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Master's thesis

Overview of small-scale freshwater aquaculture in central Vietnam: Case study of Thua Thien Hue province

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Declaration

I hereby declare that I have written this thesis entitled "Overview of small-scale freshwater aquaculture in central Vietnam: Case study of Thua Thien Hue province" by myself and all the sources have been mentioned in the references.

April 22, 2016

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Lucie Vaňousková

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Abstract

Fishery resources significantly contribute to the food and income security as well as provide employment for millions of households around the world. As capture fishery is believed to be near of its peak, aquaculture has been perceived as a promising source of fish products. This thesis focuses on the performance of small-scale aquaculture farms in Thua Thien Hue province, central Vietnam. The main aim of the thesis was to document the main techniques applied in aquaculture production with respect to intensification of fish farming systems, fish species composition, demographic profile of households and costs and benefits structure of fish farms. Data were collected during August and September 2015 via semi-structured interviews among 54 households from three different communes. The results showed that farmers practised aquaculture in cages, ponds and rice fields. Cage was determined as intensive while pond and rice field as extensive form of aquaculture. We identified seven fish species but only three of them were bred in intensive aquaculture. Generally, the most common fish species were grass carp (*Ctenopharyngodon idella*), followed by silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*) (90.7%, 38.9%, 29.6% of households respectively). Extensive farmers exceeded intensive farmers in term of household head age (54.5, 48.9 years respectively), total farm size (1.76, 0.50 ha respectively) and experience with aquaculture (11.7, 7.3 years respectively). Variable costs accounted for 86.8% and 79.8% of total costs in average for extensive and intensive aquaculture respectively; the rest were fixed costs. Intensive systems recorded higher fish production (17.6, 0.25 kg/m^2 respectively) as well gross margin (733.6, 1.8 thousand VND/m^2). Break-even point for extensive farmer was 4.91 thousand VND/m^2, while for intensive it accounted for 160.28 thousand VND/m^2. Households running more intensive aquaculture production were more profitable despite of higher costs. However economic benefit should not be the sole indicator of performance of aquaculture farms. Almost all farmers faced problem with fish disease with higher perception among intensive farmers. Thus the attention should be also focused on environmental impact of each aquaculture practices, particularly intensive cage farming in order to keep the environment in balance.

Keywords: traditional farming systems, intensification, aquaculture, household survey, break-even point, gross margin, central Vietnam

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List of Abbreviation

BCR	Benefit-cost ratio
BEP	Break-even point
FAO	Food and Agricultural Organization of United Nations
GDP	Gross Domestic Product
GSO	General Statistics Office of Vietnam
HUAF	Hue University of Agricultural and Forestry
SBV	State Bank of Vietnam
UN	United Nations
USD	United State Dollar
VAC	Vietnamese acronym combining garden, fishpond and livestock pen
VND	Vietnamese Dong
WWF	World Wildlife Fund

1. Introduction

Fishery resources significantly contribute to the food, nutritional and income security as well as provide employment for millions of households around the world (Bledar, 2007; WWF, 2015a). Fishery sector could be divided into two different branches, i.e. aquaculture and capture fishery. While production from capture fisheries is believed to be near of its peak (Lucas et al., 2012; WWF, 2015b), aquaculture has been perceived as promising source of fish products in the future (Diana, 2009; Lucas et al., 2012; FAO, 2015). However both capture fisheries and aquaculture have significant complementary roles in meeting increasing demand for fish and related products, and raising income and nutritional security among small-scale producer, fisher and poor households around the world (Tveterås et al., 2012). Additionally, fishery sector does not only contribute to food and nutritional security, but it is also unfortunately connected with environmental problems influencing both animal's natural habitat and human well-being. Among current problems which influence degradation of underwater environment as well as the number of species belong mainly pollution, poorly planned development and the effects of climate changes (Brander, 2007; Cheung et al., 2009). Fisheries are also threatened by overfishing resulting from increasing demand. All these problems not only affect underwater environment and the balance of life in the oceans, but also the coastal communities that depend on fish for their livelihoods (WWF, 2015b).

Aquaculture, which can be understood as the farming of aquatic organisms in both coastal and inland areas, has represented a rapidly growing food producing sector over the past three decades (Diana, 2009; Tveterås et al., 2012; FAO, 2015a) and continues to develop rapidly especially through its growth in Asian countries (Lucas and Southgate, 2012). In Vietnam, aquaculture is considered as an important food producing sector with positive growth during last decades (GSO, 2014). As the demand for fish has increased over the last few decades all over the world, and the trend is expected to continue due to continuously increasing population growth, wealth and growing preference for healthy food, considering fact that production from capture fisheries is stagnating, aquaculture seems to be an opportunity how to fill the gap and to meet future increase in demand for fish and seafood (Swartz et al., 2010; Bacher, 2015). Fish is a widespread, a key source of protein, essential amino-acids and minerals, especially for nutritionally vulnerable people (Béné et al., 2016). Hence, there is no question that global demand for fish will increase in the future and the sector will be striving to be more productive and sustainable to meet people's needs while reducing rural poverty and resilience of livelihoods to disaster (FAO, 2014).

Global fish production depends massively on small-scale farmers and fishers from which lion's share comprises poor people (Thilsted et al., 2016). It is estimated that livelihoods of almost 31 million people rely on small-scale fisheries and more than 158 million people globally depend on fish-related activities such as fishing, fish farming, processing or trading; and absolute majority run small-scale operation in developing countries (HLPE, 2014). Thus it is necessary to pay attention to small-scale farmers who significantly contribute to fish production and determine their situation and livelihoods. Therefore there is growing evidence of researches which are focusing on profitability and economic viability as well as advantages, constraints and overall situation of fish farming. However, do we really understand the situation with both household dependency on aquaculture and its effect on biodiversity and nature environment?

2. Literature review

2.1 Fish consumption

Globally, fish consumption has increased from an average 10.0 kg per capita per year in 1965 to 19.2 kg in 2012 (FAOSTAT, 2013), driven by higher demand from growing population, increase of incomes and better distribution. However fish consumption varies among the regions (Kawarazuka and Béné, 2011). Next figure (Figure 1) shows changes in fish supply between 1965 and 2011 in Southeast Asia with regard to Vietnam and in comparison to average world supply. According to Dey et al. (2005) fish consumption differs with economic situation of the households, both in terms of per capita consumption and type of fish species. It is assumed that higher income leads to increase of per capita fish consumption. Households considered as a poor, mainly in rural areas, consume mostly cheaper small indigenous fish species while better-off households spend greater sum of money on larger, more expensive fish (Roos et al., 2003; Dey et al., 2005) which are preferred mainly due to fewer bones, more flesh and better taste (Chamnan et al., 2009).

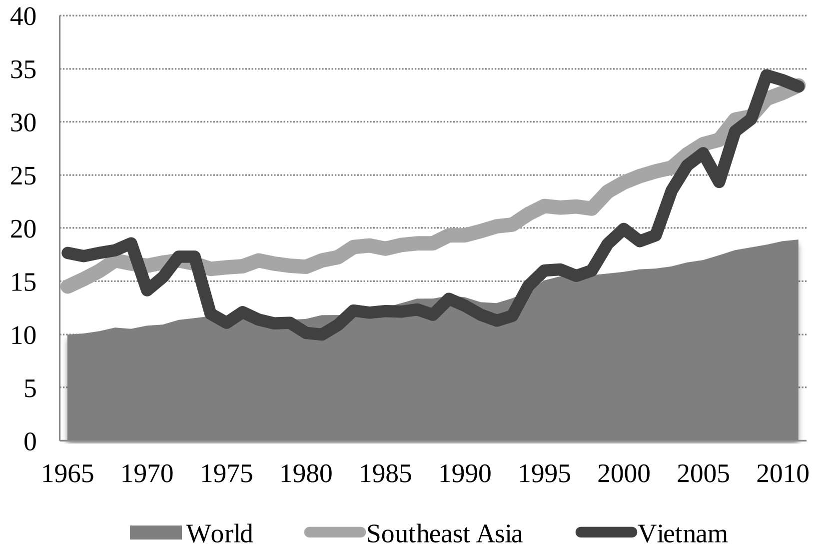

Figure 1

Fish supply (in kg/capita)

Source: FAOSTAT, 2013

According to Merino et al. (2012) per capita fish consumption can only be preserved or increased if aquaculture makes a growing contribution to the volume and stability of global fish supply as yield from global fisheries is constrained mainly by climate changes and changes in ecosystems productivity (Brander, 2007; Cheung et al., 2009). To meet current and future consumption rates is feasible only if fish resources are managed sustainably and the animal feeds industry reduces its reliance on wild fish which compete with fish for human consumption (Merino et al., 2012). Fish remains an important source of protein, energy and wide range of essential nutrients (Bogard et al., 2015b; Wheal et al., 2016). Globally, fish and seafood have already accounted for almost 17% of the population's animal protein intake and this proportion has been increasing (FAOSTAT, 2013). According to estimation of FAO (2014) fishery sector provides almost three billion people with nearly 20% of their average per capita intake of animal protein and further 4.3 billion people with almost 15% of their per capita intake. According to study of Kawarazuka and Béné (2011) fish contributed to more than one third of the total animal protein supply in 30 countries in 2010, including mainly low income food deficient countries such as Bangladesh, Uganda, Sierra Leone, Cameroon etc. For instance Dey et al. (2005) determined that the share of fish protein in total animal protein expenses was higher among groups with lower income, proving their dependence on fish as a source of animal protein. However considering other sources of protein, contribution of fish to total protein consumption was considerably low which indicate that in low income food deficient countries the most of protein comes from plants (Kawarazuka and Béné, 2011). Nowadays, many scientific studies document and evaluate the contribution of fish to food security, nutrition and health (Kawarazuka and Béné, 2011; Tacon and Metian, 2013). Fish intake is for example connected with reduced mortality risk from heart disease (Mozaffarian and Rimm, 2006) and benefit of fish consumption is also associated with weight loss (Smith et al., 2015). On the other hand, there is also risk of negative effect of fish consumption associated with fish born zoonotic trematodes which are especially widespread in Southeast Asia and are estimated to infect nearly one million people in Vietnam (Phan et al., 2010). People are mainly threatened by consumption of raw or inadequately cooked fish. Consumption of raw fish has a long tradition among dwellers of some part of Vietnam thus there is high risk of prevalence (Phan et al., 2010). However when both negative and positive effects are considered together, the positive effect of fish consumption still outbalances.

2.2 World fisheries versus aquaculture

The average world fish production growth rate of 2.8% since 1990 (FAO, 2015b) is faster than growth of human population with average annual rate 1.3% (UN, 2015) which is positive fact with respect to increase demand for food production. Thirty years ago majority of fish production came from capture fisheries while nowadays the situation has totally changed and aquaculture significantly contributes to total fish production (see Figure 2). According to FAO (2015c), aquaculture is understood as "*the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants*". Aquaculture comprises activities which intervene in rearing process in order to enhance production like stocking, feeding, protection from predators etc. Aquaculture refers to breeding and harvesting of plants and animals in marine, brackish as well as freshwater environment, i.e. ocean, lakes, reservoirs, rivers and ponds (NOAA Fisheries, 2015). On the other hand capture fisheries could be characterized as non-fed fish harvested from undomesticated ecosystems (Tveterås et al., 2012). World capture fisheries production has stagnated since the mid-1980s with an average annual production rate only 1.2% (NOAA Fisheries, 2015; FAO, 2015b), reaching the production of 94.6 million tonnes in 2014 (FAO, 2015b). To the contrary, aquaculture's year to year growth rate for production since 1985 reaches almost 8% worldwide and the production of 101.1 million tonnes in 2014 exceeded the production from capture fisheries (FAO, 2015b). Nowadays, aquaculture is estimated to account for approximately 51.7% of world fish production (FAO, 2015b) and an average annual rate makes the aquaculture one the world's fastest growing food production sector in the world. It is assumed that aquaculture will contribute approximately 63% of global fish consumption by 2030 (Thilsted et al., 2016). Global aquaculture production is dominated by Asia (89.1%), China alone accounts for 62% and aquaculture production reaches almost two thirds of total fish production there (FAO, 2015b). In Asia, 66.5% of aquaculture production comes from inland aquaculture and worldwide situation is very similar (FAO, 2015b). Aquaculture employs around 23 million people worldwide, nearly 70% of them directly and the rest indirectly (FAO, 2015c).

