercial farms are then briefly explored.

Use of hired labour in small-scale pond aquaculture

Pond aquaculture consists of a number of activities from pond construction and preparation to harvesting and marketing. As shown in Chapter 5, Section 5.2.9, several activities such as pond construction, pond preparation, and harvesting are undertaken by a mix of household and hired labour. However other activities such as feed and fingerling procurement, fertilising, weeding, sampling, marketing, processing and record keeping are undertaken mainly by household labour. 46 percent of the fish farming type A households (n = 46) and 73 percent of small-scale crop farming households (n = 69) surveyed hired labour for their fish farming and crop farming operations respectively: X^2 (1, N = 115) = 8.399, p=.004. Of the farms that hired labour, on average, seasonal labour represents 53 percent (SE = 11.01) of FTE jobs per fish farm, compared to 84 percent (SE = 4.94) of FTE jobs per crop farm: t (28.39) = -2.573, p=.016.

Comparison of employment created by small-scale pond aquaculture and crop farming

Table 38 shows sample estimates of the average number of FTE jobs generated by small-scale pond aquaculture (fish farming type A) and crop farming, per farm and per hectare, and the significance of the difference between the two.

Table 38: Average FTE jobs for hired and family labour generated by small-scale pond aquaculture (fish farming type A) and crop farming

	Small-scale pond aquaculture (fish farming type A)	Crop farming	Significance of difference between means (2)
Average FTE jobs/farm – hired labour	0.2 (0.07) (n=46)	0.4 (0.10) (n=69)	t(109.31) = -1.72, p=.088
Average FTE jobs/farm – hired and family labour	0.5 (0.10) (n=43)	1.4 (0.14) (n=65)	t(103) = -5.26, p=.000
Average FTE jobs/ha – hired labour	2.6 (1.21) (n=45)	0.1 (0.02) (n=68)	t(44.02) = 2.05, p=.047
Average FTE jobs/ha – hired and family labour	15.6 (6.14) (n=39)	0.3 (0.03) (n=64)	t(38) = 2.50, p=.017
Average FTE jobs/ha assuming only 50% of farm land is used for crop farming – hired labour	2.6 (1.21) (n=45)	0.2 (0.04) (n=68)	t(44.08) = 1.98, p=.054
Average FTE jobs/ha assuming only 50% of farm land is used for crop farming – hired and family labour	15.6 (6.14) (n=39)	0.6 (0.07) (n=64)	t(38.01) = 2.45, p=.019

Notes: SE in parentheses
(1) Labour for pond construction is not included in this comparison
(2) Independent samples t-test

Table 38 shows that while pond aquaculture generates approximately half the FTE jobs for hired labour per farm than crop farming, when measured per hectare, small-scale pond aquaculture generates over 32 times the amount of FTE jobs. Employment generation for fish farming per hectare may be overestimated however as fish ponds are generally very small compared with total farm size. Also there are economies of scale in employment that are not taken into consideration e.g. one caretaker looking after one pond could just as easily take care of 10 ponds. As the survey did not collect information on the use of farm land, FTE jobs per ha in crop farms may be underestimated as it is unlikely that all farm land owned by households is in use for crop farming at any one time. However even if it is assumed that only 50 percent of farm land is used for crop farming and the estimate of labour use per hectare on farmed land is doubled, FTE jobs per ha generated by fish farming is still significantly higher than crop farming. The average FTE jobs per ha estimated by the survey for crop farming, assuming only 50 percent of land is used, of 0.6 is the same as the estimate by Victor et al. (2010:15) of the average FTE jobs per ha generated by high input certified cocoa production in Ghana's Western Region[77] and similar to the estimate by Vigneri (2008:22) of 216.25 person days per hectare for cocoa farming in Ashanti Region in 2004, equivalent to 0.7 FTE jobs per ha.

Employment generated from small-scale pond aquaculture and SME cage aquaculture

Table 39 compares sample estimates of FTE jobs generated from small-scale pond aquaculture (fish farming type A) with those from small-scale cage aquaculture, and also compares FTE jobs generated by small-scale cage aquaculture with those from medium-scale cage aquaculture. While sample mean FTE jobs per tonne generated by small-scale pond aquaculture are half the amount generated by small-scale cage aquaculture when not including employment from pond construction, and nearly one and half times higher than small-scale cage aquaculture when employment from pond construction is included, Table 39 shows that these differences are not statistically significant (at the 10% level). This may be due partly to the small sample size of small-scale cage farms. When all SME cage farms are compared to pond aquaculture the difference in FTE jobs per tonne is also not significant (at the 10% level). It is possible that this difference would be significant if the sample size of cage farms was larger. However the present data shows little difference in FTE jobs per tonne between small-scale pond aquaculture and SME commercial cage aquaculture.

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[77] Comparison with Victor et al.'s (2010) estimate based on author's calculation averaged over 20 years assuming 1 FTE job represents one labourer working 8 hours per day, 300 days a year.

Table 39: Comparison of FTE jobs generated by small-scale pond aquaculture and SME cage aquaculture

	Small-scale pond aquaculture (fish farming type A)	**Small-scale cage aquaculture**	**Significance of difference between means** (1)	**Medium-scale cage aquaculture**	**Significance of difference between means** (2)
Average FTE jobs/t – hired labour not including pond construction (3)	0.6 (0.26) (n=22)	1.0 (0.33) (n=8)	t (28) = -0.95, p=.35	0.6 (0.23) (n=4)	t(10) = 0.90, p =.39
Average FTE jobs/t – hired labour including pond construction (3) (4)	1.5 (0.37) (n=21)	1.0 (0.33) (n=8)	t(27) = 0.69, p=.49		
Average FTE jobs/farm – hired labour not including pond construction	0.2 (0.07) (n=46)	4.3 (0.61) (n=14)	t(13.32) = -6.63, p=.000	23.7 (4.32) (n=5)	t(4.16) = -4.46, p =.01
Average FTE jobs/farm – hired labour including pond construction (3)	0.3 (0.06) (n=44)	4.3 (0.61) (n=14)	t(13.22) = -6.51, p=.000		

Notes: SE in parentheses

(1) Significance of difference between small-scale pond and cage aquaculture, independent samples t-test

(2) Significance of difference between small and medium-scale cage aquaculture, independent samples t-test

(3) Only those fish farming type A farmers that produced over 50kg in 2010 are included in the calculation for FTE jobs per tonne to avoid unrealistically high estimates, however all fish farming type A farms are included to estimate FTE jobs per farm

(4) Labour for pond construction included in the estimate is total FTE pond construction jobs annualised over 20 years

Average FTE jobs generated per farm however are significantly different between small-scale pond aquaculture and small-scale cage aquaculture, the latter generating between 14 and 18 times as many FTE jobs per farm than pond aquaculture depending on whether pond construction is taken into consideration. Similarly medium-scale cage farms on average create over 5 times as many FTE jobs per farm, than small-scale cage farms, a significant difference. Out of the 24 FTE jobs generated per medium-scale farm, 17 (SE

= 2.64) FTE jobs were suitable for poor or unskilled labourers to be trained on the job, such as feeders, security guards and general labourers, along with divers, most of whom are local fishermen.

Of the two large-scale farms surveyed, detailed employment data could only be collected from one (WAF). In 2010 WAF generated 42 FTE jobs and 0.02 FTE jobs per tonne which is a fraction of the FTE jobs per tonne generated from SME cage aquaculture shown above[78]. Only general employment data were able to be collected for Tropo, the other large-scale farm, which generated approximately 360 FTE jobs in 2011 and was projected to produce 4,300 tonnes thus creating 0.08 FTE jobs per tonne, similar to WAF.

Employment generated from SME pond aquaculture

While the comparison in this thesis is between small-scale pond farms and SME and large-scale cage farms as these are the predominant systems within the aquaculture sector in Ghana, if employment created by small-scale pond farms and commercial SME pond farms is compared, the trend is still similar to that found above. There is no significant difference in FTE jobs per tonne (not including pond construction labour) between small-scale artisanal pond farms (M = 0.6, SE = 0.26) and SME commercial pond farms (M = 0.7, SE = 0.46), t (22) = -0.21, p =.83. Similarly there is no significant difference in FTE jobs per ha (not including pond construction labour) between small-scale artisanal ponds farms (M = 2.6, SE = 1.21) and SME commercial pond farms (M = 3.3, SE = 1.01), t (46) = -0.16. p = .87. However data were only collected from 3 SME pond farms in Ashanti Region as this is not as dynamic or large a sector as SME cage aquaculture, making these results very approximate. The amount of labour required for pond construction for SME pond farms is not known however the number of ponds per farm ranged from 3 to 20 with an average pond size of 1,634m^2. Ponds of this size are usually built with bulldozers and do not create much employment compared to those

[78] WAF was going through a period of expansion when interviewed in 2011, increasing the number of cages and employees therefore these estimates are a rough approximation only.

of small-scale pond farmers built using mainly manual labour. To construct a pond of 1600m^2 would require employment of a low loader driver for 4 days and a bulldozer driver for 5 days with minimal manual labour.

Employment generated by small-scale pond and cage aquaculture per US$1,000 invested

Based on the estimated small-scale pond aquaculture (fish farming type A) budget in Appendix 9 and the average wage rates of GH¢4/day for pond construction and GH¢10.8/day for seasonal labour (calculated below), small-scale pond aquaculture generates **0.3 FTE jobs per US$1,000** invested (including pond construction) and **0.03 FTE jobs per US$1,000** not including pond construction). Based on the estimated small-scale cage farm budget consisting of 4 cages in Appendix 9, small-scale cage aquaculture generates approximately **0.1 FTE jobs per US$1,000 invested** (not including labour for cage construction. However, this is quite small relative to the cost of the cage (15%)). Data on investment costs for medium and large-scale farms were not able to be collected. It is, however, highly likely that the FTE jobs per US$1,000 invested by medium and large-scale farms are lower than for small-scale cage farms. While these estimates are only an approximation as they are based on estimated budgets, they provide an indication that if employment generated by pond construction is taken into consideration, small-scale pond aquaculture could potentially create more employment per dollar invested than SME or large-scale commercial cage aquaculture.

Wage rates for aquaculture farm workers

Table 40 shows the average daily wages for labourers on small-scale pond farms and crop farms.

Table 40: Average daily wages for labourers on small-scale fish and crop farms

	Small-scale pond aquaculture (fish farming type A)	**Small-scale crop farming**	**Significance of difference between means** (2)
Average daily wage for caretakers – GH¢/day (1)	3.0 (0.53) (n=6)	5.8 (2.11) (n=5)	t(4.51) = -1.31, p=.25
Average daily wage for regular labourers – GH¢/day (1)	7.6 (0.40) (n=27)	5.6 (0.19) (n=44)	t(37.07) = 4.34, p=.000
Average daily wage for seasonal labourers – GH¢/day (1)	7.0 (0.23) (n=108)	8.8 (0.50) (n=577)	t(681.87) = -3.33, p=.001
Average daily wage for all labourers – GH¢/day (1)	6.9 (0.21) (n=141)	8.6 (0.46) (n=626)	t(763.06) = -3.24, p=.001

Notes: SE in parentheses

(1) Average length of working day varies between fish farm and crop farm labourers, shown in Table 41 below

(2) Independent samples t-test

While the difference between average daily wage rates for caretakers on fish and crop farms is not significant (at the 10% level), the daily wage rates of regular labourers are significantly higher on fish farms compared to crop farms. The daily wage rates of seasonal and overall labourers are significantly higher for those working on crop farms compared to fish farm labourers. However the average number of hours in a working day varies between the type of labourer and between fish and crop farms. For example, as shown in Table 41 below, regular labourers on fish farms work on average 4 hours per day compared to regular labourers on crop farms who work nearly 2 hours longer per day which is a significant difference.

Table 41: Average hours worked per day by labourers on small-scale fish and crop farms

	Small-scale pond aquaculture (fish farming type A)	Small-scale crop farming	Significance of difference between means (1)
Average hours/day worked by caretakers	5.8 (1.79) (n=7)	8.6 (1.29) (n=5)	t(10) = -1.17, p=.27
Average hours/day worked by regular workers	4.0 (0.24) (n=29)	5.9 (0.10) (n=45)	t(37.51) = -7.05, p=.000
Average hours/day worked by seasonal workers	5.9 (0.23) (n=122)	5.9 (0.05) (n=612)	t(133.21) = -0.12, p=.91

Notes: SE in parentheses
(1) Independent samples t-test

Due to the varying lengths of average working days between fish farm and crop farm labourers, when daily wage rates are recalculated based on an 8 hour day, as shown in Table 42, no significant differences (at the 10% level) are found in overall wage rates. However, regular labourers on fish farms earn over twice as much for an 8 hour day as those on crop farms which is a highly significant difference.

Table 42: Average daily wages for small-scale fish farm and crop farm labourers based on an 8 hour day

	Small-scale pond aquaculture (fish farming type A)	Small-scale crop farming	Significance of difference between means (1)
Average daily wage for caretakers – GH¢/day	12.78 (6.50) (n=6)	7.26 (3.32) (n=5)	t(9) = 0.71, p=.50
Average daily wage for regular labourers – GH¢/day	16.79 (1.52) (n=27)	7.61 (0.20) (n=44)	t(69) =7.56, p=.000
Average daily wage for seasonal labourers – GH¢/day	10.80 (0.59) (n=108)	12.80 (0.81) (n=577)	t(683) = -1.06, p=.29
Average daily wage for all labourers – GH¢/day	12.03 (0.62) (n=141)	12.39 (0.75) (n=626)	t(765) = -0.23, p=.82

Notes: SE in parentheses
(1) Independent samples t-test

In reality, regular labourers on crop and fish farms do not work 8 hours a day. Crop farm labourers work on average 6 hours per day whereas fish farm labourers work 4 hours per day which would give fish farmer workers GH¢7.6 per day and crop farmer workers GH¢5.6 per day from the above table. In 2010 the minimum wage in Ghana was GH¢3.11/day which is lower than the average daily wage for all types of labourers on both types of farm.

Wages on SME and large-scale cage farms

The average daily wage rates for feeders on the 14 small-scale cage farms surveyed is GH¢3.8 (SE = 0.9). This mainly unskilled, temporary job, would be the equivalent of working as a wage labourer on a crop farm. According to the Labour Union representative of the nearby large-scale commercial banana farm in Tusker, Asuogyaman District, in 2010-2011 the wage rate for temporary workers was GH¢3.9 per day (GH¢105.3 per month) and for permanent workers GH¢4.5 per day (GH¢121.5 per month). Thus the mean wage rate of GH¢3.8 for small-scale cage farm labourers is almost the same as for agricultural wage labourers.

On medium-scale cage farms, the average daily wage rate of workers doing jobs suitable for poor, unskilled labourers or fishermen (such as feeders, security guards, general labourers and divers) was 6.7 (SE = 0.18). At the large-scale farm WAF, the lowest paid workers were paid GH¢8.4 per day and on average, skilled and unskilled workers (not including managerial staff) were paid GH¢14.7 per day.

Indirect employment created throughout the value chain

The preceding sections estimate direct employment generated by small-scale pond aquaculture and SME and large-scale cage aquaculture and do not consider the employment multiplier effects of these different aquaculture systems. Additional employment is created throughout the value chain in feed mills, hatcheries, transportation services, ice manufacturing, cage construction and production and sale of materials such as drums, pipes, ropes and nets, production of water pumps, construction of buildings, in ‘chop bars’ and banku and tilapia joints etc. The indirect employment gains described below are included in the multiplier effects estimated in Section 6.2.4 as part of the backward and forward production linkages.

Small-scale pond aquaculture has an undeveloped value chain at present. It has weak forward linkages so does not generate much employment for fish traders or processors. However it has stronger backward linkages which generate employment related to production and distribution of inputs such as rice and maize bran, groundnut peel, organic fertiliser, lime. This employment generation was unable to be directly observed or quantified however. The SME and large-scale cage farm value chains are more developed with stronger forward linkages and thus likely to create larger indirect employment opportunities. For example from direct observation at least 13 people are employed in 2 main feed distribution companies, 80 people are employed in the 6 main hatcheries, at least 150 local women clean and degut fish on harvest days on various cage farms, and over 80 women process fish oil on harvest days at the medium and large-scale farms. At least 20 wholesalers and over 600 traders, most of whom are women and trade fish as their primary livelihood activity, buy from the cage farms and the large-scale farm retail outlets of Tropo Farm, to sell to consumers, hotels, restaurants and tilapia joints etc. Thus nearly 1000 people are indirectly employed on a full or part time basis, in the SME and large-scale cage farm value chain not including the employment generated in the transport and retail sectors. Nearly 900 people are employed directly on a full or part time basis by SME and large-scale cage farms indicating that at least one indirect job is generated in the value chain for each direct job generated on-farm.

Poverty self assessment and education of SME and large-scale cage farm employees

This section presents data on poverty and education levels of those employed by SME and large-scale cage farms to understand possible poverty impacts of employment generated by cage farms. In total 86 employees on 3 small-scale farms, 5 medium-scale farms, 2 large-scale farms and the largest hatchery (Crystal Lake) were selected at random to be interviewed. 88 percent of those interviewed were full time permanent employees and the remainder were seasonal or temporary workers. Respondents were asked about their own subjective perception of their poverty level. Table 43 shows that the majority of employees surveyed considered themselves to be poor or not so poor with very few stating they were either very poor or rich. Apart from small-scale cage farm employees however, less than 50 percent of those interviewed viewed themselves as poor or very poor.

Table 43: Employees' self assessment of poverty by farm type

	Small-scale cage farm %	Medium-scale cage farm %	Large-scale cage farm %	Hatchery %	Total %
Very poor	0	0	19	0	7
Poor	57	39	19	36	33
Not so poor	29	42	38	36	38
Well off	14	17	22	27	20
Rich	0	3	3	0	2
n	**7**	**36**	**32**	**11**	**N = 86**

Table 44 shows the highest level of education of employees surveyed. Nearly all respondents had some level of education and almost 50 percent had reached middle school (MSLC) but not completed. Nearly 25 percent overall and close to 40 percent of large-scale farm employees had completed secondary school.

Table 44: Highest level of education of surveyed employees by farm type

	Small-scale %	Medium-scale %	Large-scale %	Hatchery %	Total %
None	0	6	0	0	2
Primary incomplete	0	6	0	9	4
Primary complete	14	3	3	18	6
MSLC incomplete	43	61	41	36	49
MSLC complete	43	3	9	0	8
Secondary complete	0	14	38	36	24
University/tertiary	0	8	9	0	7
n	**7**	**36**	**32**	**11**	**N = 86**

These results could suggest that overall cage farms recruit a higher proportion of ‘less poor’ than ‘poor’ workers. The results could also indicate the impact of cage farm employment on poverty levels. The relatively higher levels of education, particularly of large-scale cage farm employees, may suggest the former. However, more detailed research is needed to understand the impact of cage farm employment on poverty levels.

6.2.6 Summary of impacts and linkages between aquaculture and poverty

The direct and indirect impacts and linkages from the different aquaculture systems presented in the preceding sections are summarised in Table 45 below. Scores are assigned to each impact or linkage from each aquaculture system to indicate its current strength as follows: weak (1), medium (3) or strong (5). The table also scores the potential of linkages (at their current strength) to impact on the poor from - 5 to + 5. While some of the impacts on the poor have been studied in detail in this thesis (e.g. the direct impact of small-scale pond aquaculture on income and food security in Chapter 5) the poverty impacts of indirect linkages such as the various economic linkages and multiplier effects from different systems have not been quantified. Rather the likely impact on poverty is inferred from the strength of the linkage, supplemented with knowledge of the characteristics of the likely beneficiaries gathered from the quantitative and qualitative data collected here and the broader aquaculture and agriculture literature.

Similarly, while the actual impact of multiplier effects from different aquaculture systems on poverty are not estimated in the present analysis, the relationship between agricultural growth and poverty is well documented in the literature (Irz at al., 2001; World Bank, 2007). For example Irz et al. (2001) analyse the relationship between agricultural productivity and poverty in a cross section of developing countries and find that a 1 percent increase in agricultural yields decreases the percentage of the population living under the US$1 a day poverty line by 0.91 percent (and by 0.96 percent in SSA).

Table 45: Summary of the strength of impacts and linkages from different aquaculture systems and the likely strength of impacts on the poor

	Small-scale artisanal pond aquaculture (fish farming type A)		SME commercial cage Farming		Large-scale commercial cage aquaculture	
Direct impacts						
Impact	**Strength of impact**		**Strength of impact**		**Strength of impact**	
Increased income of poor adopters	1		0		0	
Increased food security of poor adopters	2		0		0	
Indirect impacts						
Linkages	**Strength of linkage***	**Likely strength of impact on the poor****	**Strength of linkage***	**Likely strength of impact on the poor****	**Strength of linkage***	**Likely strength of impact on the poor****
Backward linkages – purchase of inputs such as feed and fingerlings	4	3	1	1	0.5	0.5
Forward linkages – processing, trading and distribution of farmed fish	1 (3)	1 (3)	2	1 (2)	3	2 (3)
Consumption linkages – general economic activity	4	4	3	3	2	2
Investment linkages – local investment in labour intensive businesses	1	1	2	2	0	0
Service and infrastructure linkages – improved access to transportation and potable water	0	0	0	0	2	2
Institutional linkages - changes in access to markets and market exchange and/or rights and terms of access to land and water (e.g. privatisation of previously open access fishing grounds).	0	0	0	0	+3-1=2 (1)	+3-1=2 (1)
Cost of living linkages – decreased price of fish for poor consumers leading to increased real incomes and consumption linkages	1 (3)	1 (3)	1 for small-scale (2) 0 for medium-scale	1 for small-scale (2) 0 for medium-scale	0	0
Environment – changes in the natural/physical environment that may affect the poor (especially fishermen and surrounding communities)	0	0	-1 (-3)	-1 (-3)	-2 (-3 or -4)	-2 (-3 or -4)
Economic multiplier effect (the total impact of backward, forward and consumption linkages)	4	3	2	1	1	0.5
Direct employment opportunities – FTE/t/US$1,000	3	3	1	1	0.5	0.5

Notes: * Current strength of linkage, potential strength of linkage with scaling up in brackets ()
** Potential impact on poor at current strength of linkage, potential impact on poor with scaling up in brackets ()
Scoring:
Positive: weak (1), medium (3), strong (5)
Negative: weak (-1), medium (-3), strong (-5)
None (0)

The World Development Report 2008 also highlights that cross-country estimates show increased GDP from growth in agriculture is at least twice as effective in reducing poverty as increased GDP from growth outside the sector (World Bank, 2007). Thus multiplier effects from aquaculture, as part of the agriculture sector, would be expected to have an impact on poverty.

While the scoring is subjective and relative, the primary purpose of the table is to give an overview of the strength of the various impacts and linkages arising from each aquaculture system, to discern general patterns which may be lost in the detail of the preceding text and enable overall comparison between systems and their potentials for poverty alleviation.

Chapter 5 showed the direct impacts of increased income and food security are weak for poor small-scale pond farmers (though not for non-poor small-scale pond farmers). Table 45 shows these direct poverty impacts are not present at all for SME and large-scale cage farms as poor farmers are unable to adopt cage aquaculture. The economic multiplier effects and associated linkages (backward, forward, consumption and investment) have been discussed in detail in Section 6.2 above and the scores reflect the relatively strong multiplier effects for small-scale pond aquaculture (fish farming type A), medium effects for SME cage aquaculture and likely weaker effects for large-scale cage aquaculture. However as not all the benefits of economic growth are likely to accrue to the poor, the scores are not as strong for likely poverty impact as for the multiplier effects themselves. The effectiveness of economic growth to reduce poverty depends in part on the overall equality of income distribution. If growth is generated by those in higher income groups (such as large-scale and SME cage farmers) more income growth is needed to reduce poverty than if growth is generated by those in lower income groups (such as small-scale farmers) (Lustig et al., 2002). Therefore lower scores are given (in relation to the strength of the multiplier effects) for the potential poverty impacts of multipliers originating from SME and large-scale cage farms. Other linkages such as service, infrastructure and institutional linkages are only present for large-scale cage farms.

While the scores assigned to each linkage reflect the strength of the observed linkage at present, there is potential for many of these linkages to increase in strength and poverty impact if adoption of the particular aquaculture system were scaled up. Where relevant these are shown in brackets in Table 45. For example, at present forward linkages from small-scale pond aquaculture are low hence the likely poverty impact is also low. However if aquaculture adoption increased, thereby increasing the supply of fish from small-scale rural farms, employment along the value chain and the potential impact on poverty through unskilled job creation such as trading and processing of fish by poor rural women, provision of other services such as public transport, would also increase. Negative environmental impacts of declining water quality have also been scored currently as very weak for SME and large-scale cage farms but these are likely to get stronger and have a negative impact on the surrounding poor communities as the number of cage farms increase.

Some scores reflect the combined effect of more than one impact. For example, institutional changes from large-scale farms would have been given a medium score for their role in enabling low income women to bypass fish mammies and become traders, were it not for the negative effects of the privatisation of previously open access fishing grounds and the resulting social conflict. As SME and large-scale cage aquaculture expands, the potential for social conflict and negative impacts on local fishermen from further reduction in access to fishing grounds is likely to increase. Cost of living linkages have been scored as being weak for small-scale pond aquaculture. However, if adoption and hence fish supply were to increase, the potential for fish prices to decrease in more remote communities with poorly integrated fish markets and stimulate further demand for nontradable goods from increased real income is high as is the potential poverty impact.

Overall the table suggests that at present, small-scale pond aquaculture (fish farming type A) has stronger direct and indirect impact pathways and higher potential to impact on poverty than SME or large cage scale farming given equivalent increases in scale. However the small-scale pond aquaculture sector may not be the most dynamic sector in terms of growth and may also require more support than the SME and large-scale sectors in terms of reducing constraints to adoption and provision of training and extension to enable farms to become financially viable and increase production, thus the table may not be telling the whole story.

Further while most of the linkages in Table 45 are scored according to the same unit of analysis (i.e. strength of linkage per tonne of fish produced) which follows much of the analysis found in the aquaculture literature, the strength of backward linkages is related more to the level of investment in each type of aquaculture system than to the level of production (although levels of production and investment are also related). Further, the service and infrastructure linkages are not strongly related to either production or investment levels, rather they are lump sum investments made by large-scale farms. Thus making a straightforward comparison between systems becomes slightly more complex, especially if the costs of production differ between systems. The implications of this are explored further in the discussion section below.

6.3 DISCUSSION

This section discusses the results presented in Section 6.2 above in relation to other studies looking at different aspects of indirect impacts of aquaculture. The multiplier effects estimated here are compared to estimates of farm multipliers from a range of developing countries including Ghana. The estimates of employment generation from different types of aquaculture are compared to results of research from Asia and Africa relating to indirect impacts of aquaculture on poverty. The overall results are then discussed in relation to the hypothesis being tested, that indirect poverty impact pathways from increased aquaculture SME activity have more potential to impact on poverty than indirect pathways from large-scale commercial operations and direct pathways from small-scale artisanal farms, as set out in Chapter 2.

6.3.1 Multiplier effects of aquaculture

In Section 6.2.4 above, it was estimated that adding US$1.00 of new income from: (i) small-scale pond aquaculture (fish farming type A) in Ashanti Region and (ii) SME commercial cage aquaculture in Lake Volta, would potentially increase total income in the national economy by between US$3.0 and US$3.5, and between US$1.5 and US$1.6 respectively. While no multiplier estimates for the aquaculture sector in developing countries were found in the literature, there are many studies estimating agricultural and farm multipliers in Africa and Asia, discussed in the literature review in Chapter 2. Agriculture multiplier estimates from a range of studies using fixed price - models, similar to that used in the current analysis, are presented in Table 46 below.

Table 46 shows estimates of agricultural multiplier effects, adjusted downwards for inelastic supply of nontradables, ranging from 1.05 in Sierra Leone and Nigeria to 2.02 in Burkina Faso. The adjusted national farm multiplier for Ghana has been estimated to be 1.72. However, if the extra income is generated by the lowest income tercile (with MBS for nontradables at 0.93) then the adjusted farm multiplier is estimated to be 2.93 (similar to the adjusted lower national multiplier for small-scale pond aquaculture of 3). If growth is generated by the highest income tercile (with MBS for nontradables at 0.6) the adjusted farm multiplier is estimated to be 1.51 (the same as the adjusted lower national multiplier for small-scale cage aquaculture of 1.5).

Table 46: Fixed-price agricultural growth multipliers in Africa and Asia adjusted for an inelastic supply of nontradables

Study	Location	Multiplier Dollars of total income growth from US$1.00 of direct growth in agricultural income after adjustment
Bell, Hazell, and Slade (1982)	Malaysia, Muda River region	1.65
Hazell (1984)	Malaysia, Muda River region	1.64
Hazell and Haggblade (1990)	India, average	1.48
	India, Punjab and Haryana	1.74
	India, Madhya Pradesh and Bihar	1.31
Hazell, Ramasamy, and Rajagopalan (1991)	India, North Arcot, Tamil Nadu	1.64
Haggblade, Hazell, and Brown (1987)	Sierra Leone and Nigeria	1.05
Haggblade, Hazell, and Brown (1987) assuming millet, sorghum, and maize are nontradables	Nigeria, Gusau	1.97
Delgado et al. (1998)	Burkina Faso	
	National	2.02
	Local (100km radius)	0.92
	Poorest third*	2.23
	Richest third	1.72
Delgado et al. (1998)	Niger, Dosso	
	National	1.37
	Local (100km radius)	1.24
	Poorest third	1.42
	Richest third	1.37
Delgado et al. (1998)	Senegal, south-eastern Groundnut Basin	
	National	1.57
	Local (100km radius)	1.23
	Poorest third	1.54
	Richest third	1.62
Delgado et al. (1998)	Senegal, central Groundnut Basin	
	National	1.74
	Local (100km radius)	1.42
	Poorest third	2.14
	Richest third	1.61
Al-Hassan and Jatoe (2007)	Ghana	1.72
	Poorest third	2.93
	Middle third	2.03
	Richest third	1.51

Notes: Table adapted from Delgado et al. (1998:16) and extended.

Haggblade, Hammer, and Hazell (1991) compared price endogenous models to fixed price models of the kind used in this analysis and the studies presented in the table above. They found that fixed price models overestimated multipliers by 30% in Africa and 10% in Asia. The multiplier estimates in the table have been adjusted downwards accordingly.

* multiplier estimates originating from the poorest and richest income terciles are all national estimates

The adjusted lower national multiplier for small-scale pond aquaculture of 3 is nearly twice as high as the farm multiplier estimated for Ghana and 1.5 times higher than the highest agricultural multiplier estimated for West Africa by Delgado et al. (1998) of 2.02 in Burkina Faso. One reason for this is the presence of strong backward production linkages in the aquaculture sector (the production multiplier alone is estimated to be nearly 50% of the total multiplier) as discussed in Section 6.2.1 above, compared to agriculture where backward linkages in Africa are very weak (Delgado et al., 1998). The adjusted lower national multiplier estimated for SME cage aquaculture of 1.5 is half that estimated for small-scale pond aquaculture and is at the lower end of the range of agriculture multiplier estimates by Delgado et al. (1998).

Other studies from the agriculture literature also support the results presented here. For example Haggblade and Hazell (1989) compare multipliers generated by different sized farms using different technologies. The general trend seems to be slightly larger multipliers are generated from larger farms using more sophisticated technology in Asia while in Africa larger farms generate slightly smaller multipliers than smaller farms (and again multipliers are higher with more sophisticated technology which require more nontradable inputs as a ratio of output). The multipliers range from 1.25 to 1.47 for rain fed rice in Africa. The difference in their parameters compared to those used for the multiplier analysis here includes a lower level of value added in aquaculture, a higher ratio of nontradable inputs to outputs and higher MBS for nontradable goods estimated for aquaculture farmers.

It is possible that the multipliers estimated here for small-scale pond aquaculture do not reflect the reality of many small-scale artisanal farms. Brummett et al. (2008) suggest the majority of artisanal farms in SSA consist of a small number of ponds constructed and operated with family labour, use few purchased inputs, have low productivity levels, sell only a small proportion of production and generate minimal profits and little or no economic growth. This description of small-scale farms is rather different to the characteristics of the small-scale pond farms surveyed here. While these farmers have low productivity and profit levels they do however use purchased inputs, hire labour for pond construction and some hire labour for production, and sell the majority of their fish (see Chapter 5). If the multiplier estimates for small-scale pond aquaculture presented above are adjusted to take the characteristics described by Brummett et al. into account, it is likely the multiplier effect would decrease. For example keeping all else equal, if the backward linkage is reduced by approximately 50 percent (reducing the ratio of nontradable inputs to output from 0.6 to 0.3), the adjusted lower national multiplier estimate reduces by approximately 30 percent from 3 to 2. This is however still 1.3 times larger than the adjusted SME multiplier. If it is then assumed that no labour is hired for either pond construction or production, the ratio of value added to total output would either stay the same (as value added is shifted from labourers to owners) or increase (due to a decrease in output resulting from reduced inputs), further decreasing the multiplier effect. If small-scale pond farmers are making a loss then the multiplier effect would be negative.

6.3.2 Employment generation from aquaculture

Along with economic multiplier effects, direct employment generation from aquaculture has the potential to impact on poverty. The results show that average employment generation per hectare is significantly higher for small-scale pond aquaculture compared to small-scale crop farming. Few studies compare employment from aquaculture with agriculture, especially in SSA. Ahmed and Lorica (2002), focusing on Asia, suggest household labour use in aquaculture is relatively low compared with crop agriculture noting that most studies show aquaculture using very little labour, most of which is family labour. However they point to some studies suggesting aquaculture requires higher amounts of labour, for example in the Mekong Delta of Vietnam, hired labour cost accounted for nearly 37 percent of labour costs. Costa and Sampaio's 2004 study cited by Stevenson and Irz (2009), also found that shrimp farms in Brazil have higher labour demand (1.89 jobs/ha) than crop farming.

Studies that estimate employment generation by aquaculture have mixed results. Stevenson (2006) shows that labour intensity of aquaculture production varies substantially across farm types in the Philippines, and estimates mean demand for hired labour on low-input systems to be four times higher than for larger farms. Brummett et al. (2008) estimate a small-scale commercial pond farm in Cameroon generates approximately 0.5 jobs per tonne excluding pond construction which is very similar to the employment created by small-scale artisanal pond aquaculture excluding pond construction estimated here (0.6 FTE jobs per tonne). Belton et al. (2012) also estimate ‘quasi capitalist’ pangasius farmers in Bangladesh (equivalent to small-scale commercial farmers by most definitions), to generate 2 jobs per hectare which is slightly lower than employment generated by the small-scale pond farmers surveyed here (2.6 FTE jobs per ha). These results suggest that the direct employment generated by small-scale artisanal farmers in Ghana is similar to that generated by small-scale commercial farms in other countries, highlighting the ambiguous nature of definitions used to categorise farm types and by extension the difficulty of shifting support to SME farms when based on these ambiguous definitions. For example, Hishamunda and Ridler (2006) estimate intensive aquaculture uses three times more labour per hectare than extensive aquaculture in SSA. Extensive farming is unlikely to generate much if any employment and while the definition of small-scale artisanal pond aquaculture would include both extensive and semi-intensive farms, it is semi-intensive farms such as those surveyed here, that are likely to generate employment and economic growth.

While the results show no significant difference in overall hourly wage rates of labourers on small-scale pond and crop farms, regular labourers on small-scale pond farms earn over twice as much as those on crop farms for an 8 hour day. Also while the mean wage rate for small-scale cage farm labourers is almost the same as for agricultural wage labourers, on medium and large-scale cage farms wages are over one and a half times higher. This suggests that small-scale pond aquaculture and medium and large-scale cage aquaculture have the potential to increase rural wage rates. The theory that aquaculture increases labour productivity and has the potential to put upward pressure on rural wage rates is supported by results from other studies such as Dey et al. (2010) and Belton et al. (2012).

Overall the results suggest that small-scale artisanal pond farms may not create as much employment as SMEs if farmers do not hire labour to dig ponds rather using household or communal labour. However if hired labour is used for pond construction it is likely that small-scale semi intensive fish farming generates the same if not more direct employment than SME cage and pond farms per tonne and per dollar invested. Indirect employment along the value chain is currently higher from SME and large-scale cage farms, due to the undeveloped nature of the small-scale artisanal value chain and weak forward linkages. However this is partly due to the current low level of production from small-scale pond farms. If production were to increase it is likely that employment for fish traders and processors and other support services (provision of ice, transport etc.) for small-scale pond farms would develop. While some of these results are approximations due to small sample size for SME cage farms and the use of estimated budgets, when viewed alongside the multiplier estimates discussed above, they do not support the hypothesis that SME cage farms have more potential to impact on poverty than small-scale pond aquaculture or large-scale cage farms.

6.4 CONCLUSION

The direct and indirect impacts and linkages from the different aquaculture systems presented in the preceding sections and the likely impact of each on poverty were summarised in Table 45. Overall the results presented in this chapter suggest that small-scale pond aquaculture (fish farming type A) has more potential to impact on poverty in Ghana than SME and large-scale cage aquaculture, given equivalent increases in scale. This is due primarily to fish farming type A's stronger indirect linkages, ranging from higher potential multiplier effects and labour intensity to increased potential from cost of living linkages and relatively lower chances of creating negative environmental impacts, compared to SME and large-scale farming. Thus the results presented in this chapter do not support the hypothesis that indirect poverty impact pathways from growth in SME cage aquaculture have more potential to impact on poverty than indirect pathways from large-scale commercial operations and direct and indirect pathways from small-scale pond aquaculture (fish farming type A).

This conclusion does not appear to support the arguments being proposed in much of the recent aquaculture development literature, for a shift of focus away from small-scale artisanal fish farming towards more commercially oriented farmers. The apparent conflict between this emerging paradigm in aquaculture development and the results and conclusions presented here could be due to a number of reasons including definitional issues (already touched upon earlier), along with institutional issues which may be hindering the development of aquaculture in SSA. The following chapter therefore analyses these aquaculture systems in terms of the different institutional challenges they face.

CHAPTER 7: INSTITUTIONAL ANALYSIS OF AQUACULTURE SYSTEMS

7.1 INTRODUCTION

This thesis is concerned with assessing and identifying ways to increase the direct and indirect impacts of aquaculture on poverty and assessing the conditions required for pro-poor aquaculture development in Ghana. The results presented in Chapters 5 and 6 indicate that aquaculture has the potential to directly and indirectly impact on poverty and suggest that overall, small-scale artisanal pond aquaculture (fish farming type A) has more potential to impact on poverty than SME and large-scale cage aquaculture. However, at present, the small-scale artisanal pond sector is much less productive and dynamic than the more commercially oriented SME and large-scale cage aquaculture sectors. Thus there are clearly important constraints to the development of the small-scale sector that must be overcome if this potential is to be realised. While small-scale artisanal pond aquaculture (fish farming type A) was found to have the highest potential for poverty impact, SME and large-scale cage aquaculture were also found to have important potential indirect poverty impacts summarised in Table 45 in Chapter 6, including economic multiplier effects for SME cage aquaculture and forward linkage effects for large-scale cage aquaculture. This chapter builds on these results by analysing the existing institutional environment and institutional arrangements supporting the three aquaculture systems and their associated value chains, but which may also be inadequate and thus constraining their development and hence their direct and indirect impacts on poverty. The research objective and hypothesis addressed in this chapter are as follows:

Objective

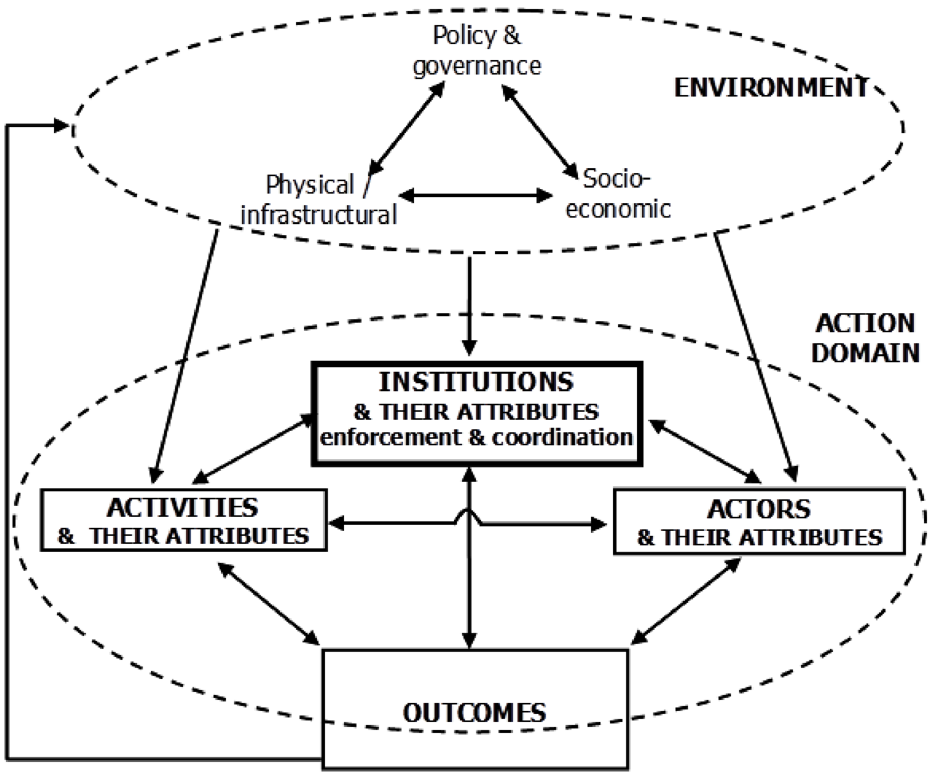
To identify the institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction in different contexts.