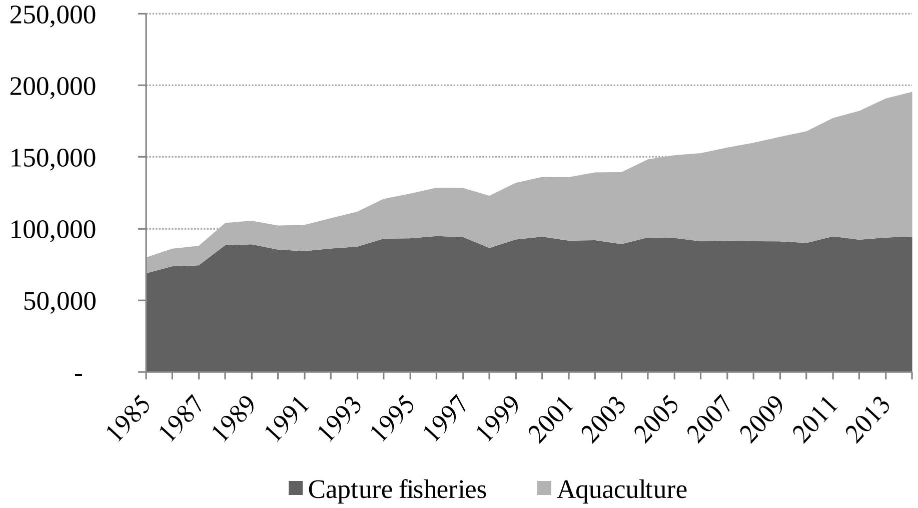

Figure 2

Global capture and aquaculture production 1985-2014

Source: FAO, 2015c

2.3 Extensive and intensive aquaculture

Aquaculture is recognized as a business that requires big capital investment in order to make reasonable profit (Ugwumba and Chukwuji, 2010) thus lack of capital could be constraint for farmers in term of covering initial cost. The largest amount of money in aquaculture business is generally spent for variable costs regardless the level of intensification (Ahmed et al., 2010). Among main variable costs usually belong costs of feed, fingerling, fertilizer and labour. The cost of feed accounts often for the highest proportion of total production costs and the importance of feed increases with the intensification of aquaculture system (Ahmed et al., 2010). Cost of feed played the most important role in several studies concerning on both extensive and intensive aquaculture (Boonchuwong et al., 2007; Phuong et al., 2007; Ahmed et al., 2010) which indicates that even if extensive systems are based on lower use of inputs feed costs still play its role there. The share of variable costs on total cost differs significantly across various production system with different input use (Kipkemboi et al., 2007; Ahmed et al., 2010; Ugwumba and Chukwuji, 2010; Nunoo et al., 2014). Intensive farms report higher variable as well fixed costs in comparison to extensive aquaculture systems (Ahmed et al., 2010; Nunoo et al., 2014) and even if intensive systems report higher input use which leads to higher total costs, intensive farms are able to generate higher profit. As Hepher (1985) mentioned is the study focusing on intensification of aquaculture, the main driving force for intensification of the fish production is increased profitability through higher yield per unit area.

The intensive production system is characterized by a relatively high stocking densities and high level of inputs such as feed or fertilizer (Ahmed et al., 2010). Nowadays, most common aquaculture systems are done in cages or ponds. Inland cage farming is the dominant form of cage farming in Asia. As Edwards (2015) determined, cage aquaculture is mostly intensive as wild low-value or trash fish are used as a main fish feed. Extensive cage aquaculture with dependence only on feed provided from environment is rare because most of water bodies do not provide sufficient natural food. Extensive aquaculture farmers generally use more supplementary feeds consisting of agriculture by-products, rice or wheat bran, cassava leaves etc. whereas intensive farmers depend more on commercially manufactured feeds and decreases dependence on the availability of natural food (Edwards, 2015). Aquaculture carrying out in ponds needs nutrient inputs to produce fish because natural productivity of ponds without external inputs is usually not satisfactory and farmers could put effort, money and resources rather to other activities than aquaculture (Prein, 2002). Fertilization is done by organic and inorganic fertilizer that promotes the growth of simple plants in the ponds. Mainly in small-scale farms aquaculture can be integrated with crop or livestock production. According to Luu (2001) integrated farming is a traditional approach for household food production, mainly in poor, rural areas. The main traditional integrated system in Vietnam is called VAC[1]. This traditional farming system is usually family-managed and covers activities including aquaculture, crop production and livestock rearing (Luu et al., 2002). Integrated aquaculture can utilize inputs in form of wastes from agricultural production and livestock, such as animal manure and agriculture by-products (Prein, 2002). Manure applied as a fertilizer is recognized as a cheap way how to enhance growth in the pond (Mataka and Kang´ombe, 2007). In more intensive systems, there is a shift from manure or sewage as the main nutrient source to inorganic fertilizers and commercial pellet feed (Prein, 2002). Integrated aquaculture has several

[1] VAC is an acronym for integrated farming system derived from the Vietnamese for garden (vuon), pond (ao) and livestock pen (chuong).

forms and one of them is aquaculture in rice fields. Deliberated stocking and fish breeding in rice fields has a long history and belongs among traditional systems mainly in Vietnam. According to Dey et al. (2013) rice-fish system has huge potential for increasing productivity, food security as well as species diversity in some of the poorest and most populous countries of Asia. Farmers can benefit from such aquaculture system, mainly in term of diversification. Value of fish produced can exceed that of rice in case of rice price fluctuation and thus has a huge importance for additional cash income generation (Prein, 2002).

Studies show that adoption of aquaculture by farmers and degree of integration between farming elements is influenced by a combination of biophysical factors such as soil fertility, pond conditions, crop and livestock farming etc. and socioeconomic factors such as access to market (Iqbal et al., 2006; Nhan et al., 2007). The lower level of adoption was observed among poor households, which is in contrast to fact that integrated agriculture-aquaculture system was promoted as a way to reduce poverty (Luu et al., 2002; Nhan et al., 2007). Adoption level is associated with limited technical and farm management skills, small land area or capital and constrained by limited availability of extension services. Nhan et al. (2007) found out that good market accessibility lead to increase of intensification of aquaculture. Trend of intensification will continue as the main driver for intensification is profit (Edwards, 2015). However selection of appropriate aquaculture system should take both potential economic benefit and adverse effect on biodiversity into consideration (Isyagi, 2007) as intensification of aquaculture may bring increased risk of diseases, introduction of invasive fish species and environmental degradation (Subasinghe et al., 2010).

2.4 Benefits and constraints of aquaculture

The main benefits from aquaculture are the increased production of fish for human consumption and other purposes, an opportunity for commercial business and last but not least generation of job opportunities, especially in rural areas where employment opportunities are very limited (FAO, 1998; Bledar, 2007).

Aquaculture can cause both positive and negative impact on environment and since its development has been facing several challenges. Experience has shown that aquaculture integrated with agriculture brings several advantages such as reuse of otherwise wasted farm resources, recycling of nutrients between farm elements (Prein, 2002) or reduced use and costs for pesticides and fertilizers (Gupta and Noble, 2001). According to Nhan et al. (2007) extracting nutrient-rich mud from pond can be used as a crop fertilizer. Fish in integrated aquaculture-agriculture can feed on animal excreta thus costs for commercial fish feed that contains fish meal from small low value marine fish can be reduced (Luu et al., 2002). The water used for aquaculture e.g. in ponds may serve for its primary purpose, irrigation of crops. Using water this way adds nutrients in organic form to the water before irrigation and could reduce the need for additional fertilizing.

Despite the benefits above aquaculture sector is facing several issues and challenges. Impact of intensive cage farming system upon the environment was observed and includes several aspects that could threaten its sustainability. Firstly, there is higher risk and occurrence of fish diseases within cage farming (Merican, 2006; Tan et al., 2006). Fish diseases can transfer from farmed fish to natural fish population or vice versa (Ferguson et al., 2007). Higher risk of disease transfer is in case of fish farming in open water (e.g. cages in the river) in comparison to pond farming, because fish are more exposed to natural fish population (Tan et al., 2006). Despite long tradition of aquaculture in Asia diseases and associated economic losses in aquaculture represent huge problem there (Bonadad-Reantaso et al., 2005). Disease is certainly one of the major constraints to production, profitability and sustainability of the aquaculture sector (Tan et al., 2006). Lack of training and no or poor technical support in term of fish disease is constraint mainly for small-scale farmers who comprise substantial part of all fish farmers in Asia and are not able to face such problem alone. Diseases are not the only problem related to natural fish population. There is also risk of fish escapes with potential threatening of natural fish population (Hindar et al., 2006; Ferguson et al., 2007).

Overcrowding and intensive stocking involves high risk of water pollution caused by nutrient loads from uneaten feed and/or excreta and can influence not only water quality but also aquatic environment (León, 2006; Mente et al., 2006; Ross et al., 2013).

Overcrowding means not only high fish densities in cages or ponds but also high concentration of e.g. cages in the same water environment. Sustainable aquaculture production should consider assessment of ecological carrying capacity for rational use of natural resources such as water bodies (David et al., 2015). In cage environment, water quality is less controllable than in ponds, however due to high stocking densities fish bred in cages are more vulnerable to rapid temperature change or drop of oxygen (Tan et al., 2006). Intensive cage and ponds farming characterized by large nutrient flows supported by use of commercial feeds and water exchange make local nutrient recycling problematic (Hao, 2006). Crucial issue in the environmental concern of cage aquaculture it limited potential for treatment of produced waste material (Cripps and Kumar, 2003) thus further aquaculture development should be planned and designed in a responsible manner that minimize as much negative impacts on water quality as possible (Hambrey and Senior, 2007).

Increasing expansion of aquaculture may be constrained due to dependence on small low-value marine fish ("trash fish") and fish meal which are used as feeding ingredients in aquaculture farming instead of being used for human consumption, especially in Asia (Tidwell and Allan, 2001; New and Wijkström, 2002; Edwards et al., 2004; Funge-Smith et al., 2005). The development of such cost-effective feeds is one of the main constraints and much of costal as well as inland aquaculture is dependent on trash fish, even in Vietnam (Edwards et al., 2004).

2.5 Fish in Vietnam

Fishery sector is one of the most dynamic and fast growing sector in Vietnam. During last 24 years, total fishery production increased approximately seven times, to 6.3 million tonnes in 2014 (GSO, 2015). Fisheries sector created approximately five million jobs in 2012 (GSO, 2014) and around eight million people derived main income from fisheries. However sector supports livelihoods of many more. Fisheries industry is estimated to contribute 10.1 % to the national GDP, showing the importance for Vietnamese economy (GSO, 2015).