Hypothesis

Due to the institutionally demanding techno-economic characteristics of aquaculture products, complementary technical and institutional development is necessary for aquaculture to develop and impact poverty.

This hypothesis is tested using the conceptual framework for institutional analysis developed by Dorward and Omamo (2009) shown in Figure 20 below.

Figure 20: Conceptual framework for institutional analysis



Source: Dorward and Omamo (2009:79)

The action domain defines the areas of activity and interest of the analysis while institutional analysis identifies and examines the important attributes of the institutions, activities, and actors in the action domain. The structure and behaviour of the action domain is established in and affected by a wider environment (physical and infrastructural, socioeconomic, and policy and governance environments). Interactions among institutions, actors, and activities lead to direct and indirect outcomes which may reinforce or change the environment, institutions, activities, and actors leading to institutional change.

Thus this chapter tests the hypothesis by first defining the two action domains under analysis (the pond and cage aquaculture sectors). It then reviews some important aspects of the institutional environment in which aquaculture development in Ghana is taking place. It goes on to assess the activities and their attributes in pond and cage culture systems focusing on the 'techno-economic' characteristics of aquaculture commodities. The implications of these characteristics for the expected institutional arrangements in the different aquaculture systems are then considered. The pond and cage aquaculture systems are then looked at individually, and the key actors and institutional arrangements observed in each system are analysed. In this analysis, actors' characteristics and economic behaviour, and the role, form and functions of institutional arrangements in reducing transaction costs and risks are highlighted. Based on this analysis, the chapter identifies key constraints to development in the different sectors and identifies actors and institutions that may be missing. The institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction are explored in the following chapter based on the findings of this analysis along with the results of Chapters 5 and 6.

7.2 RESULTS

The activities, actors and institutions analysed in this chapter are those identified within two action domains. The action domains encompass the economic exchange of farmed fish and include those actors involved in the exchange of fish produced in the three main aquaculture systems under analysis. They also include activities that directly interact with these exchanges and actors and the institutions that govern these interactions (Dorward and Omamo, 2009). In this chapter two distinct but related action domains are analysed:

i) the production and exchange of tilapia and catfish produced by small-scale artisanal pond farmers in Ashanti Region and

ii) the production and exchange of cage farmed tilapia produced by SME and large-scale commercial cage farmers in Lake Volta, Eastern Region.

While these are separate action domains with different activities, actors and institutions, there are some overlaps between the two in terms of analysis. For example the institutional environments within which each action domain is embedded are broadly similar as are many of the techno-economic characteristics of pond and cage farmed fish. However the actors involved in these two action domains along with the various institutional arrangements linking these actors within individual value chains are different and lead to different outcomes. Therefore, the results presented below start by reviewing the overall institutional environment and techno-economic characteristics of both pond and cage farmed fish without separating out the action domains, while the main part of the chapter subsequently analyses the actors and institutional arrangements in each action domain individually.

7.2.1 Operational environment

This section reviews aspects of the operational environment in which the two action domains are embedded. This environment influences and conditions how the actors, institutions and their attributes in the action domains combine to shape outcomes. The section looks at key aspects of the physical, socioeconomic and policy and governance environments.

Physical environment

In aquaculture, as in agriculture, biophysical conditions such as soil quality and water availability are important determinants of production potential. Overall most of Ghana has been found to have favourable biophysical factors suitable for aquaculture (Kapetsky, 1994; Blow and Leonard, 2007; Asmah, 2008). However Asmah's 2008 analysis of infrastructure, using road density as an indicator, showed the majority (55%) of land was only fairly suitable with the very suitable locations largely in regions along the coastal zone and the Kumasi metropolitan area. Areas with good potential for farm gate sales were relatively wide spread and market potential for commercial aquaculture production was best around Accra and Kumasi where about a sixth of the country's population reside (Asmah, 2008). This is supported by observations from the field. Most small-scale artisanal pond farmers interviewed in Ashanti Region were difficult to reach using public transport and many farmers in Amansie West District, where there is no tarmac road beyond the district capital, were located off the feeder roads and needed a 4 by 4 to reach, indicating the poor transport infrastructure and physical connection to markets faced by many rural farmers. Most SME cage farmers, however, are located in more accessible areas and can be reached by a combination of public transport in 'trotros' from Accra travelling on the main trunk road from Accra to Ho/Aflao, and hiring a shared or private taxi to access cage farms using feeder roads. Large-scale cage farms which are located in the main Lake, however, are in more remote areas and as noted in Chapter 6 have had to build access roads and put in electricity at their own expense. However both large-scale farms have had the means to build roads and to establish outlets and market areas in more accessible areas. Communication infrastructure is growing and there is good coverage of mobile phone services in the country. However, mobile phone penetration into more remote rural areas of Ghana is still inadequate and while most surveyed small-scale artisanal farmers had mobile phones, many farmers had very limited or no network coverage much of the time. This indicates that physical remoteness is compounded by lack of good quality communication infrastructure in some rural areas, constraining market development beyond individual communities.

Socioeconomic environment

Ghana's overall socioeconomic characteristics were discussed in Chapter 3 while Chapter 4 outlined some key characteristics of the survey areas. The socioeconomic environment of the two survey regions is influenced mainly by the fact that they are predominantly rural and dominated by agriculture. In 15 of the 18 districts in Ashanti Region, over half the population live in rural areas and some districts are entirely rural (such as Amansie West)[79]. Similarly in Eastern Region agriculture is the major occupation of most people in all districts, representing 55 percent of occupational activities[80]. As noted in Chapter 5, Ghana's strong economic performance since the mid-1990s has had a significant impact on poverty, though regional imbalances remain, especially between the north and south (Coulombe and Wodon, 2007). Economic growth has been driven partly by high prices for cocoa and gold. Ashanti Region is an important producer of these commodities indicating the dynamic socioeconomic environment in which aquaculture development is taking place.

Policy and governance

Ghana's macroeconomic performance has been positive over recent years, supported by relative political stability and macroeconomic reforms which have encouraged the entry of foreign investments (KPMG, 2012). This can be seen in the level of foreign investment in medium and large-scale cage farms in Lake Volta. The government has been actively building a policy and regulatory environment that is more conducive to enterprise development and Ghana was ranked twice as a top 10 reformer globally by the World Bank's *Doing Business* report (World Bank, 2013b). However there are still many constraints for example the length of time taken to find, buy and register land (often taking over 2 years for some of the SME and large-scale farmers interviewed) along with access to finance, a key challenge cited by Ghanaian businesses in general (World Bank, 2012) and the SME and large-scale commercial cage farmers interviewed.

The commercial aquaculture sector appears to be growing ahead of the development of government policy and regulations. While aquaculture is included in the 2010 Fisheries Regulations, there is currently no regulation

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[79] http://www.modernghana.com/GhanaHome/regions/ashanti.asp?menu_id=6& (accessed 26 May 2013).

[80] http://www.modernghana.com/GhanaHome/regions/eastern.asp?menu_id=6&sub_menu_id=132&gender (accessed 26 May 2013).

specifically for cage culture. There are no formal regulations specifying for example minimum distances between cage farms and this can cause conflict. Similarly there are no specific guidelines for interactions between aquaculture and fishing rights (Kaunda et al., 2010), again increasing conflict between fish farmers and fishing communities as outlined in Chapter 6. Along with the lack of regulations relating to cage culture there is also a lack of enforcement of current legislation. For example all cage farmers, small and large, are required to undertake environmental impact assessments (EIAs) before starting operations. However due to the high cost of undertaking EIAs for small-scale farmers at present this is only being enforced for medium and large farms. Similarly, the regulation relating to certification of hatcheries has only recently started to be enforced. This will hopefully improve and regulate fingerling quality, reducing uncertainty for farmers. There are also a number of illegal small-scale cage farms on Lake Volta which have been allowed to continue as the government is committed to development of the sector. The focus of government support of the aquaculture sector is shown in the 2012-2016 GNADP discussed in Chapter 3 which concentrates almost entirely on the development of SME and large commercial aquaculture with little mention of the small-scale artisanal sector.

7.2.2 Activities and their attributes

The term 'activities' includes the production and exchange processes that actors engage in and the resources and products that are managed, used, produced and exchanged (Dorward and Omamo, 2009). The attributes of these activities (including the goods and services being exchanged) are important as they can affect the benefit, costs and risks to actors and their ability to invest and take part in them (Dorward and Omamo, 2009). As noted in Chapter 2, Jaffee and Morton (1995) view the 'techno-economic' characteristics of commodities as important determinants of the institutional arrangements between actors. Dorward (2001) separates these characteristics into commodity and transaction characteristics. This section explores the commodity and transaction characteristics of farmed fish within the two action domains under analysis.

Commodity characteristics of farmed fish

The following commodity characteristics are considered in turn below: price and volume uncertainty, long production cycles, high perishability, the need for high levels of technical knowledge and for multiple specialised and coordinated inputs, quality characteristics, seasonality, economies of scale in marketing, geographical dispersion of farmers, and information asymmetry in credit provision.

Price and volume uncertainty

As noted in Chapter 5, small-scale pond farmers in Ashanti Region are dispersed over large areas and produce low volumes of fish over long production cycles leading to production volume uncertainty. This uncertainty is increased by the use of poor quality fingerlings, lack of working capital for continuous feeding, and limited fish sampling by farmers resulting in poor feeding practices and small fish. The use of mixed sex fingerlings also increases uncertainty as farmers are unable to estimate the population increase in the pond. Scattered supply leads to high costs for dissemination of technical and market information plus high transportation costs to take fish to market. Production volumes are also too low for buyers to make 'lumpy' investments in vehicles or to travel long distances to buy from only one or a few fish farms. Similarly, output is inadequate to justify investment in cold storage facilities by producers and traders, contributing to additional uncertainty and higher transaction risks and costs.

While SME cage farms are less dispersed, production from small-scale cage farms can also be uncertain and is relatively low as usually only one or two cages are harvested at a time, and production cycles are approximately 6 months. Farmers have variable access to both fingerlings and feed which are of inconsistent quality and are highly priced, further increasing volume uncertainty. Some small-scale cage farmers also lack working capital to buy feed throughout the production cycle, resulting in a higher proportion of smaller sized and lower value fish at harvest than expected. Medium and large-scale cage farmers have more certain production volumes and larger numbers of cages so can produce regularly throughout the year. However they still face production uncertainties due to variable quality inputs, for example the large-scale farm WAF was producing much lower volumes than expected at the time of interview due to a batch of poor quality fingerlings. Low supply was also a result of their harvesting most of their cages, some prematurely, to meet the high demand over Christmas.

Despite the volume uncertainty, there is less price uncertainty for farmed fish than for wild caught fish. The Ashanti Fish Farmer Association (AFFA) sets the price for tilapia and catfish in Ashanti. In 2010 the price was 4GH¢/kg regardless of size even though larger fish, especially tilapia, over 500g could fetch higher prices (generally however sizes range from 150g to 500g and are usually 200g to 250g). Most association members use this price as a guide but most pond farmers surveyed were not part of the AFFA and FC data along with survey data presented in Chapter 5 shows the farm gate price is closer to GH¢3.5/kg. Price also depends on the relative bargaining power of farmers and traders. Farmers can have a strong negotiating position if there is high demand for fresh fish within the community or if the farm is close to a town where there is high demand and higher prices for fish. Traders can also be in a strong bargaining position due to the large investment farmers have made in ponds (a specific asset) and the perishability of fish (explored more below) which can enable them to push down prices.

At the time of interview the most common size of cage farmed tilapia (approximately 330g) was selling at GH¢5.3/kg (US$3.5/kg[81]). Key informants indicated that cheap imported Chinese tilapia had been selling at a much lower price (approximately US$1/kg) despite a government ban. However, the government strengthened enforcement of the ban in 2010 which has resulted in increased demand for domestically produced cage farmed tilapia and less price uncertainty. The demand for cage farmed fish around Lake Volta decreases however when supply of wild caught fish is high. The season for wild caught white tilapia (May to June) reduces demand

[81] April 2011 exchange rate of US$1 to GH¢1.51.

and price for farmed tilapia and the supply of small pelagics which peaks around July to September during the ‘herring season’ can depress the whole market (Ames and Bennett, 1995). Unlike farmed fish prices, the price of wild caught fish fluctuates widely based on the size of fish landings and seasonal variability in supply along with distance from the source of supply (Ames and Bennett, 1995).

Long production cycles

Due to the 8 month or longer production cycle for semi-intensive pond farmed fish there is a yield lag and yield uncertainty, increasing risk for fish farmers. Long production cycles can create the need for medium term financing for producers and expose them to long-term market entry (and price) risks. The long production cycle of pond farmers and the 6 month production cycle of small-scale cage farmers, lower the elasticity of supply faced by traders causing coordination problems for them in obtaining steady supplies, meaning traders have to diversify their sources. Long production cycles do not affect medium and large-scale cage farmers in the same way as they have enough cages to time their stocking and harvesting to enable regular production throughout the year.

High perishability

Fish is highly perishable especially in the tropics. Small fish spoil within 6 to 8 hours and become rotten within 12 hours while large fish are of poor quality within a day. Packing on ice effectively preserves fish, retaining its appearance, flavour and texture. However, ice is expensive in many areas in Ghana (Ames and Bennett, 1995:376) and unavailable in some remote rural areas. Fish harvested from small-scale rural pond farms is usually sold un-iced to customers, mainly community members buying small quantities for home consumption. Traders buying larger quantities from pond and SME cage farms either buy ice from the local community or from ice sellers at the farm (or in some cases use ice provided by the farm), and pack fish directly on ice in baskets lined with sacks or in insulated ice boxes, ready to transport to market to be sold fresh.

Fish can also be cured (smoked or dried) and in Ghana wild caught tilapia is often preserved by salt drying to make ‘kobi’ while catfish is usually hot smoked in kilns made from oil drums meaning fish can be kept for several months depending on the extent they are dried. Both methods are efficient with small quantities. When compared to wild caught tilapia however cage farmed tilapia is of poorer quality when processed due to its high fat content (attributable to poor feed quality), has a shorter shelf life and is more prone to rancidity. Inability to process cage farmed fish makes its perishability more of a constraint and increases uncertainty for producers and traders. Pond farmed tilapia not fed commercially formulated feed are slightly better than cage farmed fish when processed and catfish from ponds around Kumasi which are smoked are of higher quality and value than wild caught catfish which is smoked at landing sites and suffers breakages when transported to Kumasi.

The high perishability of farmed fish and lack of cold storage facilities at small-scale pond and cage farms reduce the marketing options of producers once fish has been harvested, limiting its marketable life as a fresh commodity and the time period for processing. This increases market risks for producers as once harvested, they cannot keep the fish in their possession for long while waiting for higher prices and this can lead to an unfavourable bargaining position in relation to buyers. Perishability also increases risks of post harvest losses and reduction in quality and value of fish during transport. Thus, there may be need for investment by traders and producers in specialised and ‘lumpy’ transport and storage facilities to develop a cold chain such as refrigerated trucks, fridges and freezers. However due to the economies of scale in transportation and storage, so far there has been little investment in these by traders (and investments have only been made by a few of the larger wholesalers who have long been trading in wild caught fish). Perishability also restricts the role of storage in balancing the supply and demand of fish over time.

High level of technical knowledge required

Production of farmed fish requires technical knowledge and skill which is more specialised than in many other types of agricultural activities and is not indigenous to Ghanaian farmers. This technical knowledge can be costly to obtain, especially for poor farmers in rural areas with limited access to extension services and other information sources. Along with the relatively high fixed costs of digging ponds for poor farmers or acquiring land and establishing cages for cage farmers, the need for specialised technical knowledge means there are potentially high barriers to entry in fish farming for less skilled and less well off farmers and this requires institutions to support the flow of low cost information.

Need for multiple specialised and coordinated inputs

Pond and cage aquaculture are high 'linkage intensity' technologies as defined by Dorward et al. (2000) and discussed in Chapter 2. They require specialised inputs such as fingerlings and feed to be brought onto the farm. Fingerlings require careful transportation to ensure minimum mortality, and feed, which is bulky, is usually brought onto the farm regularly due to lack of on-farm storage facilities and/or limited working capital for bulk purchase. Input supply also requires coordination so that feeding can start at stocking. However coordination is difficult due to the variable supply of fingerlings and feed. Fish farmers need to place orders in advance with hatcheries and sometimes with feed distributers and there is still no guarantee orders will be met on time or in the right quantities. Hatcheries have limited capacity to produce large numbers of fingerlings of specified sizes[82], and supply of imported feed is hindered by shipping delays and bureaucratic customs procedures[83]. Local feed distributers are also used to smooth out the supply of feed for large-scale farmers who import feed directly, which can also affect the availability of feed for SME farmers. In the case of some pond farmers, the time needed to source fingerlings from other farmers also makes input

[82] The quality of fingerlings is also extremely variable and hard to ascertain at purchase and can only be seen sometime into the production cycle.

[83] Anecdotal evidence suggests that since Ranaan established a feed mill in Ghana, feed supply is more reliable.

coordination difficult. Producers, especially cage farmers, also rely on developed marketing chains (involving wholesalers, traders, transport service providers and ideally a cold chain) to take fish to consumers. The need for coordinated inputs to be brought to the farm along with the need for 'sophisticated' marketing chains suggest both pond and cage aquaculture are 'high linkage intensity' technologies. This implies that they require high levels of institutional development to reduce the associated transaction costs and risks (e.g. risks of opportunistic behaviour of transacting parties, costs of negotiating and enforcing contracts) and enable their successful development (Dorward et al., 2000). Without this institutional development, the transaction costs and risks may be too great, leading to market failure.

Quality characteristics

Grading of farmed fish is based on size (or number of pieces per kg) with larger fish having a higher price per kg than smaller fish. As most pond farmed tilapia fed on local feed are small, their price is not usually based on size. However cage farmed tilapia are categorised into five grades from smallest 'economy' size to largest 'Size 3' with each cage likely to contain different sized fish. Interviews with traders and farmers revealed some confusion around grades. Traders grade and sell fish by the number of pieces per kg and farmers grade and sell fish within a certain weight range[84]. This results in traders grading fish lower than farmers e.g. traders would classify a fish of 650g as Size 2 whereas farmers would classify it as Size 3 which has a higher price). The variability in size and categorisation create uncertainty for both farmers and traders and can be a major source of conflict between them, especially for small-scale cage farmers who may lack bargaining power, increasing transaction risks and costs. While traders buy according to weight in kg, they still sell to consumers by piece (e.g. 3 pieces for GH¢10). This suggests that the losses traders incur in cases where they

[84] Most traders interviewed graded fish as follows: Size 3 is one piece per kg; Size 2 is 1.5-2 pieces per kg; Size 1 is 2-3 pieces per kg; regular size is 3-4 pieces per kg; and economy size is 4-5 pieces per kg. However most fish farmers interviewed graded fish within a weight range which works out as being smaller than traders' classifications, as follows: Size 3 is 650g and above (or 3 pieces per 2kg); Size 2 is 450-500g (or 2 pieces per kg); Size 1 is 300-450 (or 3 pieces per kg); regular size is 250-300g (or 4-5 pieces per kg); and economy size is less than 250g (or 5-6 pieces per kg).

have less bargaining power than farmers (for example when buying from large-scale cage farmers, discussed below), could be passed onto consumers through higher prices for smaller sized fish. Cage farmers who produce larger fish (specifically Size 1 and 2) earn higher returns.

Seasonality

There is some limited seasonality in aquaculture production. Many pond farmers stock their ponds at the start of the rainy season in March/April and harvest at Christmas when fish demand and prices are higher. Wild caught tilapia traders (who source their produce from Barakesie dam near Kumasi and from Yeji in the north of Lake Volta) also buy from fish ponds at Christmas when wild tilapia is scarce and demand is high. While agricultural production is inherently risky due to the important influence of weather, pond aquaculture in Ashanti seems to be less so, partly because the majority of pond farmers do not rely solely on the rain and have other sources of water. However there are seasonal weather related risks such as flooding and drought and these have affected some pond farmers (see Chapter 5). SME and large-scale cage farm production is not affected much by seasons except that the seasonal variability in supply of wild caught fish affects fish prices and can reduce demand for farmed fish from July to September. Like pond farmers, many small-scale cage farmers stock their cages to harvest at Christmas.

Economies of scale in marketing

There are economies of scale in marketing both pond and cage farmed fish due mainly to high transport costs. Scattered pond farms producing low volumes make it unprofitable for traders or processors to make ‘lumpy’ investments in transport or marketing services and cold storage facilities. Due to the limited marketing infrastructure most traders and processors use public transport or hire private taxis or public vehicles (‘trotros’). Currently many cage farmed fish traders operate in groups, hiring vehicles together and some also undertake joint marketing. While most tilapia is not processed due to high demand for fresh fish, catfish smokers in Kumasi who buy fish from some pond farmers in Ashanti Region can function efficiently at relatively low production levels.

Geographical dispersion

Small-scale pond farmers are geographically dispersed (and produce low volumes) raising transport and transaction costs for buyers. SME cage farmers are less dispersed and generally form small clusters in more easily accessible areas between Akuse and Akosombo dams. The large-scale farms are located further into the lake. However, Tropo sells from outlets in Accra and WAF sells from Asikuma market. These outlets are easily accessible and therefore reduce transport and transaction costs for buyers. A related challenge is the medium to long distance between small-scale pond farms and central urban markets of Kumasi exacerbated by poor transport infrastructure. The distance between SME and large-scale cage farms from the main market centres around Accra and Kpong is less of a challenge due to better transport infrastructure between Akosombo and Accra. All the elements that comprise transaction costs and risks (ex ante and ex post transaction costs and risks along with the costs and risks of transferring ownership of goods) tend to increase with distance, for example costs related to acquiring information, communication, monitoring and enforcing contracts. Thus the further away producers are from central markets the more likely it is for market failure to occur unless transaction costs and risks are reduced.

Information asymmetry in credit provision

The relatively high fixed costs of pond and cage aquaculture, high working capital requirements especially for cage aquaculture and medium to long production cycles, create the need for medium term financing. However, as shown in Chapter 5, less than 6 percent of small-scale pond farmers had accessed credit (either formal or informal) in the past 5 years. Small-scale farmers indicated in FGDs that the main constraints to accessing credit were high interest rates[85] and the unwillingness of credit institutions such as rural banks to lend money for aquaculture projects without the borrower already having savings in the bank and a good track record in fish farming. The majority of small-scale cage farmers and all medium-scale cage farmers started their activities using their own resources with very few accessing supplementary loans from financial institutions. Barriers to financing arise due partly to asymmetric information where producers have better information than lenders about their credit worthiness (Jaffee and Morton, 1995). Asymmetric information leads to the risk of adverse selection, a screening problem where the borrower conceals information and can use contract agreements in ways not anticipated by the lender (Owusu-Antwi and Antwi, 2010). Incomplete information can also lead to moral hazard where the borrower may have incentives to change his course of action which may affect the lender negatively, such as using the money for a more risky project than agreed or for the borrower to put less effort into the project than if he were using his own money (Owusu-Antwi and Antwi, 2010). The requirements for collateral and high interest rates which hinder fish farmers accessing credit are a product of the risks and transaction costs of lending to small enterprises and the related problem of imperfect information. These issues are not specific to aquaculture but to credit provision generally and are especially prominent in the small-scale agriculture sector (Jaffee and Morton, 1995).

Table 47 below summarises the commodity characteristics described above and identifies possible gaps or bottlenecks in the flow of goods, information and finance within the aquaculture systems that may result from these characteristics.

[85] For example Pro Credit, a German Savings and Loan company in Ghana which has given loans to commercial fish farmers around Kumasi, were charging 2.2 to 5.6 percent interest per month in 2010.

Table 47: Summary of commodity characteristics of farmed fish and effects on system flows

Commodity characteristics/problems	Physical product flows	Information flows	Financial flows
Price and volume uncertainty	X	X	X
Long production cycles	X		X
High perishability	X		X
High level of technical knowledge required		X	
High linkage intensity	X	X	
Quality characteristics/heterogeneity (size)		X	
Seasonality (though limited)	X	X	X
Economies of scale in marketing/transport infrastructure	X		
Geographical dispersion (mainly pond farmers)	X	X	
Information asymmetry in credit provision			X

Notes: Table adapted from Jaffee (1995:39).
X = potential gaps or bottlenecks.

Transaction characteristics

Commodity characteristics influence transaction characteristics which determine contractual arrangements. Transaction cost economics literature focuses on exchange relationships and shows that different institutional arrangements have their own advantages and disadvantages based on their operating conditions, and emphasis is given to certain elements in defining these conditions (Jaffee, 1995). As noted in Chapter 2, Williamson (1991) identifies asset specificity, uncertainty and frequency of exchange (referred to here as transaction characteristics) as important influences on actors' preferences for spot market, hybrid (bilateral), and hierarchical contractual forms (Dorward and Omamo, 2009). Higher levels of asset specificity, uncertainty, and transaction volume and frequency are associated with increased vertical integration and decreased spot market exchange. Higher asset specificity and uncertainty raise transaction risks, increasing the transaction risk to return ratio, while potentially high returns from transactions reduce this ratio. The transaction risk to return ratio influences actors' choice of institutions. With a high ratio, longer term contractual forms such as hybrid or hierarchical arrangements which join buyers and sellers in a transaction, improve communication and provide monitoring and incentive systems to control opportunism, are preferred (Dorward and Omamo, 2009). Establishing and maintaining these arrangements can be costly however and if transaction costs are too high relative to expected returns, potential transaction partners may not invest (Dorward and Omamo, 2009).

Asset specificity

Greater investment in more specific assets (whose returns are specific to a particular set of transactions) increases the risk of financial loss if a transaction fails (Dorward and Omamo, 2009). The actor who has invested in specific assets is also susceptible to opportunistic bargaining with other transacting parties who know the actor has little other use for the asset and so must agree to their terms (Jaffee, 1995). Thus the actor is likely to look for ways to reduce the risk through contractual arrangements which ensure their investment remains profitable (Poulton and Lyne, 2009). Both pond and cage farmers have high levels of asset specificity. Small-scale pond aquaculture requires relatively ‘lumpy’ investment in pond construction and fingerlings, both specific assets that have no alternate use other than pond aquaculture, which is also the case with investments in cages and fingerlings for cage aquaculture. This type of asset specificity is known as physical specificity. As the absolute level of fixed costs increase from small-scale pond aquaculture, to SME and large-scale cage aquaculture, so do the levels of physical specificity. As described above, pond and cage aquaculture also have high degrees of specialisation in production inputs and technical knowledge (the latter known as human specificity) compared to other more common agricultural activities such as cultivation of staple crops, and this increases asset specificity (Poulton and Lyne, 2009). Intensive cage aquaculture has higher human specificity than semi-intensive pond aquaculture. The high levels of physical and human specificity indicate higher barriers to entry in both pond and cage aquaculture for less skilled and less well endowed farmers without effective channels for credit, inputs and technical advice (Jaffee and Morton, 1995).

Uncertainty and scope for opportunism

Greater uncertainty increases the potential for incomplete contracts, increasing the risk of transaction failure. Uncertainty is affected by imperfect information and bounded rationality[86] of actors, along with an unpredictable environment (where commodities are affected by seasonality, variable yields, uncertain prices etc.) which can increase actors' opportunism (e.g. traders quoting prices lower than actual central market prices to producers) (Dorward and Omamo, 2009). There is generally high uncertainty associated with fish farming, described in detail above, which increases the potential for opportunistic behaviour of traders and buyers. Uncertain volumes and scattered supply of small-scale pond farms also lead to transport difficulties for traders and imperfect market information for producers resulting in production which is not linked to supply and demand or responsive to price signals, further increasing uncertainty and transaction costs and risks.

Volume and frequency of exchange

Higher volume and frequency of exchange increases the likelihood of actors establishing hierarchical or hybrid arrangements. These arrangements decrease the incentive for opportunistic behaviour as ongoing trading relationships build trust and transacting parties know they can gain from future transactions. Increased frequency of exchange also spreads the fixed costs of the relationship over more transactions, and trading higher volumes reduces per unit transaction costs, reducing the transaction risk to return ratio (Dorward and Omamo, 2009). As noted above, small-scale pond and cage farmers have low transaction volumes and frequencies which reduce the incentive to establish non-market arrangements, due to the high fixed costs per transaction, and are thus likely to hinder market development. Medium-scale cage farmers have medium transaction volumes and frequencies and large-scale cage farmers have high transaction volumes and frequencies. Higher transaction volumes and frequencies increase the potential for hybrid or hierarchical contractual forms and are thus likely to encourage market development.

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[86] An inability to make use of all available information.

Table 48 below summarises the transaction characteristics described above, the risk to return ratio for the three main aquaculture systems and the implications of these for likely methods of coordination or institutional arrangements according to transaction cost theory (Dorward and Omamo, 2009). As there is no way of quantifying or weighting these variables the table presents a simple approximation (rating them as low, medium or high), based on the descriptions above.

Table 48: Transaction characteristics of aquaculture systems and implications for expected institutional arrangements

Aquaculture system	Asset specificity	Uncertainty	Volume and frequency of exchange	Risk/return ratio	Expected institutional arrangements
Small-scale artisanal pond aquaculture	Medium	High	Low	High (medium to high risk, low returns)	Limited market development/market failure/state intervention due to low volume and frequency of exchange
SME cage aquaculture	Medium to high	High	Low for small-scale farmers Medium for medium-scale Farmers	Medium (high risk, medium to high returns)	Hybrid arrangements (long term, relational contracts) - more market oriented hybrid arrangements for small-scale farmers due to lower volume and frequency of exchange - more hierarchy oriented hybrid arrangements for medium-scale farmers due to medium volume and frequency of exchange
Large-scale cage aquaculture	High	High	High	Medium (high risk, high returns)	Hierarchy

Notes: Predicted institutional arrangements informed by Dorward and Omamo (2009:96), Figure 3.4 (b)

Table 48 shows that due to the demanding techno-economic characteristics of aquaculture products from each system, there are medium to high levels of asset specificity and high levels of uncertainty in all systems resulting in medium to high risk return ratios. These high ratios imply that increased vertical integration through hybrid and hierarchical arrangements between and within firms is the most likely method of coordination along the value chain. It is unclear what effect the low levels of volume and exchange frequency will have on the commodity systems for small-scale pond aquaculture: it is likely, however, that it would result in limited market development unless there is state or other external intervention. Due to the high levels of asset specificity, uncertainty and overall risk faced by producers and traders in all the systems, it is unlikely that the primary form of institutional arrangements between input suppliers, producers and traders would be spot market transactions other than for surplus market clearing purposes. The following sections take the pond aquaculture and cage aquaculture action domains in turn and explore the actors and key institutional arrangements found within each, allowing comparison between the market organisation observed within each system with those predicted in Table 48 above.

7.2.3 Key actors and institutional arrangements observed in the small-scale pond aquaculture action domain

This section analyses the key actors and institutional arrangements observed in the small-scale pond aquaculture action domain. The first part of this section analyses the key actors i.e. fish farmers, local fish traders, consumers, urban traders and processors and extension staff. Many of these actors have already been discussed in Chapters 5 and 6 but the attributes which affect their economic behaviour have not been fully explored. Actors' attributes depend on their own inherent characteristics and the characteristics of their activities (discussed in the second part of this section within the context of institutional arrangements). Actors' characteristics are analysed to understand the effect on their economic behaviour. Characteristics such as actors': power; access to information; wealth; alternative livelihood options; links to urban centres; networks; education; previous experience; access to capital, land and labour; gender; and age are considered as they affect actors' levels of imperfect information, bounded rationality, self interest and opportunism (Dorward and Omamo, 2009).

The latter part of this section analyses institutional arrangements and their attributes. It was hypothesised above that there would be limited market development in the pond aquaculture sector and that linkages between actors in the cage aquaculture sector would most likely be governed by hierarchical or hybrid contractual arrangements. This hypothesis is tested here (both in the current section and in the following section on the cage aquaculture action domain), by exploration of the key institutional arrangements supporting the coordination and exchange of farmed fish in each system. While the focus is on the institutional arrangements between fish farmers and buyers (traders, wholesalers and consumers), linkages between other actors are also discussed where considered important, for example between input suppliers and farmers, and between traders in trader groups.

Key actors and their attributes

Fish farmers

As described in Chapter 5, most small-scale pond aquaculture farmers are male crop farmers engaged in diversified farm and nonfarm livelihood activities. The survey estimated approximately 43 percent of fish farming households to be below the income poverty line while wealth rankings found fish farming households were evenly distributed between three different wealth categories. Poor fish farmers are less productive and likely to be more risk averse with less access to technical and market information than non-poor fish farmers (though most fish farmers in remote rural communities are likely to have imperfect information and face high transaction costs). Fish farmers may however be less risk averse and more entrepreneurial than other types of farmers, seeing as they have invested in an uncertain and potentially risky activity. Most farmers in Ashanti Region with the ability to establish a pond farm could also engage in other livelihood activities, especially in production of commodities which are less inherently risky and technologically linkage intense than fish farming. They also have the opportunity to engage in illegal gold mining operations which many of the youth are involved in and which, while risky, is also potentially lucrative. The range of alternative livelihood options open to potential fish farmers may partly explain the low adoption of small-scale pond aquaculture. As most fish farmers sell to buyers (consumers and local traders) from within their own communities they are less likely to behave opportunistically than if they were conducting impersonal trade outside the community (as they are constrained by community norms, social capital and local enforcement mechanisms).

Traders and consumers

Local fish traders are mainly women from the community and are classed by the wealth rankings in Chapter 5 in the medium and higher wealth categories. Compared with fish farmers these traders are likely to have more market information on demand and prices outside the community, due to their involvement in wild fish marketing chains, potentially encouraging opportunistic behaviour. Consumers buying at the farm gate are mainly local community members. While both poor and non-poor community members buy farmed fish, a lower percentage of poor than non-poor non-fish farmers surveyed thought fish farming has increased community fish supply, suggesting better off community members benefit more.

Tilapia traders from Kumasi are likely to be better off than local traders, with more access to market and exchange information than pond farmers as they are full time fish traders functioning in a well established supply chain with alternative supply sources. However, most urban based wild tilapia traders are still from low income categories, indicated by the fact they are unable to afford market stalls and so sell from house to house. The main catfish processor/trader that buys catfish from pond farmers around Kumasi (discussed more below) is relatively better off and is able to pay for a permanent stall in Kejetia market, processing facilities, and part time labourers. However as she is currently unable to meet the high demand for catfish this may moderate her potentially powerful bargaining position as a monopsonistic buyer in many instances.

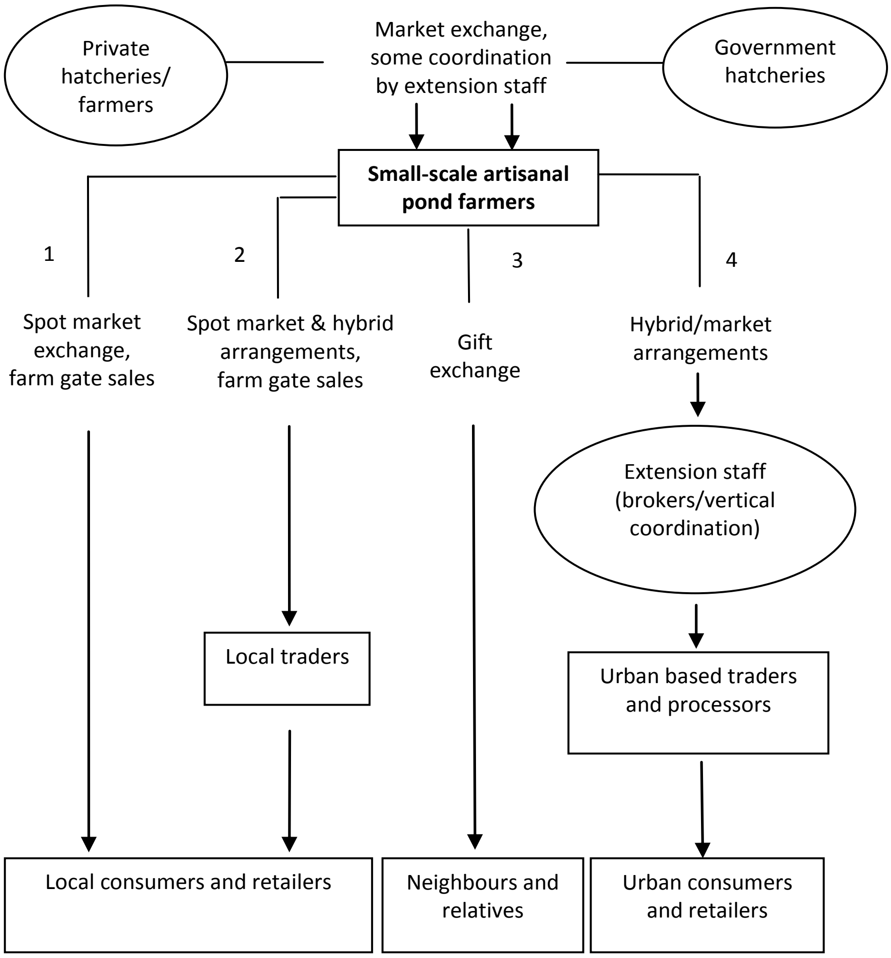
Aquaculture extension staff

Fisheries extension staff are the main public sector actors within the small-scale pond aquaculture action domain. Their role as brokers between fish farmers and buyers, along with their role in information dissemination and coordination is explored in more detail below. As public sector workers with a commitment to developing the aquaculture sector they have different incentive systems than private sector actors and are able to bear higher transaction costs and risks. Extension officers have relatively high levels of market and technical information but are not likely to behave opportunistically as farmers and traders can make complaints to the FC, and trust is important in their coordination roles. However, their limited resources mean their capacity to reach more remote fish farmers is constrained.

Key institutional arrangements and their attributes

It was suggested in Section 7.2.2 that due to high uncertainty and medium asset specificity related to fish produced by small-scale artisanal farmers, it was likely that linkages between actors would face high transaction costs and risks and there would be limited market development and/or state intervention depending on the volume and frequency of exchange. The actual organisation of the small-scale pond aquaculture sector in Ashanti reflects elements of this as overall there is limited market development beyond individual rural communities. Where the market for pond farmed fish is developing around Kumasi, this is linked to some informal state intervention in marketing in the form of extension officers acting as brokers, and also playing a coordination role in accessing fingerlings for farmers. Alternatively where rural producers sell direct to consumers one might consider this integration of production and retail functions in the same ‘firm’ as a form of hierarchy between production and marketing activities albeit on a very small-scale. As discussed below, most farmers produce and retail their fish directly to consumers at the farm gate (with some at the local market). The predominant institutional arrangement between producer/retailers and buyers is spot market purchase, usually at the farm gate. Within these spot markets not all transactions are characterised by impersonal trade as community members and local traders usually know the fish farmers and some traders have developed ongoing relationships with farmers to overcome some of the transaction risks, explored further below. Thus the predominant institutional arrangement between producers and buyers can be placed somewhere between pure spot market purchase with impersonal trade and market reciprocity or bilateral agreements between transacting parties. These arrangements are summarised in Figure 21 and explored in detail below.