The aquaculture sector began in the early 1960s and since then small-scale extensive aquaculture system such as rice-cum-fish, livestock-cum-fish and earthen ponds have been developing for domestic use (Huong, 2011; FAO, 2015d). Aquaculture sector was promoted and supported during Vietnam War because of its importance in providing food for people and military. After Vietnamese reunification, fishery sector as a whole was considered as a key economic sector for the country and aquaculture has started to increase (FAO, 2015d). Since 1999, the Vietnamese government has suggested to promote agriculture diversification of farming practices due to recognition the potentiality of aquaculture to contribute to economic situation improvement, poverty reduction and enhancement of livelihood strategies (Luu, 2002). Diversification of agriculture activities such as integration of agriculture and aquaculture assumes enhancement its sustainability (Nhan et al., 2007). Diversifying of farming practices and adapting to the production of exportable species at increased level of intensification has resulted in the rapid growth of the aquaculture sector (FAO, 2015d).

Aquaculture is considered as an important and rapidly growing sector in Vietnam. Aquaculture production increased from 0.16 million tonnes in 1990 to 3.6 million tonnes in 2014. In 1990 aquaculture in Vietnam comprised just minor part of total fishery production whereas in 2014 it was 53.9% (GSO, 2015). Aquaculture production exceeded capture fisheries production for the first time in 2007 and since then has been continuing in this trend (see Figure 3). Vietnamese fishery sector products supply both domestic and export markets. Nowadays, Vietnam is one of the main aquaculture producers after China and India, and the fourth largest exporter with export value of 6.3 billion USD in 2012 (FAO, 2014). Mainly aquaculture products from large-scale aquaculture farms are oriented for export whereas small-scale farmers, that comprise significant part of aquaculture sector, produce fish mainly for local production.

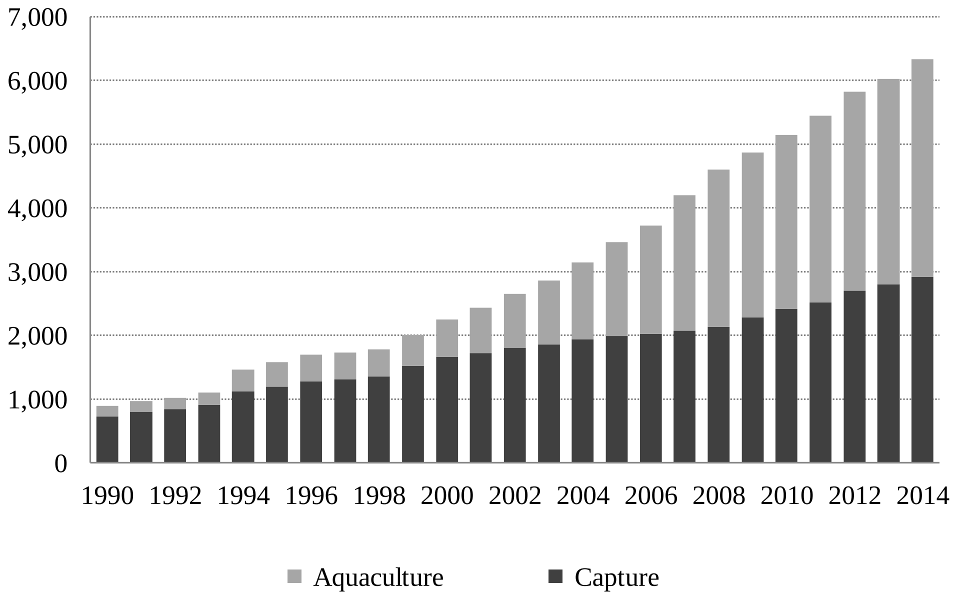

Figure 3:

Production of fishery in Vietnam during 1990-2014 (in thousand ton)

Source: GSO, 2015

Aquaculture sector in Vietnam comprises different aquaculture systems (e.g. earthen pond, net-enclosures, pen, cage) with different level of intensification (e.g. intensive, semi-intensive, extensive) and breeding various aquaculture species (e.g. fish, shrimp, crab, seaweed) (Tuyen, 2002). The distribution of aquaculture systems varies from the north through central part to the south of Vietnam (FAO, 2015d). The north part of Vietnam is characterized by freshwater fish ponds, rice field aquaculture and marine cage aquaculture whereas giant tiger prawn farming and marine cage aquaculture of finfish represent the most common practices in central part. The most diversified aquaculture techniques can be seen in the south of Vietnam. Southern part is the most famous for fish and shrimp farming in Mekong River Delta. Aquaculture practices there include pond, fence and cage aquaculture of several fish species with leading role of catfish (*Pangasius hypophthalmus* and *Pangasius bocourti*) (FAO, 2015d). Catfish together with shrimp are considered as major aquaculture products in Vietnam with key role for export. Aquaculture systems have improved during last decades mainly in the lowlands whereas only small improvements were realized in the remote mountainous regions (Pucher et al., 2015). Thus these areas would be appropriate targets of future researches focusing of their assessment with regards to aquaculture production and its potential.

Aquaculture in Vietnam has potential not only thanks to contribution to economic situation improvement or poverty reduction but also thanks to availability of water source. Water surface suitable for aquaculture in Vietnam has increased from 903 thousand ha in 2004 into 1,046 thousand ha in 2013 (GSO, 2014). In the last 1990s there was massive shift to shrimp aquaculture production mainly due to its potentiality for export (Nhuong et al., 2003). Total are used for shrimp farming in Vietnam has increased from 200,000 ha in 2000 to 478,000 ha in 2001 (Huong, 2011), reaching 632,000 in 2013 (GSO, 2014). Shrimps are farmed mainly in marine and brackish water. On the contrary inland fresh water, comprising almost one third of total water surface area, represents important water source for fish (see Table 1).

Table 1: Area of water surface for aquaculture in 2013 (in thousand ha)

TOTAL	**1,046.4**
Area of marine aquaculture	**322.2**
- Water for fish	2.2
- Water for shrimps	290.9
- Water for other aquatic products	28.8
Area of inland aquaculture	**720.6**
Brackish water	*414.7*
- Water for fish	43.1
- Water for shrimps	336.4
- Water for other aquatic products	35.2
Freshwater	*305.9*
- Water for fish	299.3
- Water for shrimps	5.0
- Water for other aquatic products	1.6
Area of water for breeding	**3.6**

Source: GSO, 2014

3. Aim of the thesis

The growth and development of aquaculture production depends on the ability to make profits and thus there is the importance to measure profitability and project future development as well as to be aware of potential risks associated with aquaculture especially, which is typical particularly in the case of small-scale farmers whose fish farming activities create essential part of their livelihood strategies (Nunoo et al., 2014). Thus, the main objective of the study research was to document what are the main techniques and approaches applied in aquaculture production in central Vietnam.

Specific objectives set up were:

(i) To classify fish farming systems according to the level of intensification

(ii) To document the fish species composition in particular farming systems

(iii) To document demographic profile of households involved in aquaculture

(iv) To compare costs and benefits structure of different fish farm techniques

4. Methodology

4.1 Study area description

The study research was performed in Thua Thien Hue province, which is located in central part of Vietnam. Total area of the province is 5,033 km2, the lion's share of the land is covered by forests (64.6%) and agriculture uses 12.1%. Population reached 1.13 million in 2014 (GSO, 2015). Kinh represents the major ethnic group in the province, however mountainous and more remote areas in the eastern parts are populated by ethnic minorities. An average population density equals to 225 persons per square km and points at high pressure on local environment and natural resources use (GSO, 2015).

Tam Giang lagoon in Thua Thien province, the largest lagoon in Southeast Asia with area of 220 km^2, provide important water source and since the early 1990s aquaculture has become the most important livelihood strategy there (Huong, 2011). Brackish water provide suitable environment for a diversity of aquatic species with shrimp in the lead. However freshwater aquaculture in the province should not be underestimated as inland fresh water is the main water source for farmed fish (GSO, 2014) and thus also source of many household's livelihoods. The research focus on freshwater aquaculture to provide more information and supplement already published studies concerning only aquaculture in Tam Giang lagoon (Tuan et al., 2009; Nguyen and Yabe, 2014; Boonstra and Hanh, 2015).

Generally, the climate in central Vietnam is tropical monsoon with two distinct seasons. The dry season last from March to August and it is influenced by southwest wind with hot dry air. From September to January there is rainy season accompanied by annually flooding occurring mainly during September and October. The average annual temperature is about 25°C (Ky et al., 2003; GSO, 2014) and relative humidity attains 84-85% (Trai et al., 2001, Villegas, 2004; GSO, 2014). Annually, this region receives a large amount of precipitation however they are unevenly distributed over the months. Average rainfalls range between 2,500 and 3,000 mm per year (Ky et al., 2003; GSO, 2014), concentrated in September, October, November and December. Next figure (Figure 4) shows composition of average rainfalls and temperature during 2012-2014.

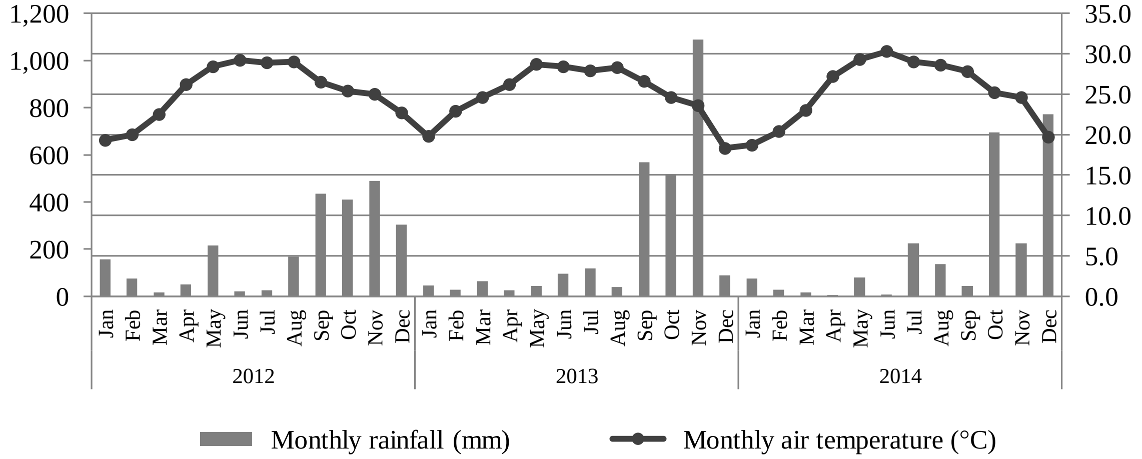

Figure 4

Average rainfall and temperature during 2012-2014

Source: GSO, 2014

4.2 Study sites characteristics

Three communes, Thuy Tan, Huong Toan and Quang Tho, were selected for our research. Thuy Tan and Huong Toan are located in peri-urban, while Quang Tho has more rural character. As it is shown in Table 2, peri-urban areas have higher population density. The discussions and cooperation with Hue University of Agriculture and Forestry (HUAF), particularly the key informant, Dr. Ngo Huu Toan from Department of Fisheries, and commune leaders enabled us to identify suitable locations for data collection. Three communes representing both rural and peri-urban areas of the province were identified as suitable for our survey (see Figure 5).

Table 2: Study sites characteristics

	Communes	Area (km^2)	Population		Districts
			total	per km^2	
Peri-urban area	Huong Toan, Thuy Tan	19.8	17,769	897	Huong Tra, Huong Thuy
Rural area	Quang Tho	9.5	6,979	735	Quang Dien

Source: Based on personal communication with representatives of People’s Committee of target communes (2015)

Quang Dien is a rural district in Thua Thien Hue province northeast of Hue city. District's area is 162.94 km^2 of which nearly 60 km^2 comprises agricultural land, 44.1 km^2 lagoon and 23.7 km^2 forest. Population of 84,984 inhabitants (Thua Thien Hue Portal, 2014) is concentrated in eleven administrative units including ten communes and one town Sia which is capital city of Quang Dien district. Within this district Quang Tho commune was chosen for data collection. It lies in southern part of Quang Dien district, approximately 15 km from Hue city. Bo River flows through the commune and supply fresh water for the cultivation of rice and other crops as well as it serves as a water source for many aquaculture farmers. Agriculture and fisheries belong to main livelihood strategies of local households.

Huong Tra is plain district located west of Hue city between Bo River and Perfume River (also known as Huong River). Area of the district is 518.5 km^2 with population of 115,268 inhabitants (Thua Thien Hue Portal, 2014). In the north part of the district 700 ha of Tam Giang lagoon stretches into the district. Administratively district is divided into 15 communes and one town. The district's administrative and economic capital is Tu Ha town. Huong Toan commune was selected for the research. It is a peri-urban commune in northern part of the district, approximately 12 km from Hue city. Among traditional industries in the commune belongs rice wine brewery or leaf conical hats and majority of the population rely on agricultural activities including aquaculture.

Huong Thuy Town, peri-urban district, with capital Phu Bai covers an area of 456 km^2 with a population of 100,658 inhabitants (Thua Thien Hue Portal, 2014). It is located approximately 12 km south of Hue city. Most of the territory west of the highway 1A is hilly while narrow plains run into a strip along the east and north-east. The district is divided into twelve administrative units including Thuy Tan commune lying on the outskirt of the district selected for the purpose of the research. Huong Thuy town experienced huge change of the economic structure. Agricultural sector predominated in the past in the area but nowadays industry and services has been replacing agricultural sector nevertheless agriculture is still significant source of livelihoods within the region and mainly in focused commune (Thua Thien Hue Portal, 2014).

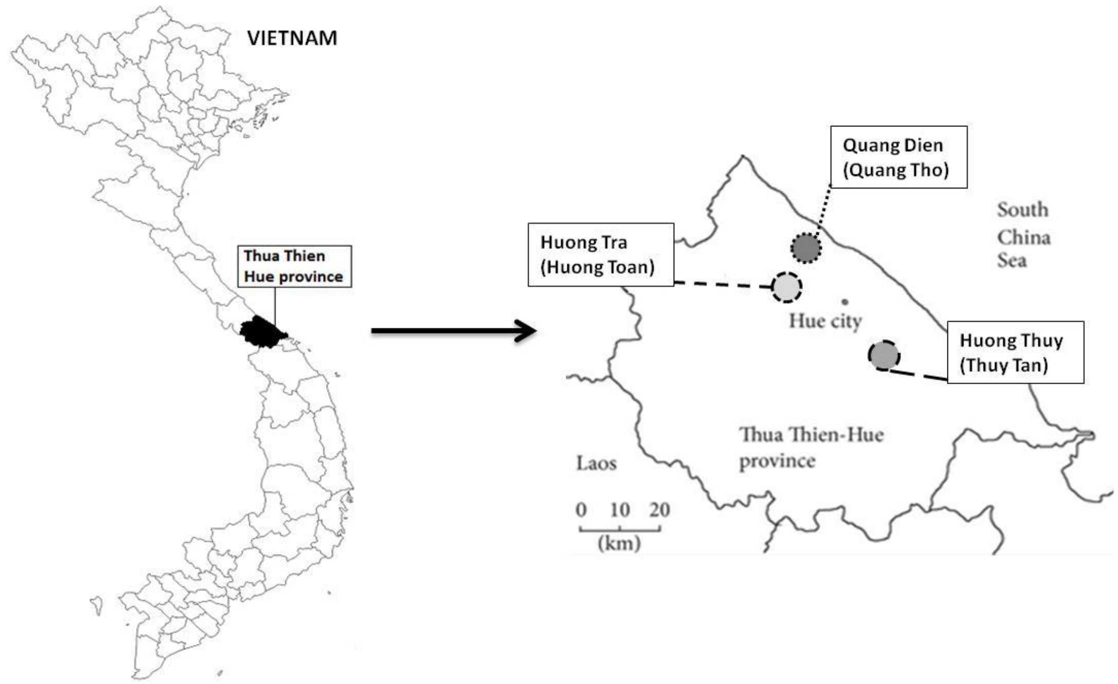

Figure 5

Map of study area

Source: author

4.3 Data collection

Data collection took place during August and September 2015 and 54 respondents were interviewed. Main criterias for including particular household in the survey were willingness to participate in the research and confirmation of running aquaculture[2] for at least one year prior to our data collection. We used semi-structured interviews with the head of the household as the main tool to obtain necessary information. Questionnaire was developed according to studies published on similar issue (Ahmed et al., 2010; Hyuha et al., 2011; Nunoo et al., 2014), tested and adjusted prior to the survey among five randomly selected households from the study area. Variables we focused on in our study are very often used by similar studies on farming systems and household economics (see Table 3). The questionnaires were developed in English, but since all of the interviewees spoke Vietnamese, the interviews were conducted in Vietnamese and simultaneously translated in English into the questionnaire by accompanying student

[2] The term "aquaculture" in our research is understood as freshwater (inland) fish aquaculture excluding molluscs, crustaceans and aquatic plants.

from HUAF (see Figure 6). Households were visited individually during the day time in their houses or directly on their plots using combination of different sampling methods: random, snowball and listing from commune authorities. Every respondent was introduced into the research topic by local stuff and asked for cooperation.

Figure 6

Data collection in Huong Toan commune

Source: Author, 2015

4.4 Questionnaire structure

Firstly, farmers were asked to provide us with the information that we could use in order to understand all types of household resources, such as age, number and gender structure household members, labour management, education and experience with fish farming, applied land-use system and cash-flow composition and balance. Secondly, we asked farmers to identify what kind of fish he/she breeds, to estimate the annual production of each fish species, level and management of commercialization, and market price. Specific attention was then given to the costs of fish production. Farmers were interviewed on the main expenditures linked to fish farming as well as equipment used at their fish farm, sources of water and fingerlings, fish processing practices and availability of extension services related to fish production. Finally, we asked farmers about their future expectations and opinions on fish farming, particularly in order to identify potential barriers that would hinder the efficiency and/or further development of fish production at household level.

Table 3. Variables used in our questionnaires		
Variable	Description	References
Household member	All people living regularly in the household together with household head	Kipkemboi et al., 2007; Heubach, 2011; Melaku et al., 2014; Nunoo et al., 2014;
Household head age	Age of household head	Kamanga et al., 2009; Hogarth et al., 2013; Nunoo et al., 2014
Gender of the household head	Whether household is headed by man or woman	Kamanga et al., 2009; Melaku et al., 2014; Nunoo et al., 2014;
Years of schooling of household head	Total length of school attendance of household head	Fisher, 2004; Kipkemboi et al., 2007; Nunoo et al., 2014;
Years of schooling	Total length of school attendance of household members older than 14 years	Kipkemboi et al., 2007; Melaku et al., 2014; Morsello et al., 2014
Dependant members	Number of people living in the household younger than 15 and older than 60 years	Quang and Anh, 2006; Heubach, 2011
Male labour	Number of men between 15 and 60 years in the household	Quang and Anh, 2006; Fu et al., 2009
Female labour	Number of women between 15 and 60 years in the household	Quang and Anh, 2006; Fu et al., 2009; Heubach et al., 2011
Farm size	Total area of the farm	Ahmed et al., 2010; Meleku et al., 2014; Nunoo et al., 2014;
Income generation	All cash income from particular activities; other income include money received from relatives and/or government	Kipkemboi et al., 2007; Fu et al., 2009; Meleku et al., 2014; Nunoo et al., 2014
Expenditures	All cash expenditure spent for particular activities	Kipkemboi et al., 2007
Farming experiences	Number of years of experience with fish farming	Hyuha et al., 2011; Nunoo et al., 2014

4.5 Data analysis

All data from the questionnaires were cleared and transferred into the data set in MS Office Excel® and pre-coded. Data were analysed from 54 samples and processed through statistical analysis software STATISTICA ©StatSoft 12. Firstly, descriptive analysis and Student's t-test was applied in order to compare fish farming techniques as well as to determine significant differences in demographical and socio-economic characteristics of our study groups (Polesny et al., 2014). Secondly, in order to compare traditional and improved aquaculture techniques, cost-benefit analysis was applied (Cruz et al., 2000; Engle and Neira, 2005; Nunoo et al., 2014). Indicators used in cost-benefit analysis are explained in next table (Table 4).

Table 4. Cost-benefit analysis indicators

Indicators	Description
Variable costs	Expenses that are actually paid and vary with the quantity of fish produced (such as fingerlings, feed, fertilizer, transportation, hired labour, water and other).
Fixed costs	Costs independent on the operation, such as depreciation of ponds, cage, rice field, equipment and interest on investment. Depreciation was calculated using straight line method by dividing the establishment cost/purchasing price by the lifespan of the equipment.
Total costs	Sum of variable and fixed costs.
Gross income	Total value of production, i.e. quantity of fish produced multiply by their selling price.
Gross margin	Gross income and variable costs difference.
Net income	Gross income and total costs difference or gross margin less fixed costs.
Break-even point (BEP)	It is value of production when total costs and revenue are equal and there is no gain or loss. Equation used for calculation BEP in non-homogenous production is: fixed costs divided by difference of one and quotient of variable costs and value of production (gross income).
Benefit-cost ratio (BCR)	Gross income divided by total costs. BCR of 1 means that operation is at a break-even position. BCR > 1 means that benefit is greater than costs.

Source: based on Kipkemboi et al., 2007; Ahmed et al., 2010; Hyuha et al., 2011; Nunoo et al., 2014; Potkany and Krajcirova, 2015.

5. Results

5.1 Identification of main fish farming techniques

Three different fish farming techniques commonly used by targeted households in the study area were identified. Our respondents were producing fish in cages, in ponds or directly in their rice fields (see Figure 7). Techniques using rice fields and ponds for fish production were considered as rather extensive, while cages as intensive practices, particularly according to the value and amount of necessary inputs (see Table 5). Cage aquaculture dominated in both peri-urban and rural areas.

Table 5: Classification of the respondents according to their style of running aquaculture

Study site	Extensive aquaculture		Intensive aquaculture
	Rice field aquaculture (n=9)	Pond aquaculture (n=12)	Cage aquaculture (n=33)
Peri-urban area	9	5	22
Rural area	0	7	11

5.1.1 Rice field aquaculture

In case of rice field aquaculture, fish were bred directly in the rice fields. This type of aquaculture was characterized by large area for fish breeding, with an average size of 2.4 ha. Five out of nine rice field aquaculture farmers bred fish with manure application in order to support natural plant growth in the rice fields, because besides additional commercial feed fish fed also on natural food organisms, leftovers from rice cultivation and small animals, e.g. yellow snails. Mostly pig and buffalo manure were used however manure from quails also occurred within one farm. Water for rice field aquaculture was supplied from neraby river by 22.2% of rice field aquauculture farmers, 33.3% of them relied solely on groundwater and rainfalls and the rest of farmers combined water supplied from river with groundwater and rainfalls. In term of source of fingerlings, majority of them were obtained from commercial fingerling producers, only one farmer stated using besides fingerlings from producers also wild fingerlings. Only polyculture combining several fish species was applied in rice field aquaculture.