Figure 21: Small-scale pond aquaculture value chain and key institutional arrangements



Notes: Market channels in order of importance for surveyed rural pond farmers: 1=most important, 4= least important

Social reciprocity

Of the 69 fish farmers surveyed, approximately 35 percent did not undertake a main harvest in 2010 and only 44 percent sold any fish. While this could be due to a number of factors (including production cycles over 12 months, the desire to keep fish in the pond as an indicator of wealth, the use of fish in ponds as a form of financial capital etc.), this low figure indicates limited market development and corresponds to the prediction above that with low volume and frequency of transactions, market failure occurs. The majority of farmers surveyed did however give away some fish in 2010 suggesting the importance of gift exchange or social reciprocity (Dorward and Omamo, 2009), especially for poorer fish farmers who on average gifted a higher percentage of their total harvest than non-poor fish farmers, meaning their actual volume of sales was even smaller (see Table 23 in Chapter 5). Gift exchange means payment for fish is not in money but in increased social capital. Gifting fish could also increase the fish farmer's direct and indirect access to labour, food, money and social support from community members (Dorward and Omamo, 2009).

Farm gate sales to consumers and local traders

Almost all farmers surveyed sell fish directly to consumers, their most important marketing channel, indicating a short supply chain with few intermediaries and limited market development. Nearly 70 percent of fish farmers also sell fish to local fish traders. Over 50 percent sell to consumers and local traders at the farm gate where fish quality is checked, prices are negotiated and fish is exchanged 'on the spot'. The majority of farmers reduce the uncertainty and risk associated with selling a highly perishable product by undertaking selective rather than total harvests, thus avoiding holdup problems and reducing the potential for buyers to behave opportunistically. Over 40 percent of farmers also sell to traders, consumers and retailers directly in the village at the local market. In most villages there is high demand for fresh fish and farmers can sell their harvest easily. However community members may not have the purchasing power to buy highly priced fresh fish and from the PBs presented in Chapter 5 it seems farm gate prices are often not high enough for farmers to cover production costs and make much, if any, profit. While only 25 percent of fish farmers surveyed indicated low price of fish being a major or minor problem, the average farm gate price of pond farmed fish was approximately GH¢3.5/kg in 2010 whereas the farm gate price of cage farmed fish for similar sizes was between GH¢3.9 and GH¢4.8/kg indicating low prices in rural areas. The low prices received by small-scale pond farmers could be partly due to their weak bargaining power in sales to traders and their acceptance of some gift exchange element in sales to community members.

Selling to local traders

Selling to traders is a secondary marketing channel for farmers. Traders carry more of the burden of coordination costs of exchange than producers especially in more remote communities where transport and communication infrastructure are less developed. These high transaction costs help to explain the limited market development for fish farming in rural areas beyond individual communities. The high costs provide incentives for development of hybrid arrangements and collective action of producers and/or traders where possible. The local traders who buy farmed fish in communities are mainly wild caught fish traders and in many villages surveyed these traders lacked interest in buying farmed fish. However in some villages closer to larger market centres where there is high demand for fresh fish which can fetch high prices, traders are more interested. For example in the village of Tweapease, one trader has developed relationships with a number of fish farmers and buys their fish to sell in the nearby mining town of Obuasi, while a number of other traders want to do the same.

Coordination roles of extension staff

The FC plays a vertical and complementary coordination role. FC staff assist farmers to source fingerlings from other farmers or from government hatcheries, provide technical information and advice on stocking and feeding, and help with harvesting and marketing (see Chapter 5). Some pond farmers near Kumasi have been helped by FC extension staff, acting as brokers, to sell their catfish to a processor/trader from Kejetia Market (Kumasi’s Central Market) trading mainly in smoked marine fish. The processor/trader began selling smoked catfish in 2008 due to increasing demand from customers and started sourcing catfish directly from some SME pond farmers around Kumasi. However as a result of her inability to source adequate fish supplies due to lack of information, she developed a relationship with extension staff and built up enough trust to now rely on them to act independently to source fish for her. The processor/trader smokes 100-200kg of catfish per week but even with the help of the extension staff she does not always get the supply she needs. The extension officers travel to the fish farm for harvesting, start the preservation process of salting as soon as the fish are harvested and deliver the fish to her. They use their own personal vehicle and the farmer and processor/trader share the fuel cost. The processor/trader pays the fish farmers in cash and though there is no formal agreement to pay the extension staff, they are usually ‘dashed’ something small by both the farmers and the processor/trader for each exchange.

The extension staff bear much of the transaction costs of searching for farmers ready to harvest, travelling on harvest day and sometimes before to check the amount and size of fish, inspecting the size and quality of fish at harvest and sometimes negotiating prices with farmers on behalf of the processor/trader etc. but are not fully remunerated for it. Some of these costs (e.g. those related to supply information and harvesting) are part of their job as extension officers. The additional costs of negotiating price or enforcing the previously negotiated price between farmer and processor, monitoring fish quality and delivering the fish to the processor are all extra costs, however are viewed by them as part of their contribution to sector development. These costs are also partly borne by the farmer and processor/trader who give the staff something small for each exchange as noted above. At the time of interview due to the overall higher transport and transaction costs involved with transacting with smaller more remote farmers with more uncertain supply, most farmers surveyed had not been linked to the processor/trader, only the farmers that were more regularly in contact with extension staff closer to Kumasi. As shown in Chapter 5, extension staff helped 20 percent of non-poor fish farmers and only 7 percent of poor farmers surveyed to harvest in 2010 indicating the low level of marketing assistance given to small-scale rural pond farmers.

Overall FC extension staff are extremely under resourced and unable to reach all fish farmers. The FC is linked to farmers through district level FFAs (two of the three districts surveyed have FFAs), but is unable to help FFA members market their fish as, first, many cannot produce a reliable surplus and, second, farmers, traders and extension staff face high transport and other related constraints. The FFAs are mainly a forum for information exchange between farmers and a way to receive training from the government and do not play much of a vertical or horizontal coordination role at present. No private sector coordination mechanisms were observed but at the time of interview the commercial feed supplier Ranaan was negotiating with the FC to use their training facility and hatchery in Kumasi to establish a training centre for fish farmers. Ranaan would then support the hatchery to produce high quality, all male fingerlings and help farmers to source these fingerlings. The fingerlings would be 12-15g as opposed to 5g or less which is the standard size sold by most hatcheries in Ghana, so the risk of mortality would be reduced for the farmer and taken on by the hatchery. By encouraging the farmers to buy Ranaan feed along with increasing the productivity of farmers through the trainings and sourcing of good quality fingerlings, Ranaan hopes to increase its market for feed.

Selling to wild tilapia traders from Kumasi

Many better off farmers located close to Kumasi, also use the FC to help market their fish. Tilapia is often sold to staff at institutions in Kumasi where FC staff have links, such as MoFA and various chop bars and restaurants. There are very few farmed fish traders operating around Kumasi and currently extension staff are cultivating relationships with several wild tilapia traders who are increasingly interested in farmed tilapia due to declining supplies from the wild. These traders are among the approximately 100 traders who buy wild tilapia from fishermen at Barakese dam, Kumasi’s main water source, and sell around Kumasi, either house to house, in markets, or to various restaurants and hotels serving fresh tilapia. They sell most of their fish within a day or two and often sell fish on credit for up to a week to restaurants and chop bars. Extension staff have connected a few interested traders to fish farmers and taken them to harvests to buy relatively small amounts of fish (approximately 20kg each) at the farm gate where prices are negotiated directly. At the time of interview these traders had not been linked to any of the rural pond farmers surveyed.

Most of the wild tilapia traders in Kumasi interviewed were not interested in selling farmed tilapia due to its light weight compared to wild tilapia, due to the better market for wild tilapia because of its larger size, and due to the inferior quality of farmed tilapia when smoked. Most of these traders only buy farmed tilapia at Christmas when demand is high and wild tilapia supply is inadequate. In the past, some pond farmers used to sell directly to a trader who was also a fish farmer. Having realised the problem of fish marketing, he had bought a cold van and advertised to attract fish farmers and customers. He went farm to farm, aggregating fish and selling to restaurants and hotels in Kumasi. He could not, however, maintain the regularity of supply (or the size of the fish which needed to be 'table size', over 500g) so retailers stopped buying from him and he went out of business. This example is a good illustration of the wider problem of low volume and frequency of transactions in the small-scale sector, contributing to coordination risk (the risk of an investment failing because no other actors in the supply chain make the necessary complementary investments) in turn leading to a 'low level equilibrium trap', explored in more detail in the discussion section below. The transaction costs of sourcing uncertain supplies from small and scattered farmers producing small sized fish is too great at present for traders to invest in building relationships with farmers unless they have a good market where they can sell at high prices and balance some of these costs. As wild caught tilapia becomes scarcer and demand for smoked catfish in Kumasi increases, it is likely more traders will turn to processing and trading farmed fish, but only if transaction costs can be lowered and/or returns increased.

7.2.4 Key actors and institutional arrangements observed in the cage aquaculture action domain

This section looks at the key actors and institutional arrangements in the cage aquaculture action domain. Due to the overlap in actors between the SME and large-scale cage farm systems, the actors associated with each system are analysed together in the first part of the section to reduce repetition. The institutional arrangements supporting the SME and large-scale cage aquaculture systems are then discussed separately and the value chains encompassing the key actors, market channels and institutional arrangements related to small, medium and large-scale cage aquaculture are illustrated in Figure 22, Figure 23 and Figure 24.

Key actors in the SME and large-scale cage aquaculture action domain

SME cage farmers

SME cage farmers are in much higher socio-economic categories than small-scale artisanal pond farmers. As noted in Chapter 6, small-scale cage farm owners are mainly professionals from Accra, absentee farmers who usually visit the farm on weekends. These farm owners are well educated and relatively well resourced and thus have access to technical and market information. However, as these farms have been established only recently, farm owners' level of information on transaction partners is likely to be imperfect, so that costs of searching, screening, bargaining, transferring, monitoring and enforcing processes of exchange between both input suppliers and buyers are likely to be high. This reduces their bargaining power with traders who have more information about other farmers and the market (discussed below). There seems to be a high turnover of small-scale cage farms, with many going out of business while new ones are coming up. This could partly be due to the lack of experience and expertise of small-scale cage farmers, because they leave the running of their farms to often untrained and casual labourers, leading to low productivity and profitability.

Three of the five medium-scale cage farmers surveyed are expatriates with good technical knowledge. Fish farming is the primary occupation of four of the five farmers who manage their farms themselves and employ trained staff. These farmers have better access to technical, market and exchange information than small-scale farmers and are likely to be more risk taking and have a stronger bargaining position in relation to buyers than small-scale cage farmers.

Large-scale cage farmers

Tropo is owned by an expatriate private investor whereas WAF is a joint venture between the Royal Danish Fish Group from Denmark and a local partner, mainly funded by soft loans and grants from international donors. These are large private enterprises that have a lot of power in the farmed fish marketing systems, with good information on markets and exchange. Tropo is the main price setter; however, both Tropo and WAF face high transaction risks due to their large investments in specific assets, explaining their more hierarchical structures (discussed below).

Traders and wholesalers

The majority of cage farmed fish traders, while not poor, are from lower income households located in towns and urban centres around Lake Volta and Accra. Most traders interviewed had not had any secondary education and some had had no formal education at all. For most, trading farmed fish is their only occupation and other than petty trading they have limited alternative employment opportunities. Some had been trading in wild fish before but others had not had any experience in trading fish before they started. As many of these traders buying from SME and WAF cage farms work in groups, they have higher levels of market and exchange information than small-scale cage farmers. Due also to the perishability of the fish and the limited ability of farmers to take fish to market, traders often behave opportunistically, especially with small-scale cage farmers as discussed above. Traders buying from Tropo outlets and WAF however have limited scope for opportunism as there is no negotiation, prices and grades are set and demand is higher than supply.

Three of the four wholesalers/group leaders observed are female. All have higher socio-economic status than traders in varying degrees (the fish mammie from Kasoa and the male wholesaler from Accra are much better off than the other group leaders from Kpong) and due to their purchasing power can behave more opportunistically than traders, especially where they are in a monopsonistic position such as when buying from small-scale cage farms. Wholesalers are able to sell fish to traders on credit. Nevertheless, due to the scarce supply of fish and the ability of traders (those who do not need credit) to buy fish individually from Tropo and other SME cage farms, they are not as powerful as fish mammies in the wild fish sector. Group leaders also face transport costs and transaction costs and risks, for example those related to ensuring repayment of credit.

Input suppliers

The main feed supplier, Ranaan, is a private sector company with the major share of the feed market and it can set high prices due to limited alternative supplies. Hatcheries are both public and private but they all lack capacity to produce large numbers of high quality fingerlings and they all charge high prices. Their investment in specific assets involves high losses from transaction failures, hence the need for advance payment or forward market contracts with farmers. However due to high costs to farmers of monitoring the terms of exchange, (the quality and quantity of fingerlings), hatcheries can behave opportunistically (specification opportunism) in some instances.

Key institutional arrangements in the SME cage aquaculture system

SME cage aquaculture has high levels of uncertainty and medium to high levels of asset specificity depending on the scale of investment. Therefore the likely method of coordination for SME cage farms was hypothesised to be hybrid arrangements, leaning more toward market oriented arrangements for small-scale farmers (with lower volume and frequency of exchange) and more toward hierarchy for medium-scale farmers (with medium volume and frequency of exchange). Small-scale cage farms were generally found to have developed a variety of hybrid arrangements with buyers while medium-scale farms were observed to have developed a different mixture of institutional arrangements. These arrangements are summarised in Figure 22 and Figure 23 and explored in detail below.

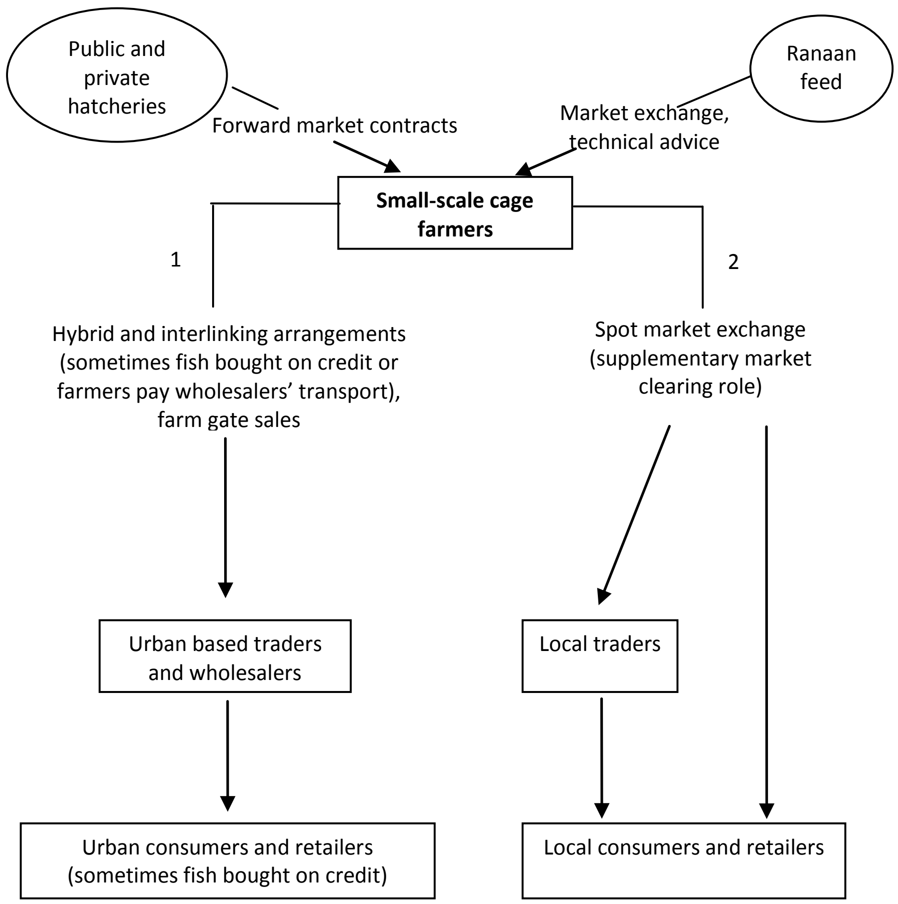
SME sales to traders

The majority of SME cage farms sell some fish directly at the farm gate to retailers and consumers but sell primarily to traders and wholesalers who come from and distribute fish to markets and retailers in Accra, other nearby urban centres such as Tema, Ashaiman and Kasoa, and further afield from Aflao on the Togo border. Traders also come from towns such as Kpong on Lake Volta, close to a landing site for wild caught fish from the lake and where wild fish is traditionally traded by the road side, in the market and by the lake. Farmed fish is distributed by a network of primarily female traders, many of whom traded in wild fish before switching to trading a mixture of farmed and wild fish or completely switching to farmed fish. This network of traders and wholesalers buy fish from all the SME and large-scale cage farms on Lake Volta. As estimated in Chapter 6, there are approximately 20 wholesalers and over 200 traders within this network (and an additional 400 traders who buy mainly from Tropo's outlets in Accra). Many belong to trader groups (discussed in the large-scale cage aquaculture subsection below). Very few traders are from communities located around the cage farms, partly because SME cage farmers do not sell to local fish traders on credit, unlike fishermen who usually have established credit arrangements with local fish traders.

Hybrid arrangements for small-scale cage farms

All SME cage farms surveyed sell to several regular traders and wholesalers. The majority of small-scale farms surveyed have developed relationships with particular buyers whom they call at harvest time and often sell to on credit, ranging from three days to one month. Two of the 14 small-scale cage farmers surveyed also pay the transport costs of wholesalers who buy over one tonne. These hybrid market reciprocity arrangements are informal but based on trust developed from personalised repeat trading. Although fish is mainly exchanged at the current market price set by Tropo, they are not pure spot market transactions due to the provision of credit and in some cases payment of wholesalers' transport costs. Despite these relationships and perhaps because some are relatively new, traders can still behave opportunistically: 9 of the 14 small-scale farmers surveyed indicated that traders' not sticking to the agreed price was a major problem. The traders and wholesalers with whom farmers have not developed relationships and other buyers (such as local traders and consumers from the community) who buy at the farm gate, make spot market purchases and play a supplementary market clearing role, especially for smaller fish that are less demanded and less profitable.

Figure 22: Small-scale cage aquaculture value chain and key institutional arrangements

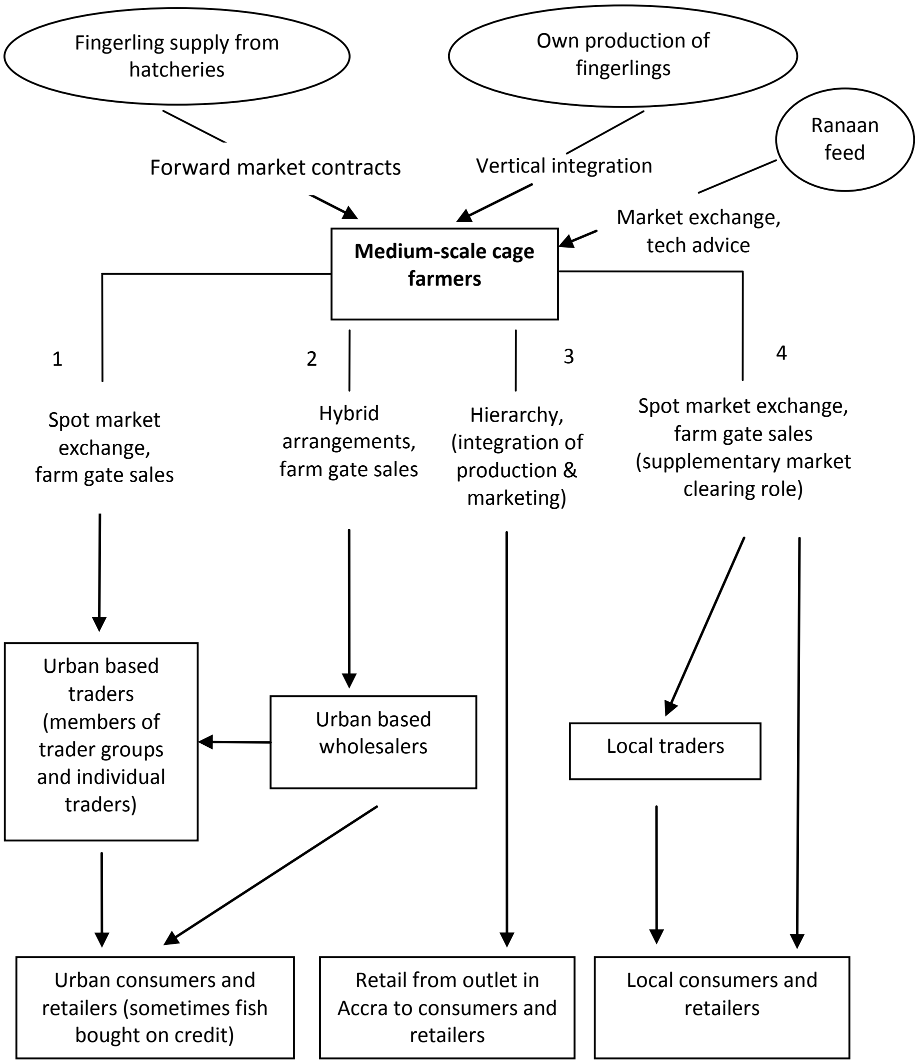


Notes: Market channels in order of importance for surveyed small-scale cage farmers: 1=most important, 2= least important

Mixture of arrangements for medium-scale cage farms

Medium-scale cage farmers in accessible areas and who harvest regularly (three of the five farms interviewed) have predominantly market based arrangements with traders to whom they sell fish at the farm gate. Of these three farms, two have no arrangements with their buyers who are mainly traders with high demand. One sells primarily to a small number of wholesalers buying one to two tonnes at a time and with whom he has developed relationships. These three farmers have no incentives to invest in hierarchical arrangements between production and marketing. Another medium-scale farmer who was undertaking his first harvest at the time of interview found himself in a weak bargaining position. However, despite the high number of traders and his relationship with a wholesaler, due to the high volume of fish harvested and lack of cold storage facilities leading to opportunistic behaviour of traders over fish grading and price. To avoid this problem, the final medium-scale cage farm surveyed, located in a less accessible area, hires a refrigerated truck to transport his fish to sell directly to consumers, retailers and traders at market prices at an outlet of a fellow medium-scale fish farmer (not surveyed) in Tema. However this was the only hierarchical arrangement between production and marketing observed among SME farmers. The predominance of market arrangements, not hypothesised above, appears to be due to the excess demand for fish diminishing sellers' risks (unless they flood the market with a particularly large harvest which the market cannot easily absorb).

Figure 23: Medium-scale cage aquaculture value chain and key institutional arrangements



Notes: Market channels in order of importance for surveyed medium-scale cage farmers: 1=most important, 4= least important

Information flows

Cage aquaculture is knowledge intensive and various sources of information and training of varying quality are available to farmers. However as noted above, most small-scale cage farmers are absentee farmers. Most have caretakers, employed on a temporary and informal basis and paid monthly wages to look after the farms and feed the fish: it is these caretakers that require training. Only 4 of the 14 small-scale farms surveyed have caretakers with some external training while the remaining have had on the job or no training at all. Most of the medium and both large-scale cage farms employ trained managers. Ranaan feed gives technical advice on production including a feeding chart as part of their service. WRI also gives technical advice to cage farmers who buy their fingerlings and employs a number of extension staff. Crystal Lake hatchery conducts occasional week long residential trainings on cage aquaculture and related topics. There are also many one day training courses on fish farming run by private companies but these are of dubious quality. There is only one active district level FC extension officer, who barely goes to the field, and 6 of the 14 small-scale farms and 3 of the 5 medium-scale farms interviewed indicated lack of access to extension services was a major problem. As a result many small-scale cage farmers have very limited working knowledge of cage aquaculture and do not employ trained staff to manage their farms, resulting in poor production practises and variable productivity and fish sizes.

Arrangements for input supply

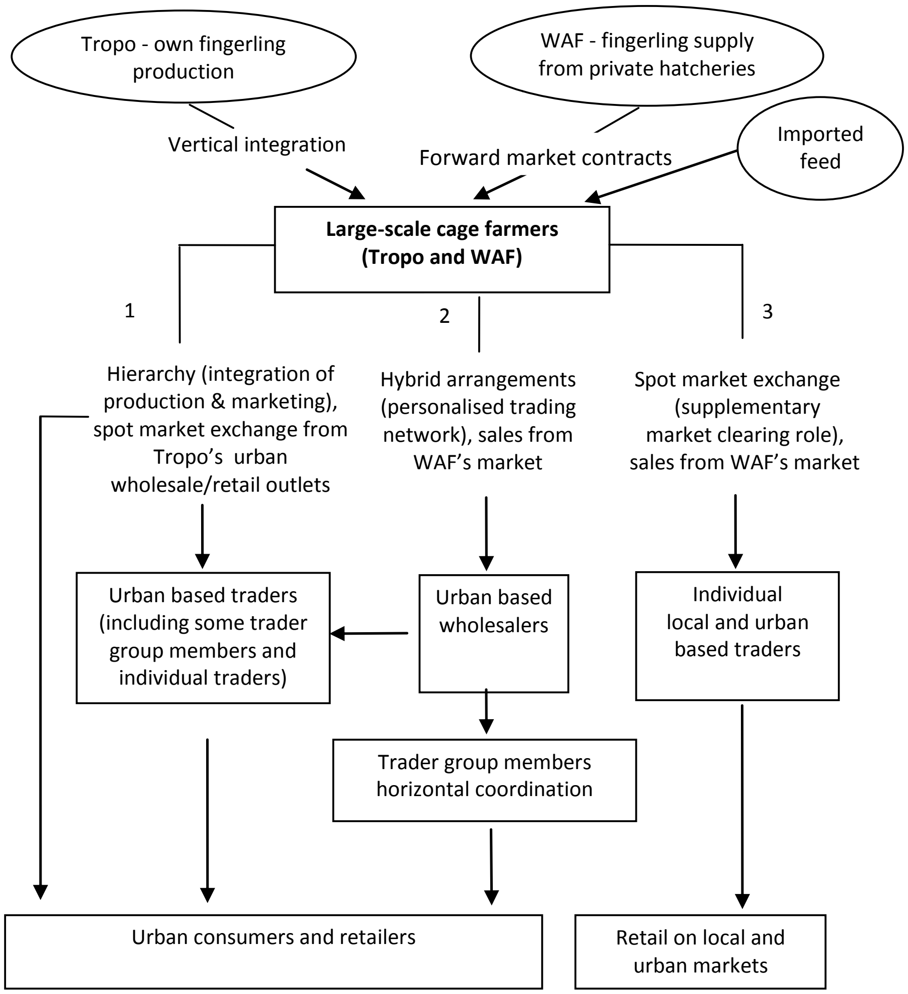
To reduce the production risk associated with poor quality and limited supply of fingerlings currently available on the market, some medium-scale cage farmers produce their own. Small-scale cage farmers however are unable to do this due to the high levels of specialised technical knowledge and capital required. Instead, they make informal forward market arrangements with fingerling suppliers ordering specified quantities and sizes of fingerlings ranging from two weeks to several months in advance, at set market prices. Farmers usually pay in advance or pay half up front and the rest on receipt. However there can be issues of enforcement due to the limited capacity of fingerling suppliers to produce large amounts of fingerlings and ensure orders are met on time and to the specified requirements. Opportunistic behaviour of private fingerling suppliers was reported by some farmers, for example not supplying the number and/or sizes ordered, neither of which are easily detectable by farmers and result in lower than expected harvests. High fingerling mortality is also a major risk and can be caused by poor transportation or rough handling along with the cage environment itself. Some hatcheries transport fingerlings to farms for a fee. Most hatcheries will replace dead fingerlings if farmers provide evidence by collecting them. Hatcheries usually also give 5 percent more fingerlings than are paid for, but mortality is generally higher, estimated by many farmers to be around 15 to 20 percent.

Some medium-scale cage farms also import feed directly from abroad, but the large fixed costs of establishing a feed mill to integrate all input and production activities is too high for fish farms. Small-scale farmers do not import feed directly as they require much less feed so rely on spot market purchases from local commercial feed distributers. However these are subject to variable supply, and delays then force farmers to find alternative feed at short notice, often resulting in use of feed of different size pellets and protein content than required.

Key institutional arrangements in the large-scale cage aquaculture system

Due to the high levels of uncertainty, asset specificity and volumes and frequency of exchange, it was suggested above that hierarchical arrangements would dominate the large-scale cage aquaculture system. This was observed to be true for the two large-scale cage farms surveyed. The value chain and institutional arrangements are summarised in Figure 24 and discussed below.

Figure 24: Large-scale cage aquaculture value chain and key institutional arrangements



Notes: Market channels in order of importance for surveyed large-scale cage farmers: 1=most important, 3= least important

Hierarchy of large-scale cage farms

Both Tropo and WAF exhibit hierarchical arrangements between production and marketing. When Tropo increased production by changing from pond to cage aquaculture, it vertically integrated production and marketing by establishing urban wholesale/retail outlets. The increased volume and frequency of exchange accompanying Tropo's intensification of production would have provided an incentive to invest in hierarchical arrangements, as fixed costs of exchange decrease as they are spread over more transactions. Vertical integration has reduced the transaction costs and risks faced by Tropo related to negotiating and bargaining with powerful wholesalers, has stimulated consumer demand in a market which is in its early stages of development, and has allowed Tropo to increase its market share and reach a much higher number of buyers than it would if it was still selling at the farm gate. Many of these buyers are individual traders, who can now bypass the fish mammies and buy fish at a lower price, plus a large number of new entrants into farmed fish trading, mainly low income women from Accra and surrounding areas. While WAF has not integrated all its production and marketing activities like Tropo, it has integrated production with the first stage of marketing by building a market place in Asikuma so that fish is not exchanged at the farm gate, and the benefits of being a seller in a seller's market are maintained. The retail end of fully or partially vertically integrated operations such as Tropo and WAF face lower risks than independent traders and wholesalers in a seller's market when fish supplies are uncertain.

Trader groups

Of the estimated 200 traders within the cage farmed fish trading network, approximately half belong to one of five trader groups from Greater Accra and Eastern Regions (Accra, Kasoa, Asutuare and two groups from Kpong). Four of the groups are headed by a wholesaler (or a 'fish Queen' in the case of the Kasoa group) while the Asutuare group is composed only of traders and joins the Accra group when buying fish from WAF (discussed below). The groups were formed in response to the scarce and uncertain supply of farmed fish relative to demand. For example the Asutuare group, formed in 1999 and one of the oldest groups, consists of 20 members mostly from one extended family and was established to guarantee access to fish from Tropo farm when it first started as a pond farm[87]. Many members had been trading individually in wild fish since 1990 but when Tropo started pond aquaculture near Asutuare they switched to trading farmed fish. Demand outstripped supply as increasing numbers of wild fish traders decided to trade farmed fish so Tropo encouraged traders to form groups to guarantee supply. Since

[87] While currently Tropo is the largest cage farm on Lake Volta, it started in the late 1990s as a pond farm located in Asutuare in Eastern Region which was converted into to their hatchery once it started its cage operations.

Tropo opened wholesale and retail outlets around Accra from 2007/2008 onwards and no longer sells at the farm gate, the group now buys mainly from WAF and SME cage farms.

When WAF started, traders were sold fish on credit as a strategy to increase WAF's market share. However due to the low recovery rate WAF stopped this and now sells in bulk to the wholesalers heading the four groups. This arrangement lowers WAF's transactions costs compared to dealing with many small traders, and passes the risk and cost of providing credit to traders onto the wholesalers. These group leaders were WAF's first loyal bulk buyers; thus, the system is based on patronage and trust. WAF sells over 70 percent of their fish to the four group leaders, each of whom buys one to two tonnes per market day (twice a week) at a 3-5 percent discount, having placed an order one week in advance. The wholesalers then sell on to their traders at market price, some on credit. The Kasoa group leader sends a truck from Kasoa to buy fish from WAF and sells the fish to traders in Kasoa while the other wholesalers and trader groups go to WAF to buy and distribute the fish from there.

The horizontal coordination among traders enables them to overcome some of the transaction costs and risks associated with trading in a highly perishable good with uncertain supply over a large area of operation and with poor marketing and transport infrastructure. The main advantage for traders of belonging to a group is more certainty over access to fish supplies in a seller's market as it ensures priority access to fish from WAF and increases the likelihood of obtaining the more desired larger sized fish. Belonging to a group also reduces transportation costs as traders can share the cost of hiring a trotro or other vehicle. Group members are often able to get fish on credit from their group leaders, usually for 2 weeks, and sometimes from other group members. This can be important as many traders also sell to their customers on credit, especially tilapia joints and chop bars. Group membership also helps traders to reduce costs related to monitoring fish grading; for example, in the Asutuare group when a farm is ready to harvest, one member will travel to the farm and inspect the fish to make sure the fish are mainly Size 1 or larger and will inform the other members. Often small-scale farms harvest a majority of smaller fish due to poor feeding practices which traders would not know until the day of harvest, thus increasing information costs and making futile trips to farms.

Personalised trading network

The personalised trading network that has developed around WAF is based on repeat trading and informal understanding between WAF and the group leaders/wholesalers and helps to reduce the costs of bargaining, monitoring, enforcement and information in an uncertain environment as detailed above. However as noted by Jaffee (1995:51) there are some limitations to personalised trading networks which may hinder adaptation to market changes that require adjustment in trading relationships and they may also have production cost disadvantages, since group preference for buying from WAF may leave other less expensive supply alternatives undeveloped. Also while 'insider trading networks' such as these trader groups may reduce transaction costs of insiders, they provide significant barriers to entry to individual traders outside the groups, many of whom indicated they were unable to join these groups.

Input supply

Like some of the medium-scale farmers, Tropo produces its own fingerlings and at the time of interview WAF had just installed a hatchery on site but was still buying fingerlings until the hatchery was functional. Vertically integrating fingerling supply with production overcomes a number of constraints: reducing logistical costs of purchasing fingerlings from a number of different hatcheries and reducing risk and uncertainty related to variable supplies, sources and quality. For similar reasons, both farms import feed directly from abroad mainly due to the reduced cost and to ensure adequate and assured quality supply.

Summary of results

Table 49 summarises the information presented in the previous sections.

Table 49: Key characteristics of commodities, transactions, actors and institutional arrangements for each aquaculture system

Characteristics of commodities, transactions, actors and institutional arrangements		Small-scale artisanal pond aquaculture	SME cage aquaculture	Large-scale cage aquaculture
Commodity characteristics				
Price and volume uncertainty		Medium	Medium	Medium
Production cycle		Long	Medium	Medium
Perishability		High	High	High
Level of technical knowledge required		Medium	High	High
Linkage intensity		Medium	High	High
Quality characteristics/heterogeneity (size)		Low	Medium	Medium
Seasonality		Medium	Low	Low
Economies of scale in marketing/transport		High	High	High
Geographical dispersion		High	Medium	Medium
Information asymmetry in credit		High	High	High
Transaction characteristics				
Uncertainty		High	High	High
Asset specificity		Medium	Medium to high	High
Volume and frequency of exchange		Low	Low (SSF) Medium (MSF)	High
Risk/return ratio		High	Medium	Medium
Expected institutional arrangements				
Market, hybrid and/or hierarchy		Limited market development/ market failure/ state intervention	SSF - Market oriented hybrid arrangements MSF - Hierarchy oriented hybrid arrangements	Hierarchy due to high volume and frequency of exchange
Key actors and attributes				
Producers	**Technical & market information**	Low	Low to medium	High
	Self interest	Medium	High	High
	Opportunism	Low	Low (SSF) Medium (MSF)	Medium
	Bargaining power over traders	Low	Low (SSF) Medium (MSF)	High
Traders/ whole-salers	**Market information**	Medium	High	High
	Self interest	High	High	High
	Opportunism	High	High (SSF) Medium (MSF)	Medium
	Bargaining power over producers	Medium	High (SSF) Medium (MSF)	Low
Extension staff	**Technical & market information**	Medium	Medium	Medium
	Self interest	Medium	Medium	Medium
	Opportunism	Medium	Medium	Medium
Observed institutional arrangements				
Overall market development		Low	Medium	Medium
Gift exchange/social reciprocity		Yes	No	No
Spot market exchange (producers & buyers)		Yes	Yes	Yes
Hybrid arrangements (producers & buyers)		No	Yes	Yes
Hierarchy (production & marketing)		No	No	Yes
Trader associations		No	Yes	Yes
Coordination by extension staff		Some	No	No

Notes: SSF - Small-scale cage farmers. MSF - Medium-scale cage farmers

7.3 DISCUSSION

This section outlines the general outcomes of the systems analysed above with regard to system development and potential for growth. Missing actors and institutions within systems are also identified and with the findings of this chapter are explored with respect to their wider theoretical and policy implications. These implications are then discussed in the context of the debate surrounding the effectiveness of supporting small-scale non commercial rural fish farmer development to promote poverty reduction, increasingly being questioned by some analysts (e.g. Brummett et al., 2008; Little et al., 2012) as noted in Chapters 2 and 6. The section concludes by assessing the hypothesis being tested, in the light of the overall results of this chapter.

7.3.1 System outcomes and potential for growth

As noted above, the current organisation of the small-scale pond aquaculture sector suggests it is stuck in a low level equilibrium trap. This is explored in more detail below. In essence the outcome of this situation implies that at the moment new entrants have little incentive to adopt aquaculture, current farmers have little incentive to intensify production, and traders have little incentive to invest in marketing fish from rural artisanal pond farmers in urban markets. It is possible that the situation may gradually evolve if local demand for fish rises due to higher local incomes from cocoa, artisanal mining etc. However, production levels and market development are unlikely to shift to an alternative, more commercial equilibrium in the short to medium term unless producers are able to benefit from higher urban market prices through developing institutional arrangements to reduce transaction costs and risks and increase non-market coordination along the value chain.

The lack of credit institutions serving small-scale fish farmers is also a factor limiting the poor growth potential of the system. Fish farming, even on a small artisanal scale, can demand relatively high lumpy investments in pond construction[88] and fingerlings. Intensification often requires increased purchased inputs of fingerlings, feed and fertiliser (along with improved management practices) thus medium term credit may be needed. However, as noted above, small-scale lending to scattered farmers for risky enterprises results in high transaction costs for lenders and high risks of default. These must be covered by high interest rates increasing the risk for farmers thus both decreasing demand and increasing lending costs (Binswanger and Rosenzweig, 1986). Owusu-Antwi and Antwi (2010) suggest that high costs, high interest rates, lack of collateral, lack of innovation and high delinquency rates are the main constraining factors in rural credit markets in Ghana. The absence of affordable, accessible and good quality training and technical information is also a constraining factor and is generally lacking for farmers, many of whom do not have much or any interaction with extension staff. While the district FFAs play an information exchange role, to increase productivity farmers require more improved technical knowledge and training.

These findings suggest limited growth potential for the small-scale system at present. While Asmah (2008) estimated that the mean annual growth rate in number of pond farms (97 percent of which were classified as non commercial) established since 2000 is 16 percent in Ghana and 26 percent in Ashanti Region, over 50 percent of the small-scale pond farmers on the FC list for the three study districts were found to be non functional. Therefore it is unclear whether in fact this growth is coming from more commercial peri-urban pond farmers (who may still have been regarded by Asmah as ‘non commercial’ based on commonly used definitions and characterisations, explored further in Chapter 8) while more rural artisanal farming is declining. In any case, it is unlikely that the artisanal pond aquaculture sector will develop to any great extent without a reduction in transaction costs and risks and/or an increase in returns through a ‘developmental coordination’ approach, discussed below. Thus, while there are some important outcomes related to increased income and household assets for non-poor producers

[88] Unless farmers construct ponds themselves and with family or community labour, however the majority of farmers were found to have hired labour to construct ponds.

discussed in Chapter 5, there are few noteworthy or widespread benefits at present for consumers and other actors such as poor groups within the community that could potentially benefit from the relatively high multiplier effects of a well developed small-scale pond aquaculture sector as presented in Chapter 6.