5.1.2 Pond aquaculture

Pond aquaculture could be described as breeding and rearing of fish in mostly very simple earthen man-made basins. In fact it was only manually or mechanically dug hole filled with water. Pond size differed a lot ranging from 200 to 5,000 m^2 with an average size around 1,850 m^2. The number of ponds owned by farmers ranged from one to eight with two ponds per farm in average. Farmers applied mostly organic manure from pigs and buffalos for fertilizing the pond and one farmer stated using quail manure. Only two farmers also limed the pond and one farmer did not use any kind of fertilization. Identically as in case of rice field aquaculture, fish were fed with combination of commercial fish feed and natural products growing in the pond owing to manure application. Farmers mostly combined fish species in one pond. Only three farmers practised monoculture. Water for filling the pond was solely supplied from nearby river. All the farmers used fingerlings from commercial producers but four of them combined them with own fingerlings.

5.1.3 Cage aquaculture

Cage aquaculture occurred only along the river basin and was characteristic by high fish densities. The average cage size was 20.3 m^2 and farmers owned nearly three cages in average. The highest number of cages owned by farmers was 10 while majority had only two cages. The most often farmers owned bamboo cages followed by steel and iron (84.8%, 57.6% and 12.1% of famers respectively). As cages were placed in the river no additional water source was used. Fertilizer was not applied in cage aquaculture and fish were fed by commercial feed as well as leftovers from agriculture production. Monoculture was practised by intensive farmers as they were focusing on less fish species that they were able to breed separately in cages. Fingerlings were obtained from commercial fingerling producers only.

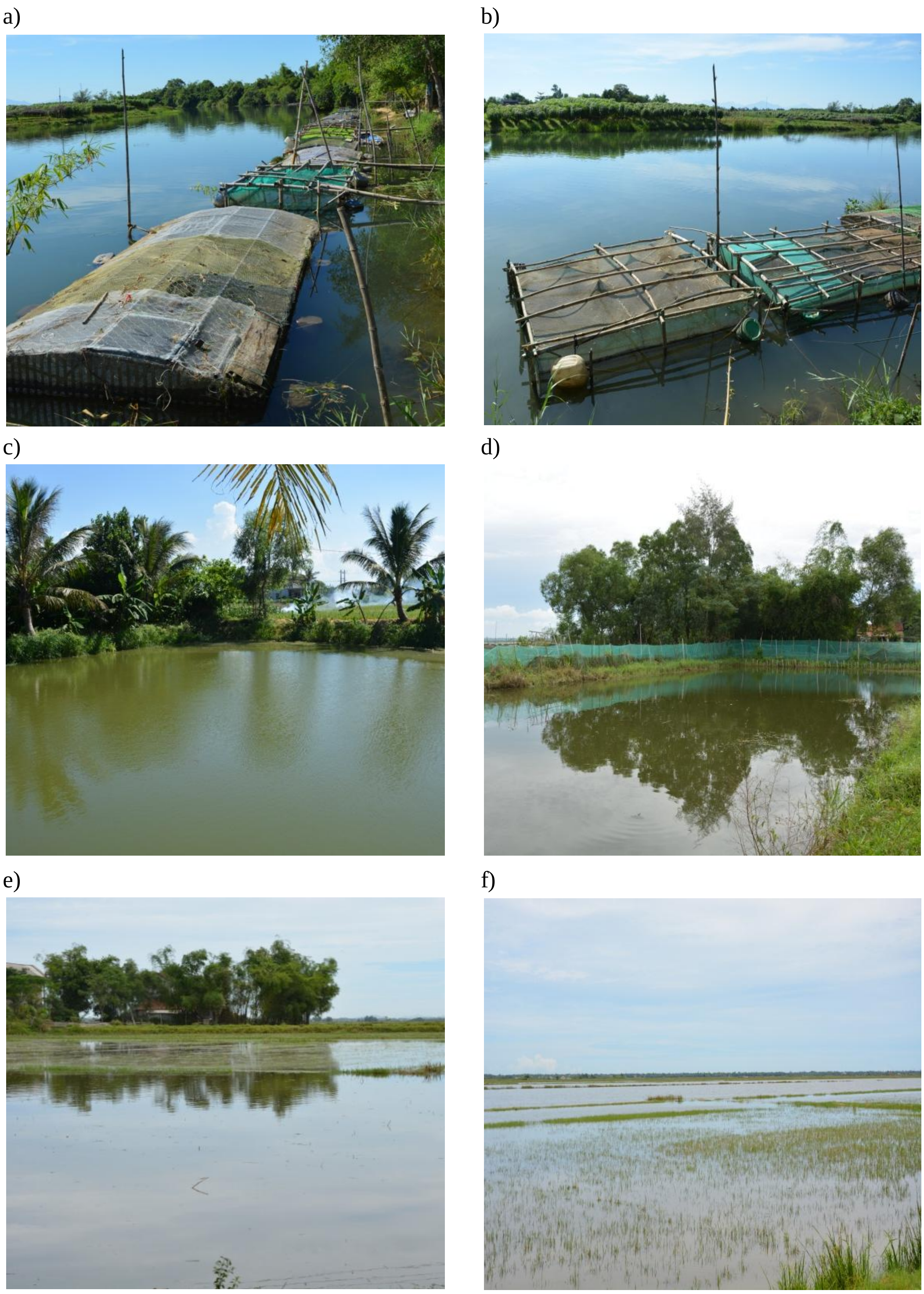

Figure 7

Typical fish farms in the target areas

Source: Author, 2015

Note(s): Cages in a) Quang Tho, b) Huong Toan; Ponds in c) Quang Dien, d) Thuy Tan; Rice fields in e) Thuy Tan, f) Huong Toan

5.2 Identification of main fish species with special regard to fish farming practice

Grass carp (*Ctenopharyngodon idella* Val.), common carp (*Cyprinus carpio* L.), silver carp (*Hypophthalmichthys molitrix* Val.), nile tilapia (*Oreochromis niloticus* L.), red tilapia (*Oreochromis* sp.), red pomfret (*Colossoma brachypomum*) and walking catfish (*Clarias batrachus* L.) were identified as fish species bred by local households in their fish farms. Generally, grass carp was the most common bred fish species in the study area followed by silver carp and common carp (90.7%, 38.9% and 29.6% of household respectively). All identified fish species were common in extensive fish farms while intensive ones tented to breed less fish species, in average 3.10 (±0.94) and 1.24 (±0.61) fish species per farm respectively. Difference between number of fish species bred in extensive and intensive aquaculture was statistically significant (P-value=0.000). Generally, composition of the most common bred fish species in extensive aquaculture was evenly distributed among grass carp, common carp and silver carp while only grass carp comprised for 80.5% of fish species composition in intensive aquaculture. Complete fish species composition in each aquaculture practice is shown in Figure 8.

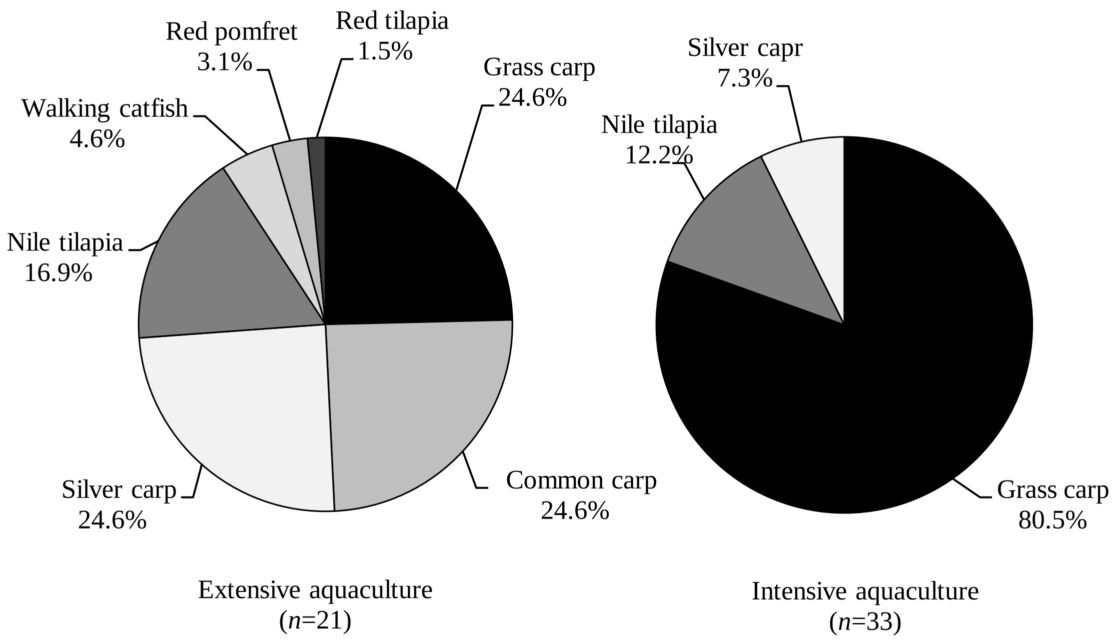

Figure 8

Fish species composition in different aquaculture practices

5.3 Fish production

Based on our results majority of fish production came from extensive farming systems with an average annual production of 1,614 kg (± 2,542) while intensive systems produced annually only 628 kg (±229). Although total annual production from extensive fish farming was higher and difference between extensive and intensive aquaculture was significant (P-value=0.033), annual production per square meter was totally different. Intensive aquaculture was able to produce seventy times more per square meter than extensive aquaculture (17.6 kg and 0.25 kg per m^2 respectively) with statistically significant difference (P-value=0.000).

Generally, majority of fish production from both extensive and intensive aquaculture was intended for selling at market (94.5% and 97.1% respectively) while household consumption created just minor part from whole production in both areas. Since share of production intended for market and consumption was very similar in both fish farming systems, there was no statistically significant difference. Most of farmers preferred to sell their fish production via middleman in both extensive and intensive system (90.5%, 93.9% respectively). From intensive farmers, 3.0% of respondent sold their fish by themselves and the same percentage of farmers combined selling via middleman and by themselves. Contrary to intensive farmers, extensive farmers more often preferred to sell their production by themselves (9.5% of respondents). All the fish farmers preferred to sell their fish fresh and nobody processed them.

Grass carp was not only the most commonly bred fish species but also the most valuable fish species with the average selling price 59.8 (±7.7) thousand VND per kg in extensive aquaculture and 65.1 (±3.7) thousand VND per kg in intensive fish farming system. Difference in selling price of grass carp was statistically significant (P-value=0.002). This was the only one exception when difference in selling price was documented among particular farming techniques. Silver carp was sold in extensive and intensive aquaculture for the average price of 24.1 (±5.5) and 25.0 (±3.5) thousand VND per kg respectively. Also nile tilapia has not noticed any difference between average selling prices (23.8±6.7 thousand VND per kg, 26.0±5.3 thousand VND per kg respectively). Unlike intensive aquaculture where no more fish species were bred, extensive fish farming practices noticed breeding of another four fish species, namely common carp, red tilapia, walking catfish and red pomfret and their average selling prices were recorded (39.1±4.6, 40.0±0.0, 30.0±6.2 and 23.5±2.1 thousand VND per kg respectively). Generally, intensive farmers sold their fish production for higher average price than extensive farmers (61.24 and 39.12 thousand VND per kg), considering production of each fish species and its selling price.