Elements of this limited market development were also found in the small-scale cage aquaculture sector, although all small-scale cage farm owners surveyed were attempting to overcome the transaction costs related to accessing output markets by developing hybrid arrangements with traders. While many traders were found to behave opportunistically, most farmers had started their operations very recently so these relationships have not been established for long. There is therefore scope for reduction in opportunism as relationships mature and trust is built. There is also good potential for further development due to the higher socio-economic status of small-scale cage farm owners, their increased access to market and technical information, the relative proximity of cage farms to input markets around Akosombo and to lucrative output markets in and around Accra, and the expected high returns compared to risks. However increased productivity relies partly on training farm managers/caretakers on efficient feeding practices as well as the supply of good quality fingerlings. The impact of the system on rural communities is limited at present (explored in Chapter 6) but the potential for multiplier effects and by implication the impact on poverty is important as adoption increases and cage farms become more sustainable.

Unlike small-scale pond and cage farms, medium and large-scale cage farmers were found to have the resources and knowledge to overcome many of the constraints facing smaller farmers, through establishing hybrid and hierarchical arrangement. Both systems are developing and increasing in output and have high potential for growth and to contribute to national fish supplies. While large-scale cage farms have low potential multiplier effects, the outcome of the institutional arrangements supporting both medium and large-scale systems on low income women traders is an important benefit.

7.3.2 Coordination failure and low level equilibrium traps

From the above analysis it appears that growth of the small-scale pond aquaculture system (and to a lesser degree the small-scale cage aquaculture system), is currently constrained. Intensification of aquaculture, like most agricultural intensification, requires technical change along with input, credit and marketing systems to increase production and supply fish to consumers at competitive prices (Poulton et al., 2006). Credit may be needed to enable increased purchase of good quality fingerlings and feed as well as for potential new entrants to construct ponds, thus problems with delivery of both credit and inputs to fish farmers are linked. In turn limited credit and input supply can hinder development of output markets as without increased production, sale of surplus fish will be low, leading to higher transaction costs and risks for buyers (as seen in the small-scale pond aquaculture system). The outcome of these mutually reinforcing problems, is transaction failure where transaction returns are lower than the costs and risks involved (Poulton et al., 2006; Dorward et al., 2005a).

High costs of coordination and opportunism constrain market development and limit access to more lucrative urban markets and are key causes of transaction failure. They pose serious challenges for making the simultaneous and complementary investments needed at a number of different points in the supply chain for it to function (Dorward et al., 2005b). The high risk of coordination failure in the small-scale pond aquaculture system was illustrated above by the case of the fish trader in Kumasi who invested in a cold van and sold fish from rural pond farmers to urban retailers but was unable to sustain his business due to the irregular supply of table size fish. The trader’s investment in marketing services was not matched by investment by farmers in increased quantity and quality of supply, resulting in transaction failure. Similarly, opportunism was seen in the small-scale cage system where traders have stronger bargaining power than farmers and often do not pay the agreed price, which could lead to transaction failure in some cases and be a contributing factor to the high turnover of small-scale cage aquaculture farms. Transaction failure can then lead to a low level equilibrium trap[89] which occurs where constraints, low levels of institutional development, lack of incentives for actors to invest, limited economic activity and thin markets and poor coordination continually reinforce each other and restrict economic and technological development (Dorward et al., 2003; Dorward et al., 2005a and 2005b; Poulton et al., 2006).

Thus, the key challenge for small-scale pond and cage aquaculture development is to develop supply chains that are able to offer farmers a range of input (feed and fingerlings), financial, technical, information and other services at the same time as enabling them to access urban and other markets that offer higher prices. It is likely that state provision of public goods will not be enough to stimulate growth of the small-scale pond aquaculture sector in the survey areas. As argued by Dorward et al. (2005a) and illustrated above, non-market coordination is needed to overcome the risks that constrain the simultaneous and complementary investments needed along the supply chain. The non-market coordination mechanisms required, and the potential actors and institutional arrangements that could provide and support them, are explored in the following chapter.

7.3.3 Institutional perspective in current aquaculture development discourse

As mentioned above, some analysts are questioning the efficacy of focusing on small-scale artisanal fish farmers to impact on poverty and increase fish production. They argue for the need to support SME farmers while also broadening the current emphasis on producers to include the whole value

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[89] Poulton et al. (2006) illustrate the effect on the optimal level of supply chain investment of increased marginal factor costs (MFCs), especially at low levels of supply chain investment, when costs of opportunism, coordination and rent seeking are added to transformation costs. They show that when these transaction costs and risks are taken into consideration, optimal supply chain investment (where Marginal Value Product is equal to MFC) can occur at multiple equilibriums. There may then be a critical threshold level of total supply chain investment below which the marginal returns to investment are negative and below this threshold the supply chain is stuck in a low level equilibrium trap. They use this analysis to help explain individual choices around a stable low level equilibrium in smallholder farming areas with an atomistic market of many small players without non-market coordination or collective action which is a common situation in SSA.

chain. The question of which aquaculture systems have the most potential to impact on poverty was addressed in Chapter 6 where it was argued that small-scale artisanal pond aquaculture (fish farming type A) in Ashanti Region has more potential to impact directly and indirectly on poverty compared to SME cage farming in Eastern Region for a given level of value added. However the current chapter has shown that the small-scale artisanal pond aquaculture system has the highest constraints to growth and faces difficult challenges in realising this potential. Medium and large-scale systems, on the other hand, may have less potential to impact on poverty than the small-scale artisanal sector, but hold the most potential for growth and to impact on national fish supplies. Therefore while there may appear to be some divergence between the results of this thesis and the changing view relating to which system has the most potential to impact on poverty, there may in fact be more convergence of views once systems' relative potential for growth is taken into account. These issues are explored further in the following chapter.

The argument that a value chain approach is needed to maximise the development of aquaculture is supported by the analysis in this thesis. Chapter 6 showed that the indirect poverty impacts of any aquaculture system, through economic multiplier effects and other linkages along the value chain and in the local economy should be considered when understanding each system's potential for poverty impact and growth. However the increased focus of analysts on value chain development along with the policy and institutional environment and market access, does not appear to go far enough in addressing the high transaction costs and risks associated with the coordination and exchange of aquaculture commodities along the value chain or the need for 'development coordination' (Dorward et al., 2005b) to overcome constraints to aquaculture development. As discussed above, high transaction costs and risks pose many challenges to aquaculture development especially in areas with poor institutional development, typical of rural areas in SSA where aquaculture has failed to take off. NIE theory suggests that development of risk reducing institutional arrangements is needed in these areas for market development of 'linkage intense technologies'. Institutional arrangements observed in the SME and large-scale aquaculture systems above support this theory.

Pouomogne and Pemsl (2008) highlight that recent surveys have identified socio-economic and institutional factors, specifically related to accessing inputs and capital, and market development, to have much more influence on aquaculture development than agro-ecological or technological factors. However the insights from these surveys have not led to recommendations which focus specifically on institutional arrangements, reducing transaction costs and risks, and overcoming opportunism and coordination challenges (Dey et al., 2008; Russell et al., 2008; Brummett et al., 2008 and 2011). Rather, the individual recommendations of these various studies are focused on value chain development and technical support, and are not coherently linked in such a way that emphasises the need to support actors to make simultaneous and complementary investments in the supply chain to reduce coordination risk and transaction failure.

However Pouomogne and Pemsl (2008) note that by the end of the last DfID-funded project to develop small-scale IAA systems in Cameroon, production had increased and this demanded and led to the development of a collective marketing strategy with a local NGO managing purchase of fingerlings on credit, basic technical training, collective harvesting, and joint marketing (through linking farmers with urban fish traders) of 32 members of local farmers' groups. Fish farmers could obtain quality fish seed at a lower price and get higher prices for fish, while others who benefited from buying fingerlings on credit established small fish farms which had survived the 3 years since the project ended. This type of intervention addressing several elements of the supply chain simultaneously is an example of the 'developmental coordination' approach discussed above and should be explored further. However Brummett et al. (2011) note of the same project that peri-urban farmers with market access responded much better to project interventions than small-scale rural artisanal farmers with poor market access, and their results were more sustainable as were their rates of return to donor investments. Thus it was concluded that in areas with limited market access, while aquaculture adoption and productivity can be increased and local food security enhanced, the sustainability of interventions without extension subsidies is questionable.

The experience of the project, which Brummett et al. (2011) state is typical of many small-scale aquaculture support projects undertaken in SSA over the past five decades, supports the argument above that access to urban markets with higher prices can intensify aquaculture and shows that small-scale rural artisanal farmers face much higher constraints to growth than those closer to markets and those who are well resourced. However the conclusions and recommendations do not reflect the importance of institutional innovation (such as the case of collective marketing and supply chain coordination above or of alternative business models be they support for contract farming schemes or development of forward contracts between farmers and traders) as a potentially low cost and high impact intervention area which could help rural farmers overcome constraints and access markets.

Thus it could be suggested that the failure of interventions, directed mainly at small-scale farmers, to develop African aquaculture over the past five decades, may not be entirely due to the low growth potential of small-scale fish farmers *per se*, but rather a result of the lack of attention to overcoming the transaction costs and risks facing farmers and other actors functioning in weak institutional environments, to make complementary and mutually dependent investments in supply chains (as argued by Dorward et al., 2005b for smallholder agricultural development). It could further be suggested that the reasons for the limited development of aquaculture in SSA are related to the overall lack of development in SSA and are similar to the reasons that smallholder agriculture, especially in staple crops, in SSA has also not intensified. Belton and Little (2011) observe that the expansion of Asian aquaculture generally accompanied high growth rates in other rural and urban sectors so can be viewed as a product of development and not a driver of it. Belton and Little (2011) cite Kelly et al. (2003) who conclude that the failure of interventions to intensify staple crop production in SSA is inevitable without prior development by the state of public goods such as infrastructure and services, themselves indicators of development. Dorward et al. (2004) argue that state-led development policies in successful Green Revolutions kick started markets by overcoming coordination failures and stimulated activity by large organisations (within which economic exchange and coordination could occur) in poor rural areas where the basic necessary conditions for growth such as communications infrastructure and productive technologies had been established. In this way, farmers and other actors in the small-scale agriculture sector had been able to escape the low level equilibrium trap by the time liberalisation occurred. However in SSA prior necessary conditions had not been established therefore government efforts to kick start markets and develop large organisations in rural areas failed. As agriculture had not escaped from the low level equilibrium trap, later market liberalisation was unable to stimulate market development (Dorward et al., 2005b). These arguments can thus shed some further light on the failure of interventions to develop small-scale aquaculture in SSA and support the contention in this chapter that developmental coordination to overcome transaction costs and risks and transaction failure, is necessary for aquaculture to develop and realise its full potential for poverty impact in SSA.

7.4 CONCLUSION

The techno-economic characteristics of farmed fish from different aquaculture systems along with actors, institutional arrangements and their attributes were analysed in this chapter and summarised in Table 49. Overall the results suggest that the demanding commodity and transaction characteristics and high linkage intensity of aquaculture in different systems result in medium to high risk to return ratios and require non-market institutional arrangements to support their efficient coordination and exchange. While medium and large-scale farmers were observed to have the resources and high returns to overcome these constraints through various institutional arrangements which coordinate individual activities in the supply chain, small-scale pond and cage farmers, especially the former, require institutional development to support system development. Therefore the hypothesis being tested, that due to the institutionally demanding techno-economic characteristics of aquaculture products, complementary technical and institutional development is necessary for aquaculture to develop and impact poverty, is supported by the findings of this chapter. The types of institutional innovations which can potentially support the development of these aquaculture systems and increase their uptake, productivity and poverty impact, along with the implications of the results from Chapters 5 and 6, are explored in the following chapter.

CHAPTER 8: CONCLUSION

8.1 INTRODUCTION

The objective of this thesis is to understand the actual and potential impacts of different aquaculture systems on poverty and livelihoods in Ghana and the institutions required for aquaculture development to maximise its potential for poverty reduction. These issues have been explored by: i) investigating the direct poverty and livelihood impacts of small-scale artisanal pond aquaculture in Ashanti Region; ii) assessing the significance of indirect impacts such as economic linkages and employment, of the three main aquaculture systems in Ghana (small-scale artisanal pond aquaculture, SME and large-scale commercial cage aquaculture) and their implications for pro-poor growth; and iii) analysing these systems from an institutional perspective to understand the institutions needed for different aquaculture systems to have the highest potential to promote poverty reduction in different contexts.

This chapter reviews the key findings from the previous three chapters in order to understand the overall implications of these results. These implications are discussed in the context of the emerging paradigm in aquaculture development, referred to in previous chapters, which is shifting away from a narrow focus on supporting small-scale artisanal, non commercial, poor fish farmers (the predominant approach to supporting aquaculture by governments and aid agencies in SSA in previous decades) towards a broader value chain focus on SME commercial farming (e.g. Little et al., 2012). This discussion is then expanded to explore some examples of institutional arrangements and innovations which may have relevance for the promotion of aquaculture in Ghana in the context of weak institutional development, a context found in many rural areas in SSA where aquaculture is being promoted. The outcomes of these discussions and the results of this thesis are then brought together by outlining some broad principles for pro-poor aquaculture development in Ghana to inform policies aimed at maximising the potential for aquaculture to impact on poverty in Ghana and more widely in SSA. Some areas for further research are then suggested and the chapter ends with some concluding remarks.

8.2 SUMMARY OF KEY FINDINGS

8.2.1 Direct impacts of small-scale pond aquaculture on poverty in Ashanti Region

The results presented in Chapter 5 explored the differences between livelihood status, activities and outcomes of fish and non-fish farming households surveyed in Ashanti Region. This descriptive analysis showed that poor farmers are able to adopt pond aquaculture suggesting that aquaculture has the potential to directly impact on poverty. Fish farming households were found to have over 30 percent higher average income and nearly 2.5 times higher off-farm income than non-fish farming households. Non-poor fish farming households were found to have over double the off-farm income of non-poor non-fish farming households. Fish farming households also had significantly higher household wealth (measured by the household asset index) than non-fish farming households and non-poor fish farming households had a higher household asset index score than non-poor non-fish farming households. Overall, therefore, fish farming households appear to be better off than non-fish farming households in terms of income, household wealth and slightly better off in terms of food adequacy. Significantly higher levels of income, household assets and off-farm income of non-poor fish farming households compared to poor fish farming households suggest that there may be an asset threshold over which fish farming allows higher income and asset accumulation. It also suggests that fish farming may have a higher potential to improve livelihoods for non-poor households over the asset threshold, than for poor households below the asset threshold.

To account for possible differences in household characteristics, other than participation in fish farming, which may cause differences in poverty status and livelihood outcome indicators between fish farming and non-fish farming households, a household Income Determination Model (IDM) was used. The

IDM statistically controlled for differences in observable characteristics between households and was used to assess the factors that contribute to differences in income between fish farming and non-fish farming households. The conclusions of the descriptive analysis above are supported by the results of the IDM which indicated that participation in fish farming type A (where fish farmers are trained and/or use fertiliser in their ponds, a proxy for use of Better Management Practices (BMPs)) is associated with a 54 percent increase in household income when controlling for other household characteristics. Participation in fish farming type B, where farmers are not trained and do not use fertiliser, was not found to have a significant association with income, suggesting little difference in income between non-fish farming and fish farming type B households. Although the tests for endogeneity and selection bias indicated no problems in the IDM, it is not possible to categorically state that fish farming type A causes income to increase. However the model suggests that fish farming has a positive effect on income and the differences in income (and most likely other outcome indicators such as household wealth) found in the descriptive statistics were not merely due to differences in household characteristics between groups. The results also suggest that adoption of fish farming is not necessarily associated with higher incomes unless farmers have been trained and/or use BMPs, in which case household income may be increased. However as noted above, the descriptive analysis points to the existence of an asset threshold over which fish farming allows income and capital accumulation, and also a threshold in the use of BMPs. The results of the descriptive analysis and IDM together therefore indicate that while fish farming type A increases income for non-poor farmers, poor farmers (under the BMP and asset thresholds) are less likely or able to participate in fish farming type A. Therefore it can be argued that while small-scale aquaculture is likely to have a strong impact on income and household wealth of non-poor farmers practising fish farming type A, it is unlikely to have much impact on poor farmers unless their resource constraints can be overcome and they are also able to engage in and benefit from fish farming type A.

Overall the results presented in Chapter 5 do not strongly support the hypothesis being tested that small-scale aquaculture has positive direct impacts on poverty and livelihoods of *poor* households in Ashanti Region. However the results do suggest that small-scale aquaculture has positive direct impacts on the livelihoods of *non-poor* households, and the magnitude of these impacts depends on the household and livelihood characteristics and aquaculture production systems of fish farmers in Ashanti Region, and the institutional and infrastructure context. The results also suggest that while aquaculture does not appear to have direct poverty impacts on poor households in Ashanti Region at present, it does have the potential to directly benefit poor fish farming households if their resource constraints can be overcome and they are able to use and benefit from BMPs. Chapter 5 therefore identified two broad categories of small-scale farmers (poor and non-poor) that experience different levels of direct impacts from small-scale aquaculture under present conditions.

8.2.2 Indirect impacts of different aquaculture systems on poverty in Ghana

Given that as discussed above, fish farming was found to have direct impacts on non-poor farmers practising fish farming type A, Chapter 6 assessed the importance of actual and potential indirect impacts of: i) small-scale artisanal pond aquaculture (fish farming type A); ii) SME commercial cage aquaculture; and iii) large-scale commercial cage aquaculture. The national economic multiplier effect generated by fish farming type A was estimated to be approximately twice that of SME cage aquaculture (between 3.0 and 3.5, and between 1.5 and 1.6 respectively). Overall the economic multiplier effects and associated linkages (backward, forward, consumption and investment) were found to be relatively strong for small-scale pond aquaculture (fish farming type A), medium for SME cage aquaculture and weaker for large-scale cage aquaculture. However as not all the benefits of economic growth from each aquaculture system are likely to accrue to the poor, small-scale pond aquaculture was estimated to have more potential to indirectly impact on poverty at a medium level, as compared with weaker impacts from SME cage aquaculture, with large-scale cage aquaculture generating the weakest impacts.

Chapter 6 also estimated that small-scale artisanal pond farms (practising fish farming type A) may not create as much employment as SMEs if farmers do not hire labour to dig ponds, although if they do it is likely that small-scale pond aquaculture generates the same if not more direct employment than SME cage and pond farms per tonne of fish produced and per dollar invested. Indirect employment along the value chain was found to be higher from SME and large-scale cage farms at present due to the undeveloped nature of the small-scale pond aquaculture value chain and weak forward linkages.

The results therefore indicate that at present, small-scale pond aquaculture (fish farming type A) by non-poor farmers has stronger indirect impact pathways and higher potential to impact on poverty than SME and large cage scale farming (and small-scale artisanal pond aquaculture by poor farmers practising fish farming type B). Thus for equivalent increases in scale, it is likely that small-scale pond aquaculture (fish farming type A) by non-poor farmers would have the most potential to impact on poverty. The results from Chapter 6 therefore do not support the hypothesis that SME cage aquaculture has more potential to impact on poverty than small-scale pond aquaculture or large-scale cage aquaculture.

8.2.3 Institutional analysis of aquaculture systems in Ghana

The techno-economic characteristics of farmed fish from different aquaculture systems along with actors, institutional arrangements and their attributes were analysed in Chapter 7. Overall the results suggest that the demanding techno-economic characteristics and high linkage intensity of aquaculture in different systems result in medium to high risk to return ratios and require non-market institutional arrangements to support their efficient coordination and exchange. Analysis of the current organisation of the small-scale pond aquaculture system suggested the sector is stuck in a low level equilibrium trap: new entrants have little incentive to adopt aquaculture, most current farmers have no motivation to intensify production, and traders have little incentive to invest in marketing fish from rural artisanal pond farmers in urban markets. In order to overcome this trap, producers need to be able to benefit from higher urban market prices through the development of institutional arrangements to reduce transaction costs and risks and increase non-market complementary coordination along the value chain. However, while these difficulties currently constrain growth of the small-scale pond aquaculture system (and to a lesser degree the small-scale cage aquaculture system), medium and large-scale farmers have resources and higher returns which enable them to overcome these constraints through various institutional arrangements that coordinate individual activities in the supply chain. Small-scale pond and cage farmers, especially the former, thus require support for institutional development to encourage system development.

This analysis indicates that the key challenge for small-scale pond and cage aquaculture development is to develop coordinated supply chains that are able to offer farmers a range of input (feed and fingerlings), financial, technical, information and other services at the same time as enabling them to access urban and other markets that offer higher prices. It was suggested that state provision of public goods would not be enough to overcome the risks that constrain the simultaneous and complementary investments needed along the supply chain and non-market coordination would be required. The findings of Chapter 7 support the hypothesis that due to the institutionally demanding techno-economic characteristics of aquaculture products, complementary technical and institutional development is necessary for aquaculture to develop and impact poverty.

8.3 DISCUSSION OF RESULTS IN THE CONTEXT OF THE EMERGING PARADIGM SHIFT IN AQUACULTURE DEVELOPMENT

This section discusses the key findings of the thesis in the context of the emerging paradigm in aquaculture development discussed in Chapter 2. The current move away from a narrow focus on poor producers, which has been the dominant approach to developing the aquaculture sector in SSA for several decades (Brummett et al., 2008), is supported by the results of this thesis. It is unclear however whether the arguments in the aquaculture development literature (advocating for: expanding support to include 'commercial', 'quasi-capitalist', SMEs; and taking a wider value chain or 'whole industry' approach (Brummett et al., 2008; Beveridge et al., 2010; Little et al., 2012)) are fully, or only partially, supported by the thesis results. This is due to some areas of ambiguity within the emerging paradigm. This section briefly summarises the key findings of the thesis and explores the ambiguities within the emerging paradigm highlighted by these findings.

Overall the thesis results suggest that potential impacts on poverty (direct or indirect) and growth potential together constitute a necessary and sufficient set of conditions for pro-poor aquaculture development. Individually each of these conditions is necessary for pro-poor aquaculture development but neither is sufficient on its own. Table 50 shows scores for the performance of each aquaculture system on these two dimensions based on the analysis in the previous chapters.

Table 50: Summary of poverty impact and growth potential of different aquaculture systems in Ghana

	Small-scale, artisanal, 'non commercial', pond aquaculture systems		'Commercial' cage aquaculture systems		
Contribution to pro-poor development	**Fish farming type B (poor farmers)**	**Fish farming type A (non-poor farmers)**	**Small-scale**	**Medium-scale**	**Large-scale**
Direct poverty impacts	✓	x	x	x	x
Indirect poverty impacts	x	✓✓✓✓	✓✓	✓✓	✓
Current growth potential (farmers' technical, institutional and financial capabilities)	✓	✓✓	✓✓✓	✓✓✓✓	✓✓✓✓✓

Notes:

x	= none
✓	= weak
✓✓✓	= medium
✓✓✓✓✓	= strong

Table 50 suggests that the highest potential for aquaculture development poverty impacts in Ghana does not reside with small-scale, artisanal, 'non commercial' pond aquaculture (fish farming type B) undertaken by poor farmers (with very limited growth potential despite potential direct poverty impacts) nor with 'commercial' cage aquaculture undertaken by SME and large scale farmers (with limited poverty impacts despite high growth potential). Instead it is the 'intermediate' aquaculture system, classified here as small-scale, artisanal, 'non commercial' pond aquaculture (fish farming type A), practised by non-poor farmers, that holds the greatest potential – as a result of its strong indirect poverty links and low but nevertheless important potential growth impacts if the constraints to growth faced by non-poor, small-scale artisanal fish farming type A farmers, can be addressed by supportive investment.

The current rethinking in the aquaculture development literature of how aquaculture can reduce poverty most effectively by supporting value chain development of more commercial aquaculture, rather than focusing only on poor producers (Little et al., 2012) is thus broadly in line with the results of the thesis which also suggest that aquaculture development has more potential to reduce poverty through indirect, rather than direct, impact pathways. However, the extent to which the results support or question the shift towards 'commercial' aquaculture (e.g. Moehl et al 2006; Brummett et al., 2008) and a value chain approach (e.g. Beveridge et al., 2010) depend critically upon: i) the definition and classification of different types and scales of fish farming; ii) the importance of economic linkage effects (including but not limited to employment generation along the value chain); iii) the growth potential of different aquaculture systems and the role of institutional development in overcoming constraints to growth; and iv) the objectives of policies and interventions seeking to expand aquaculture. These four issues are considered in turn.

Challenges of definition

The thesis results' suggestion that non-poor, small-scale fish farmers, categorised here as 'non commercial', have a higher potential to impact on poverty than 'commercial' aquaculture SMEs may appear to question the move towards 'commercial' aquaculture in the emerging paradigm. However, this apparent difference may be partly due to the difficulties of defining and characterising the wide variety of aquaculture systems and farmers between different contexts. These difficulties are illustrated by examination of a range of different aquaculture classifications used in the literature. These classifications tend to focus on very broad farmer categorisations such as ‘commercial’ or ‘non commercial’ (Ridler and Hishamunda, 2001; Moehl et al., 2006), and extensive, artisanal, SME or large-scale (Brummett et al., 2008). Each category then encompasses a range of farm types that differ in scale and intensity of production, amount of hired labour and purchased inputs, production levels, market orientation and overall motivation for fish farming. Consistent application of these categorisations in particular situations is difficult – as the Ghana case illustrates.

Thus, as noted in Chapter 2, Moehl et al. (2006) define ‘non commercial’ farmers as farmers with ponds (as opposed to primarily fish farmers) who produce predominantly for profit. While the small-scale farmers surveyed in this study in Ghana are farmers with ponds as part of diversified livelihood strategies, the primary motivation for the majority of both poor and non-poor farmers is profit (see Chapter 5). Thus there is some ambiguity as to which category (commercial or non commercial) these farmers belong to. Asmah (2008) estimated nearly 97 percent of fish farms in Ghana were ‘non commercial’ according to the criteria outlined by Ridler and Hishamunda (2001). Hence, the majority of small-scale artisanal fish farmers surveyed for this thesis, including the non-poor farmers practising fish farming type A, are likely to be defined as ‘non commercial’. Similarly Beveridge et al. (2010:3) suggest that while aquaculture may be one component of a diversified livelihood strategy for the smallest commercial enterprises, many SMEs are characterised by livelihoods largely dependent on aquaculture and by production that is typically semi-intensive with production levels between 1 and 100 tonnes per farm per annum. The non-poor, small-scale fish farmers surveyed here fit some but not all of these criteria and fall well below the minimum one tonne per annum to be considered SMEs. These ambiguities are also reflected in the characterisation of artisanal farmers. Overall, the small-scale farmers classified as artisanal in this thesis do not correspond to the characteristics of Brummett et al.'s (2008) artisanal farmers (see Chapter 6, Section 6.3.1). However the characteristics of the surveyed poor, small-scale farmers appear to correspond much more closely with Brummett et al.'s artisanal farmers (particularly in relation to their levels of production and proportion of fish sold) than those of the non-poor, small-scale farmers (see Chapter 5). These non-poor farmers however also do not resemble the commercial SME farmers characterised by Brummett et al. and are located between artisanal and SME categories, while also overlapping with both on certain characteristics.

Little et al. (2012) note that definitions of aquaculture based on scale of production using indicators of area and levels of inputs and/or outputs reveals contradictions. Belton et al. (2012) argue for a 'relations of production' approach defining aquaculture in terms of relationships ('quasi-peasant', 'quasi-capitalist' and 'capitalist') as a way of overcoming some of the difficulties with relating scale to levels of intensity, employment, and production. While overall, these categories still correspond to the definitions related to commercial orientation discussed above, these new categories enable a wider range of farm characteristics to be incorporated including use of hired labour, farmer motivations, aquaculture's place in farmer's livelihoods, while also situating the farms in various value chains. Belton et al. (2012) found that in Bangladesh, commercially oriented 'quasi capitalist' aquaculture may have stronger potential to reduce poverty than 'quasi-peasant' aquaculture. Using this typology, both poor and non-poor small-scale pond aquaculture farmers surveyed here fall under the 'quasi peasant' (similar to 'non commercial') rather than the 'quasi capitalist' (similar to 'commercial') category[90], though it could be argued that the non-poor farmers

[90] Small-scale pond aquaculture analysed for this thesis corresponds to 'quasi-peasant' aquaculture (poor farmers practising fish farming type B fit in the low production intensity group and non-poor farmers practising fish farming type A fit in the moderate production intensity group). Small-scale cage aquaculture corresponds to 'quasi capitalist' aquaculture (moderate or intensive production intensity), medium-scale cage aquaculture corresponds to 'capitalist' aquaculture (moderate or high production intensity) and large-scale commercial cage aquaculture corresponds to 'capitalist' aquaculture (high production intensity).

fall somewhere between the two due to their use of hired labour (see Chapter 6).

Figure 25 locates the different categories of fish farmers analysed in this thesis within the standard classifications commonly used, to illustrate these ambiguities.

Figure 25: Definitions of aquaculture systems and fish farmer categories

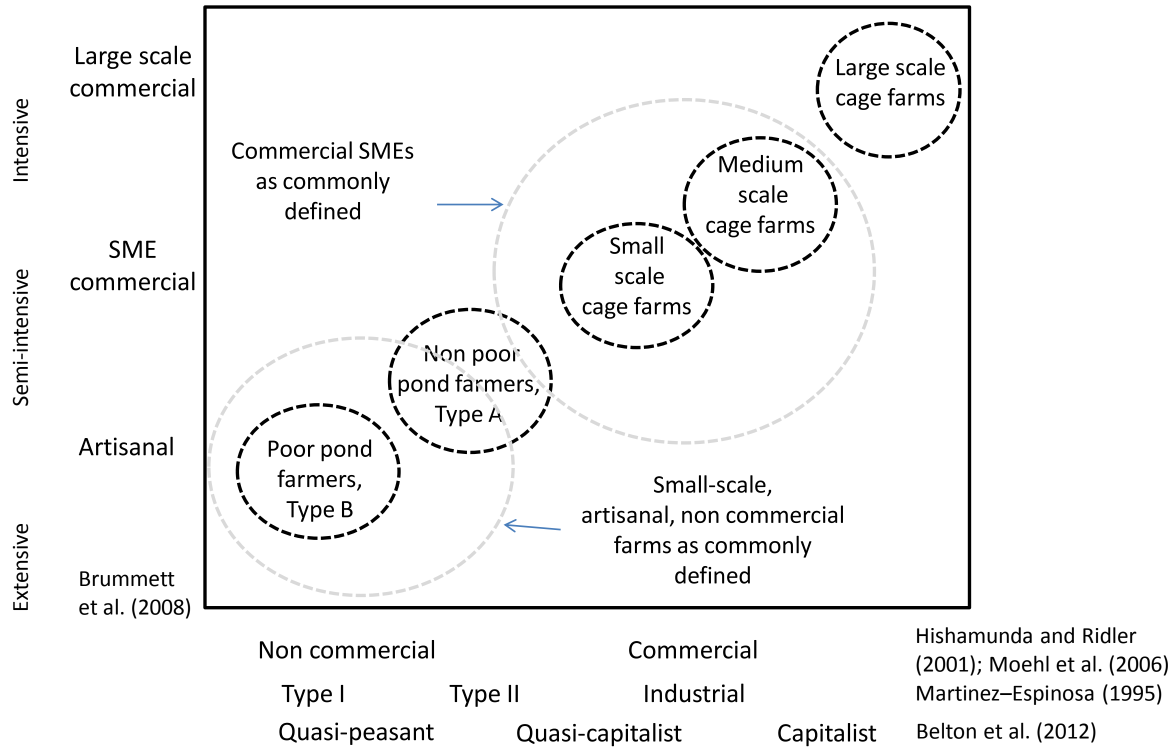

Figure 25 shows that non-poor, small-scale farmers practicing fish farming type A are located somewhere between: artisanal and SME; 'non commercial' and 'commercial'; and 'quasi-peasant' and 'quasi-capitalist' categories, while overlapping more with artisanal, 'non commercial', 'quasi-capitalist' categories. The binary classification by Martinez-Espinosa (1995) of Type I and Type II rural aquaculture representing the 'poorest of the poor' and 'less poor' farmers respectively appears to correspond best with the poor and non-poor small-scale farmers analysed in this thesis. It is clear however that the non-poor, small-scale farmers practising fish farming type A, identified in this thesis as having the highest potential for poverty impact in Ghana, do not fit neatly into the standard, commercially oriented categories which the emerging paradigm is moving towards.

This discussion indicates that the categories commonly used to define types and scales of aquaculture systems and farmers, do not reflect the wide spectrum of fish farmers operating in SSA nor correspond to the reality of the Ghanaian small-scale artisanal and SME farmers surveyed here. These broad categories are thus likely to cause some confusion when targeting interventions and development assistance. They are also a source of ambiguity between the findings of this thesis and the emerging paradigm's move towards supporting 'commercial' aquaculture. In reality farmers are located along a continuum and the classification of aquaculture systems and farmers are likely to differ between contexts. Relying on these broad classifications to help to target aquaculture development efforts may risk overlooking important aquaculture systems and fish farmer categories with high potentials to impact on poverty. It is therefore important to further develop an understanding of relevant classifications of aquaculture systems and farm types that are more easily comparable across different contexts.

The importance of economic multiplier effects

The shifting focus of aquaculture development strategies towards support of 'commercial' farmers may not only be a response or reaction to the apparent failures of past efforts to develop the small-scale 'non commercial' aquaculture sector, but is also in line with changing paradigms in the wider development sector. Belton and Little (2011) citing Gibbon and Schulpen (2002), refer to this as the current private-sector development consensus among multilateral and bilateral institutions based on the understanding that economic growth (needed for poverty alleviation) is best achieved through facilitating private sector development (e.g. World Bank, 2007). The current shift towards 'commercial' aquaculture development appears to be influenced by this general development trend and is thus partly based on the view that 'commercial' SMEs and 'quasi capitalist' enterprises have more potential to impact on poverty through generating employment along the value chain and creating economic growth than ‘non commercial’, ‘quasi peasant’, artisanal aquaculture (Brummett et al., 2008; Belton et al., 2012; Little et al., 2012). This argument does not, however, appear to be grounded in analysis or evidence of the relative importance of potential economic multiplier effects (incorporating both production linkages along the value chain as well as consumption linkages) and other economic linkage effects generated by different aquaculture systems to impact on poverty (investigated in Chapter 6). While there have been an increasing number of studies recently showing the potential of commercial aquaculture to create employment on-farm and along the value chain (e.g. Faruque, 2007; Irz et al, 2007a; Macfadyen et al., 2011; Belton et al., 2012), there are no studies estimating economic multiplier effects of aquaculture in developing countries.

Chapter 6 has shown the most important indirect benefits of aquaculture development on poverty are likely to be through economic multiplier effects. The magnitude of these effects is determined to a large extent by consumption linkages. It appears therefore that though the results of this thesis are in agreement with broadening support beyond poor fish farmers, they also question the shifting of support to ‘commercial’, SME, ‘quasi-capitalist’ fish farms on the basis that they create higher indirect poverty impacts, when there is no evidence that this category of fish farmer has the potential to generate higher economic multiplier effects than other farmer categories. The results of this thesis have shown that in Ghana, non-poor small-scale farmers practising fish farming type A, likely to be characterised as ‘quasi peasant’ and ‘non commercial’ according to commonly used definitions, have the potential to create greater economic multiplier effects and broad based economic growth and hence higher poverty impacts than ‘commercial’, ‘quasi capitalist’ SME cage aquaculture farmers. These results again suggest that the poverty impacts generated by different aquaculture systems and farmer groups are likely to differ between contexts. Thus, the characteristics of different types of farmers and the range of economic linkages arising from different systems, must be understood if support is to be correctly targeted to the aquaculture systems and farmer categories with the highest potentials to impact on poverty in different contexts.

Institutional innovation to overcome constraints to growth in aquaculture development

The analysis in this thesis supports the general trend towards taking a broader value chain perspective for aquaculture development. This perspective is important not only due to the benefits of employment generation along value chains, but also due to the importance of making simultaneous and complementary investments along the value chain in order for aquaculture systems to grow and hence realise their potential to impact on poverty, economic growth and local and national food security (see Chapter 7). The potential for aquaculture systems to grow is related to the potential of producers to intensify (based on their technical and institutional capabilities) and of systems to attract new entrants. While non-poor farmers practising fish farming type A may have the greatest poverty impact potential, the small-scale artisanal sector also faces the highest constraints to growth. This is due to the high transaction costs and risks faced by actors within the small-scale sector, leading to transaction failure and a low level equilibrium trap, and the lack of financial and social resources of dispersed farmers to overcome these challenges to growth. Thus despite its potential for poverty impact in Ghana, supporting the small-scale artisanal sector would appear to be much more challenging and expensive for donors and governments than supporting the SME sector where farmers have higher levels of financial and social resources to overcome constraints, are less dispersed and are already linked to growing urban markets and demand for fish. Therefore, there may be more convergence between the findings of the thesis and the move towards ‘commercial’ aquaculture development when systems’ relative potential for growth is considered, but the move towards more ‘commercial’ aquaculture development should not be taken too far.

While this thesis has compared aquaculture systems at a given level of output or value added (see Chapter 6), assessing the potential impact of these aquaculture systems on poverty according to levels of donor investment may also contribute to debates about the emerging paradigm which suggests that aquaculture SME's give higher returns on donor investment than small-scale artisanal farmers (Brummett et al., 2011). However this analysis is difficult to undertake with the available evidence, especially without knowing what form donor investment should take. Chapter 7 found that development of aquaculture in Ghana may be better supported through institutional rather than (or in addition to) technical or other types of support, and institutional innovations do not require huge investments of donor funds. Rather they require knowledge and understanding of the institutional arrangements and environment of these farming systems. Focusing on returns to donor investment therefore may not be so relevant without consideration of these issues. While the small-scale artisanal sector may face the greatest challenges to growth, if these challenges can be overcome through coordinated value chain development facilitated by institutional innovation, it may still hold the most potential for poverty impact in Ghana. Thus not only is a broader value chain approach important for aquaculture development, so is institutional innovation to maximise the potential for aquaculture system growth.

Objectives of policies and interventions to develop aquaculture

Another issue in clarifying some of the ambiguities around the thesis results and the move towards supporting 'commercial' aquaculture is the recognition of a number of distinct but overlapping goals for aquaculture development in SSA namely: national food (or fish) security goals, development and poverty reduction goals, and local and/or household food security goals. It is likely in most contexts, and certainly in Ghana, that different aquaculture systems may be best suited to addressing different goals. For example the thesis results suggest that non-poor artisanal farmers practising fish farming type A have the most potential to generate economic multiplier effects and thus reduce poverty. Commercial SME and large-scale cage aquaculture on the other hand has more potential to impact on national fish supplies and face less constraints to growth than fish farming types A and B which have more potential to impact on the household food security of poor fish farming households. Donor and national government objectives for the aquaculture sector in SSA usually encompass this range of goals. If projects designed to achieve household food security and poverty alleviation goals are then judged on their ability to increase national fish supplies, they may unfairly be viewed as unsuccessful. If the priority of governments is to increase national fish supplies, targeting support towards commercial SME and large-scale fish farming would be a more appropriate strategy.

Taking account of these considerations, the key findings of this thesis and their implications for aquaculture development discussed in this section can be summarised using Figure 26 below.