5.4 Socioeconomic and demographic characteristics of targeted households

Men seemed to have a leading role in decision-making process covering farm management in the study area. Based on our data, out of total number of 54 interviewed persons, there were 94.4% and 5.6% male and female farmers respectively. All the respondents belonged to Kinh ethnic group and age of household heads ranged from 30 to 71 years with an average age of 51.1 years. Household size ranged from two to nine members however households mostly had four members.

In general, significant differences between extensive and intensive aquaculture were documented, particularly in term of farm size, farming experiences and household head age (Table 6). Extensive aquaculture farmers exceeded those realizing intensive aquaculture by household head age. From the survey, the youngest farmer was 30 years old carrying out intensive aquaculture while the oldest farmer was noticed in extensive aquaculture at the age of 71. In term of aquaculture farming experiences, those with extensive aquaculture significantly exceeded intensive aquaculture farmers. To the contrary, households realizing intensive farming showed little bit higher years of schooling however difference between two groups was not statistically significant. Only one head of household from extensive aquaculture stated that he has never attended school while minimum years of schooling for intensive farmers were four years in case of two farmers.

Tables 6: Household characteristics: human and land resources						
Indicator	Unit of measure	Extensive aquaculture farmers (n = 21)		Intensive aquaculture farmers (n = 33)		T-test
		Mean	SD	Mean	SD	P-value
Household members	number	3.95	1.80	4.30	1.38	0.423
Dependant members	number	1.00	1.22	1.06	0.83	0.828
Labour force	number	2.95	1.53	3.24	1.58	0.509
Male labour	number	1.52	0.98	1.73	1.04	0.477
Female labour	number	1.43	0.93	1.52	0.87	0.729
Household head age	years	54.52	8.36	48.90	10.50	0.045**
Years of schooling	years	7.56	2.06	8.23	1.92	0.229
Farming experience	years	11.71	6.14	7.30	4.77	0.005***
Farm size	ha	1.76	1.55	0.50	0.38	0.000***

Note(s): *, **, and *** are significance at 90%, 95% and 99% respectively.

The highest education among all heads of household was completed high school education in length of twelve years with nine years as most often claimed length of studies. No interviewed farmers have attended university. Farm size was another important indicator showing the most statistically significant difference among aquaculture techniques. Extensive farmers tended to have more farm size at their disposal while intensive farmers had to make do with only one third of extensive farmer's farm area.

The cash income and its structure were important factors for understanding local livelihoods strategies. Our results showed that there was statistically significant difference in total annual household cash income between two focused aquaculture techniques (Table 7). Significant differences in cash income distribution were observed in income generating from rice, annual crops and livestock. Extensive aquaculture farmers had less income than intensive farmers from annual crops, comprising for 1.2% and 13.2% of total income respectively, and from small business (4.3% and 7.3% respectively). On the contrary extensive farmers exceed intensive farmer in cash income derived from rice (representing 32.8% and 19.1% of total income respectively) and livestock (20.7%, 8.3% respectively). Income from homegardens that served primarily for subsistence purposes in both study groups, together with salary, created just minor insignificant part of the total income. Based on this finding we can describe extensive aquaculture farmers as more focused on rice and livestock while intensive aquaculture farmer derived their cash security more from rice and annual crops. For both extensive and intensive farmers, aquaculture played crucial role in their livelihood strategies and represented the most important income, contributing to household income generation by 39.2% and 50.6% respectively. Nevertheless difference in cash income from aquaculture between intensive and extensive aquaculture farmers was not statistically significant. The fact that aquaculture played significant role in household income was in correspondence with statements of all respondents who claimed that had started aquaculture in order to increase household cash income.

Tables 7: Annual household cash income (in thousand VND)

Indicator	Extensive aquaculture farmers (*n* = 21)		Intensive aquaculture farmers (*n* = 33)		T-test
	Mean	SD	Mean	SD	P-value
Total	118,771	18,544	74,691	27,745	0.020**
Rice	38,976	33,534	14,258	13,687	0.000***
Annual crops	1,376	2,498	9,885	14,673	0.011**
Homegarden	48	218	0	0	0.213
Aquaculture	46,524	57,557	37,818	16,073	0.397
Livestock	24,571	35,511	6,167	11,927	0.008***
Salary	643	1,963	303	1,741	0.509
Small business	5,143	9,420	5,424	8,238	0.908
Others	1,490	3,571	836	2,387	0.423

Note(s): *, **, and *** are significance at 90%, 95% and 99% respectively.

1 USD = 21,900 VND as of January 2016 (SBV, 2016).

In term of annual household cash expenditures, extensive farmers recorded higher expenses in comparison with intensive farmers (115,773 thousand VND, 64,386 thousand VND respectively) and difference between total expenditures in study groups was statistically significant (P-value=0.011). Total expenditures comprised expenses for farm, household, health, paying back the credit and government taxes. Annual household cash expenditure distribution, shown in next figure (Figure 9), indicates that extensive aquaculture farmers spent more than half of expenditure (56.1%) for farm expenses including fish farming while in intensive fish farming farm expenses created less than half of total expenditure (48.6%). Extensive farmers also paid more money for paying back the credit and for government taxes. On the contrary intensive farmers tended to spend more money for education and health.

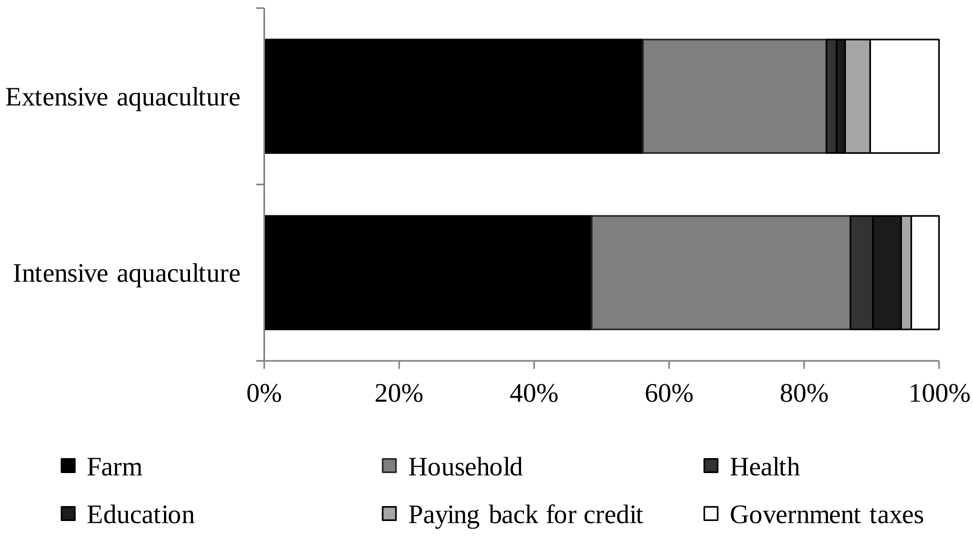

Figure 9

Annual household cash expenditures distribution

5.5 Land resources and use

As mentioned above, an average farm size of extensive and intensive aquaculture households was 1.76 and 0.50 ha respectively. Among the interviewed farmers, two households owned amount of land smaller than 1,000 m^2, exactly 815 m^2 and 715 m^2. These households belonged to the intensive aquaculture farmers. To the contrary, minimum farm size of extensive aquaculture households was land around 3,000 m^2. In term of size structure, certain differences occurred in each aquaculture practices. The highest share of farm size comprised rice fields in both extensive and extensive aquaculture (67.3% and 74.5% respectively) with the difference that extensive farmers used their rice fields for both rice production and aquaculture purposes while intensive farmers focused only on rice production. Fish ponds in extensive aquaculture created 12.1% of farm size while cages in intensive production comprised only nearly 1% of total farm size. Fields used for annual crops comprised just minor part within extensive households (8.6%) while in case of intensive households it was more than twice as much (18.9%). Homegardens where crops like cassava, pomelo or jackfruit were produced mainly for household consumption, comprised for only 4.4% of farm size of extensive households and 12.9% of intensive ones.

5.6 Cost-benefit analysis

5.6.1 Cost structure

Costs of production were categorized into variable and fixed costs and computed per m^2 of cage, pond or rice field. Variable costs accounted in average for 86.8% and 79.8% of the total costs for extensive and intensive aquaculture respectively; the rest were fixed costs. From Figure 10 is obvious that extensive aquaculture farmers applied more types of variable costs connected with fish farming than those using intensive techniques.

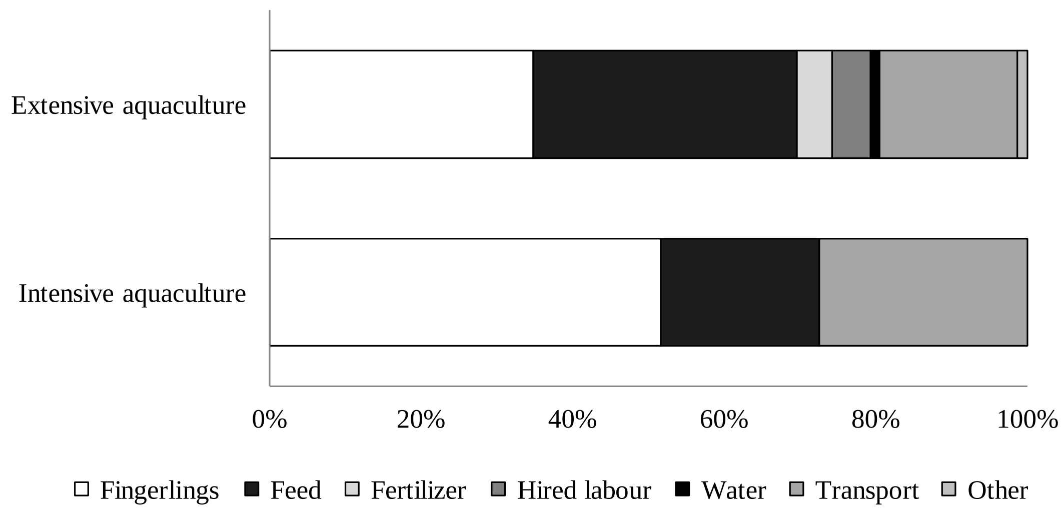

Figure 10

Variable cost composition in different aquaculture techniques

Among the variable costs, the costs of fingerlings dominated in both extensive and intensive aquaculture and accounted for 34.8% and 51.6% respectively. Costs of feed comprised the same share of 34.8% as fingerlings in extensive aquaculture whereas in intensive fish farming they were at the third place with the share of 20.9%. Intensive aquaculture farmers declared costs for transportation as the second important cost with share of 27.5%. These costs in extensive fish farming comprised for 18.1%. Unlike intensive aquaculture farmers extensive farmers reported costs connected with hired labour, fertilizers, water and other costs (5.1%, 4.6%, 1.2% and 1.4% respectively).

Variable costs per m^2 showed us statistically significant differences in all types of variable costs among studied group except other costs where no significant difference was observed due to insignificant values (see Table 8). Total variable costs were almost sixty times higher in intensive fish farming in comparison to extensive aquaculture.

Tables 8: Variable costs (in thousand VND/m^2)

Indicator	Extensive aquaculture farmers (n = 21)		Intensive aquaculture farmers (n = 33)		T-test
	Mean	SD	Mean	SD	P-value
Fingerlings	2.37	2.20	210.58	269.51	0.001***
Feed	2.37	2.54	85.16	52.46	0.000***
Fertilizers	0.32	0.32	0.00	0.00	0.000***
Hired labour	0.35	0.61	0.00	0.00	0.002***
Water	0.09	0.21	0.00	0.00	0.021**
Transportation	1.24	1.79	112.33	107.18	0.000***
Others	0.10	0.44	0.00	0.00	0.213
Total	6.82	5.42	408.07	338.88	0.000***

Note(s): *, **, and *** are significance at 90%, 95% and 99% respectively.