Figure 26: Potential of different aquaculture systems to reduce poverty and increase production in Ghana

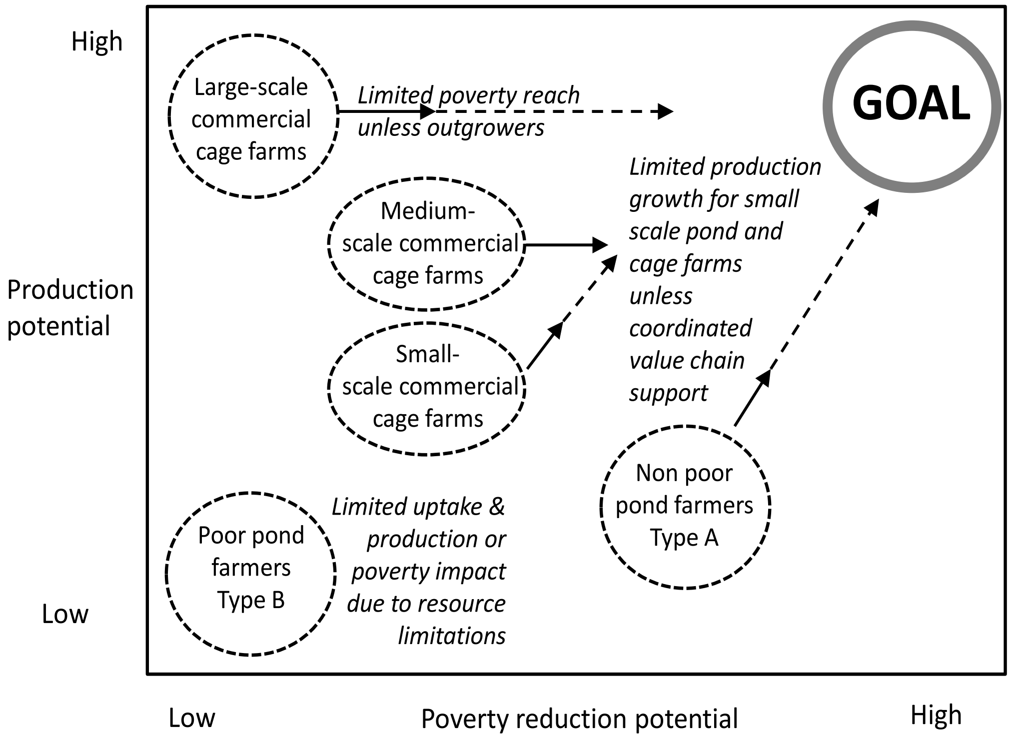

Figure 26 highlights two of the main goals of aquaculture development discussed above: increased national fish production and poverty reduction. The figure illustrates the potentials of the different aquaculture systems analysed in this thesis to increase production and reduce poverty in Ghana. Poor farmers practising fish farming type B have the least potential to reduce poverty or increase national fish production (though they do have potential to increase household food security). Non-poor small-scale farmers practising fish farming type A have the highest potential to reduce poverty but less potential to increase national production, though both of these potentials would increase if coordination along the value chain was supported through institutional innovation (discussed further in Section 8.4 below). At present small-scale commercial cage farmers have low to medium potential to increase fish production and reduce poverty however their potential to increase national fish production would also increase through coordinated value chain support. Medium-scale cage farmers have medium potential to increase production and low to medium potential to reduce poverty. Large-scale commercial cage farmers have the highest potential to increase national fish production but low potential to reduce poverty, unless they develop institutional innovations to benefit small-scale farmers for example through contract farming schemes (discussed below).

While the findings of this thesis support the emerging paradigm's view of the limited potential of poor aquaculture producers to impact on poverty either directly or indirectly, there remains some ambiguity around the category of fish farmer that has the most potential to reduce poverty through indirect impact pathways. Thus, in order to correctly identify and target the aquaculture systems and farmer categories with the highest potential for poverty impact in different contexts, increased emphasis and clarity are required on the following areas within the emerging paradigm:

i) an understanding of farm classifications which are relevant across aquaculture systems and contexts needs to be developed;

ii) the aquaculture systems and farmer categories targeted for support should be those with the potential to generate the strongest economic multiplier effects;

iii) institutional innovation to overcome high transaction costs and risks is a key requirement for aquaculture systems to grow and hence realise their potential to impact on poverty, economic growth and local and national food security (discussed below).

8.4 EXAMPLES OF INSTITUTIONAL ARRANGEMENTS FOR NON-MARKET COORDINATION

The failure to develop small-scale aquaculture in SSA may not be due to the low growth potential of small-scale fish farmers *per se*, but rather a result of the lack of attention to overcoming the transaction costs and risks facing farmers and other actors functioning in weak institutional environments, to make complementary and mutually dependent investments in supply chains. This section presents examples of some potential institutional arrangements which could be relevant for non-market coordination of small-scale pond and cage aquaculture to overcome these transaction costs. While the exact type and form of the institutional innovations required to develop the small-scale aquaculture sector in Ghana requires further research which is beyond the scope of this thesis, some examples of the types of coordination mechanisms which could be considered, especially forward market contracts and contract farming models are explored below.

Contract coordination represents institutional arrangements between spot market exchange and hierarchy or vertical integration (as found in the large-scale cage farms in Chapter 7) and can offer many of the advantages of vertical integration while allowing producers to retain some independence (Jaffee, 1995:52). Contracts which cover a production cycle and trade in promised rather than already produced goods are referred to as forward market contracts and can vary in form and intensity. Forward resource/management contracts combine forward market sale and purchase commitments with conditions which require producers to use particular inputs and production methods. Arrangements such as these, which incorporate many factor and product transactions, are found in a variety of agreements including franchising and contract farming in the agriculture sector (Jaffee, 1995:53). When comparing a wide range of institutional measures to enhance commodity system coordination, efficiency and market power, Jaffee (1995:62) finds that only two types of arrangement, forward contracts and vertical integration (hierarchy), positively affect all flows, risks and market issues that are likely to hinder market development including information, product, and financial flows, procurement and market risk, and achievement of economies of scale and market power.

Delgado (1999) assesses the role of vertical integration of smallholders with processors and marketers of high value items in SSA and suggests the most common arrangements of contract farming and producer co-operatives provide some of the most lucrative opportunities available to smallholders in SSA. Contract farming arrangements are described as ways to enable small-scale farmers to behave independently except for having a contract with other farmers, traders, processors for the supply of at least one input or factor, and/or sales of output, thus providing the non-market coordination required to support many small-scale farmers. In their guide to contract farming Eaton and Shephard (2001) identify a range of contract farming models (e.g. centralised, nucleus estate, multipartite or joint venture, intermediary and informal models) which are suitable to address the coordination needs of different commodities and their characteristics, resources of the contractor, the social and physical environments and the needs of the farmers and their farming systems. They emphasise that these arrangements must be commercially rather than donor or government driven in order to be successful. A range of contract types are also identified, summarised by Jaffee and Morton (1995) as marketing contracts, production-management contracts and resource providing contracts in order of increasing levels of control given to the contractor with regard to production management and provision of inputs.

Bijman (2008) notes that products which have heterogeneity in quality and are high value, perishable and technically difficult to produce are more likely to require vertical coordination between buyers and sellers (as argued in Chapter 7). Bijman (2008) indicates that contract farming is thus likely to be used for perishable products such as dairy and commodities which involve technical difficulty in production such as poultry and quality sensitive products such as high value fruits and vegetables. Thus contract farming is likely to be appropriate for production of farmed fish, which incorporates all these commodity characteristics. Delgado (1999) also arrives at similar conclusions using a rough analysis which scores 24 commodities commonly produced in rural Africa for the presence of 10 commodity specific transaction cost factors related to production and marketing, identifying the common forms of market organisation observed in SSA for each commodity. Aquaculture was among the commodities with the highest level of production and marketing related transaction costs (scoring 8 out of 10, the same as cocoa, industrial swine, palm oil and tobacco, with export vegetables, Arabica coffee, dairy, tea and cut flowers scoring higher). The market organisation of all these commodities were found to involve predominantly contract farming and/or large farms. Delgado argues that due to the significant transaction costs associated with aquaculture (as well as with other commodities such as cotton and cocoa) in both production and marketing, it is difficult for independent smallholders to undertake and is better suited to contract farming than large farms due to factors such as quality specificity and the difficulties of monitoring producer effort.

In a rare case study of institutional innovation in aquaculture development in SSA, Karaan (2009) uses a transaction costs approach, similar to Delgado (1999), to show the importance of coordination in the mussel mariculture industry in South Africa. The small-scale sector is characterised by high levels of asset specificity, uncertainty and low transaction volumes and frequency, similar in many ways to the small-scale artisanal pond aquaculture and small-scale cage aquaculture sectors analysed in this thesis. Karaan compares the transaction costs of mussel farming and their possible causes in relation to a range of institutional arrangements. Franchising[91] followed closely by contract farming were found to be more favourable coordination arrangements to deal with these transaction costs than large-

[91] Karaan (2009:248) cites Rudolph (1999) in defining business-format franchising (not product or brand franchising) as a contractual relationship between two or more businesses when certain conditions hold which make this arrangement more long term and vertically integrated than conventional contract farming. Franchisees are provided with the resources, services and inputs required for them to use the franchisor's business model giving franchisees a competitive advantage over other independent farmers. This requires payment of an initial fee and royalties to the franchisor and requires a long term contractual relationship amongst other conditions (Karaan, 2009).

scale vertically integrated farms or small-scale independent farmers engaged in spot market exchange. The theoretical advantages of this type of coordination arrangement were also reflected in practise as the case study was based on a fishing and mussel farming company which implemented a successful pilot project where growers (in this case fishing company workers) were provided assets on a cost-recovery basis as well as extension services, guaranteed markets, inputs on credit, and other logistical assistance.

While no established contract farming or franchising models for aquaculture were observed during field work for this thesis, the relevance of these types of vertically coordinated arrangements for aquaculture development is reflected in the growing private sector interest in establishing such business models in Ghana. At the time of survey, a social enterprise called Tilapiana was conducting pilot testing in Ghana with a view to establishing an aquaculture social enterprise using a franchise business model. Tilapiana's website states that 'just as traditional franchises provide a business in a box, Tilapiana provides a "Profit in a Pond" and gives its franchisees all of the training, supplies, and resources necessary to successfully run a Tilapiana Fish Farm'[92]. While the current status of the project is unknown, it is an indication that innovative institutional arrangements such as franchising for non-market coordination may have an important role to play in developing the small-scale aquaculture sector and that incentives exist for social entrepreneurs and other private sector actors such as larger scale farmers and agribusiness companies to invest in these contractual arrangements. Franchising may be a superior business model to contract farming for small-scale pond aquaculture among poorer farmers in Ghana as a key constraint to adoption is the high and lumpy investment needed in specific assets of pond and fingerlings. As a more vertically integrated model than contract farming, franchising could help to overcome this constraint by facilitating and encouraging farmers to invest in these specific assets, giving them the assurance that the complementary investments needed to make their

[92] http://tilapiana.com/?page_id=57 (accessed 8 March 2013).

investment profitable are also being made along the supply chain at the same time.

This interest in developing commercially driven institutional arrangements is also seen in the cage aquaculture sector. The Triton Group, an international seafood trading company with an annual turnover of over US$500 million, was in the process of establishing a cage farm in Lake Volta in 2010/2011. The company had decided to vertically integrate their marketing activities with production by producing farmed fish to sustain their seafood trading business and compensate for the declining supplies from capture fisheries. The cage farm was at the pilot stage at the time of interview but was expected to expand rapidly as Triton was planning to invest US$20 million in the coming three years on a feed plant, hatchery, and grow out cage farm. The manager indicated that Triton was interested in establishing a contract farming scheme with small-scale cage farmers once their farm and input production operations were established in 2013/2014. Triton plans to produce 10,000 tonnes of fish per year but requires a further 50 to 100,000 tonnes. However due to the high risks involved in large-scale production related to management of such a large labour force[93] such as shirking, as well as theft which was thought to be an even bigger problem (also experienced by both Tropo and WAF), Triton plans to establish a contract farming scheme with small-scale cage farmers who can take on these risks. The farmers would make an agreement with Triton where they would provide collateral in the form of property deeds, land[94] etc. to reduce the incentive for side selling and contract default and ensure compliance. The agreement would involve supply of fingerlings, feed and technical advice to farmers along with output marketing where Triton would set the price of fish that they will buy from them in 6 months in a forward contract[95].

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[93] For 100,000 tonnes it was estimated that 1,500 local labourers would be needed along with 100 expatriates

[94] While land and property may be hard for small-scale artisanal farmers to offer as collateral, this is not the case for small-scale cage farmers who are generally better off (see Chapters 6 and 7).

[95] The economics to produce 1kg of fish in this way were calculated as follows:
Seed cost of US$0.3, feed cost of US$1.2, additional costs (e.g. labour, capital costs etc.) of US$0.7 totalling US$2.2. Triton would then buy at US$2.8/kg and sell at US$3/kg.

As noted above, contract farming involves risks of farmers defaulting on contracts due to side selling, production failure or avoidance of credit repayment. Contractors may also face high transaction costs due to the small size of farmers and their dispersion in rural areas while small-scale farmers may have less bargaining power than with sales to independent buyers. These risks can be reduced if contract farming is coupled with farmer cooperation. Farmer cooperation through establishment of farmer organisations can also provide services to farmers. For example Delgado (1999) points to cases of specialised producer co-operatives, such as dairy co-operatives in Kenya that process and market milk and that often play a similar role to contract farming arrangements in enabling access to assets, information, services and markets, especially for perishable items such as milk, which could also be appropriate for farmed fish. While Kenya has a long and mixed history of supporting smallholder dairy farmers (Omore et al., 1999), there have been successes in the promotion of coordination systems for development of the dairy sector and small farmer intensification in recent years through the 'hub' business model established by Heifer International and scaled up through the East Africa Dairy Development project funded by the Bill and Melinda Gates Foundation (BMGF). The hub model is a system for facilitating complementary investments in the smallholder dominated milk supply chain and overcoming coordination failure, for a perishable good such as milk with some similar techno-economic characteristics to those of farmed fish.

The Hub Model was developed to increase access of small farmers in remote rural areas to lucrative urban output markets, and respond to the need for training, services and supplies to increase smallholder dairy farm productivity. Heifer International – Kenya[96] launched a pilot farmer owned milk collection and chilling centre with a Dairy Farmers Cooperative Society between 1996 and 1999 (where farmers and community members are shareholders in the business) and supported scaling up of a further three

[96] Funded by USAID and Heifer International.

from 2000 to 2003. In 2008 these plants were further scaled up with funding from BMGF, and numbered 20 in 2010 and supplied 10 percent of Kenya's commercially processed milk (Kruse, 2012). Farmers supply their surplus milk to the dairy plant via a network of local transporters. The plant tests, filters, and chills the milk, and sells it on to processors at higher prices than individual farmers are paid due to the large volume of quality controlled milk they can deliver. The well established milk plants have evolved into complex and financially independent rural business centres referred to as Chilling Hubs (CHs), the most successful of which have an annual turnover of over US$2 million, over 70 percent of which is farmer income (Kruse, 2012). These CHs have expanded to include agro-vet supply shops, animal health assistants and veterinary services, artificial insemination services, and deliver farm services, inputs and extension training to farmers. These services have further increased farmers' productivity and enabled the CHs to provide community services such as health insurance and village banking and credit facilities to become financially viable (Kruse, 2012).

Dairy farmers in Kenya face a number of similar constraints to small-scale pond farmers in Ashanti Region outlined in previous chapters such as poor infrastructure and transportation services, limited government services and extension, inadequate private sector service provision and missing markets for credit. These constraints are being successfully addressed through the CHs which provide coordinated and complementary input and marketing services to farmers enabling production intensification and supply chain development despite the weak institutional environment. However the small-scale aquaculture sector in Ghana does not have as long a history of support as the small-scale dairy industry in Kenya. Large numbers of smallholders own dairy cows for household milk consumption in Kenya while in Ghana there are very low number of functional fish farmers. An important prerequisite for the success of the CH model is the ability for farmers to produce a surplus. It appears that the establishment of such a model for aquaculture in Ghana would therefore have to be preceded by direct government or donor support or other means for increasing the level of adoption and productivity of small-scale fish farming beyond a certain threshold, after which a financially sustainable CH or a comparable 'cold store' model could be developed. Also while the volume of smallholder dairy transactions is low, the transaction frequency is high (often daily) albeit seasonal, whereas small-scale fish farming has low volume and frequency of transactions over long production cycles requiring production coordination to ensure a steady supply of fish. While it is beyond the scope of this thesis to study the experiences of this model in depth, analysis of successful coordination models such as this could yield important lessons for promoting small-scale aquaculture in Ghana and elsewhere in SSA and help develop a vision of how the sector could be organised in the future.

In response to farmer demands, a coordination model called One Stop Aqua Shops (OSAS), similar in concept to the CHs above, was started in India by the Network of Aquaculture Centres of Asia-Pacific's (NACA) Support to Regional Aquatic Resources Management (STREAM) initiative in 2005 in Eastern India, benefiting 20,000 farmers[97]. The model has been replicated in Pakistan and Vietnam (Wood and Mayer, 2007) and is currently being piloted in Western Kenya by a consortium of partners coordinated by FARM Africa and funded by DfID. In India the OSASs act as hubs for commercial and small-scale farmers to access good quality seed, feed and technical advice, and help farmers develop linkages with markets and service providers including rural banks (Wood and Mayer, 2007). The OSAS function under a range of models for example in India, some were established by the local Department of Fisheries and others by federations of farmer self help groups (Haylor et al., 2005). In Western Kenya the project is aiming to develop a network of commercially viable franchised outlets in up to 6 locations servicing up to 1000 farmers with local entrepreneurs as franchise owners[98]. While there is limited documentation on OSAS and their impact, and they require more widespread piloting, they provide examples of institutional innovations which have the potential to overcome some of the constraints

[97] http://www.maendeleo-atf.org/News/aquashop.html (accessed 10 June 2012)

[98] http://www.maendeleo-atf.org/News/aquashop.html (accessed 10 June 2012)

discussed in Chapter 7 and above, such as the risk of commitment failure and the need for value chain coordination to enable simultaneous and complementary investments in the aquaculture value chains. The OSAS may thus be an effective way to encourage private sector driven growth of the aquaculture sector and create private-public partnerships in service provision.

The various examples discussed above show the potential for institutional innovation and coordination to overcome some of the transaction costs and risks of small-scale fish farmers in rural areas.

8.5 PRINCIPLES FOR AQUACULTURE DEVELOPMENT

This section outlines some broad principles for aquaculture development, distilled from the results of this thesis, to help guide the development of the small-scale pond aquaculture sector in Ghana. For aquaculture to have the highest potential to impact on poverty, both directly and indirectly, access of small-scale artisanal farmers to the necessary assets, information, skills, capital, services and input and output markets needs to be improved in order to enable them to respond to the growing demand for fish in local and urban markets. These principles therefore focus on the need for institutional innovation and development to enhance the capacity of private sector actors to address the problems of service delivery in thin rural markets for the small-scale artisanal aquaculture sector, though they are also applicable to the development of cage aquaculture, especially the small-scale cage aquaculture sector.

Public goods alone are not sufficient to develop the aquaculture sector

The findings of this thesis lead to the conclusion that while state provision of transport and communications infrastructure, aquaculture research and extension, good governance, and other public goods required to strengthen the institutional environment are extremely important for overall development and economic growth, on their own they may not be enough to encourage private sector participation and investment in the small-scale aquaculture sector. The role of government and other development actors promoting aquaculture in Ghana should be aimed not only at developing a favourable *institutional environment* but also at promoting *institutional arrangements* that reduce the high transaction costs and risks currently faced by all actors within the sector while increasing their transaction returns.

Institutional innovation

If small-scale aquaculture is to be promoted then support is required to facilitate the development of different institutional arrangements to improve farmers' access to production services and output markets, overcome risks of coordination and market failure, engaging both state and private actors. Government policy may be required to support the development of credit, input and output markets so that the transaction costs and risks for farmers and traders and other actors are reduced and they are encouraged to increase their participation in these markets and the wider value chain. Once these markets have increased in volume and effective institutional arrangements have developed to support them and transaction costs and risks have lowered sufficiently, external involvement in these markets can be reduced (Dorward et al., 2004). Since government may not itself have the capacity to develop the necessary institutional arrangements or to effectively support institutional development, there is likely to be an important role for NGOs, donors and development agencies to undertake interventions to develop key credit, input and output markets and institutional arrangements to support aquaculture development. The role of Heifer International and BMGF in developing and scaling up the dairy CHs in Kenya discussed above may provide instructive examples here.

Action research should also be supported to develop and test different types of institutional arrangements (Dorward et al., 2004) with a focus on interlinked contractual arrangements through contract farming and franchise type schemes. As discussed above, these business models appear to provide promising opportunities for growth of the small-scale pond and cage aquaculture sectors. Large farms can also represent a potentially useful source of skills and assets to help organise smallholders into contract farming or franchising schemes and government can play an important role to encourage these types of arrangements by exploring and facilitating links between large farms or agribusiness firms and small-scale farmers. Promoting farmer organisations, building farmers' capacity for example in numeracy and recordkeeping and developing good working relationships between farmers groups and agribusiness is also important. Coordination of input supply and output marketing can be supported by facilitating links between farmers, processors, traders and fingerling suppliers. While this is already being done at a low level by extension staff as noted in Chapter 7, their coordination role is limited by lack of resources and most small-scale artisanal fish farmers in rural areas are not reached therefore development of alternative coordination mechanisms is required.

Stakeholder coordination

Public and private stakeholders need to be brought together, either by government or through a private organisation such as the national Ghana Aquaculture Association[99] (GAA), to address critical issues in the aquaculture sector (such as poor quality fingerlings) and to encourage coordinated investment in the supply chain. Key stakeholders should include small and large farmers, input suppliers, credit providers, traders, farmer organisations, relevant government departments, research organisations, donors and NGOs.

8.6 THESIS LIMITATIONS AND AREAS FOR FURTHER RESEARCH

Limitations in the research conducted for this thesis result from limited resources and data available for analysis of some of the issues addressed in Chapters 5 and 6.

Chapter 5 used a quasi-experimental approach to assessing the impact of small-scale aquaculture as constructing a treatment and comparison group

[99] If the GAA is the coordinating body, stakeholder interests and representation of small-scale pond farmers will have to be overcome. At present, though it is not functional, its membership consists mainly of commercial farmers and service providers.

using an experimental design was not possible. While sampled fish farmers were informally matched with a sample of ‘equivalent’ non-fish farmers, and multivariate regression analysis was used to control for observable characteristics, a rigorous counterfactual scenario was not constructed making it difficult to definitively establish causality between increased income and aquaculture. Further research is needed on the impact of aquaculture on poverty using methodologies that are as close to an experimental design as possible (i.e. randomised control trials), preferably using a ‘difference in difference’ estimation method, in order to overcome the attribution problem and establish causality between aquaculture development and poverty reduction.

The parameters used to estimate the potential economic multiplier effects from fish farming type A and SME cage farming in Chapter 6 were estimated using a range of data sources. The limitations of these estimates were discussed in Chapter 6, Section 6.2.4. A particular weakness was the reliance on budget data which may not be representative of the two groups. However the very large differences between the estimated multiplier effects for the two groups suggest that the broad finding of substantial differences is robust. Nevertheless further research is needed to estimate more precise multiplier effects from aquaculture development, using better representative data to estimate parameters for the multiplier models.

Although Chapter 6 assessed potential environmental linkages of different aquaculture systems, the thesis does not compare the consumption of and contribution to ecosystem services by these different systems. While the growth potentials of different aquaculture systems have been emphasised, assessing the environmental and ecological sustainability of this growth was beyond the scope of the thesis. However consideration of the sustainability of development of different aquaculture systems should be an important component of a comprehensive assessment of aquaculture’s potential contribution to poverty reduction. Further research is thus required to investigate the linkages between different aquaculture systems, the environment and ecosystem services.

Building on the findings of this thesis, further research is also needed to better understand the situation of poor fish farmers in Ghana and if there is an asset and/or a BMP threshold under which fish farmers are unable to increase income and use BMPs respectively, as suggested in Chapter 5. If so, research on the resource constraints faced by poor farmers and ways to overcome these to enable them to maximise the benefits from aquaculture may be required. Alternative production practices or technologies such as Integrated Aquaculture Agriculture (IAA) may also need to be researched for poorer farmers who adopt fish farming primarily to increase fish for home consumption. Research could build on the farmer participatory experiments by Lightfoot et al. (1996) which showed the potential positive impact of IAA on farm sustainability in Ghana. Evidence from Malawi suggests that IAA significantly increases overall farm sustainability as well as protein consumption (Dey et al., 2007). Further research could also investigate the possible poverty alleviation and resilience effects of aquaculture on poor farmers (as opposed to the poverty reduction effects assessed in this thesis). Further research may also be needed to assess the potential poverty impact of SME pond aquaculture development, not investigated in this thesis.

This thesis reports on only one country case study and as noted above, the impact of different aquaculture systems and farmer categories on poverty are likely to vary between contexts. More case studies are needed on aquaculture's direct and indirect contribution to poverty reduction in other SSA countries. Further research is also required on the specific institutional innovations needed in different contexts and on how their development is best facilitated. While contract farming, franchising and the hub model were all discussed as examples of potentially appropriate institutional arrangements, effective institutional innovations need to be developed through participatory action research to enable experimentation with different models, to understand the type of institutional arrangements needed and the forms they should take in different contexts.

8.7 CONCLUDING REMARKS

Promotion of pro-poor aquaculture development requires careful consideration of farmer characteristics and production practices, the relative importance of direct and indirect benefits generated by different aquaculture systems in different contexts, the transaction costs and risks faced by farmers and how they can be overcome, and the institutional environment in which fish farmers and other actors within the sector operate. While it may seem to make intuitive sense that development of 'commercial' SME farming holds more potential to create economic growth and impact on poverty than growth of 'non commercial' artisanal farmers, decisions to target support to one category of farmer over another based on broad and ambiguous definitions have important implications for the direction, focus and impacts of aquaculture development in Ghana and other SSA countries and could result in the misdirecting of aid and aquaculture development efforts.

This thesis has shown that non-poor fish farmers who have been trained and/or are using BMPs (fish farming type A) hold the most potential to impact on poverty indirectly through generating broad based economic growth. However, these better off farmers, would still be categorised as artisanal or 'non commercial' according to standard definitions used by most analysts. The results of this thesis also suggest that support for poor farmers predominantly engaged in fish farming type B and who are unable or unlikely to use BMPs, is not likely to be effective in increasing farmers' incomes or generating economic growth unless their resource constraints are overcome. However due to the demanding techno-economic characteristics of farmed fish and high transaction costs and risks associated with rural aquaculture production and marketing, it is likely the constraints faced by poor farmers would be difficult to overcome. It is these farmers whose characteristics are more likely to correspond to those of the artisanal, 'non commercial' and 'quasi peasant' farmers described in much of the literature. These poor fish farmers may benefit more, along with other poor non-fish farmers, from the potential indirect economic multiplier and other linkage effects generated by small-scale aquaculture development by non-poor rural fish farmers using

BMPs, than through direct impacts of aquaculture. Therefore depending on the definition and characterisation of fish farmers used, the results of this thesis could be seen to either support or question the emerging paradigm. If fish farming type A farmers are categorised as commercial micro enterprises then the thesis results support the paradigm shift. However, it is more likely that these farmers lie somewhere between 'non commercial' and 'commercial' categories and some may be in the process of transitioning between the two. Therefore a more nuanced approach to aquaculture development, which takes in to account the existence of a wide spectrum of farmers whose characteristics and needs differ between contexts and locations as do their categorisations between 'non commercial' or artisanal and 'commercial' farmers, is required if the paradigm shift in aquaculture development is to be successful in being more effective than past efforts to develop the sector in SSA.

Along with highlighting the importance of non-poor small-scale artisanal farmers engaged in fish farming type A to maximise the poverty impact of aquaculture development in Ghana, through their relatively stronger economic multiplier effects, this thesis has also shown the value of taking an institutional perspective on aquaculture development. The transaction costs and risks facing small-scale pond and cage farmers and other actors in the associated value chains are key constraints to aquaculture development, especially in contexts where institutional development is weak. Non-market coordination and institutional innovation are necessary to overcome these costs and risks and for the small-scale aquaculture sector to develop and realise its potential for poverty reduction in Ghana. Such an institutional perspective has not been emphasised in aquaculture development efforts in the past and may well be an important reason that previous efforts to develop small-scale aquaculture in SSA have not been successful. The need for aquaculture development efforts to pay more attention to this is perhaps the most important lesson from this thesis.

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APPENDIX 1: HOUSEHOLD SURVEY QUESTIONNAIRE

We are conducting a study on rural aquaculture. We are interested in understanding the situation of fish farming households in your area and how fish farming has affected people's lives. Your participation in this study will be very useful in generating valuable insights. We would like to assure you that all responses at the individual level would be kept strictly confidential to safeguard your identity. Do you agree to be interviewed?

Yɛreyɛ nhwehwɛ mu bi wɔ nkuraankuraa ɛkuadwuma ho, yɛn ani bɛgye ho sɛ yɛ bɛhu tebea a nkurofoɔ a ɛyɛn nsuomu nnam no wɔ mu, ne senea nsuomo nnaw yɛn aka wɔn a wɔyɛn no asetena. Woho a wode bɛhyɛ saa dwumadi yi mu bɛboa ama yɛanya adwuma no mu nhumu yie. Yɛn ani bɛgye ho sɛ yɛ bɛka akyɛrɛ wo sɛ mmuae biara a wode bɛma yɛn wɔha no yɛ nea yeremma obiara nte bi. So wani gye ho sɛ yɛ bɛbisabisa wo nsɛm bi?

Consent: Interviewer signs that respondent has consented to be interviewed: ……………………………………

Name of Respondent: ……………………………………………

Telephone number: ……………………………………………

Questionnaire ID Number (to be filled in the office)

	Village	District	Region	Country
Location			Ashanti	Ghana
Code				

Name of Interviewer	
Date of Interview	
Time Started	
Time Finished	

Checked by	
Date	

Instruction to interviewer: Fill in the blanks and/or choose the code corresponding to each response.

A. BACKGROUND

1. Have you farmed fish in the past 2 years? ***Wa yɛn nsuomu nam wɔ mfe mienu a atwam no?***	1=yes ***(Go to Q2)*** 2=no ***(Go to 1.a.)***	
1.a. If not, why? ***Sɛ ɛyɛ daabi a, adɛnti?***	…………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	
1.b. Have you completely stopped farming fish? ***So wagyae nsuomu nnam yɛn koraa?***	1=yes ***(Go to Q1.c.)*** 2=no ***(End interview)***	
1.c. If yes, why? ***Sɛ aane a, aden ntia?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ………………………………………………………***(End Interview)***	
2. What year did you start fish farming? ***Afe bɛn mu na wohyɛɛ nsuommu nnam yɛn ase?***		
3. What is your link to fish farming? Are you an owner-operator or caretaker? ***Saa adwuma yi (nsuomu nnam adwuma yi) so ɛyɛ wo ankasa wadwuna:so ɛyɛ wo ankasa wadwuma, anaase; wohwɛ so ma obi; ɛyɛ ɛkuo bi dea?***	1=owner-operator 2=caretaker 3= other (specify) ……..	
4: What type of fish farming do you do? ***Nsuo mu nnam adwuma no, ɛmu deɛ ɛwɔ he na woyɛ?*** ***(Multiple response)*** 1=yes 2=no	Extensive (no feeding)	
	Semi intensive (using mixture of commercial and non commercial feed)	
	Intensive pond aquaculture (using only commercial feed)	
	Other (specify) ___________________	
		1=yes 2=no
5: What type of fish do you farm? ***Enam bɛn na wo yɛn wɔn?*** ***(Multiple response)*** 1=yes 2=no	Tilapia	
	Catfish	
	Heterotis	
	Other (specify) __________	
6. How many ponds did you harvest from in the past 12 months? ***Ponds dodow sɛn na wo yii nam firiimu bɛyɛ bosome dummienu a atwam yi?***		

B. HUMAN CAPITAL

7. How many years have you resided in this village? ***Mfe dodow sɛn na wode atena kurow yi so?***		
8. Where did you reside before? ***Ɛhe fa na na wote ansa na worebɛtena kurow yi mu?***	1= Here since birth 2=Elsewhere in Ashanti Region 3=Elsewhere in Ghana 4=abroad ………………	
9. To what religious group do you belong? ***ɔsom bɛn na wo wɔ mu?***	1= Christian 2=Muslim 3=Traditional 4=No religion 5=Other (specify)…………	
10. To what ethnic group do you belong? ***Wo ye deɛn nii?***	1= Asante 2= Akwapim 3=Fanti 4=Other Akan 5=Ga-Adangbe 6=Ewe 7=Guan 8=Nzema 9=Hausa 10=Dagomba 11=Mamprusi 12=Gonja 13=Grussi/Frafra 14=Dagarti 15=Kusasi 16=Kassena-Nankani 17=Konkomba 18=Nanumba 19=Builsa 20=Other (specify)………………………	
11. How many people are there in your household? ***Wɔ a woni wɔn ti fie no, mo doduɔ yɛ sɛn?*** ***(A person is considered part of the household if he/she usually lives and eats his/her meals in the household's dwelling/compound and if he/she is not away from the household for more than 9 months a year)***		
12. How many are male? ***Mmerema ahi na ɛwɔ hɔ?***		
13. How many are female? ***Mmaa ahi na ɛwɔ hɔ?***		
14. How many are 14 years of age and younger? ***Wɔnaa wɔn adi mfie duɛnan ɛni wɔn a wɔmo ɛ***ndii ***mfie duɛnan wɔmo duduɔ ɛyɛ sɛn?***		
15. How many are 65 years of age and older? ***Wɔnaa wɔn adi mfie ɛduosea ɛnum aboroso no wɔn doduɔ yɛ sɛn?***		
16. How many are going to school? ***Emu duduɔ sɛn na ɛkɔ sukuul?***		
17. How many household members own a non-farm enterprise? ***Wo fie foɔ no, ɛmu duduɔ sɛn na ɛwɔ ɛdwuma a ɛnyɛ ɛfuo?***		
18. How many household members are engaged in paid employment? ***Wo fie foɔ no, ɛmu duduɔ sɛn na wɔ ɛdwuma etua ɛdwumayɛfuɔ ɛka?***		

19. Information on Household head, spouse and fish farmer. ***(Fill in the table below)***

No	**Household member** **Col. 1**	**Sex** Is (the household member) male or female? ***ɔyɛ ɔbaa anaa barima?*** **Col. 2**	**Marital Status** What is (the household member's) marital status? ***So (edin) aware anaa ɔnwaree?*** **Col. 3**	Age **(in yrs)** How old is (the household member)? ***(Edin) adi mfie sɛn?*** **Col. 4**	**Highest level of education** What is the highest level of school (household member) has attended? ***Ehefa na(edin} kɔɔ sukuu kɔd uu yɛ*** **Col. 5**	Primary Occupation **(respondent to decide which is most important occupation)** What is (the household member's) most important occupation in the dry season? And in the rainy season? ***Adwuma titiriw bɛn na (edin) yɛ no ɔpɛ bere ɛna sutɔ bere?*** **Col. 6**	**Col. 7**	Secondary Occupation **(respondent to decide which is second most important occupation)** What is (the household member's) second most important occupation in the dry season? And in the rainy season? ***Sɛ woyi adwuma titiriw a (edin) yɛ no firi hɔ a nea ɛwɔ he na ɛdi hɔ wɔ sutɔ bere ne ɔpɛ bere mu?*** **Col. 8**	**Col. 9**
						Dry season	**Rainy season**	**Dry season**	**Rainy season**
1	Household head								
2	Spouse								
3	Fish farmer if not one of the above								

Col. 2: 1=male, 2=female
Col. 3: 1=married 2=never married 3=widowed 4=separated
Col. 5: 0=None 1=pre-primary 2=primary incomplete 3=primary completed 4= MSLC incomplete 5=MSLC complete 6=secondary incomplete 7=secondary completed 8=university degree 9=other (specify)...............
Cols. 7 to 10: 1=fish farmer 2=maize farmer 3=cocoa farmer 4=farmer of other crops 5=livestock raiser 6=skilled public sector worker 7=unskilled public sector worker 8= skilled private sector worker (artisan) 9= un unskilled private sector worker (labourer, trader) 10=business person – own account 11=business person – employee 12=housewife 13=unpaid family labour (in the home) 14 = unpaid family labour (on-farm or enterprise) 15= house helper/maid 16=below school age 17= at school 18=in higher education 19= unemployed 20= invalid 21=others (specify)___________

20. What are the three most important sources of your household income? Include remittances, if any.
Nneɛma mmiensa a ɛdi kan a ɛma wo nya sika wɔ wabusua yi mu paa ne deɛn. Sɛ yemane wo sika a fa ka ho yɛ no nidiso nidiso fa fi akɛseɛ mu.

Degree of Importance	**Income Source** **Col. 1**	**Percent of Total Household Income (%)** **Col. 2**
1st		
2nd		
3rd		

Col. 1: 1=fish farming 2= cocoa farming 3=farming of other crops 4= livestock raising 5=salaried employment (skilled) 6=salaried employment (unskilled) 7=trading/vending 8=wage labour 9=own enterprise (farm) 10=own enterprise (nonfarm) 11=remittances 12=others (specify) ……………………

21. What percentage of total household income came from fish farming in the past 12 months? ***Sika a abusua no nya fii nsuomu nnam yɛn mu bɛyɛ afe ni no, bɛyɛ ɔha mu nkyekyemu ahe?***	

22. What is the division of labour between men, women and children within your household in the following activities related to fish-farming? Which activities are done by hired labour? Which activities are done by the Government Fisheries Department?

Nnwuma bɛn na mmarima, mmaa ne mmofra a wɔyɛ wabusuafoɔ ne apaafoɔ ɛyɛ wɔ nsuomunnam adwuma no ho. Adwuma bɛn na Aban asoɔyɛfoɔ a yɛfrɛ wɔn fisheries foɔ no yɛ fa nsuomu nnam yɛn adwuma no ho?
(Read out each activity and fill in the table below)

Activity	**Labour Division** **Col. 1**	**Hired Labour 1= yes 2 = no** **Col. 2**	**Government Fisheries Department 1= yes 2 = no** **Col. 3**
Pond construction/ ***Pond tuo***			
Pond preparation/ ***Pond a yeresiesie mu***			
Fingerling procurement/ ***Adwenemma ne mpataa mma a worekɔtɔ***			
Feed procurement/ ***Mmoa no aduane a worekɔtɔ***			
Fertilising/ ***Ɔyɛasase yie***			
Feeding/ ***Wo mmoa no aduane ma***			
Weeding/ ***Pond no ho adodɔadodɔ***			
Sampling fish for growth/ ***Woo yi mmoa no bi afiri pond no mu ahwɛ sɛdeɛ wɔn nyini te***			
Harvesting/ ***Woo yi ɛnnam no afi pond no mu***			
Marketing/ ***Woo tɔn ɛnnam no***			
Processing/ ***Wo resiesie ɛnnam no ho***			
Record keeping/ ***Wo reyɛ mmoa no ho kyerew tohƆ***			
Others (specify) _____________ ***nea ɛkeka hoo***			

Col.1
1= Household labour - purely male activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmarima nkoaa adwuma
2= Household labour - mainly male activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmarima na Ɛtaa yƐ saa adwuma yi
3= Household labour - purely female activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmaa nkoaa adwuna
4= Household labour - mainly female activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmaa na ɛtaa yɛ saa adwuma yi
5= Household labour - shared by both males and females/ *Wo abusuafoɔ a woyɛ wo mmoa* - mmaa ne mmarima nyinaa yɛ bi
6= Household labour - purely children's activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmofra nkoaa adwuma
7= Household labour - mainly children's activity/ *Wo abusuafoɔ a woyɛ wo mmoa* - ɛyɛ mmofra na ɛtaa yɛ saadwuwa yi
99=not applicable (N.A.)

C. NATURAL CAPITAL

23. Access to Land ***(Fill in the table below).***

Landholding	**Size**	
	No. of Units Col.1	**Unit Col. 2**
23a. What is the area of land owned by the household? ***Asaase a wodi yɛ kua a ɛyɛ wo ni wo abusuafoɔ dea no, ne kɛseɛ yɛ sɛn?***		
23b. What is the area of land **leased** from the government or the chief? ***Wo asaase a wo de yɛ kua dwuma a ɛfiri aban anaa ohene hɔ no, ne kɛseɛ no ɛyɛ sɛn?***		
23c. What is the area of land **rented** from others? What is it used for? ***Wo asaase a wo de yɛ kua dwuma a wo ahan no ne kɛseɛ no ɛyɛ sɛn?***		
23d. What is the area of land used for **sharecropping**? ***Wo asaase a wo de yɛ kua dwuma no emu dodow sɛn na wode ayɛ dɔ ma yɛ nkyɛ.***		
23e. What is the area of agricultural land **leased** to others? ***Wo asaase a yɛ de yɛ kua dwuma a wodi ama afoforoɔ no, ne kɛseɛ no ɛyɛ sɛn?***		

Col. 2: 1=square meters 2=hectares 3= acres 4= feet 5=other (specify_______)

24. What sources of freshwater are available to you for your fish farming operations? ***Nsuo a wobɛtumi de ayɛn nnam ahorow Sɛn na wahu wɔ ha? (Multiple response)*** 1=yes 2=no	deep well/ground water	
	Rainwater	
	irrigation canal	
	river/stream/lake	
	Reservoir	
	others (specify) ……	
25. How many pond(s) do you currently have access to for fish farming? ***Ponds dodow sɛn na wobɛtumi de ayɛn nsuo mu nnam seesei yi ara?***		

26. Access to ponds (***Fill the table below)***

Ponds	**No.**	**Size**		**Used for What?**	**Functional in 2010? 1=yes 2=no**
		No. of units	**Units**		
		Col. 1	**Col. 2**	**Col. 3**	**Col. 4**
26.a. List the surface area of each pond **owned.** What is the size of each pond? What is each one used for? Which ones were functional in 2010? ***Kyerɛ yɛn wo pond biara a ɛyɛ wo dea sɛnea ne kɛseɛ teɛ*** ***Edeɛn na wodi biara ɛyɛ?*** ***Deɛhi na ɛyɛɛ adwuma paaa afi 2010 ni mu?***					

Col. 2: 1=square meters 2=hectares 3= acres 4=feet 5= other (specify_______)
Col. 3: Land use 1=rearing pond 2=nursery pond 3= hatchery 4=other (specify______) 5=other (specify_____)

D. SOCIAL CAPITAL

27. What sources of information (e.g. advice, technical assistance etc.) on fish farming are available to you? How useful have they been? (very poor, poor, satisfactory, good, very good?).

Mmeae a wobɛnya nsuomunnam yɛn ho nsɛm bɛn na wo nnim? ɔkwan bɛn so na ɔmo aboa wo? (ɛnyɛ koraa, ɛnyɛ, ɛyɛ kakra, ɛyɛ, ɛyɛ paa?). (Multiple response) (Read out options and fill in table below)

Provided by	1=yes 2=no Col. 1	Quality Col. 2
a. other farmers/ ***akuafoɔ afoforo***		
b. friends/relatives ***nnanfoɔ*** / ***abusuafoɔ***		
c. government extension staff/ ***Extensionfoɔ***		
d. university/ ***Sukuupɔn***		
e. NGO		
f. hatchery/ ***Baabi a yɛyɛn nsuomu nnam mma***		
g. radio		
h. TV		
i. feed supplier/ ***Wɔn a wɔtɔn mmoa no aduan***		
j. other (specify)________________		
k. other (specify)________________		

Col. 2: 1=very poor/ ***ɛnyɛ koraa*** 2= poor/ ***ɛnyɛ*** 3= satisfactory/ ***ɛyɛ kakra*** 4=good/ ***ɛyɛ*** 5=very good/ ***ɛyɛ paa*** 99=NA

28. Have you received any training in fish farming? ***So wanya nsuo mu nnam yɛn ho ntetеɛ bi da?***	1=yes ***(Go to Q29)*** 2=no ***(Go to Q30)***	

29. If yes, who provided the training? When? How useful was it? ***(Fill in table below)***.

Se mmuaeɛ no yɛ aane a,Hwan na Ɔmaa wo saa ntetеɛ no? Dabɛn na wo faa saa nteteyeɛ ni mu? Mfasoɔbɛn na sa ntetеɛ yi ɛdi abere wo?

Provided by Whom? Col. 1	Year Col. 2	How useful? Col. 3

Col.1: 1=Agricultural Extension staff 2= Government Fisheries Department 3=NGO 4=University 5=Private Company 6-other specify……………

Col. 3: 1=very poor/ ***ɛnyɛ koraa*** 2= poor/ ***ɛnyɛ*** 3= satisfactory/ ***ɛyɛ kakra*** 4=good/ ***ɛyɛ*** 5=very good/ ***ɛyɛ paa*** 99=NA

30. How many times in the last 12 months did members of your household visit or contact a fisheries extension agent or an agricultural/fisheries extension center to discuss fish production? ***Mpɛn dodow ahe wɔ bosome 12 a atwam ni na wabusua no mu nii bi kɔsraa Agric Extension foɔ no, anaa Fisheries foɔ no, anaa wɔn asoeɛ hɔ kɔ dii ɛnnam yɛn no ho nkɔmmɔ.***		
31. How many times in the last 12 months has any aquaculture extension agent visited? ***Mpɛn dodow ahe wɔ bosome 12 a atwam ni na Fisheries Extension mpaninfoɔ no bɛsraa wo?***		
32. At present, are you a member of any livelihood association (including Fish Farmers' Association, Cooperative Society etc.)? ***Mprenpren so woka nkɔsoɔ kuo bi ho, te sɛ nsuomu nnam yen kuo anaa nkabom kuo bi ho?***	1=yes ***(Go to Q33)*** 2=no ***(Go to Q34, Section E)***	

33. If yes, what association(s) are you a member of? How has your association helped disseminate information on fish farming technology and management practices? What else has your association helped you with? How long have you been a member of the association?

Sɛ mmuaeɛ no yɛ aane a, ɛkuo bɛn na woka ho? Ɛkwan bɛn so na ɛkuo no aboa wo ama wanya ɛnnam yɛn ho nimdeɛ a ɛbɛboa wo wɔ wadwuna no mu. ɛdeɛ bɛn bio na ɛkuo no aboa wo wɔ mu. Mfie dodow ahe na wode ayɛ ɛkuo yi ba. (***Fill in table below)***

No.	Name of Association Col. 1	Role of the Association in Information Dissemination on Technology Col. 2	Role of Association in other areas (e.g. input purchase, marketing, credit etc.) Col. 3	No. of Years as Member Col. 4
1.				
2.				
3.				

E. FINANCIAL CAPITAL

34. Have you received any financial assistance (for anything including fish farming) in the past 5 years? ***Wɔɔ mfie nnum a atwan yi no so woanya mmoa a ɛfa sika ho a ɛbɛboa wo wɔ wadwuma yi ho?***	1=yes ***(Go to Q35)*** 2=no ***(Go to Q36)***	

35. If yes, when did you obtain assistance? How much did you obtain? Who provided the financial assistance? What was it used for?

Sɛ mmuae no yɛ aane a? Bere bɛn na wo nyaa saa mmoa no? Sika dodow ahe na wo nyaa yɛ. hena na ɔde maa wo. Deɛn na wodi sika no yɛɛ yɛ? (Fill in the table below)

Year Col. 1	Amount (cedis) Col. 2	Provided by Col. 3	Use of the Funds Col. 4

Col. 3: 1= trader 2=moneylender 3=feed supplier 4=fingerling supplier/hatchery 5=relatives/friends 6=private financier 7=rural bank 8=commercial bank 9=cooperative/association 10=NGO 11=government agency 12=savers group 13=village fund 14=others (specify)………..

36. Have you received any other assistance (apart from financial and technical assistance) for your fish farming operations (e.g. labour or seed supply etc.) in the past 5 years? ***So woanya mmoa foforo a ɛnyɛ sika anaa nsuo mu nnam yɛn ho nimdeɛ, ɛma saa wadwuma yi wɔ mfie nnum a atwamu yi?***	1=yes ***(Go to Q37)*** 2=no ***(Go to Q38, Section F)***	

37. If yes, when did you receive assistance? What kind of assistance did you receive? Who provided the assistance?

Sɛ mmuae no yɛ aane a? Bere bɛn na wo nyaa saa mmoa no? Mmoa bɛn na wo nyaa yɛ? Hena na ɔde saa mmoa no maa wo? (Fill in table below)

Year Col. 1	What kind of assistance? Col. 2	Provided by? Col. 3

Col. 3: 1= trader 2=moneylender 3=feed supplier 4=fingerling supplier/hatchery 5=relatives/friends 6=private financier 7=rural bank 8=commercial bank 9=cooperative/association 10=NGO 11=government agency 12=savers group 13=village fund 14=others (specify)………..

F. PHYSICAL CAPITAL

38. Is the main house/dwelling unit: ***Ɛfa efie no ara ho/anaa baabi a woteɛ ho: (read out options)***	1=owned/ ***wo ankasa dea*** 2=rented/ ***wo han*** 3=free use/ ***wo te mu kwa*** 4=others (specify)/ ………….	
39. What materials are used for outside walls of the best house? ***Ɛnneɛma bɛn na wɔde ayɛ afie a edi mu paa no abɔnten fasuo no?***	1= mud/mud bricks 2= wood 3= corrugated iron 4= stone/burnt bricks 5=cement/concrete 6=other (specify)………………..	
40. What materials are used for the roofing of the best house? ***Ɛnneɛma bɛn na wode abɔ afie a edi mu paa no so?***	1= thatch/grass/straw 2= wood 3= corrugated iron 4= cement/concrete 5=asbestos 6=other (specify)…………………	

41. What household assets and facilities do you own? Which are functioning?

Ɛnneɛma a yɛde siesie ɛdan mu bɛn na mo wɔ? Ɛmu nea ɛwɔ he na ɛyɛ adwuma? (Read out assets and fill in table below).

Item	1=yes 2=no Col. 1	Functioning Col. 2
a. Radio		
b. Television		
c. Electric fan		
d. Refrigerator		
e. Telephone/cell phone		
f. Gold jewelry		
g. Bicycle		
h. Boat		
i. Motorcycle		
j. Vehicle (jeep, pick-up, van, etc.)		
k. Water pump		
l. Flush toilet		
m. Latrine		

Code for Col. 2: 1=owned and functioning 2=owned but not functioning 99=NA

42. Please describe the situation you face in the **rainy season** and the **dry season** regarding the following (Is it very difficult, difficult, neither difficult nor easy, easy or very easy?):
Me pa wo kyɛw kyerɛkyerɛ yɛn tebea a wo kɔ mu wɔ sutɔ bere ne ɔpɛ bere mu ɛfa nsɛm a ɛdidiso yi ho (ɛhoo asɛm yɛ den paa, ɛhoo asɛm yɛ den, ɛhoo asɛm yɛ den kakra, ɛhoo asem yɛ mmerɛw, ɛhoo asɛm yɛ mmerɛw paa?)

Facilities	**Rainy season Col. 1**	**Dry season Col. 2**
a. Road access/ ***Lorry akwan ho asɛm***		
b. Access to transport facilities (to transport people/fish/goods/livestock)/ ***Car a yɛde fa nnipa ho nsɛm***		
c. Availability of communication facilities/ ***Mfidie a ɛma yɛ ne obi di nkitaho ho asɛm***		
d. Access to input markets/ ***Beaeɛ a mo tɔ nsuomu nnam wɔyɛn ho nsɛm***		
e. Access to output markets/ ***Beaeɛ a mo tɔn nusomu nnam wɔ ho nsɛm***		
f. Access to a reliable water supply for fish farm/ ***Nsuo a ɛboa ma mo yɛn nnam afe mu no nyinaa***		

Cols 1 and 2: 1=Very Difficult 2=Difficult 3=Neither Difficult nor Easy 4=Easy/ ***ɛhoo asem yɛ mmerɛw*** 5=Very Easy

G. LIVELIHOODS AND AQUACULTURE

		1=yes 2=no	Rank
43. Who or what influenced you to go in to fish farming? Rank them in order of importance. ***Whana, anaa deɛn na ɛmaa wo kɔ yɛn nsuomu nnam?Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.*** ***Read out options (Multiple Response)*** 1=yes 2=no	observation of other fish farms/ ***wo hwɛɛbi wɔ beaɛ bi a wahyɛda ayɛ bi sɛ nnipa nhwɛ***		
	discussions with other farmers/ ***wo ne afoforo bɔɔ ho nkɔmmɔ***		
	discussions with extension worker/ ***wo ne extension adwumayɛfo no bɔɔ ho nkɔmmɔ***		
	advert/programme on TV, radio and/or newspaper ***Adwuma no ho dawurubɔ/wɔ TV so***		
	encouragement from gold mining company/ ***Yɛ nyaa ɛho anigyeno fii Adwuma a ɛtu sika kɔkɔɔ foɔ hɔ***		
	others (specify)/ ***nea ɛkeka ho…………………***		
		1=yes 2=no	Rank
44. Currently, what is your main goal(s) for your fish farming operations? Rank them in order of importance. ***Mprepren wo botaeɛ a ɛwo nsuomu nnam yɛn no ho ne sɛn? Sɛ woyɛ no nnidiso nnidiso a, ɛmu he naɛhia paa.*** ***Read out options (Multiple Response)*** 1=yes 2=no	to increase profit/ ***sɛ ɛbɛma manya mfasoɔ***		
	to increase availability of fish for own consumption/ ***sɛ ɛbɛma manya nsuomu nnam pii adi***		
	to increase farm sustainability/ ***sɛ ɛbɛma kua dwuma akɔ so bere nyinaa***		
	to reduce seasonality of farm income/ ***sɛ ɛbɛma manya sika bere biara***		
	to spread the risk of farm activities/ ***sɛ ɛbɛsi afuo foforo no anan, sɛ afuo no bi sɛe a***		

	others (specify) ……………………..		

45. What is your average culture period? ***Ɛdi mmere pɔtee bɛyɛ sɛn ansa ana wayi ɛnnam no?*** ***(Indicate the number of months)***	

46. How often do you harvest your fish? ***Ɓpɛn dodoɔ ahe na woyi ɛnam yi bi?***	1=quarterly 2= twice yearly 3=once a year 4=less than once a year 5=no specific schedule	

47. In which month(s) did you harvest your main fish harvest in the past 12 months? ***Bosome bɛn mu na wo yii nam paa wɔ bosome dummienu a atwam yi?*** ***(Multiple Response)*** 1=yes 1=no	1= Jan	
	2=Feb	
	3=March	
	4=April	
	5=May	
	6=June	
	7=July	
	8=August	
	9=September	
	10=October	
	11=November	
	12= December	
	13=Didn't harvest	
	14=other	

48. Value of Annual Fish Production in 2010

Type of fish	Sold		Quantity of fish eaten	Quantity of fish given away	Others (specify)	Total Harvest: Sold, Eaten, Given Away, etc. (kg)
	Quantity of fish sold (kg) ***Ɛnnam dodow sɛn na wo tɔm Yɛ***	Amount received ***Sika dodow ahe na wo nya fii mu*** **(if they can't remember ask the farm gate price and calculate) (cedis)**	***Ɛnnam dodow ahe na mo dii yɛ*** **(kg)**	***Ɛnnam dodow ahe na wode kyɛɛ nkurofo*** **(kg)**	______________ **(kg)**	***sɛ wo ka ne nyinaa bom a, ɛnnam dodow ahe na wo yii yɛ***
Col. 1	**Col. 2**	**Col. 3**	**Col. 5**	**Col. 6**	**Col. 7**	**Col. 8**
TOTAL						

Col. 1. 1=tilapia 2=catfish 3=heterotis 4= Others (specify)…………………………………………..

Interviewers' note: If the farmer is unable to answer ask the respondent to estimate how many '34 buckets' (25kgs) of fish they sold, ate and gave away and then calculate

49. How did you pay for the initial investment cost of your fish farming operations? Rank them in order of importance. ***Ɔkwan bɛn so na wofa tuaa ɛka a wo bɔɔ no kane wɔ nsuomu nnam yɛn adwuma yi ho? Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.*** ***(Multiple Response)*** 1=yes 2=no		1=yes 2=no	Rank
	With own savings		
	With a loan from a financial institution		
	With a loan from a friend/relative		
	With assistance from the gold mining company		
	Other (specify)………………		
		1=yes 2=no	Rank
50. Where do you obtain your main stocking material? Rank them in order of importance. ***Ɛhe fa na wo nyaa ɛnam no mma, a wode hyɛɛ aseɛ no fii yɛ? Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.*** ***(Multiple Response)*** 1=yes 2=no	From a government hatchery		
	From a private hatchery		
	From other farmers		
	From own ponds		
	From the wild		
	6= other (specify)………….		
51. Do you use all male fingerlings? ***So wo tumi di mmarima mma no nkwiaa di yɛnsuƆmunam kua adwuma no anaa?***	1=yes 2=no 3=sometimes		
52. At present what do you feed your fish? Rank them in order of importance. ***Seesei ɛdeɛn na wo de ma wo nsuomu nnam no di? Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.*** ***(Multiple Response)*** 1=yes 2=no		1=yes 2=no	Rank
	Formulated floating commercial feed		
	Formulated sinking commercial feed		
	Farmer's own prepared feed		
	Rice bran and groundnut peels		
	Maize bran and groundnut peels		
	Plankton		
	Brewing waste (e.g. malt, pito)		
	Cocoyam leaves		
	Pawpaw leaves		
	Food waste		
	Other (specify)…………………		
53. Do you use fertilisers in your ponds? ***So wode ɔyɛasaaseyiye (fertilisers) gu ponds no mu?***	1=yes ***(Go to Q54)*** 2=no (G***o to Q55)***		

54. What type of fertiliser do you use? ***Ɔyɛ asaaseyiye bɛn na wode di dwama?***

Fertiliser Category	Using or Not? 1=yes 2=no
Organic/***Black soil e.g Poultry manure, cow dung etc.***	
Inorganic (chemical)/***aburokyire yɛasaaseyiye***	

55. Which of the following problems have you experienced in your fish farming operations? Have they been major, minor or insignificant problems?

Ɔhaw a edidi so yi mu nea ɛwɔ, he na wahyia wɔ nsuomu nnam yen adwuma yi mu. So na ɔhaw no yɛ kɛseɛ anaa ketewa? **(*Multiple response) Read out problems below.***

Problem	Significance Col. 1
a. Limited supply of fingerlings on the market/***Ɛnam no mma a ne nya ɛyɛ den***	
b. Limited supply of feed on the market/***Won aduane a ne nya ɛyɛ den***	
c. Late supply of feed/ ***Won aduane no, ɛkyɛ ansa na aba?***	
d. Limited supply of fertiliser on the market/***ɔyɛ asaase yie no nsɛm, ne duduɔ wo dwom te sɛn***	
e. High price of fingerlings/ ***Ɛnam no mma a ne boɔ yɛ den***	
f. High price of feed/***Won aduane a ne boɔ yɛ den***	
g. High price of fertiliser/***ɔyɛ asaase yie a ne boɔ yɛ den***	
h. Difficulty of recruiting labourers/ ***Apaafoɔ ho asɛm a ɛyɛ den***	
i. High cost of labour/ ***Apaafoɔ boɔ a ɛyɛ den***	
j. Lack of technical knowledge/ ***Adwuna no ho nimdee a wonya***	
k. Poor water quality for fish farming/ ***Nsuo a ɛnye papa a wode yɛ adwuma no***	
l. Disease (describe)/***Nyarewa(kyerɛkyerɛmu)***__________________________	
m. Existence of predators (e.g. birds, etc.)/ ***Ɛmmoa bi a ɛkyekye ɛnnam no***	
n. High fish mortality rate/ ***ɛnnam no ɛtaa wu paa***	
o. Theft/ ***Korɔnosɛm***	
p. Conflict with others/ ***Wo ne afoforo ntɛm ntawatawa die***	
q. High cost of constructing structures (ponds, etc.)/ ***Ponds no tuo ne ɛho nneɛma a ne boɔ ɛye den***	
r. Lack of access to land/***Nsaase sɛm a ɛho yɛ den***	
s. Lack of access to credit/***Sika sem a ɛho ye den***	
t. Lack of access to extension services/***Extension adwunay ɛfoɔ no a yɛnnya wɔn mma wɔn mmoa yɛn***	
u. Declining net profits***/ Mfasoɔ a yɛnya wɔ adwuma no so a ɛso rete dabiara***	
v. Drought/ ***ɔpe***	
w. Flooding/ ***nsuyiri***	
x. Others (specify)/***Nneɛma foforo*** _________________________	

Col. 1: 1=major 2=minor 3=insignificant

H. FUTURE OF AQUACULTURE OPERATIONS

56. What are your plans for your fish farming operations in the next five years? ***Ntotoyɛ*** **bɛn na wo wɔ** ***ma saa adwuma yi wɔ Mfie nnum a edi hɔ no?***	1= continue 2= expand 3=reduce 4=discontinue 5= undecided	
57. Why? ***Adɛn ntia?***	…………………………………………………… …………………………………………………… …………………………………………………… ……………………………………………………	

I. LIVELIHOODS - AGRICULTURE AND LIVESTOCK

58. What were the staple crops that your household produced in the past year. Rank them in order of importance. ***Edeɛn ɛnobayɛ na wo ni wo fie fɔ enya yɛ afi a ɛtwaa mu yi? Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.***		1=yes 2=no	Rank
	plantain		
	cassava		
	yam		
	rice		
	maize		
	cocoyam		
	other (specify)…………….		
59. What were the cash crops that your household produced in the past year. Rank them in order of importance. ***Edeɛn ɛnobayɛ na wo ni wo fie fɔ enya yɛ afi a ɛtwaa mu yi? Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.***		1=yes 2=no	Rank
	cocoa		
	vegetables		
	oil palm		
	coconut		
	citrus		
	maize		
	other (specify)…………….		
	other (specify)…………….		

60. Of the following animals, which ones does your household own? How many of each? ***Mmoa yi a edidi so yi mu nea ɛwɔ he na mo wɔ bi? ɛbiaa dodow yɛ sɛn?*** ***(Read out list of animals one by one and record the number owned by the household for each)***	1=draught animals (e.g. horse, bullock, donkey) ***ɛmmoa a yɛde wɔn yɛ kuadwuma***	
	2=cattle including cows	
	3=sheep	
	4= goats	
	5=pigs	
	6=rabbits	
	7=chicken	
	9=other livestock (specify)	
	10= others (specify)………………………	

J. INCOME

61. How much did your household receive in the last 12 months from each of the following sources including the value of any payment in the form of goods?

Sika dodow ahe na wabusua nya fii nneɛma a ɛdidid so yi mu wɔ bosome dummienu a atwamu yi sɛ wode nneɛma bi a ɛnye sika ɛka ho anaa?

	SOURCE	INCOME (cedis)
1.	**Transfers from the state/ aban sika**	
	a. Pension/ *pension sika*	
	b. Illness/disability *ɛdɛm anaa yareɛ bi maa wonyaa sika*	
	c. Social assistance payment/ *sika bi a yɛde boa ahiafoɔ*	
	d. Other (specify)/ *nea ɛkeka ho*____________________	
2.	**Rental income/ *sika a yɛnya fi ade hire mu***	
	a. Land/ *asaase*	
	b. House/ *ɛfie*	
	c. Car/ *kaa*	
	d. Other (specify) *nea ɛkeka ho*_____________________	
3.	**Sale of assets (specify)/ *agyapadeɛ bi a yɛtɔn***	
	a.	
	b.	
	c.	
4.	**Sale of crops (specify)/ *aduade a yɛtɔn***	
	a.	
	b.	
	c.	
	d.	
	e.	
5.	**Sale of livestock (specify)/ *ayɛmoa a yɛtɔn***	
	a.	
	b.	
	c.	
	d.	
6.	**Sales of livestock produce (e.g. milk, eggs etc.) (specify)/ *ayɛmoa ho biibi a yɛtɔn*___**	
	a.	
	b.	
	c.	
7.	**Sale of fish/ *nsuomu nnam a yɛtɔn***	
	a.	
8.	**Employment/ *adwumasɛm***	
	a. Salary, wages, allowances in employment/ *akatua a yɛnya wɔ adwuma mu*	
	b. Other (specify)/ *nea ɛkeka ho*__________________________	
9.	**Household enterprises (specify)/ *ɛfie nnwuma (kyerɛkyerɛ mu)***	
	a.	
	b.	
	c.	
10.	**Gifts (including remittances)/ *akyɛdeɛ (amanɔne sika ka ho)***	
	a. Cash/ *sika*	
	b. Food/ *aduane*	
	c. Other (specify)/ *nea ɛkeka ho*____________________________	
11.	**Other income**	
	a. Private pension	
	b. Investment income, interest from savings	
	c.	
	d.	
	e.	

K. EMPLOYMENT

62. How many people have worked on your fish farming operations for the past 12 months? What types of workers are they? How many days did they work? How much were they paid?

Nnipa dodw sɛn na ayɛ adwuma wɔ wo nsuomu nnam yɛn adwuma yi ho wo bosome dummienu a atwam ni? ɔmo yɛ adwumayɛfo ko bɛn? Nna dodou sɛn na wɔ yɛɛ adwum no? Sika dodow ahe na wo tuaa yɛ?

Type of Worker	Number of persons Col. 1	No. of days worked Col. 2	No. of hrs worked per day Col. 3	Average monthly wage Col. 4	Total Salary/ Wages paid for last 12 months (cedis) Col. 5	Additional benefits if any Col. 6
Owner						
Caretaker						
Regular workers						
Seasonal labourers						
Family labour						
Others _________						

Cols 1-7: 99=NA

63. Did you hire any labourers to work on your crop farming operations in 2010? ***Wo fa edwumayɛ foƆ bi ma wƆn yɛɛ adwuma wƆ wo afuo num?***	1=yes 2=no	

L. OUTPUT MARKETS

64. To whom do you sell your fish harvest? ***Henanom titiriw na wo tɔn ɛnnam no ma wɔn? (Multiple response, insert code 1=yes 2=no)*** 65. Rank in order of importance. ***Sɛ woyɛ no nnidiso nnidiso a, ɛmu nea ɛwɔ he na ɛhia paa.*** 66. Where do you sell your fish harvest for each type of buyer? ***Ɛhe fa na wotɔn nnam no ma wɔn a wɔtɔ no ɛwɔ nsutɔ bere no mu.*** 1= at the farm gate 2 = in the village 3= in the town 4= in other towns (specify where)…………………… 67. Who determines the final price of your product in each market channel? ***Hena na ɔkyerɛ ɛboɔ a ɛsɛ sɛ wotɔn nnam no? (Multiple response)*** 1=myself 2=buyer/trader 3=Fish Farmer Association 4=Cooperative Society 5=Government (Fisheries Department) 6=we negotiate 7=others (specify)…………….		Q.64 1=yes 2=no	Q. 65 Rank	Q.66	Q.67
	Trader				
	Wholesaler/ assembler				
	Retailer (incuding restaurants)				
	Consumer				
	Other (specify) …………………				

68. What were your reasons for choosing each market outlet? ***Ɛdeɛn nyinasoɔ na ɛmaa wotɔn ɛnam no wɔ baabi a wotɔn no no?*** 1=existence of a buyer-seller relationship 2=convenience (proximity/trader comes over) 3 =offers the best price 4=buyer pays in cash 5=others (specify)………. 99=NA	Trader	
	Wholesaler/assembler	
	Retailer (incuding restaurants)	
	Consumer	
	Other (specify)…………………	

69. What restricts you from seeking other market outlets? ***Ɛdɛn na ɛsi wokwan sɛ wobɛpɛ baabi foforo aka baabi a wotɔn ɛnam no ho?***	……………………………………………………………………… ……………………………………………………………………… ……………………………………………………………………… ………………………………………………………………………

70. What problems have you faced in marketing your fish? Have these problems been major, minor or insignificant?
ɔhaw bɛn na wanya wɔ wo nnam tɔn no mu? So Ɔhaw no ƐyƐ kƐse, anaa nea edi hɔ anaa ketewaa bi? (Read out options and fill in table below)

Problem	Significance Col. 1
a. Traders do not stick to agreed price/ ***wɔn a ɛtɔn nnam no bi ntaa ntɔn no ɛboɔ a yɛagge atom***	
b. Unable to take fish to market due to lack of transportation/ ***yɛ ntumi mfa nnam no nkɔ dwa so ɛsane sɛ car ho asɛm yɛ den nti***	
c. Unable to take fish to market due to lack of cold storage facilities/***yɛ ntumi mfa nam no nkɔ dwa so ɛsiane sɛ yɛ ni ɛsuokokyea adaka nti***	
d. Unable to get buyers to come to the farm when fish are ready/***yɛ ntumi nya atɔfoɔ mma wɔn mma mmɛtɔ ɛnnam no ɛwɔ afuom ha bere a ɛnnam no anyin no***	
e. Low price of fish/ ***ɛnnam no boɔ yɛ fo dodow***	
f. Lack of demand as consumers prefer wild caught fish/***Nnipa bɛbree no pɛ nsutene mu nnam no kyɛn nea yɛ yɛn wɔn no***	
g. Lack of demand for smaller size fish/ ***wɔn ani ngye ɛnnam a ɛsusua ho***	
h. Others (specify)/ ***nea ɛkeka ho***……………………..	
i. Others (specify)/***nea ɛkeka ho***……………………..	

Col. 1: 1=major 2=minor 3=insignificant

71. What harvesting system do you practice? ***ɔkwan ben so na wofa so yi ɛnnam no tɔn?***	1=selective (selection of desired fish size for sale and harvesting is done more than once) 2=partial (size selection does not matter and harvesting is done more than once) 3=complete (all the fish are harvested only once)	
72. In the **dry** season what percentage of fish do you sell?: ***Wo ɔpɛ brɛ mu no ɛnnam no mu ɔha mu nkyekyem sɛn na wotɔn?***	1=fresh/ ***nnam mono***	
	2= frozen/ ***nea yɛde ahyɛ fridge mu***	
	3=salted/ ***nea yɛahyɛ no nkyene***	
	4=dried/ ***nea yɛahata***	
	5= smoked/ ***nea yɛaho***	
	6= other (specify)/ ***nea ɛkekaho***	
73. In the **rainy** season what percentage of fish do you sell?: ***Wo sutɔ brɛ mu no ɛnnam no mu ɔha mu nkyekyem sɛn na wotɔn?***	1=fresh/ ***nnam mono***	
	2= frozen/ ***nea yɛde ahyɛ fridge mu***	
	3=salted/ ***nea yɛahyɛ no nkyene***	
	4=dried/ ***nea yɛahata***	
	5= smoked/ ***nea yɛaho***	
	6= other (specify)/ ***nea ɛkekaho***	

M. FOOD AND NUTRITION ***(Ask the respondent's wife or the most knowledgeable household member on food items consumed)***

74. How often does your household consume the following items in a typical week during the **dry season**? (No. of days) ***Wɔ ɔpɛ brɛ mu no, mpɛn dodow ahe na mo di nnuane a edidi so yi wɔ nawɔtwe no mu?***	Farmed fish/ ***nsuomu nnam a yɛ yɛn wɔn***	
	Wild caught fish/ ***Ɛnnam a yɛ kye wɔn wɔ nsutene mu***	
	Eggs/ ***nkosua***	
	Meat/ ***Ɛnnam a ɛnyɛ nsuomu nnam***	
	Milk	
	Vegetables/ ***atosodeɛ***	
75. How often does your household consume the following items in a typical week during the **rainy season**? (Number of days) ***Wɔ sutɔ brɛ mu no, mpɛn dodow ahe na mo di nnuane a edidi so yi wɔ nawɔtwe no mu?***	Farmed fish/ ***nsuomu nnam a yɛ yɛn wɔn***	
	Wild caught fish/ ***Ɛnnam a yɛ kye wɔn wɔ nsutene mu***	
	Eggs/ ***nkosua***	
	Meat/ ***Ɛnnam a ɛnyɛ nsuomu nnam***	
	Milk	
	Vegetables/ ***atosodeɛ***	
76. How many days in the last 7 days did your household eat farmed fish? ***Nna dodow ahe wɔ nnawɔtwe mu na mo abusua no di ɛnnam a yɛ yɛn wɔn wɔ nsuomu?***		
		1=yes 2=no
77. If you eat tilapia, where do you get the tilapia that your household consumes? ***Sɛ wo di apataa a, hene fa na wo nya apataa na wo fie foɔ no di? (Multiple response)*** 1=yes 2=no	Own farm	
	Caught from open waters	
	Purchased from the market	
	Neighbors, friends and relatives	
	Fish farms in the village	
	Fish farmers in other villages	
	Others (specify)…………………………..	
	We do not eat tilapia	
		1=yes 2=no
78. If you eat catfish, where do you get the catfish that your household consumes? ***Sɛ wo di adwene a, Ɛhe fa na mo abusua no nya adwene a mo di no? (Multiple response)*** 1=yes 2=no	Own farm	
	Caught from open waters	
	Purchased from the market	
	Neighbors, friends and relatives	
	Fish farms in the village	
	Fish farmers in other villages	
	Others (specify)…………………………..	
	We do not eat catfish	
79. What percentage of the fish your household consumed in the past year came from your own farm? ***Sɛ yerekyekyem ɔha a, ɛnnam a mo adi no afe nie no mu sɛn na ɛyɛ wo nsuomu nnam?***		

80. Over the last 12 months how has your household's consumption changed for the following types of fish compared to the year before? Has it increased, decreased or stayed the same? ***Sɛ yɛde afe wɛi toto nea atwam ni no ho a, ɔkwan bɛn so na wabusua no nnam a wodi no asesa wɔ nnam a edidid so yi ho?so akɔ soro anaa ɛso ate anaa ɛte sɛdeɛ ɛteɛ.***	1=increased 2=decreased 3=no change	a. Tilapia/ ***apataa***	
		b. Catfish/ ***adwene***	
		c. Other fresh water fish/ ***nsuo mu nnam foforo biara***	
		d. Other marine fish/ ***Ɛpo mu nnam biara***	

81. Over the last 12 months, how difficult was it to provide adequate food for your household in each month? Was it: ***Wo bosome dummienu a atwaa ni no ɔkwan bɛn so na na ɛyɛ den ma wo sɛ wobe nya aduane a edi mu wɔ bosome biara mu?Na:***	1=very difficult / ***Na ɛyɛ den paa*** 2=difficult/ ***ɛyɛ den kakra*** 3=neither difficult nor easy/ ***ɛno a ɛnyɛ den ɛno nso a ɛnyɛ mmerɛw*** 4=easy/ ***na ɛyɛ mmerɛw*** 5=very easy/ ***na ɛyɛ mmerɛw paa***	Jan 2010	
		Feb 2010	
		Mar 2010	
		April 2010	
		May 2010	
		June 2010	
		July 2010	
		Aug 2010	
		Sept 2010	
		Oct 2010	
		Nov 2010	
		Dec 2010	
82. For the very difficult months, explain why they were so difficult. ***Wɔ bosome a na ɛmu yɛ den paa no kyerɛ yen nea ɛnti a na ɛmu ɛyɛ den saa.***	…………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………………………………………………………………………………… …………..		

N. POVERTY AND VULNERABILITY

83. Do you consider your household to be: ***So wo bu wabusua no sɛ***: ***(Read out options)***	1=very poor/ ***ahia wɔn paa*** 2=poor/***ahia wɔn*** 3=not so poor/***ɛnhiaa wɔn kɛse*** 4=well off/***ɛyɛ mma wɔn*** 5=rich/ *wɔ* ***yɛ asikafoɔ***	

84. What type of crisis have you experienced in the last 12 months?
ɔhaw bɛn na wakom wɔ bosome dumeɛnu? (read out crises and fill in table below).

Crisis	1 = yes **2 = no** **Col.1**
a. flood/ ***nsuyiri***	
b. drought/ ***ɔpɛ***	
c. illness in the family/ ***abusua no mu nii bi yaree***	
d. death of a household member/ ***abusua no mu nii bi wuuyɛ***	
e. loss of job/ ***adwuma a ɛfii nsa***	
f. eviction/ ***yɛ tuumi***	
g. financial loss from livelihood/ ***me bɔɔka wɔ madwuma mu***	
h. others (specify) ***nea ɛkeka ho***______________________	

85. How did you cope with the crisis? How significant was each coping strategy used, major, minor or insignificant?
ɔkwan bɛn so na wofa gyinaa ano? ɔkwan a wofaa so no, sɛn na na ɛbiara yɛ soronko? (Read out strategies).

Coping Strategy	Significance Col. 1
a. got a loan from money lender/ ***me nyaa bosea fii obi a ɔbɔ bosea hɔ***	
b. got a loan from friends, relatives, and other persons/ ***me nyaa bosea fii nnamfoɔ, abusuafoɔ ne nnipa afofoforo hɔ***	
c. sold household assets (appliances, etc.)/ ***me tɔn me fie nneɛma bi***	
d. sold livestock/ ***me tɔn me nnyɛnmmoa bi***	
e. sold jewelry/ ***me tɔn magudeɛ bi***	
f. sold land/ ***me tɔn masaase bi***	
g. used family savings/ ***me de abusua no sika bi a yɛ de ato hɔ na ɛyɛɛ***	
h. pawned jewelry *me de magude*/ ***ɛ kɔ sii awoa***	
i. pawned land *me de masaase*/ ***kɔ sii asiwa***	
j. did extra work to earn money***/adwuma bi a ɛka ho di sika bi baayɛ***	
k. others (specify)/***nea ɛkekaho***___________________________	

Col.1: 1=major 2=minor 3=insignificant

O. POVERTY AND AQUACULTURE

86. Does fish farming primarily benefit the poor or the rich? ***Nsuomu nnam yɛn wɔ hɔ yi ɛhe foɔ na ɛboa ɔnw paa, ahiafoɔ anaa asikafoɔ?***	1=poor 2=rich 3=both 4=neither 5=it depends 6=don't know	
87. How? ***ɔkwan bɛn so?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	
88. Do the poor practice fish farming? ***So ahiafoɔ yɛ saa adwuma yi bi anaa?***	1=yes ***(Go to Q90)*** 2=no ***(Go to Q89)*** 3=don't know ***(Go to Q90)***	
89. If not, why not? (probe if necessary e.g. lack of information, financial resources, suitable land etc.) ***Sɛ ɔmo nyɛ bi a, adɛn ntia?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	
90. Does fish farming have any negative Impact on the poor? ***So nsuomu nnam yɛn adwuma no tumi de ɔhaw bi a ɛnyɛ ba ahiafoɔ so?***	1=yes ***(Go to Q 91)*** 2=no ***(Go to Q92)***	
91. If yes, what? ***Sɛ aane a, ɛyɛ dɛn?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	
92. What impact has fish farming had on your household? ***Ɛden nsunsuansoɔ na nsuomu nnam yɛn anya wɔ wabusua so?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	

93. Has fish farming had any impact on the community? ***So nsuomu nnam yɛn anya nsunsuasoɔ bi wɔ mpɔtam ha?*** ***(Interviewer can probe –*** ***e.g. increased fish availability, employment).***	1=yes ***(Go to Q 94)*** 2=no ***(Go to Q95, Section R)***
94. If yes, what? ***Sɛ mmuaeɛ no yɛ aane a? ɛyɛ dɛn?***	…………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………

APPENDIX 2: CAGE FARMER SURVEY QUESTIONNAIRE

A. BACKGROUND

1. What year was this fish farm established?		
2. Are you the owner-operator or a caretaker?	1=owner-operator 2=caretaker 3= other (specify) …………	
3. Are you Ghanaian?	1=yes, 2=no	
4: What type of fish farming do you do? (medium of production) ***(Multiple response)*** 1=yes 2=no	Extensive/culture based fisheries (no feeding)	
	Semi intensive pond aquaculture (using mixture of commercial and non commercial feed)	
	Intensive pond aquaculture (using only commercial feed)	
	Intensive cage culture	
	Other (specify)………………….	
		1=yes 2=no
5: What type of fish do you farm? ***(Multiple response)*** 1=yes 2=no	Tilapia	
	Catfish	
	Heterotis	
	Other (specify) __________	
6. How many cages did you harvest in 2010?		