Fixed cost covered mainly depreciation of equipment and pond/cage/rice field. Generally, deprecation of equipment comprised minor part in intensive aquaculture since lion's share comprised depreciation of cage. As mentioned above, farmers have used three types of cages, i.e. steel, bamboo and iron. According to farmer's statement, steel cages were quite expensive with average acquisition costs around 26 mil VND, varying with cage size. In comparison to steel cages, bamboo cages were much cheaper, with an average cost 5 mil VND. However, an average bamboo cage lifespan was lower than steel cage (3 years, 15 years respectively). Unlike intensive aquaculture equipment depreciation comprised almost as same share as depreciation of pond in case of extensive farmers. Generally, total fixed costs per m^2 were higher in intensive aquaculture (see Table 10). The equipment widely used by great number of farmers included nets, boots, ropes, scales, wheelbarrow and shovels. More expensive equipment such as pumps was owned by 40.0% of farmers whereas only one quarter of farmers owned boat.

5.6.2 Gross margin analysis

Total gross margin for intensive aquaculture farmers was higher than that for extensive, on average (Table 9) although there was no significant difference between aquaculture systems. Nevertheless difference between gross margins/m^2 was significant, showing us that intensive farmers are able to generate much higher profit per area than those carrying out extensive aquaculture. Table 9 also shows that intensive farmers were able to generate higher gross margin per household member as well as per labour force.

Tables 9: Gross margin (in thousand VND)

Indicator	Unit of measure	Extensive aquaculture farmers (*n* = 21)		Intensive aquaculture farmers (*n* = 33)		T-test
		Mean	SD	Mean	SD	P-value
Gross margin	Total	13,470	43,932	25,033	14,242	0.165
Gross margin	m^2	1.82	4.18	733.62	547.90	0.000^{***}
Gross margin	household member	2.880	7,825	6,006	3,381	0.048^{**}
Gross margin	labour force	4,494	11,324	8,224	5,041	0.116

Note(s): *, **, and *** are significance at 90%, 95% and 99% respectively.

5.6.3 *Break-even point analysis*

The average annual gross income from aquaculture varied from 8.64 thousand VND/m^2 in extensive farming to 1,142 thousand VND/m^2 in intensive aquaculture (Table 10). Despite higher production costs, the average net income was higher in intensive farming. Gross margin in both aquaculture systems showed that farms were able to generate positive returns to variable costs. In spite of higher costs, the BCR was higher in intensive farming comparing to extensive farms. The findings indicate that intensive farms are able to recover 2.23 thousand VND per 1 thousand VND of investments while extensive farmers generate return of only 1.10 thousand VND. BEP for extensive farmers was 4.91 thousand VND/m^2 while for intensive it was 160.28 thousand VND/m^2. Farmers are being profitable above these points.

Table 10: Cost-benefit indicators (in thousand VND/m^2)

Indicator	Extensive aquaculture farmers (*n* = 21)	Intensive aquaculture farmers (*n* = 33)
	Mean	Mean
Total gross income	8.64	1,141.69
Total variable costs	6.82	408.07
Total fixed costs	1.03	102.99
Total costs	7.85	511.06
Gross margin	1.82	733.62
Total net income	0.79	630.63
Benefit-cost ratio	1.10	2.23
Break-even point	4.91	160.28

5.7 Self-perception of local threats from external environment, farmer's attitudes towards aquaculture and perception of barriers

In the research, we tried to understand how local households perceive possible threats that could affect their livelihood strategies. From next table (Table 11) is obvious that there was no statistically significant difference in perceiving neither shortage of money nor lack of food between extensive and intensive aquaculture farmers. Households claimed lack of money mainly between December and February. Extensive farmers perceived drought as a most important risk affecting them for more than three months per year in average. Nevertheless drought was crucial risk also for intensive farmers who recorded it as a second serious risk. Significant differences were observed in perceiving of floods and fish diseases. Both extensive and intensive aquaculture farmers perceived floods as a threat that affected their livelihoods however it seemed to be more risky for intensive fish farmers that faced floods for longer time period. The most statistically significant difference was related to perception of diseases that affect fish production. According to our findings extensive farmers faced a fish disease within nearly two months whereas intensive farmers within almost four months per year.

Tables 11: Farmer's risk perception (in months)

Indicator	Extensive aquaculture farmers (*n = 21)*		Intensive aquaculture farmers (*n* = 33)		T-test
	Mean	SD	Mean	SD	P-value
Cash shortage	2.71	2.69	2.52	2.28	0.772
Food shortage	0.57	1.47	0.45	1.06	0.736
Floods	2.19	0.51	2.48	0.67	0.091*
Drought	3.29	1.15	2.94	1.25	0.310
Fish diseases	1.86	1.31	3.91	1.42	0.000***

Note(s): *, **, and *** are significance at 90%, 95% and 99% respectively.

Farmers reported several obstacles that they faced during fish farming. Majority of farmers in extensive and intensive aquaculture (90.5 and 100% respectively) considered fish diseases as the most serious problem that hinders the efficiency and/or development of their fish farm. The second most serious problem for extensive aquaculture farmers was market access (81.0%), followed by lack of money (76.2%). Intensive aquaculture farmers considered lack of money (78.8%) to be more serious than market access which is regardless very significant (63.6%). Among other barriers in extensive and intensive fish farming belonged floods (61.9, 54.5% respectively) and difficulties in accessing loans (61.9, 42.4% respectively). Predators seemed to be more serious problem for extensive farmers (47.6%) since only 6.1% of intensive aquaculture farmers considered it as important barrier. The most common predators according to farmers were birds followed by snakes. Farmers from intensive aquaculture did not mention any problem with poaching whereas 14.3% of extensive farmers had problem with poachers.

Farmers from both aquaculture practices perceived increasing number of aquaculture farms in their surroundings in comparison with five years ago. Extensive aquaculture farmers observed increased number of fish farms by only 38.1% whereas 90.1% of intensive farmers saw accumulation of fish farms. Situation with aquaculture as same as was five years ago perceived 57.1% of extensive farmers. The rest of farmers did not perceive any changes. In term of profit from aquaculture both extensive and intensive aquaculture farmers noticed higher profit in comparison with previous years (57.1 and 63.7% respectively). Unchanged profit was recorded by 38.1 and 33.3% respectively and only very small proportion of respondent perceived lower profit (4.8 and 3.0% respectively). Future expectations of aquaculture profitability were very similar in both study groups and are shown in next figure (Figure 11).

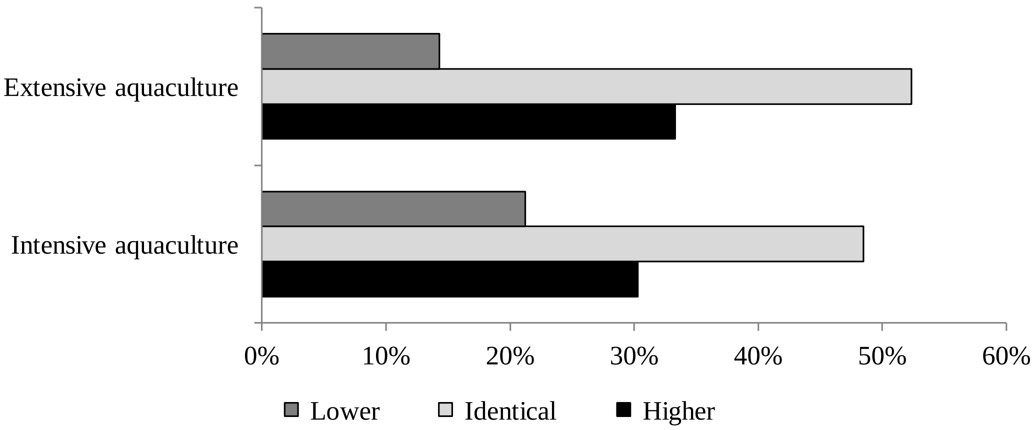

Figure 11

Future expectation of aquaculture profitability

In term of participation in farmers association or cooperative, 90.5% of extensive aquaculture farmers stated that they were members of association regarding fish production whereas in case of intensive fish farmers it was only 63.6%. Main advantages derived from membership in cooperative association were almost identical for both extensive and intensive aquaculture farmers and thus they are presented together in next figure (Figure 12).

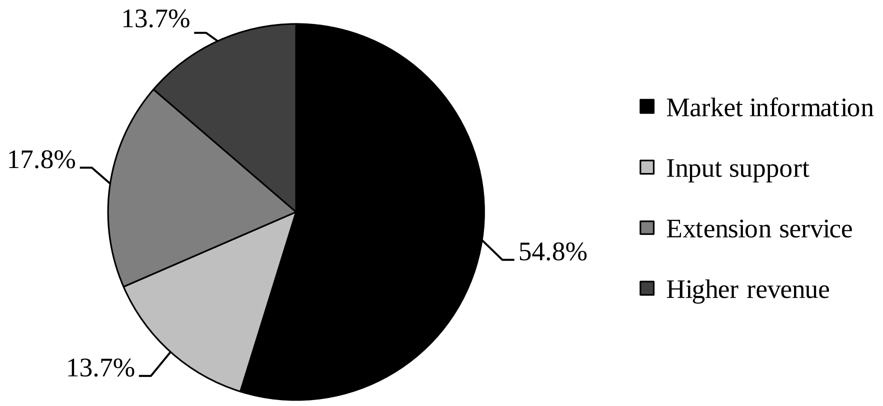

Figure 12

Main advantages concerning membership in farmer association

Farmers faced several problems that hindered fish farming and its profitability and therefore it was interesting to ask whether farmers had an opportunity to take an advantage of any kind of extension services. From farmers responses we found out that only 24.2% of intensive aquaculture farmer used extension services. Extensive fish farmers had better experiences with extension services and used them by 52.4%. Extension services were provided mainly by agricultural experts from universities or local agricultural offices. Small percentage of intensive farmers (12.1%) stated that they relied on advices from their neighbourhood and relatives.

We found out that record keeping was very poor among all the respondents. Only one farmer from intensive aquaculture kept record about fish production. Situation with record keeping was better within extensive fish farmers, nevertheless still low, accounting for 19% of respondents.

6. Discussion

6.1 Comparison of our results with other published studies

Based on our results, we identified three different aquaculture practices within study area that were further categorized according to the value and amount of necessary inputs into extensive and intensive practices. The aquaculture production in both research groups comprised significant part of household livelihood strategies however certain differences were observed not only in socioeconomic or demographic situation of focused household but also in term of cost-benefit analysis.

Correspondingly to Ghana (Nunoo et al., 2014), extensive aquaculture farmers, e.g. pond a rice field fish famers, were older than intensive farmers producing fish in cages, with an average age of 54.5 and 48.9 years respectively. However average age of both groups was higher in comparison to studies from Bangladesh (Karim et al., 2016). Extensive aquaculture farmers were more experienced in farming nevertheless with less years of schooling in comparison to intensive farmers. Similar results can be found in study from Ghana (Nunoo et al., 2014). According to Onumah and Acquah (2010) younger fish farmers are more technically efficient than older farmers and are also more willing to produce their fish within new production systems. Technical efficiency seems to decrease with higher level of formal schooling (Onumah and Acquah, 2010) however on the contrary Battese et al. (1996) found out that technical inefficiencies of production tend to be smaller for older farmers and those who achieved higher education level. Thus it is not possible to unambiguously claim that older or better educated people tend to be less or more technical efficient and willing to adopt new methods. Apart from age and education there are also factors such as economic situation, land area, farm management skills or availability of extension services that can influence adoption of aquaculture system (Iqbal et al., 2006; Nhan et al., 2007).