7. Information on respondent***. (Fill in the table below)***

No	**Fish farm owner**	**Sex**	**Marital Status** What is your marital status?	Age **(in yrs)** How old are you?	**Highest level of education** What is the highest level of school you attended?	Primary Occupation **(respondent to decide which is most important occupation)** What is your most important occupation in the dry season? And in the rainy season?		Secondary Occupation **(respondent to decide which is second most important occupation)** What is your second most important occupation in the dry season? And in the rainy season?	
	Col. 1	**Col. 2**	**Col. 3**	Col. 4	**Col. 5**	Col. 6	Col. 7	Col. 8	Co. 9
						Dry season	**Rainy season**	**Dry season**	**Rainy season**
1	Farm owner								

Col. 2: 1=male, 2=female
Col. 3: 1=married 2=never married 3=widowed 4=separated
Col. 5: 0=None 1=pre-primary 2=primary incomplete 3=primary completed 4= MSLC incomplete 5=MSLC complete 6=secondary incomplete 7=secondary completed 8=university degree 9=other (specify)…………..
Cols. 7 to 10: 1=fish farmer 2=maize farmer 3=cocoa farmer 4=farmer of other crops 5=livestock raiser 6=skilled public sector worker 7=unskilled public sector worker 8= skilled private sector worker (artisan) 9= un unskilled private sector worker (labourer, trader) 10=business person – own account 11=business person – employee 12=housewife 13=unpaid family labour (in the home) 14 = unpaid family labour (on farm or enterprise) 15= house helper/maid 16=below school age 17= at school 18=in higher education 19= unemployed 20= invalid 21=others (specify)___________

8. What percentage of your total household income came from fish farming in 2010?	

9. Access to Land ***(Fill in the table below).***

Landholding	**Size**	
	No. of Units Col.1	**Unit Col. 2**
9a. What is the area of land owned by the household?		
9b. What is the total area of land used for fish farming?		

Col. 2: 1=square meters 2=hectares 3= acres 4= feet 5=other (specify______)

10. Access to cages (***Fill the table below)***

Cages	**No.**	**Size**						**Functional in 2010? 1=yes 2=no**
		Length m2	**Breadth m2**	**Diameter m**	**Depth m2**	**Total volume m3**	**Quantity**	
		Col. 1	**Col.2**	**Col. 3**	**Col. 4**	**Co. 5**	**Col. 6**	**Col. 7**
10.a. What is the size of each cage owned? 10.b. Which ones were functional in the past 12 months?								

If more than 14 list average size of cage and number of each size

B. **PRODUCTION**

11. What is your average culture period? (in months)		
12. How often do you harvest your fish?	1=weekly, 2=twice a month, 3=once a month, 4= quarterly, 5= twice yearly, 6=once a year 7=less than once a year, 8=no specific schedule	

		1=yes 2=no
13. In which month(s) did you harvest your main fish harvest in 2010? ***(Multiple Response)*** 1=yes 1=no	1= Jan	
	2=Feb	
	3=March	
	4=April	
	5=May	
	6=June	
	7=July	
	8=August	
	9=September	
	10=October	
	11=November	
	12= December	
	13=Didn't harvest	
	14=other	

14. Value of Annual Fish Production from cages in 2010

Per cage	**Sold**		**Quantity of fish eaten (kgs)**	**Quantity of fish given away (kgs)**	**Others (specify) ______________ (kgs)**	**Total Harvest: Sold, Eaten, Given Away, etc. (kgs)**
	Quantity of fish sold (kgs)	**Amount received**				
Col. 1	**Col. 2**	**Col. 3**	**Col. 5**	**Col. 6**	**Col. 7**	**Col. 8**
TOTAL						

Col. 1. 1=tilapia 2=catfish 3=heterotis 4= Others (specify)…………………………………………..

15. What was your average size at harvest (kgs)?	
16. Why did you decide to harvest at that size?	

C. INITIAL INVESTMENT

17. How much was the initial investment/start up cost of your fish farming operations? (Including cost of acquiring land if applicable, cages, EPA approval, stocking of cages, labour etc.) GH¢	
18. In what year did you make this investment?	

		1=yes 2=no	Rank
19. How did you pay for the initial investment cost of your fish farming operations? Rank them in order of importance. ***(Multiple Response)*** 1=yes 2=no	With own savings		
	With a loan from a financial institution		
	With a loan from a friend/relative		
	With assistance from an NGO		
	With assistance from a friend/relative		
	Other (specify)………………		

D. INPUTS

		1=yes 2=no	Rank
20. Where do you obtain your main stocking material? Rank them in order of importance. ***(Multiple Response)*** 1=yes 2=no	WRI (pure Akosombo strain)		
	Another government hatchery		
	Crystal Lake (pure Akosombo strain)		
	Data Stream (pure Akosombo strain)		
	Aqua Consult		
	Tropo Farms		
	Maleka Farms		
	Fish Reit		
	Another private hatchery (specify)………….		
	Other farmers		
	Own ponds		
	The wild		
	Other (specify)………….		
21. Do you have any special arrangements with your fingerling suppliers (e.g. purchase on credit, cheaper if bulk purchase etc.)? If so, what?			
22. Do you use all male fingerlings?	1=yes 2=no 3=sometimes		
23. Do you use the Akosombo strain of tilapia to stock your cages? (bought from Akosombo, Crystal Lake and/or Data Stream)?	1=yes 2=no 3=sometimes		

<table>
<tr><td>24. If yes, what impact has the use of the Akosombo strain had on your fish farming operations?
(e.g. increased profit, shorter growth cycle, increased number of cycles per year, larger fish size, increased feed costs etc….)</td><td colspan="3"></td></tr>
<tr><td rowspan="5">25. At present what do you feed your fish?
Rank them in order of importance.
(Multiple Response)
1=yes 2=no</td><td></td><td>1=yes 2=no</td><td>Rank</td></tr>
<tr><td>Formulated floating commercial feed</td><td></td><td></td></tr>
<tr><td>Formulated sinking commercial feed</td><td></td><td></td></tr>
<tr><td>Farmer’s own prepared feed – what ingredients do you use?</td><td></td><td></td></tr>
<tr><td>Other (specify)…………………</td><td></td><td></td></tr>
<tr><td>26. If you prepare your own feed what ingredients do you use?</td><td colspan="3"></td></tr>
<tr><td rowspan="9">27. Where do you get your feed from? Rank in order of importance.

(Multiple response)
1=yes 2=no</td><td></td><td>1=yes 2=no</td><td>Rank</td></tr>
<tr><td>Ranaan</td><td></td><td></td></tr>
<tr><td>Nikolesi (Atimpoku)</td><td></td><td></td></tr>
<tr><td>Pira feed depot at Akrade</td><td></td><td></td></tr>
<tr><td>Paul Ansong</td><td></td><td></td></tr>
<tr><td>Maleka</td><td></td><td></td></tr>
<tr><td>CSG Fish Farming (Bioma)</td><td></td><td></td></tr>
<tr><td>Import from abroad</td><td></td><td></td></tr>
<tr><td>Others……………………..</td><td></td><td></td></tr>
<tr><td>28. Do you have any special arrangements with your feed suppliers? (e.g. purchase on credit, cheaper if bulk purchase etc.)</td><td colspan="3"></td></tr>
</table>

E. PROBLEMS

29. Which of the following problems have you experienced in your fish farming operations? Have they been major, minor or insignificant problems? **(*Multiple response) Read out problems below.***

Problem	**Significance Col. 1**
a. Limited supply of fingerlings on the market	
b. Limited supply of feed on the market	
c. Late supply of feed	
d. Late supply of fingerlings	
e. High price of fingerlings	
f. High price of feed	
g. Low quality fingerlings	
h. Difficulty of recruiting labourers	
i. High cost of labour	
j. Lack of technical knowledge	
k. Poor water quality for fish farming	
l. Disease (describe) ___________________________	
m. Existence of predators (e.g. birds, etc.)	
n. High fish mortality rate	
o. Theft	

p. Conflict with others	
q. High cost of constructing structures (cages, etc.)	
r. Lack of access to land	
s. Lack of access to water	
t. Lack of access to credit	
u. Lack of access to extension services	
v. Declining net profits	
w. Drought	
x. Flooding	
y. Turnover/fish kill in August 2010	
z. Water pollution from Akosombo Textiles and other companies	

Col. 1: 1=major 2=minor 3=insignificant

F. INCOME

30. What income bracket would you put your household in for 2010? (i.e. total household earnings from all sources including sale of crops, livestock, assets, employment, remittances, government transfers etc. for 2010). Tick	0-2500 GH¢	
	2500-5000 GH¢	
	5000-7500 GH¢	
	7500-10000 GH¢	
	10000-12500 GH¢	
	12500-15000 GH¢	
	15000-20000 GH¢	
	20000-25000 GH¢	
	25000-30000 GH¢	
	30000-35000 GH¢	
	35000-40000 GH¢	
	40000-45000 GH¢	
	50000-60000 GH¢	
	60000- 70000GH¢	
	Over 70000 GH¢	

G. EMPLOYMENT

31. What permanent and temporary staff were employed in your fish farm in 2010?

Position Col. 1	No. engaged Col. 2	Skilled / unskilled Col. 3	Perm/ temp Col. 4	Number of days worked per year Col. 5	Number of hours worked in a day Col. 6	Average pay per month (or per day if casual staff) Col. 7	No employed from nearby communities Col. 8	Training Col. 9

Col. 9 1=on the job training, 2=on the job training with support of non company staff resource persons, 3= external, in country training 4=external, out of country training, 5=other(specify)…………….

H. OUTPUT MARKETS

<table>
<tr><td rowspan="6">32. To whom do you sell your fish harvest?
(Multiple response) 1=yes 2=no)

33. Rank in order of importance.

34. Where do you sell your fish harvest for each type of buyer?
1= at the farm gate 2 = in the village
3= in the town
4= in other towns (specify where)……………………

35. Who determines the final price of your product in each market channel?

1=myself 2=buyer/trader
3=Fish Farmer Association
4=Cooperative Society 5=Government (Department) 6=we negotiate
7=others (specify)…………....</td><td></td><td>Q.33
1=yes
2=no</td><td>Q. 34
Rank</td><td>Q.35</td><td>Q.36</td></tr>
<tr><td>Trader (500kgs and below)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wholesaler/ assembler</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Retailer (including restaurants)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Consumer</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other (specify)…………………</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">36. How many regular traders does the farm deal with?</td><td colspan="2"></td></tr>
<tr><td>37. Do you have any special arrangements with any
0f your customers - wholesaler/ traders?
E.g. sale of fish on credit, reduced prices for bulk purchase etc.</td><td colspan="5">………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………</td></tr>
<tr><td>38. Does the farm have a schedule of fish sales to the public?</td><td colspan="3">1=yes, 2=no</td><td colspan="2"></td></tr>
<tr><td>39. What is the interval of sales?</td><td colspan="3">1=weekly, 2=twice weekly,
3=once a fortnight 4=monthly,
5=quarterly, 6=other……………….</td><td colspan="2"></td></tr>
<tr><td rowspan="2">40. How much fish can a regular wholesaler/trader,
obtain in a week and/or a month from this farm?</td><td colspan="3">Kgs in a week</td><td colspan="2"></td></tr>
<tr><td colspan="3">Kgs in a month</td><td colspan="2"></td></tr>
</table>

41. Additional notes on value chain: e.g. where do the traders sell the fish? To the community or does it go to Accra/Tema/Kumasi etc??

……
……
……
……
……
……

42. What restricts you from seeking other market outlets?	…………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………

43. What problems have you faced in marketing your fish? Have these problems been major, minor or insignificant?

Problem	**Significance Col. 1**
a. Traders do not stick to agreed price	
b. Unable to take fish to market due to lack of transportation	
c. Unable to take fish to market due to lack of cold storage facilities	
d. Unable to get buyers to come to the farm when fish are ready	
e. Low price of fish	
f. Lack of demand as consumers prefer wild caught fish	
g. Lack of demand for smaller size fish	
h. Difficulty in agreeing a fair price for different size categories of fish	
i. Others (specify) ……………………..	
j. Others (specify) ……………………..	

Col. 1: 1=major 2=minor 3=insignificant

44. What harvesting system do you practice?	1=partial (size selection does not matter and harvesting is done more than once) 2=complete (all the fish are harvested only once)	
45. In the **dry** season what percentage of fish do you sell?:	1=fresh from cage	
	2=fresh on ice	
	3= frozen	
	4=salted	
	5=dried	
	6= smoked	
	7= other (specify)	
46. In the **rainy** season what percentage of fish do you sell?:	1=fresh from the cage	
	2=fresh on ice	
	3= frozen	
	4=salted	
	5=dried	
	6= smoked	
	7= other (specify)	
47. If iced or frozen, who provides ice or freezing facility?	1= farm 2= buyer 3= local ice producers/ sellers near the farm 4=other ………………	

I. POVERTY

48. Do you consider your household to be: ***(Read out options)***	1=very poor 2=poor 3=not so poor 4=well off 5=rich	

J. SOCIAL CAPITAL

49. Are you a member of a Fish Farming Association?	1=yes 2=no	

50. If yes, what association(s) are you a member of? How has your association helped disseminate information on fish farming technology and management practices? What else has your association helped you with? How long have you been a member of the association?
………
………
………
………
………

K. BUDGET

52. Budget for 2010

Item	Quantity	Unit	Unit Price	Total Cost	% of total costs
Variable costs					
Hired labour					
Permanent					
Temporary					
Skilled/unskilled Ratio and % labour cost to each					
Feed					
Feed type 1……………..					
Feed type 2……………..					
Feed type 3………………					
Fingerlings					
Electricity					
Fuel					
Other costs 1					
Other costs 2					
Other costs 3					
Fixed costs					
Operators salary					
Lease costs					
Maintenance costs					
Cage					
Equipment					
Water rent					
Marketing costs					
Preservation					
Processing					
Storage					
Transport					
Commissions					
Waste					
Other costs					
Total cost					
Gross revenue					
Net profit					

53. What was the average cost of your cages?

What was the average cost of each cage? GH¢	Dimensions	Volume	Quantity bought	Year bought

L. LINKAGES WITH SURROUNDING COMMUNITIES

54. What is the status of your relationship with the nearest community/communities?	1=needs improvement 2=good 3=very good	
55. What are the distances between your farm and the two nearest communities (km)	Distance to community 1	
	Distance to community 2	
56. Have any of the infrastructure or other investments made for the purposes of developing your fish farm had any impacts (positive or negative) on nearby communities? E.g. building of access roads, electrification etc.?	1=yes 2=no	

57. If yes, which ones?

Fish farm investment activity	Year	Cost (GH¢)	Impact on community
1.			
2.			
3.			
4.			
5.			

58. Have you used the profits from fish farming to invest in any other local activities? E.g. starting up new businesses etc.	1=yes, 2=no	

59. If yes, which ones?

Investment activity	Year	Cost (GH¢)	Impact on community
1.			
2.			
3.			
4.			
5.			

60. Has the farm been involved in any other specific developmental activity of nearby communities?	1=yes 2=no	

61. If yes, which ones?

Development activity	Year	Cost (GH¢)	Impact on community
1.			
2.			
3.			
4.			
5.			

62. What other impacts has your fish farm had on nearby communities? E.g. Increased fish supply, increased employment (labourers, traders, processors, tilapia joints, transporters of fingerlings/fish/feed etc.), reduced price of fish, increased adoption of cage aquaculture within the community, reduced livelihoods for fishermen through decreased access to fishing grounds, etc.
………
………
………
………
………
………
………
………
………

63. What constraints to growth does your farm and the fish farming sector in Ghana face? E.g. Demands for traceability, certification requirements, lack of cold chain, government regulations, difficulty exporting, EPA requirements, high costs of doing business etc.

……
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……
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……
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……

APPENDIX 3: EXPRESSIONS FOR MARGINAL BUDGET SHARES AND EXPENDITURE ELASTICITIES[100]

Using equation (2) in Section 4.3.2:

$$\omega_{ij} = \alpha_j + \beta_j \ln(x_i) + z_i \gamma_j + \upsilon_{ij}, \qquad i = 1,2, \ldots \ldots n \qquad \text{(A1)}$$

the MBS for good *j* and household *i* is defined as follows:

$$mbs_{ij} = \frac{\partial c_{ij}}{\partial x_i}$$

where c_{ij} is the consumption of good *j* by household *i*, and x_{ij} is the total consumption by household *i*.

The budget share of good *j* and household *i* is defined as:

$$\omega_{ij} = \frac{c_{ij}}{x_i}$$

so the partial derivative of the budget share with respect to total consumption is:

$$\frac{\partial \omega_{ij}}{\partial x_i} = \frac{x_i \frac{\partial c_{ij}}{\partial x_i} - c_{ij} \frac{\partial x_i}{\partial x_i}}{x_i^2} = \frac{\beta_j}{x_i} \qquad \text{(A2)}$$

By solving for $\frac{\partial c_{ij}}{\partial x_i}$ in equation (A2) we get:

$$mbs_{ij} = \beta_j + \frac{c_{ij}}{x_i} = \beta_j + \omega_{ij} \qquad \text{(A3)}$$

The OLS estimates and the mean budget shares can be used to calculate MBS (A3).

The expenditure elasticity of good *j* for household *i* is computed as:

$$\eta_{ij} = \left(\beta_j + \omega_{ij}\right) \frac{1}{\omega_{ij}} = \frac{\beta_j}{\omega_{ij}} + 1 \qquad \text{(A4)}$$

[100] The derivation of expressions for MBS and expenditure elasticity is taken from Castaldo and Reilly (2007).

APPENDIX 4: CAGE FARM LABOURER SURVEY QUESTIONNAIRE

Questionnaire ID……………………………………
Name of farm…………………………………………
Location …………………………………………………
Date………………………………………………………..

1.Name of labourer…………………………………………………………………………………………………

2. Gender……

3. Age…….

4. Highest level of education……………………………………………………………………………………..

5. Marital status…….

6. Home town (within community, district, region, Ghana)

………

7. Are you the head of your household?...

8. How many people are there in your household?…………………………………………………………

9. How many dependents do you have?………………………………………………………………………….

10. What is your position at the farm? Is it skilled/unskilled, permanent/temporary/seasonal?

………
………

11. Are you engaged in any other occupations? E.g. are you also a fisherman, a farmer etc?………
………

12. What are your core activities at the farm?
………
……..
………
………

13. Cash earnings per month (or per day if seasonal labourer)

………

14. How does this compare to wages for other jobs that you may be qualified for? e.g. agricultural labourer. Give examples.
………
………
………
………

15. Other benefits of the job (knowledge gained, training opportunities, loan possibilities, bonus, social security contribution, health provision support, appreciation of work, increased access to fish, other benefits…)

………
………
………
………

16. What alternative employment could you get? Are there other jobs readily available to you?
………
………
………
………

17. Duration at current farm…………………………………………………………………………………………………

18. Past jobs (last 5 years, list most recent first)

………
………
………
………
………
……..

19. Do you consider your household to be: very poor, poor, not so poor, well off or rich?..

20. What impact (positive and/or negative) has working at the fish farm had on your household?
………
………
………
………
………
………
………
……

21. If from a nearby community, what impact (positive/negative) have the fish farms in this area had on your community?

………
………
………
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………
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………

APPENDIX 5: SUPPLEMENTARY TABLES FOR HOUSEHOLD SURVEY DATA ANALYSIS PRESENTED IN CHAPTER 5

Table 1: Location of sample households by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
District	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Amansie West	27	28	28	24	31	27	25	30	27
Amansie Central	33	26	29	29	22	26	31	24	27
Adansi North*	40	46	43	48	47	47	44	46	45
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: *Including 2 fish farmer and 2 non-fish farmer households from Obuasi Municipality

Table 2: Poverty headcount of surveyed population by fish farming status

Poverty status	Fish farmer households	Non-fish farmer households	Total households
	%	%	%
Poor	47	63	55
Non-poor	53	37	45
Total population (Nos.)	**595**	**622**	**1217**

Table 3: Household's own perception of poverty by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Very poor and poor	37	31	33	57	41	50	49	35	42
Not so poor	53	38	45	24	38	30	36	38	37
Well off	10	31	22	19	22	20	15	27	21
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 4: Household and demographic characteristics of sample households by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Female headed households (%)	10	0	4	0	9	4	4	4	4
Married household heads (%)	93	97	96	98	88	93	96	93	94
Average household size	9.3 (0.68)	8.1 (0.58)	8.6 (0.45)	9.3 (0.47)	7.3 (0.48)	8.4 (0.36)	9.3 (0.39)	7.7 (0.39)	8.5 (0.28)
Average age of household head	51.0 (1.95)	46.9 (1.90)	48.7 (1.38)	50.8 (1.61)	47.1 (1.91)	49.2 (1.24)	50.9 (1.23)	47.0 (1.34)	48.9 (0.92)
Average number of children age 14 and below	4.0 (0.45)	2.7 (0.30)	3.3 (0.27)	3.3 (0.27)	2.8 (0.34)	3.1 (0.21)	3.6 (0.25)	2.8 (0.22)	3.2 (0.17)
Average number of household members going to school	4.7 (0.50)	4.0 (0.37)	4.3 (0.30)	4.6 (0.34)	3.5 (0.42)	4.1 (0.27)	4.6 (0.29)	3.8 (0.28)	4.2 (0.20)
Average dependency ratio (2)	101.9 (13.33)	67.4 (7.45)	82.4 (7.40)	83.8 (9.06)	87.7 (12.51)	85.5 (7.41)	91.3 (7.68)	76.5 (7.02)	84.0 (5.22)
Average number of years household head has resided in the village	36.2 (3.52)	30.2 (2.48)	32.8 (2.09)	31.4 (2.74)	30.7 (3.48)	31.1 (2.15)	33.4 (2.17)	30.4 (2.06)	31.9 (1.50)
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: (1) Standard errors (SE) in parentheses

(2) Dependency ratio: number of people aged under 15 years and 65 years and over, divided by no of people aged 16-64, multiplied by 100

Table 5: Education of household head by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
None/pre primary	20	8	13	17	6	12	18	7	13
Completed primary	80	90	86	81	94	86	81	92	86
Completed MSLC	63	67	65	67	63	65	65	65	65
Completed secondary	17	23	20	21	13	18	19	18	19
University	3	8	6	5	0	3	4	4	4
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 6: Primary occupation of household head in dry season by fish farming and poverty status

	Fish farmer household heads			Non-fish farmer household heads			Total household heads		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Fish farmer	10	10	10	0	0	0	4	6	5
Maize farmer	0	0	0	2	0	1	1	0	1
Cocoa farmer	23	13	17	19	28	23	21	20	20
Farmer of other crops	57	39	46	57	50	54	57	44	50
Livestock raiser	3	3	3	0	3	1	1	3	2
Unskilled worker	0	8	4	2	0	1	1	4	3
Skilled worker	0	13	7	5	3	4	3	9	6
Business person-own account	3	10	7	10	9	10	7	10	8
Business person-employee	3	3	3	2	0	1	3	1	2
Unemployed	0	0	0	2	6	4	1	3	2
Others	0	3	1	0	0	0	0	1	1
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 7: Primary occupation of household head in rainy season by fish farming and poverty status

	Fish farmer household heads			Non-fish farmer household heads			Total household heads		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Fish farmer	17	8	12	0	0	0	7	4	6
Maize farmer	3	3	3	2	6	4	3	4	4
Cocoa farmer	57	59	58	69	69	69	64	63	64
Farmer of other crops	23	18	20	26	22	24	25	20	22
Livestock raiser	0	0	0	0	0	0	0	0	0
Unskilled worker	0	3	1	2	0	1	1	1	1
Skilled worker	0	5	3	0	0	0	0	3	1
Business person-own account	0	3	1	0	3	1	0	3	1
Business person-employee	0	3	1	0	0	0	0	1	1
Unemployed	0	0	0	0	0	0	0	0	0
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 8: Primary occupation of spouse of household head in dry season by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Fish farmer	4	3	3	0	0	0	1	2	2
Maize farmer	0	0	0	2	0	2	1	0	1
Cocoa farmer	7	16	12	12	22	16	10	19	14
Farmer of other crops	57	29	41	54	37	47	55	32	44
Livestock raiser	4	0	2	0	4	2	1	2	2
Unskilled public or private sector worker	11	26	20	10	7	9	10	18	14
Skilled public or private sector worker	4	5	5	0	7	3	1	6	4
Business person-own account	14	18	17	17	19	18	16	19	17
Business person-employee	0	0	0	2	0	2	1	0	1
Unemployed	0	0	0	2	4	3	1	2	2
Others	0	3	0	0	0	0	0	2	1
Total households (Nos.)	**28**	**38**	**66**	**41**	**27**	**68**	**69**	**65**	**134**

Table 9: Primary occupation of spouse of household head in rainy season by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Fish farmer	7	3	5	0	0	0	3	2	2
Maize farmer	7	0	3	2	4	3	4	2	3
Cocoa farmer	54	42	47	76	48	65	67	45	56
Farmer of other crops	18	21	20	17	33	24	17	26	22
Livestock raiser	0	0	0	0	0	0	0	0	0
Unskilled public or private sector worker	7	21	15	3	4	4	4	14	9
Skilled public or private sector worker	0	5	3	0	4	2	0	5	2
Business person-own account	7	5	6	2	7	4	4	6	5
Business person-employee	0	0	0	0	0	0	0	0	0
Unemployed	0	0	0	0	0	0	0	0	0
Others	0	3	2	0	0	0	0	2	1
Total households (Nos.)	**28**	**38**	**66**	**41**	**27**	**68**	**69**	**65**	**134**

Table 10: Average land size by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Size of land owned (ha)	6.0 (1.38) Median 3.5	8.2 (1.28) Median 5.1	7.2 (0.94) Median 4.1	4.4 (0.75) Median 3.7	7.2 (1.35) Median 4.9	5.7 (0.73) Median 4.1	5.1 (0.72) Median 3.5	7.8 (0.93) Median 4.9	6.4 (0.59) Median 4.1
Size of land leased (ha)	0.1 (0.08) Median 0	0	0.04 (0.04) Median 0	0.02 (0.02) Median 0	0.3 (0.32) Median 0	0.2 (0.14) Median 0	0.1 (0.04) Median 0	0.1 (0.14) Median 0	0.1 (0.07) Median 0
Size of land rented (ha)	0.1 (0.11) Median 0	0.2 (0.12) Median 0	0.2 (0.08) Median 0	0.1 (0.08) Medan 0	0.8 (0.52) Median 0	0.4 (0.23) Median 0	0.1 (0.06) Median 0	0.4 (0.24) Median 0	0.3 (0.13) Median 0
Size of land sharecropped (ha)	1.4 (0.95) Median 0	1.0 (0.49) Median 0	1.1 (0.49) Median 0	1.7 (0.69) Median 0	0.9 (0.36) Median 0	1.4 (0.42) Median 0	1.6 (0.56) Median 0	0.9 (0.31) Median 0	1.3 (0.32) Median 0
Farm size (land owned, leased, rented and sharecropped) (ha) (1)	7.6 (1.52) Median 4.5	9.4 (1.44) Median 5.9	8.6 (1.05) Median 5.3	6.3 (1.06) Median 4.1	9.2 (1.62) Median 6.9	7.6 (0.93) Median 4.9	6.8 (0.88) Median 4.1	9.3 (1.07) Median 6.1	8.0 (0.70) Median 4.9
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

(1) Average farm size is the sum of land owned, leased, rented and sharecropped but is not necessarily the amount of land under production

Table 11: Housing conditions by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Households who own their homes	90	77	83	79	72	76	83	75	79
Households with corrugated iron roofs	93	100	97	93	97	95	93	99	96
Households with outside walls made of mud/bricks	50	62	57	57	69	62	54	65	59
Households with outside walls made of wood	3	0	1	2	0	1	3	0	1
Households with outside walls made of stone/burnt bricks	27	5	15	14	13	14	19	9	14
Households with outside walls made of cement/concrete	20	33	28	26	19	23	24	27	25
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 12: Households owning livestock by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Households owning draught animal	0	3	1	0	0	0	0	1	1
Households owning cattle	0	5	3	2	0	1	1	2	2
Households owning sheep	20	33	28	17	22	19	18	28	30
Households owning goats	37	33	35	57	38	49	49	35	42
Households owning pigs	7	10	9	2	6	4	4	8	6
Households owning rabbits	0	5	3	0	0	0	0	3	1
Households owning chicken	77	59	67	86	75	81	82	66	74
Households owning grasscutter	3	5	4	0	0	0	1	3	2
Households owning livestock	87	72	78	93	75	85	90	73	82
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 13: Livestock ownership by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Average number of draught animals owned	0	0.05 (0.05)	0.03 (0.03)	0	0	0	0	0.03 (0.03)	0.01 (0.01)
Average draught animal (TLUs) (1)	0	0.04 (0.04)	0.02 (0.02)	0	0	0	0	0.02 (0.02)	0.01 (0.01)
Average number of cattle owned	0	0.4 (0.34)	0.2 (0.19)	0.1 (0.07)	0	0.04 (0.04)	0.04 (0.04)	0.2 (0.19)	0.1 (0.09)
Average cattle (TLUs)	0	0.3 (0.24)	0.2 (0.13)	0.1 (0.05)	0	0.03 (0.03)	0.03 (0.03)	0.2 (0.13)	0.1 (0.07)
Average number of sheep owned	4.3 (2.47)	3.9 (1.34)	4.1 (1.30)	1.6 (0.79)	2.3 (0.88)	1.9 (0.58)	2.7 (1.13)	3.2 (0.83)	3.0 (0.70)
Average sheep (TLUs)	0.4 (0.25)	0.4 (0.13)	0.4 (0.13)	0.2 (0.08)	0.2 (0.09)	0.2 (0.06)	0.3 (0.11)	0.3 (0.08)	0.3 (0.07)
Average number of goats owned	3.6 (1.25)	3.1 (1.02)	3.4 (0.79)	4.7 (1.27)	2.5 (0.75)	3.7 (0.80)	4.2 (0.90)	2.8 (0.65)	3.5 (0.56)

Average goat (TLUs)	0.4 (0.13)	0.3 (0.10)	0.3 (0.08)	0.5 (0.13)	0.3 (0.07)	0.4 (0.08)	0.4 (0.09)	0.3 (0.07)	0.4 (0.06)
Average number of pigs owned	1.7 (1.22)	1.0 (0.53)	1.3 (0.61)	0.5 (0.48)	0.4 (0.32)	0.5 (0.30)	1.0 (0.58)	0.7 (0.33)	0.9 (0.33)
Average pig (TLUs)	0.3 (0.24)	0.2 (0.11)	0.3 (0.12)	0.1 (0.10)	0.1 (0.06)	0.1 (0.06)	0.2 (0.12)	0.2 (0.07)	0.2 (0.07)
Average number of rabbits owned	0	0.4 (0.31)	0.2 (0.18)	0	0	0	0	0.2 (0.17)	0.1 (0.09)
Average rabbit (TLUs)	0	0.01 (0.01)	0.002 (0.002)	0	0	0	0	0.002 (0.002)	0.001 (0.001)
Average number of chickens owned	19.9 (3.42)	33.7 (2.99)	27.7 (7.50)	18.6 (3.95)	41.1 (24.67)	28.4 (10.88)	19.2 (2.69)	37.0 (13.44)	28.0 (6.67)
Average chicken (TLUs)	0.2 (0.03)	0.3 (0.13)	0.3 (0.07)	0.2 (0.04)	0.4 (0.25)	0.3 (0.11)	0.2 (0.03)	0.4 (0.13)	0.3 (0.07)
Average number of grasscutters owned	1.3 (1.33)	0.9 (0.68)	1.1 (0.70)	0	0	0	0.6 (0.56)	0.5 (0.38)	0.5 (0.34)
Average grasscutter (TLUs)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0	0	0	0.01 (0.01)	0.005 (0.004)	0.01 (0.003)
Average total livestock holdings (TLUs)	1.3 (0.45)	1.6 (0.40)	1.5 (0.30)	1.0 (0.23)	1.0 (0.28)	1.0 (0.18)	1.1 (0.23)	1.3 (0.26)	1.2 (0.17)
Total households (Nos.)	**30**	**38**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

(1) Tropical Livestock Units (TLUs) based on Jahnke (1982) using the following conversion factors: draught animals, 0.80; cattle, 0.70; sheep, 0.10; goats, 0.10; pigs, 0.20; rabbits, 0.01; chickens, 0.01; and grasscutters, 0.01. Conversion factors for rabbits and grasscutters were not estimated by Jahnke (1982) but are assumed here to be equal to chickens (0.01)

Table 14: Sources of credit by fish farming and poverty status

	Fish farmer households			**Non-fish farmer households**			**Total households**		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
	%	%	%	%	%	%	%	%	%
Relatives/Friends	0	33	25	25	0	14	20	17	18
Private financier	0	0	0	0	33	14	0	17	9
Rural bank	0	33	25	125	0	71	100	17	55
Cooperative/ Association	0	0	0	0	33	14	0	17	9
NGO	0	0	0	0	33	14	0	17	9
Government agency	100	0	25	0	0	0	20	0	9
Other	0	67	50	0	0	0	0	33	18
Total households (Nos.)	**1**	**3**	**4**	**4**	**3**	**7**	**5**	**6**	**11**

Table 15: Staple crops grown by households in 2010 by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Plantain	97	92	94	90	94	92	93	93	93
Cassava	93	85	88	98	94	96	96	89	92
Yam	77	59	67	60	59	59	67	59	63
Rice	3	8	6	0	9	4	1	8	5
Maize	83	82	83	83	84	84	83	83	83
Cocoyam	83	72	77	79	78	78	81	75	78
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 16: Cash crops grown by households in 2010 by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Cocoa	83	79	81	83	94	88	83	86	85
Vegetables	63	49	55	64	66	65	64	56	60
Oil palm	77	85	81	67	75	70	71	80	76
Coconut	23	23	23	14	19	16	18	21	20
Citrus	27	38	33	26	19	23	26	30	28
Maize	90	90	90	83	91	86	86	90	88
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 17: Sale of crops by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
	%	%	%	%	%	%	%	%	%
Cocoa	87	74	80	83	94	88	85	83	84
Vegetables	23	23	23	21	19	20	22	21	22
Oil palm	47	49	48	50	47	49	49	48	48
Coconut	3	3	3	2	3	3	3	3	3
Citrus	10	15	13	2	9	5	6	13	9
Maize	37	38	38	45	50	47	42	44	43
Plantain	50	56	54	50	56	53	50	56	53
Cassava	43	54	49	69	56	64	58	55	57
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Table 18: Labour participation and government extension services involved in fish farming activities by poverty status

	Fish farmer households		
	Poor	Non-poor	Total
	%	%	%
Pond construction			
Household labour	87	87	87
Hired labour	93	87	90
Government extension services	10	18	14
Pond preparation			
Household labour	87	87	87
Hired labour	80	67	72
Government extension services	10	15	13
Fingerling procurement			
Household labour	83	90	87
Hired labour	20	10	14
Government extension services	20	18	19
Feed procurement			
Household labour	87	95	91
Hired labour	7	0	3
Government extension services	10	5	7
Fertilising			
Household labour	53	79	68
Hired labour	0	0	0
Government extension services	0	5	3
Feeding			
Household labour	97	95	96
Hired labour	10	10	10
Government extension services	0	3	1
Weeding			
Household labour	87	95	91
Hired labour	33	31	32
Government extension services	0	0	0
Sampling for fish growth			
Household labour	70	82	77
Hired labour	20	8	13
Government extension services	10	18	14
Harvesting			
Household labour	83	90	87
Hired labour	47	38	42
Government extension services	7	21	14

Marketing			
Household labour	77	79	78
Hired labour	17	3	9
Government extension services	3	5	4
Processing			
Household labour	63	74	70
Hired labour	20	5	12
Government extension services	3	0	1
Record keeping			
Household labour	73	74	74
Hired labour	13	0	6
Government extension services	3	3	3
Total households (Nos.)	**30**	**39**	**69**

Table 19: Type of household labour used in fish farming activities by poverty status

	Fish farmer households		
	Poor	Non-poor	Total
	%	%	%
Pond construction			
Purely male	67	67	67
Mainly male	3	0	1
Purely female	0	0	0
Mainly female	0	0	0
Shared by both males and females	13	21	17
Purely children	0	0	0
Mainly children	3	0	1
Total	87	87	87
Pond preparation			
Purely male	77	77	77
Mainly male	0	3	1
Purely female	0	0	0
Mainly female	0	0	0
Shared by both males and females	10	8	9
Purely children	0	0	0
Mainly children	0	0	0
Total	87	87	87
Fingerling procurement			
Purely male	73	90	83
Mainly male	3	0	1
Purely female	7	0	3
Mainly female	0	0	0
Shared by both males and females	0	0	0
Purely children	0	0	0
Mainly children	0	0	0
Total	83	90	87
Feed procurement			
Purely male	77	95	87
Mainly male	3	0	1
Purely female	7	0	3
Mainly female	0	0	0
Shared by both males and females	0	0	0
Purely children	0	0	0
Mainly children	0	0	0
Total	87	95	91

Fertilising			
Purely male	30	64	49
Mainly male	10	13	12
Purely female	7	0	3
Mainly female	0	0	0
Shared by both males and females	7	3	4
Purely children	0	0	0
Mainly children	0	0	0
Total	53	79	68
Feeding			
Purely male	80	82	81
Mainly male	0	0	0
Purely female	10	0	4
Mainly female	0	0	0
Shared by both males and females	7	13	10
Purely children	0	0	0
Mainly children	0	0	0
Total	97	95	96
Weeding			
Purely male	87	92	90
Mainly male	0	0	0
Purely female	0	0	0
Mainly female	0	0	0
Shared by both males and females	0	3	1
Purely children	0	0	0
Mainly children	0	0	0
Total	87	95	91
Sampling for fish growth			
Purely male	63	82	74
Mainly male	0	0	0
Purely female	0	0	0
Mainly female	0	0	0
Shared by both males and females	7	0	3
Purely children	0	0	0
Mainly children	0	0	0
Total	70	82	77

Harvesting			
Purely male	73	85	80
Mainly male	0	3	1
Purely female	0	3	1
Mainly female	0	0	0
Shared by both males and females	10	0	4
Purely children	0	0	0
Mainly children	0	0	0
Total	83	90	87
Marketing			
Purely male	57	38	46
Mainly male	0	8	4
Purely female	17	15	16
Mainly female	0	8	4
Shared by both males and females	3	10	7
Purely children	0	0	0
Mainly children	0	0	0
Total	77	79	78
Processing			
Purely male	33	28	30
Mainly male	7	10	9
Purely female	17	21	19
Mainly female	7	13	10
Shared by both males and females	0	3	1
Purely children	0	0	0
Mainly children	0	0	0
Total	63	74	70
Record keeping			
Purely male	63	69	67
Mainly male	0	3	1
Purely female	3	3	3
Mainly female	0	0	0
Shared by both males and females	7	0	3
Purely children	0	0	0
Mainly children	0	0	0
Total	73	74	74
Total households (Nos.)	**30**	**39**	**69**

Table 20: Production cycle of fish farmers by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
Production cycle (months)	11.2 (1.10) Range: 6 - 24	8.9 (0.73) Range: 4 - 24	9.9 (0.64) Range: 4 - 24
Total farmers (Nos.)	**22**	**30**	**52**

Notes: SE in parentheses

Table 21: Production, revenue and distribution of tilapia by fish farming households in 2010 by poverty status

	Fish farmer households		
	Poor	**Non-poor**	**Total**
Average total tilapia harvested (kg)	40.4 (8.59) Range: 0 - 175	131.4* (37.39) Range: 0 - 1020	91.6 (21.98) Range: 0 - 1020
Average amount of tilapia sold (kg)	21.5 (5.86) Range: 0 - 100	109.2 (34.43) Range: 0 - 1000	71.5 (20.38) Range: 0 - 1000
Average amount of on-farm consumption of tilapia (kg)	11.9 (3.67) Range: 0 - 100	14.8 (6.23) Range: 0 – 216	13.5 (3.86) Range: 0 - 216
Average amount of tilapia given away (kg)	7.0 (2.01) Range: 0 – 40	7.8 (2.40) Range: 0 – 80	7.5 (1.61) Range: 0 – 80
Average amount received for tilapia sold (GH¢)	74.5 (23.71) Range: 0 – 500	359.7 (112.09) Range: 0 - 3000	236.8 (66.61) Range: 0 - 3000
Total households (Nos.)	**28**	**37**	**65**

Notes: SE in parentheses

*Based on 36 households

Table 22: Production, revenue and distribution of catfish by fish farming households in 2010 by poverty status

	Fish farmer households		
	Poor	**Non-poor**	**Total**
Average total catfish harvested (kg)	20.7 (6.54) Range: 0 – 105	125.0 (41.17) Range: 0 - 931	78.2 (23.75) Range: 0 - 931
Average amount of catfish sold (kg)	15.1 (5.95) Range: 0 - 100	100.7 (37.70) Range: 0 - 875	62.3 (21.57) Range: 0 – 875
Average amount of on-farm consumption of catfish (kg)	3.5 (0.98) Range: 0 - 15	15.7 (6.94) Range: 0 – 216	10.2 (3.91) Range: 0 – 216
Average amount of catfish given away (kg)	20.2 (0.75) Range: 0 – 15	8.6 (4.00) Range: 0 – 120	5.7 (2.26) Range: 0 – 120)
Average amount received for catfish sold (GH¢)	59.5 (24.04) Range: 0 – 400	341.4 (123.36) Range: 0 - 3500	215.0 (72.45) Range: 0 – 3500
Total households (Nos.)	**26**	**32**	**58**

Notes: SE in parentheses

Table 23: Fish farmers who harvested fish in 2010 by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Fish farmers who harvested fish	82	84	83
Total farmers (Nos.)	**28**	**37**	**65**

Table 24: Fish farmers who sold fish in 2010 by poverty status

	Fish farmers		
	Poor	**Non-poor**	**Total**
	%	**%**	**%**
Fish farmers who sold fish	40	51	46
Total farmers (Nos.)	**30**	**39**	**69**

Table 25: Income in 2010 by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**	**Poor**	**Non-poor**	**Total**
Average total household income	2,173 (253.42)	7,453 (828.47)	5,124 (571.54)	1,951 (174.84)	6,457 (749.28)	3,899 (425.59)	2,043 (146.28)	6,998 (564.51)	4,486 (354.76)
Average per capita income	233 (16.89)	937 (74.90)	626 (60.01)	215 (15.89)	904 (90.41)	513 (56.36)	223 (11.60)	922 (57.58)	567 (41.25)
Average total farm income	1,720 (189.81)	4,980 (623.44)	3,542 (407.36)	1,677 (178.97)	5,326 (783.62)	3,255 (409.56)	1,695 (130.11)	5,138 (489.58)	3,392 (288.38)
Farm income (%)	79	67	69	86	82	83	83	73	76
Average total off-farm income	454 (205.00)	2,473 (633.61)	1,582 (383.31)	273 (71.45)	1,131 (331.36)	644 (155.77)	349 (94.78)	1,860 (381.96)	1,094 (203.80)
Off-farm income (%)	21	33	31	14	18	17	17	27	24
Total households (Nos.)	**30**	**38**	**68**	**42**	**32**	**74**	**72**	**70**	**142**

Notes: SE in parentheses

Table 26: Seasonal diversity of food items consumed, by fish farming and poverty status

	Fish farmer households			Non-fish farmer households			Total households		
	Poor	Non-poor	Total	Poor	Non-poor	Total	Poor	Non-poor	Total
Average number of days per week fish is consumed in the dry season	6.6 (0.20)	5.8 (0.36)	6.1 (0.22)	6.4 (0.21)	6.7 (0.13)	6.5 (0.13)	6.5 (0.15)	6.2 (0.21)	6.3 (0.13)
Average number of days per week eggs are consumed in the dry season	1.7 (0.32)	2.0 (0.29)	1.8 (0.21)	1.7 (0.20)	1.5 (0.33)	1.7 (0.18)	1.7 (0.18)	1.8 (0.22)	1.7 (0.14)
Average number of days per week meat is consumed in the dry season	2.2 (0.37)	3.5 (0.40)	3.0 (0.29)	2.9 (0.27)	3.2 (0.36)	3.0 (0.22)	2.6 (0.22)	3.4 (0.27)	3.0 (0.18)
Average number of days per week milk is consumed in the dry season	0.3 (0.11)	1.3 (0.31)	0.8 (0.19)	0.7 (0.22)	0.8 (0.26)	0.7 (0.17)	0.5 (0.14)	1.0 (0.21)	0.8 (0.12)
Average number of days per week vegetables are consumed in the dry season	6.9 (0.10)	6.9 (0.13)	6.9 (0.08)	6.9 (0.14)	7.0 (0.00)	6.9 (0.81)	6.9 (0.09)	6.9 (0.07)	6.9 (0.06)
Average number of days per week fish is consumed in the rainy season	6.4 (0.25)	5.5 (0.37)	5.9 (0.24)	6.4 (0.21)	6.7 (0.13)	6.5 (0.13)	6.4 (0.16)	6.0 (0.22)	6.2 (0.14)
Average number of days per week eggs are consumed in the rainy season	1.7 (0.32)	2.2 (0.32)	2.0 (0.23)	1.8 (0.20)	1.5 (0.34)	1.7 (0.19)	1.8 (0.18)	1.9 (0.23)	1.8 (0.15)
Average number of days per week meat is consumed in the rainy season	2.2 (0.37)	3.4 (0.41)	2.9 (0.29)	2.8 (0.30)	3.1 (0.33)	2.9 (0.22)	2.6 (0.23)	3.3 (0.27)	2.9 (0.18)
Average number of days per week milk is consumed in the rainy season	0.3 (0.11)	1.7 (0.36)	1.1 (0.23)	0.9 (0.28)	1.0 (0.32)	0.9 (0.21)	0.6 (0.17)	1.4 (0.25)	1.0 (0.15)
Average number of days per week vegetables are consumed in the rainy season	6.9 (0.10)	6.6 (0.23)	6.7 (0.14)	6.8 (0.12)	6.6 (0.28)	6.7 (0.14)	6.9 (0.08)	6.6 (0.18)	6.7 (0.10)
Total households (Nos.)	**30**	**39**	**69**	**42**	**32**	**74**	**72**	**71**	**143**

Notes: SE in parentheses

APPENDIX 6: CHI SQUARE TEST RESULTS FOR HOUSEHOLD SURVEY DATA ANALYSIS PRESENTED IN CHAPTER 5

Reference (1)	Variable	Description of test	df (2)	N	X^2	p value	phi
Table 7	Proportion of households under the poverty line	Difference between FF and NF	1	143	2.52	0.11	-0.13
Table 2, Appendix 5	Proportion of population under the poverty line	Difference FF and NF population	1	1217	30.71	<0.001	-0.16
Table 8	HH own perception of poverty	Difference between poor & non-poor HHs	1	143	2.64	0.1	-0.14
Table 8	HH own perception of poverty	Difference between FF and NF	1	143	4.07	0.04	-0.17
Table 11	HH ownership of land	Difference between FF and NF	1	143	5.36	0.02	0.2
Table 11	Sharecropping	Difference between FF and NF	1	143	1.35	0.25	-0.1
Section 5.2.4 & Table 11, Appendix 5	HH who own their homes	Difference between FF and NF	1	143	1.04	0.31	0.09
Table 11 Appendix 5	HH who own their homes	Difference between poor & non-poor HHs	1	143	1.63	0.20	0.11
Table 11 Appendix 5	HH with corrugated iron roofs roofing mat	Difference between FF & NF	1	143	0.56	0.46	0.06
Table 11 Appendix 5	HH with corrugated iron roofs roofing mat	Difference between poor & non-poor HHs	1	143	2.73	0.099	0.14
Table 13	TV ownership	Difference between FF & NF	1	143	0.68	0.41	0.07
Table 13	TV ownership	Difference between poor & non-poor HHs	1	143	3.2	0.07	-0.15
Table 13	Refrigerator ownership	Difference between FF & NF	1	143	3.6	0.06	0.16
Table 13	Refrigerator ownership	Difference between poor & non-poor HHs	1	143	5.63	0.02	-0.2
Table 13	Phone/mobile ownership	Difference between FF & NF	1	143	2.76	0.097	-0.14
Table 13	Phone/mobile ownership	Difference between poor & non-poor HHs	1	143	9.47	0.002	-0.26
Table 13	Bicycle ownership	Difference between FF & NF	1	143	0.19	0.66	0.04

Reference	Variable	Description of test	df	N	X^2	p value	phi
Table 13	Bicycle ownership	Difference between poor & non-poor HHs	1	143	1.92	0.17	-0.12
Table 13	Motorcycle ownership	Difference between FF & NF	1	143	0.59	0.44	0.06
Table 13	Motorcycle ownership	Difference between poor & non-poor HHs	1	143	1.78	0.18	-0.11
Table 13	Vehicle ownership	Difference between FF & NF	1	143	3.75	0.053	0.16
Table 13	Vehicle ownership	Difference between poor & non-poor HHs	1	143	1.52	0.22	-0.1
Table 13	Water pump ownership	Difference between FF & NF	1	143	7.51	0.06	0.23
Table 13	Water pump ownership	Difference between poor & non-poor HHs	1	143	0.46	0.5	-0.06
Table 13	Latrine ownership	Difference between FF & NF	1	143	0.32	0.57	0.05
Table 13	Latrine ownership	Difference between poor & non-poor HHs	1	143	1.35	0.25	-0.1
Table 12 Appendix 5	Livestock ownership	Difference between FF & NF	1	143	1.13	0.29	-0.089
Table 12, Appendix 5	Livestock ownership	Difference between poor & non-poor HHs	1	143	6.98	0.008	0.221
Table 15	Association membership	Difference between FF & NF	1	143	19.27	0.01	0.37
Table 15	Association membership	Difference poor & non-poor FF	1	143	0.056	0.81	-0.02
Figure 14	HH facing crisis	Difference between FF & NF	1	143	2.35	0.13	-0.13
Figure 14	HH facing crisis	Difference between poor & non-poor HHs	1	143	1.91	0.17	0.17
Figure 14	Crisis – Flood	Difference between FF & NF	1	143	0.4	0.53	0.05
Figure 14	Crisis – Flood	Difference between poor & non-poor HHs	1	143	0.003	0.96	-0.004
Figure 14	Crisis drought	Difference between FF & NF	1	143	7.46	0.006	-0.23
Figure 14	Crisis drought	Difference between poor FF & NF	1	72	7.86	0.005	-0.33
Figure 14	Crisis drought	Difference between poor & non-poor HHs	1	143	2.05	0.16	0.12

Reference	Variable	Description of test	df	N	X^2	p value	phi
Figure 14	Financial loss	Difference between poor & non-poor FF	1	143	3.05	0.08	-0.15
Figure 14	Financial loss	Difference between FF & NF	1	143	2.76	0.097	0.14
Section 5.2.8 & Table 16, Appendix 5	Vegetable production	Difference between FF & NF	1	143	1.43	0.23	-0.1
Section 5.2.8 & Table 16, Appendix 5	Vegetable production	Difference between poor & non-poor HHs	1	143	0.85	0.36	0.077
Section 5.2.8 & Table 16, Appendix 5	Oil palm production	Difference between FF & NF	1	143	2.29	0.13	0.13
Section 5.2.8 & Table 16, Appendix 5	Oil palm production	Difference between poor & non-poor HHs	1	143	1.73	0.19	-0.11
Section 5.2.8 & Table 16, Appendix 5	Citrus production	Difference between FF & NF	1	143	1.9	0.17	0.12
Section 5.2.8 & Table 16, Appendix 5	Citrus production	Difference between poor & non-poor HHs	1	143	0.18	0.67	-0.036
Section 5.2.8	Proportion of HHs engaged in HH enterprises	Difference between FF & NF	1	143	2.93	0.09	-0.14
Section 5.2.8	Proportion of HHs engaged in HH enterprises	Difference between poor & non-poor FF	1	69	1.65	0.20	-0.16
Section 5.2.8	Proportion of HHs engaged in HH enterprises	Difference between poor & non-poor HHs	1	143	0.58	0.45	0.06
Section 5.2.9	HHs using fertiliser (organic and/or inorganic)	Difference between poor & non-poor FF	1	69	3.63	0.057	-0.23
Section 5.2.9	HHs using organic fertiliser	Difference between poor & non-poor FF	1	69	7.614	0.006	0.332
Section 5.2.9	HHs using inorganic fertiliser	Difference between poor & non-poor FF	1	69	2.926	0.087	-0.206
Table 18	Fish farmers contacting extension agents	Difference between poor & non-poor FF	1	69	0.43	0.51	0.08
Table 18	Extension agents visiting fish farmers	Difference between poor & non-poor FF	1	69	5.4	0.02	-0.28
Table 18	Contact with extension agents	Difference between poor & non-poor FF	1	69	2.78	0.095	0.2
Section 5.2.9	FF received training	Difference between poor & non-poor FF	1	69	0.722	0.40	-0.1

Reference	Variable	Description of test	df	N	X^2	p value	phi
Table 20	Motivation to adopt fish farming from observation of other farms	Difference between poor & non-poor FF	1	69	6.125	0.013	0.3
Table 21	Goal increase profit	Difference between poor & non-poor FF	1	69	0.036	0.85	-0.023
Table 21	Goal increase fish own consumption	Difference between poor & non-poor FF	1	69	5.99	0.048	0.24
Table 21	Goal increase farm sustainability	Difference between poor & non-poor FF	1	69	3.91	0.048	0.24
Table 21	Goal reduce seasonality farm income	Difference between poor & non-poor FF	1	69	3.14	0.08	0.21
Table 21	Goal minimize risk	Difference between poor & non-poor FF	1	69	0.89	0.34	0.11
Section 5.2.9 Figure 18	Did not undertake a main harvest in 2010	Difference between poor & non-poor FF	1	69	3.31	0.07	0.22
Section 5.2.9 & Table 24, Appendix 5	Sale of fish	Difference between poor & non-poor FF	1	69	0.868	0.35	0.112
Table 25	Impact of fish farming on HH income	Difference between poor & non-poor FF	1	69	0.911	0.34	-0.116
Table 25	Impact of fish farming on HH fish consumption	Difference between poor & non-poor FF	1	69	2.112	0.15	0.176
Table 26	Impact of fish farming on community fish supply	Difference between FF & NF	1	139	5.441	0.02	0.198
Table 26	No impact of fish farming on community	Difference between FF & NF	1	139	3.448	0.06	-0.157
Table 26	Impact of fish farming on community fish supply	Difference between poor & non-poor	1	139	5.188	0.02	-0.193
Table 26	Impact of fish farming on community fish supply	Difference between poor & non-poor FF	1	139	1.036	0.31	-0.124
Table 26	Impact of fish farming on community fish supply	Difference between poor & non-poor NF	1	139	3.251	0.07	-0.212

Notes: (1) Tables refer to those in Chapter 5 unless otherwise stated

(3) df = degrees of freedom

HH = household(s), FF = fish farming households, NF = non-fish farming households

APPENDIX 7: INDEPENDENT SAMPLES T-TEST RESULTS FOR HOUSEHOLD SURVEY DATA ANALYSIS PRESENTED IN CHAPTER 5

Reference (1)	Description	Mean	SE	df (2)	T-Statistic	p value	Mean difference	95% CI (3)
Table 9	**HH Size**							
	Poor HHs	9.29	0.39					
	Non-poor HHs	7.72	0.39	141	2.86	0.005	1.57	0.49 to -2.66
Table 9	**Age HH head**							
	Poor HHs	46.96	1.34					
	Non-poor HHs	50.9	1.23	141	2.17	0.03	3.95	0.34 to 7.55
Table 4, Appendix 5	**Dependency ratio FF**							
	Poor HHs	101.86	13.33					
	Non-poor HHs	67.39	7.45	46.48	2.26	0.03	34.47	3.74 to 65.20
Table 4, Appendix 5	**Dependency ratio**							
	Poor HHs	91.33	7.68					
	Non-poor HHs	76.54	7.02	141	1.42	0.16	14.79	5.79 to 35.37
Table 4, Appendix 5	**No of children FF**							
	Poor HHs	3.97	0.45					
	Non-poor HHs	2.69	0.3	67	2.44	0.018	1.27	0.23 to 2.32
Table 4, Appendix 5	**No of children**							
	Poor HHs	3.6	0.25					
	Non-poor HHs	2.75	0.22	141	2.56	0.012	0.85	0.19 to 1.51
Table 10	**HH head education (yrs) – FF**							
	Poor HHs	8.48	0.71					
	Non-poor HHs	9.87	0.54	65	-1.58	0.12	-1.39	-3.14 to 0.37
Table 12	**Ha land owned**							
	FF	7.24	0.94					
	NF	5.65	0.73	140	1.34	0.18	1.59	-0.75 to 3.93

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 12	**Ha land owned**							
	Poor HHs	5.1	0.72					
	Non-poor HHs	7.76	0.93	131.15	-2.26	0.025	-2.65	-4.97 to -0.34
Table 12	**Ha land owned –FF**							
	Poor HHs	6.03	1.38					
	Non-poor HHs	8.19	1.28	66	-1.14	0.26	1.89	-5.94 to 1.62
Table 12	**Ha land owned –NF**							
	Poor HHs	4.44	0.75					
	Non-poor HHs	7.24	1.35	49.23	-1.81	0.08	-2.8	-5.90 to 0.31
Table 12	**Land owned FF&NF - poor HHs**							
	FF	4.44	0.75					
	NF	6.03	1.38	70	1.09	0.28	1.59	-1.32 to 4.50
Table 12	**Land owned - non-poor FF&NF**							
	FF	7.24	1.35					
	NF	8.19	1.28	68	0.51	0.61	1.87	-2.78 to 4.69
Table 12	**Total farm size ha**							
	FF	8.58	1.05					
	NF	7.55	0.93	140	0.74	0.46	1.03	-1.73 to 3.78
Table 12	**Total farm size ha**							
	Poor HHs	6.83	0.88					
	Non-poor HHs	9.29	1.07	140	-1.78	0.08	-2.46	-5.19 to -0.28
Table 12	**Total farm size ha – FF**							
	Poor HHs	7.59	1.52					
	Non-poor HHs	9.36	1.44	66	-0.84	0.41	-1.77	--5.99 to 2.45
Table 12	**Total farm size ha – NF**							
	Poor HHs	6.29	1.06					
	Non-poor HHs	9.2	1.62	72	-1.56	0.12	-2.91	-6.62 to 0.80
Table 12	**Total farm size ha – poor HHs**							
	FF	7.59	1.52					
	NF	6.29	1.06	70	0.73	0.47	1.3	-2.27 to 4.88

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 12	**Total farm size ha - non-poor HHs**							
	FF	9.36	1.4					
	NF	9.2	1.62	68	0.075	0.94	0.16	-4.16 to 4.48
Table 13, Appendix 5	**Total livestock holding (TLU)**							
	FF	1.46	0.3					
	NF	0.97	0.18	111.24	1.43	0.5	0.5	-0.18 to 1.17
Table 13, Appendix 5	**Total livestock holding (TLU)**							
	Poor HHs	1.12	0.23					
	Non-poor HHs	1.3	0.26	141	-0.528	0.6	0.34	-0.86 to -0.5
Table 14	**Durable good index**							
	FF	36.76	7.07					
	NF	18.78	4.08	109.5	2.2	0.03	17.98	1.8 to 34.15
Table 14	**Durable good index**							
	Poor HHs	20.27	5.18					
	Non-poor HHs	34.75	6.2	136.39	-1.79	0.08	-14.48	--30.45 to 1.50
Table 14	**Durable good index FF**							
	Poor HHs	22.22	9.52					
	Non-poor HHs	47.95	9.87	66.34	-1.88	0.07	-25.73	-53.11 to 1.65
Table 14	**Durable good index NF**							
	Poor HHs	18.88	5.82					
	Non-poor HHs	18.66	5.64	72	0.027	0.98	0.22	-16.30 to 16.75
Table 14	**Durable good index – poor HHs**							
	FF	18.66	5.64					
	NF	18.88	5.82	72	0.027	0.98	0.22	-17.77 to 24.44
Table 14	**Durable good index - non-poor HHs**							
	FF	47.95	9.87					
	NF	18.66	5.64	59.14	2.58	0.012	29.29	6.55 to 52.03

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 17	**Number of fish farmer visits to extension agents**							
	Poor HHs	1.34	0.47					
	Non-poor HHs	2.97	0.75	60.74	-1.83	0.07	-1.63	-3.41 to 0.14
Table 17	**No of extension visits to FF**							
	Poor HHs	1.28	0.46					
	Non-poor HHs	3.18	0.89	66	-1.72	0.09	-1.9	-4.11 to 0.30
Table 22	**Area individual pond size- FF**							
	Poor HHs	408.34	67.75					
	Non-poor HHs	659.89	139.81	49.68	-1.62	0.112	-251.55	-563.64 to -60.55
Table 22	**Total area ponds owned – FF**							
	Poor HHs	787.22	175.83					
	Non-poor HHs	1187.52	234.64	59.91	-1.37	0.18	-400.29	-986.82 to 186.23
Table 22	**Total area functional ponds – FF**							
	Poor HHs	681.46	117.29					
	Non-poor HHs	1165.29	230.36	50.9	-1.87	0.07	-483.83	-1002.82 to 35.16
Section 5.2.8	**Production cycle –FF**							
	Poor HHs	11.18	1.1					
	Non-poor HHs	8.87	0.73	50	1.83	0.07	2.32	-.35 to 4.98
Table 21, Appendix 5	**Total tilapia harvest – FF**							
	Poor HHs	40.38	8.59					
	Non-poor HHs	131.44	37.39	38.65	-2.37	0.02	-91.07	-168.69 to -13.45
Table 21, Appendix 5	**Total amount Tilapia sold – FF**							
	Poor HHs	21.54	5.86					
	Non-poor HHs	109.22	34.43	38.08	-2.51	0.016	-87.68	-158.38 to -16.98
Table 21, Appendix 5	**HH tilapia consumption – FF**							
	Poor HHs	11.88	3.67					
	Non-poor HHs	14.78	6.23	63	-0.37	0.71	-2.91	-18.58 to 12.77

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 21, Appendix 5	**HH tilapia given away – FF**							
	Poor HHs	6.96	2.01					
	Non-poor HHs	7.84	2.4	63	-0.27	0.79	-0.87	-7.13 to 5.38
Table 21, Appendix 5	**HH revenue sell tilapia – FF**							
	Poor HHs	74.5	23.71					
	Non-poor HHs	359.68	112.09	39.19	2.49	0.017	-285.18	-516.89 to 53.47
Table 22, Appendix 5	**Total catfish harvest – FF**							
	Poor HHs	20.65	6.54					
	Non-poor HHs	125	41.17	32.56	-2.5	0.018	-104.35	-189.19 to -19.5
Table 22, Appendix 5	**Total amount catfish sold – FF**							
	Poor HHs	15.12	5.95					
	Non-poor HHs	100.67	37.7	32.53	-2.24	0.03	-85.54	-163.24 to -7.85
Table 22, Appendix 5	**HH catfish consumption – FF**							
	Poor HHs	3.52	0.98					
	Non-poor HHs	15.7	6.94	32.22	-1.74	0.09	-12.18	-26.45 to 2.09
Table 22, Appendix 5	**HH catfish given away – FF**							
	Poor HHs	2.02	0.75					
	Non-poor HHs	8.64	4	33.18	-1.63	0.11	-12.18	-26.45 to 2.09
Table 22, Appendix 5	**HH revenue sell catfish – FF**							
	Poor HHs	59.46	24.04					
	Non-poor HHs	341.38	126.36	33.23	-2.19	0.04	128.62	-543.53 to -20.30
Table 23	**Total fish harvest – FF**							
	Poor HHs	55.8	11.83					
	Non-poor HHs	239.81	69.23	38.09	-2.62	0.013	-184.01	326.18 to -41.84
Table 23	**Total fish yield (kg/ha/year) – FF**							
	Poor HHs	1303.14	310.14					
	Non-poor HHs	2487.24	681.35	41.58	-1.58	0.12	-1183.68	-2694.89 to 327.54

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 23	**Total amount total fish sold – FF**							
	Poor HHs	35.57	10.35					
	Non-poor HHs	196.27	64.05	37.87	-2.48	0.018	-160.7	-292.06 to -29.34
Table 23	**Total on-farm fish consumption – FF**							
	Poor HHs	15.07	4.2					
	Non-poor HHs	33.77	13.29	42.99	-1.69	0.19	-18.7	-46.81 to 9.42
Table 23	**Total per capita on-farm fish consumption – FF**							
	Poor HHs	1.86	0.5					
	Non-poor HHs	4.7	1.6	42.9	-1.69	0.098	-2.84	-6.22 to 0.55
Table 23	**HH fish given away - FF**							
	Poor HHs	8.84	2.35					
	Non-poor HHs	15.31	5.63	63	-0.95	0.35	-6.47	-20.06 to 7.12
Table 23	**HH revenue sell total fish – FF**							
	Poor HHs	129.71	40.53					
	Non-poor HHs	654.92	211.19	38.63	-2.44	0.019	-525.2	-960.31 to -90.1
Table 27	**Total HH income**							
	FF	5123.88	571.54					
	NF	3899.34	425.59	140	1.74	0.085	1224.55	-169.52 to 2618.62
Table 27	**Total HH income**							
	Poor HHs	2043.39	146.28					
	Non-poor HHs	6997	564.51	78.23	-8.5	<0.001	-4954.48	-6115.4 to -3793.57
Table 27	**Total HH income-FF**							
	Poor HHs	2173.43	253.42					
	Non-poor HHs	7453	828.47	43.76	-6.09	<0.001	-5279.75	-7026.07 to 3533.44
Table 27	**Total HH income – NF**							
	Poor HHs	1950.5	174.84					
	Non-poor HHs	6457.19	749.27	34.39	-5.86	<0.001	-4506.69	-6069.65 to 2943.73

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 27	**Total HH income – poor HHs**							
	FF	2173.43	253.42					
	NF	1950.5	174.84	70	0.75	0.46	222.93	-370.66 to 816.53
Table 27	**Total HH income - non-poor HHs**							
	FF	7453.19	828.47					
	NF	6457.19	749.27	68	0.88	0.38	996	-1269.03 to 3261.03
Table 27	**Total farm income**							
	FF	3541.59	407.36					
	NF	3254.99	409.56	140	0.5	0.62	286.6	-857 to 1430.96
Table 27	**Total farm income**							
	Poor HHs	1694.81	130.11					
	Non-poor HHs	5138.16	489.58	78.71	-6.8	<0.001	-3443.35	-4451.72 to -2434.99
Table 27	**Total farm income – FF**							
	Poor HHs	1719.57	189.81					
	Non-poor HHs	4980.03	623.44	43.7	-5	<0.001	-3260.46	-4574.12 to 1946.81
Table 27	**Total farm income – NF**							
	Poor HHs	1677.12	178.97					
	Non-poor HHs	4432.8	783.62	34.25	-4.54	<0.001	-3648.82	-5281.89 to -2015.75
Table 27	**Total farm income – poor HHs**							
	FF	1719.57	189.81					
	NF	1677.12	178.97	70	0.16	0.87	42.45	-487.73 to 572.43
Table 27	**Total farm income - non-poor HHs**							
	FF	4980.03	623.44					
	NF	5325.94	783.61	68	-0.35	0.73	-345.91	-2319.6 to 1627.79
Table 27	**Total off-farm income**							
	FF	1582.29	383.31					
	NF	644.35	155.77	88.73	2.27	0.02	937.94	115.8 to 1760.09

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 27	**Total off-farm income**							
	Poor HHs	348.58	94.78					-2294.7 to
	Non-poor HHs	1858.71	381.96	77.47	-3.84	<0.001	-1511.13	-727.56
Table 27	**Total off-farm income – FF**							
	Poor HHs	453.87	205					-3360.98 to
	Non-poor HHs	2473.16	633.61	44.53	-3.03	0.004	-2019.29	-677.60
Table 27	**Total off-farm income – NF**							
	Poor HHs	273.38	71.45					
	Non-poor HHs	1131.25	331.26	33.89	-2.53	0.016	-857.87	-1546.84 to -168.9
Table 27	**Total off-farm income – poor HHs**							
	FF	453.87	205					
	NF	273.38	71.45	70	0.94	0.35	180.49	-203.27 to 564.24
Table 27	**Total off-farm income - non-poor HHs**							
	FF	2473.16	633.61					
	NF	1131.25	331.36	55.09	1.88	0.07	1341.91	-90.99 to 2774.81
Table 27	**Per capita income**							
	FF	626.44	60.09					
	NF	513.07	56.36	140	1.38	0.17	113.37	-49.53 to 276.26
Table 27	**Per capita income**							
	Poor HHs	222.58	11.6					-816.43 to
	Non-poor HHs	921.99	57.58	74.6	-11.91	<0.001	-699.41	-582.38
Table 27	**Per capita income – FF**							
	Poor HHs	232.81	16.89					-859.47 to
	Non-poor HHs	937.19	74.9	40.72	-9.18	<0.001	-704.38	-549.3
Table 27	**Per capita income – NF**							
	Poor HHs	215.27	15.89					-875.44 to
	Non-poor HHs	903.93	90.41	32.92	-7.5	<0.001	-688.66	-501.87
Table 27	**Per capita income – poor HHs**							
	FF	232.81	16.89					
	NF	215.27	15.89	70	0.74	0.46	17.54	-29.55 to 64.62

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 27	**Per capita income - non-poor HHs**							
	FF	937.19	74.9					
	NF	903.93	90.41	68	0.29	0.78	33.26	-198.94 to 265.47
Table 28	**Percentage income from fish farming**							
	Poor HHs	7.62	2.69					
	Non-poor HHs	8.08	2.27	67	-0.13	0.9	-0.46	-7.45 to 6.52
Table 29	**HH Asset index**							
	FF	50.5	7.72					
	NF	29.82	4.17	105.11	2.36	0.02	20.68	-3.28 to 38.09
Table 29	**HH Asset index**							
	Poor HHs	31.55	5.33					
	Non-poor HHs	48.17	6.86	132.45	-1.91	0.057	-16.62	-58.92 to -0.085
Table 29	**HH Asset index FF**							
	Poor HHs	33.88	9.77					
	Non-poor HHs	63.29	11.09	67	-1.99	0.058	-29.42	-58.92 to -0.085
Table 29	**HH Asset index - NF**							
	Poor HHs	29.88	6					
	Non-poor HHs	29.74	5.68	72	0.51	0.99	0.14	-16.76 to 17.04
Table 29	**HH Asset index -poor HHs**							
	FF	33.88	9.77					
	NF	29.88	6	70	0.37	0.72	3.99	-17.71 to 25.7
Table 29	**HH Asset index -non-poor HHs**							
	FF	63.29	11.09					
	NF	29.74	5.68	55.84	2.69	0.01	33.55	8.59 to 58.51
Table 30	**Number of days eat fish - DS**							
	FF	6.12	0.22					
	NF	6.53	0.13	109.64	-1.59	0.12	-0.41	-0.92 to 0.1

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 30	**Number of days eat meat - DS**							
	FF	2.96	0.29					
	NF	3.04	0.22	128.98	-0.23	0.82	-0.84	0.80 to 0.63
Table 30	**Number of days milk consumed – DS**							
	FF	0.84	0.19					
	NF	0.7	0.17	141	0.55	0.58	0.14	-.36 to 0.63
Table 30	**Number of days fish is eaten - DS**							
	Poor HHs	6.47	0.15					
	Non-poor HHs	6.18	0.21	141	1.13	0.26	0.29	-.22 to .79
Table 30	**Number of days meat is eaten - DS**							
	Poor HHs	2.61	0.22					
	Non-poor HHs	3.39	0.27	141	-2.24	0.03	-0.78	-1.48 to -.09
Table 30	**Number of days milk is consumed - DS**							
	Poor HHs	0.51	0.14					
	Non-poor HHs	1.03	0.21	141	-2.09	0.04	-0.51	-1 to -.27
Table 30	**Number of days fish eaten - FF DS**							
	Poor HHs	6.57	0.2					
	Non-poor HHs	5.77	0.36	58.33	1.95	0.057	0.8	0.023 to 1.62
Table 30	**Number of days meat is eaten - FF DS**							
	Poor HHs	2.2	0.37					
	Non-poor HHs	3.54	0.4	67	-2.4	0.019	-1.34	-2.45 to -0.22
Table 30	**Number of days milk is consumed - FF DS**							
	Poor HHs	0.3	0.11					
	Non-poor HHs	1.26	0.31	47.19	2.94	0.005	-0.96	-1.61 to -.30
Table 30	**Number of days fish eaten - NF DS**							
	Poor HHs	6.4	0.21					
	Non-poor HHs	6.69	0.13	66.55	-1.17	0.25	-0.28	-0.77 to 0.20

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 30	**Number of days meat is eaten - NF DS**							
	Poor HHs	2.9	0.27					
	Non-poor HHs	3.22	0.36	72	-0.71	0.48	-0.31	-1.19 to 0.56
Table 30	**Number of days milk is consumed - NF DS**							
	Poor HHs	0.67	0.22					
	Non-poor HHs	0.75	0.26	72	-0.25	0.81	-0.08	-0.75 to 0.59
Table 30	**Number of days eat fish - RS**							
	FF	5.87	0.24					
	NF	6.5	0.13	6.98	-2.32	0.02	-0.63	-1.17 to -0.09
Table 30	**Number of days eat meat - RS**							
	FF	2.88	0.29					
	NF	2.93	0.22	128.59	-0.13	0.89	-0.005	-0.77 to 0.67
Table 30	**Number of days milk consumed - RS**							
	FF	1.06	0.23					
	NF	0.92	0.21	141	0.45	0.65	0.14	-.47 to 0.75
Table 30	**Number of days fish is eaten - RS**							
	Poor HHs	6.36	0.16					
	Non-poor HHs	6.03	0.22	141	1.23	0.22	0.33	-0.20 to 0.87
Table 30	**Number of days meat is eaten - RS**							
	Poor HHs	2.56	0.23					
	Non-poor HHs	3.27	0.27	141	-2.01	0.047	-0.71	-1.41 to -0.01
Table 30	**Number of days milk is consumed -RS**							
	Poor HHs	0.62	0.17					
	Non-poor HHs	1.35	0.25	124.88	-2.41	0.017	-0.73	-1.33 to -0.13
Table 30	**Number of days fish eaten - FF RS**							
	Poor HHs	6.37	0.25					
	Non-poor HHs	5.49	0.37	63.77	1.98	0.07	0.88	-0.006 to 1.77

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 30	**Number of days meat is eaten - FF RS**							
	Poor HHs	2.17	0.37					
	Non-poor HHs	3.44	0.41	66.95	-2.3	0.03	-1.27	-2.37 to -0.17
Table 30	**Number of days milk is consumed - FF RS**							
	Poor HHs	0.27	0.11					
	Non-poor HHs	1.67	0.36	44.41	-3.71	0.001	-1.4	-2.16 to - .64
Table 30	**Number of days fish eaten - NF RS**							
	Poor HHs	6.36	0.21					
	Non-poor HHs	6.69	0.13	65.84	-1.34	0.19	-0.33	-0.82 to 0.163
Table 30	**Number of days meat is eaten - NF RS**							
	Poor HHs	2.83	0.3					
	Non-poor HHs	3.06	0.33	72	-0.52	0.61	-0.23	-1.11 to 0.16
Table 30	**Number of days milk is consumed -NF RS**							
	Poor HHs	0.88	0.28					
	Non-poor HHs	0.97	0.32	72	-0.21	0.84	-0.09	-0.94 to 0.76
Table 31	**FCS RS**							
	FF	37.58	1.06					
	NF	37.96	0.9	141	-0.27	0.78	-0.38	-3.12 to 2.36
Table 31	**SFC RS**							
	FF	53.87	2.37					
	NF	54.82	1.73	126.44	-0.33	0.75	-0.95	-6.77 to 4.86
Table 31	**FCS RS**							
	Poor HHs	36.63	0.77					
	Non-poor HHs	38.94	1.14	123.75	-1.69	0.094	-2.32	-5.04 to 0.4
Table 31	**SFC RS**							
	Poor HHs	52.01	1.79					
	Non-poor HHs	56.75	2.26	141	-1.64	0.103	2.88	-10.43 to 0.96
Table 31	**FCS FF RS**							
	Poor HHs	35.3	0.57					
	Non-poor HHs	39.33	1.79	45.38	-2.15	0.04	-4.03	-7.81 to -0.26

Reference	Description	Mean	SE	df	T-Statistic	p value	Mean difference	95% CI
Table 31	**SFC FF RS**							
	Poor HHs	48.9	2.85					
	Non-poor HHs	57.69	3.49	67	-1.87	0.07	-8.79	-17.78 to 0.19
Table 31	**FCS NF RS**							
	Poor HHs	37.57	1.25					
	Non-poor HHs	38.47	1.29	72	-0.49	0.62	-0.9	-4053 to 2.74
Table 31	**SFC NF RS**							
	Poor HHs	54.24	2.26					
	Non-poor HHs	55.59	2.73	72	-0.39	0.70	-1.36	-8.37 to 5.66
Table 32	**Food Vulnerability Easy/Very easy months**							
	FF	10.03	0.32					
	NF	9.2	0.33	141	1.79	0.08	-0.83	-0.08 to 1.73
Table 32	**Food Vulnerability Easy/Very easy months** **Non-poor HHs**							
	FF	10.36	0.41					
	NF	9.28	0.5	69	1.68	0.09	1.07	-0.2 to 2.35

Notes: (1) Tables refer to those in Chapter 5 unless otherwise stated

(2) df = degrees of freedom

(3) CI = confidence interval

FF = fish farming households, NF = non-fish farming households

FCS = Food Consumption Score

SFC = Simple Food Count

DS = dry season, RS = rainy season

APPENDIX 8: ENDOGENEITY TEST RESULTS FOR THE INCOME DETERMINATION MODEL PRESENTED IN CHAPTER 5

Variables tested for endogeneity	**Hausman's Specification Test Results**					
(log) per capita income and:	**Efficient under H0**	**Consistent under H1**	**df**	**Statistic**	**Pr > ChiSq**	**Hypothesis test result**
All fish farmers	OLS	2SLS	15	10.73	0.7713	H1 is rejected, model is efficient under OLS
Fish farmers type A	OLS	2SLS	16	10.81	0.8209	H1 is rejected, model is efficient under OLS
Fish farmers type B	OLS	2SLS	15	11.61	0.7083	H1 is rejected, model is efficient under OLS

Notes: If there is endogeneity, the probability limit of the OLS and 2SLS estimators will differ (the 2SLS estimator is consistent whereas the OLS estimator is inconsistent), and H0 is rejected. If there is no endogeneity, the probability limit of the OLS and 2SLS estimators will be the same (they are both consistent estimators, but OLS is efficient), and H0 is not rejected.

OLS = Ordinary Least Squares

2SLS = 2 Stage Least Squares

df = degrees of freedom

APPENDIX 9: ESTIMATED BUDGETS USED FOR MULTIPLIER ESTIMATIONS

Estimated budget for small-scale fish farmers (fish farming type A) in Ashanti Region

	Budget (GH¢)	% of Total Cost	% of input which is regionally non tradable	% of input which is nationally non tradable
Fixed costs (1)				
Pond construction (labour)	100	20	VA	VA
Pond construction (materials - PVC pipes)	20	4	0	100
Variable costs				
Hired labour	30	6	VA	VA
Lime	7	1	100	100
Fertiliser	10	2	100	100
Fingerlings	162	32	0	100
Transportation	43	9	20	20
Feed	119	24	100	100
Equipment (water pump/nets)	9	2	0	100
Total cost (GH¢)	500			
Total Revenue (GH¢)	533			
Profit (GH¢)	33		VA	VA
Gross profit margin (%)	6			

Notes: Budget based on 1 pond of 600m^2 producing tilapia and catfish.

Budget estimates based on participatory budgets (see Table 24, Chapter 5, Section 5.2.9) and key informant interviews.

VA = value added

(1) Fixed costs of pond construction (labour and materials) annualised over 20 years

Estimated budget for commercial SME cage farmers

	Budget (GH¢)	% of Total Cost	% of input which is regionally non tradable	% of input which is nationally non tradable
Farmer fixed costs				
Cage materials	817	1	8	46
Cage labour	148	0.2	VA	VA
Land rent	200	0.3	VA	VA
Boat	40	0.05	100	100
Equipment	20	0.03	0	100
Miscellaneous	42	0.05	50	100
Farmer variable costs				
Fingerlings	9000	12	10	100
Feed	65760	85	5	10
Labour	960	1	VA	VA
Trader variable costs (1)				
Fish	99840	95		
Ice	947	1	100	100
Transport	3946	4	20	20
Degutting	474	0.45	VA	VA
Farmer total cost (GH¢)	76,987			
Farmer total revenue (GH¢)	99,840			
Farmer profit (GH¢)	22,853		VA	VA
Farmer gross profit margin (%)	23			
Trader total cost (GH¢)	105,207			
Trader total revenue (GH¢)	113,099			
Trader profit (GH¢)	7,892		VA	VA
Trader gross profit margin (%)	7			

Notes: Budget based on 4 cages for 6 month production cycle

VA = value added

(1) Trader costs and revenues are included to estimate forward linkages