Aquaculture farms were run mainly by male farmers which in accordance with study of Nunoo et al. (2014) from Ghana, where aquaculture was principally male-oriented particularly in relation to pond preparation, input acquisition, application of fertilizer or harvesting. Also Asmah (2008) noted the low number of fish farms owned by women in subsistence fish farming. He attributed it to the fact that in Ghana men have been traditionally considered as heads of households who should probably be owners and responsible for farming in the name of the head of family. Even though men dominate fish production in aquaculture, they still rely on participation of women and other family members (Rutaisie et al., 2010) whose activities are limited to feeding, harvesting, processing and marketing (Asmah, 2008). Interestingly, women comprised majority (63%) of surveyed pond farmers in Bangladesh (Karim et al., 2016) which is totally distinct form information above. One of the major barriers for women to entry aquaculture production sector is high initial costs in term of land, training and pond construction which is particularly true for single women as they often lack collateral required to borrow money (Ndanga et al., 2013).

Farmers diversified their household cash income however aquaculture comprised major part and played significant role in household livelihoods strategies in both aquaculture systems. Aquaculture comprised 39.2% of extensive farmer's total cash income whereas intensive farmers reported higher proportion from aquaculture accounting for 50.6%. Based on our findings we can assume that extensive aquaculture farmers who hold larger farm size, three times larger in average than intensive aquaculture farmers, had better opportunity to generate income from other sources such as livestock or rice cultivation thanks to large land at their disposal. Intensive farmers had only small farm size to their disposal and thus they were forced by their situation to intensify production due to lack of land. Their income then relied more on aquaculture and annual crops. It seems that thanks to availability of land extensive farmers had no need to intensify their production while intensive aquaculture farmers have to cope with small farm area. Even if aquaculture contributed significantly to household's income it is appropriate that farmers did not rely solely on one activity and they were able to generate income also from other activities even if almost all are associated with agriculture. Income diversification is one of survival strategies and means of risk distribution in case of failure or contingency (Carletto et al., 2007) and according to Olale and Henson (2012) households with higher formal education and those who are members of an association have higher probability of diversifying income.

Increase of income seems to be an underlying reason for undertaking aquaculture. All the respondents claimed that they started with aquaculture in order to increase income and thus only minute amount of production was consumed within household. The same reason as our interviewed farmers had also majority of farmers in Ghana who highlighted the role of aquaculture in generating cash income rather than household consumption (Nunoo et al., 2014), farmers in Thailand (Boonchuwong et al., 2007) or catfish farmers in Vietnam (Phuon et al., 2007). Interestingly, two various studies from Uganda reported totally different opinions. Study of Isyagi (2007) determined that main reason to start fish farm for majority of farmers was to increase profit while Hyuha et al. (2011) claimed that most of farmers (70%) produced fish mainly for family consumption and only surpluses were sold off at local market. Thus there are two main reasons for fish farming, to increase profit or supply fish for household consumption however reasons differ across regions and probably depend on current household situation, their preferences and ability to generate income from other activities.

Aquaculture production requires certain conditions and inputs. Availability of water source is underlying element for aquaculture feasibility. Water quality is the most important factor affecting fish health and performance of aquaculture production. All the famers realizing cage and pond aquaculture relied solely on rivers as a water source. One third of farmers from rice field aquaculture relied solely on rainfalls and groundwater. Our findings are quite different from study in Ghana where 59.5% of pond farmers relied on ground water and rainfall and only 39.2% used water from river (Nunoo et al., 2014). Also Ahmed et al. (2010) found out that principal water source for pond farmers in Bangladesh were rainfall and groundwater. However to rely on groundwater and rainfalls is quite risky mainly in dry season, when water level in ponds can dramatically decrease and may result in higher fish densities and cause various quality problems or loss of fish (Nunoo et al., 2014). According to Tan et al. (2006) water in cages in rivers in less controllable than in ponds however fish in cages are more vulnerable due to high stocking densities. Thus it is advised to provide farmers with trainings to understand water quality requirements and to avoid problems associated with temperature, oxygen concentration, pH or turbidity.

In correspondence with study in Ghana (Nunoo et al., 2014) only extensive farmers applied fertilizer or manure, we only noted difference in manure source. Our respondents used mainly manure from pig and buffalo whereas farmers in Ghana relied on poultry, sheep and goat manure. The application of manure is considered as the cheapest way how to increase pond productivity at minimal cost (Mataka and Kang´ombe, 2007). Kipkemboi et al. (2007) found out that application of manure in ponds increases fish yields however the differences in gross margin between manured and unmanured ponds were small.

Our data furthermore documented that intensified practices showed lower species diversity. It could be caused by the fact that intensive farmers practised monoculture in cages and thus were focusing on selected species with regards to selling price. Grass carp comprised 84% of fish species distribution among intensive farmers and also belonged among the most valuable fish with the highest selling price. We assume that cage farmers were focusing on the grass carp in order to earn higher income that seems to be good strategy from economic point of view since they were more profitable than extensive farmers who showed higher species diversity. Extensive farmers mostly (75.0%) combined several fish species in ponds. It is comparable with pond farmers in Ghana who reported polyculture by 55.4% (Nunoo et al., 2014). On the other hand quite different results can be seen within more intensive farmers; almost all our interviewed cage farmers practised monoculture while 92.3% intensive pen farmers in Ghana reported polyculture (Nunoo et al., 2014). According to Abdelghany and Ahmad (2002) polyculture of nile tilapia, common carp and silver carp is commonly practised in more extensive systems with fertilization which correspond with situation of pond farmers in our study. The combination of these three species may ensure maximal utilization of natural food available in ponds due to different feeding habits of selected fish species.

No fish processing was done within our respondents and farmers preferred to sell their fish fresh as they were able sell them for higher price in comparison to processed fish. Cheaper fish for household consumption were usually bought at local market. This is consistent with other studies (Ahmed et al., 2010; Hyuha et al., 2011; Nunoo et al., 2014) where farmers preferred to sell fresh fish because of higher revenues and only fish that could not be sold fresh were processed.

In general, farming technique seems not to have significant influence on selling price since the only difference was observed in price of grass carp. Intensive aquaculture farmers sold grass carp for higher price than extensive farmers however other fish species reported similar prices. This finding is consistent with study of catfish in Bangladesh were no differences in selling price between different farming systems were observed (Ahmed et al., 2010). However if we consider distribution of fish species in each aquaculture systems, intensive farmers focusing mainly on grass carp were able to sell their production for higher price than extensive farmers whose production consists of more different less valued fish species.

We observed that lion's share of total cost comprised for variable costs in both extensive and intensive aquaculture (86.8% and 79.8% respectively). Share of variable cost is comparable to 77.4%, 73.2% of extensive and intensive farmers respectively in Ghana (Nunoo et al., 2014). On the other hand, share of variable cost is lower if we compare it with 94.5% and 90.9% in intensive and extensive pond aquaculture respectively in Bangladesh (Ahmed et al., 2010), 93.0% in small-scale aquaculture in Uganda (Hyuha et al., 2011) or 98.1% in Nigerian catfish farms (Ugwumba and Chukwuji, 2010).

Interestingly to other studies, we observed cost of fingerlings as most significant, comprising for 34.8% and 51.6% of variable cost in extensive and intensive fish farms respectively. Our findings differs from study of Ahmed et al. (2010) who recorded that cost of fingerlings constituted only small proportion of total production costs (5% and 10% in intensive and extensive farming respectively). Also Asmah (2008) reported cost of fingerlings comprising only 15.6% and 22.2% at extensive and intensive pond farmers respectively in Ghana. Share of costs of fingerlings from our study is more similar to Ghanaian cage farmers (Nunoo et al., 2014) whose cost of fingerling accounted for 44.1%. Cost of feed usually comprise the highest share of total costs in aquaculture which is documented by 73.6% in Nigeria (Ugwumba and Chukwuji, 2010), 75.8% and 58.5% in intensive and extensive catfish farms respectively in Bangladesh (Ahmed et al., 2010) or 84.0% in catfish farms in Vietnam (Phuong et al., 2007). In our research costs of feed came at second place with share of 34.8% and 20.9% of variable costs for extensive and intensive farmers respectively which is again in accordance with study from Ghana where feed comprised 23.0% and 48.8% of variable costs in extensive and intensive farms respectively (Nunoo et al., 2014). With regard to cost of feed, Abdelghany and Ahmad (2002) suppose that there is necessity of optimum feeding rates in order to avoid using higher feeding rates than necessary. Feeding practices can significantly influence cost of feed and high feeding rates could result in lower economic return as well as water quality problem. Their study proved that net profit was increased with increase in feeding rates however overfeeding reduced farm profitability more than not using supplementary feed at all.

Intensive farmers reported better performance in term of cost-benefit analysis as they reported higher value of production, gross margin as well as net income which is consistent with other studies where more intensive farming system produced higher profit (Asmah, 2008; Ahmed et al., 2010; Nunoo et al., 2014). On the contrary study of Phuong et al. (2007) in Vietnam reported that intensive farmers had higher gross revenues however gross margin and net profit was higher in more extensive aquaculture using only farm-made feed. Both gross margin and net income were positive for extensive as well as intensive aquaculture farmer nevertheless intensive farmers obtained significantly higher values. Nunoo et al. (2014) reported negative gross margin and net income in case of small-scale pond farmers that implied that under present conditions small-scale operations were not economically viable in Ghana. The positive gross margin reported in both groups suggests that it is profitable to operate in the short-term and all variable costs of production are covered (Engle and Neira, 2005). Gross margin accounting for 1.82 thousand VND/m^2 of extensive farmers is comparable with value 3.4 thousand VND/m^2 of pond farmers in southeast Vietnam studied by Duc (2009) whereas 733.62 VND/m^2 in case of cage farmers was much higher and showed higher profitability of intensive systems.

According to Asmah (2008) positive net income indicates profitability and potential viability. The positive net income observed in both aquaculture practices indicates that aquaculture is profitable even in the longer term. However net income of extensive farmers accounting for 0.79 thousand VND/m^2 was quite small and together with BCR equal to 1.10 leads to the question how sustainable these systems are in a long term and if such profit is sufficient. Even if intensive farms had high total costs, their BCR accounted for 2.23 bringing them higher benefit than to extensive farmers. On the contrary, Ahmed et al. (2010) reported BCR of 2.12 and 1.64 for extensive and intensive farms respectively, claiming that BCR lower in intensive farms was due to intensive feeding regimes. Zhu et al. (2011) examined the role of stocking densities on economic performance of aquaculture. Results of their study performed in China showed that the highest stocking densities required the highest total expenditures however provided the lowest net income resulting in the lowest BCR while the highest BCR was obtained with the lowest density. The fact that total costs of production of interviewed farmers were higher in intensive aquaculture and therefore it is cheaper to produce per square meter of extensive aquaculture system than intensive is supported by other studies (Hyuha et al., 2011; Nunoo et al., 2014). Nevertheless intensive aquaculture farms even if they were more capital intensive, they produced higher profit.

Record keeping claimed by respondents was very poor, accounting for only 9.3% of all respondents with higher occurrence among extensive farmers. However it is not exceptional situation among small-scale farmers as noted also in other studies (Huyha et al., 2011; Nunoo et al., 2014). Keeping records should not be underestimated since it is the only source of information by which farmers can keep cost and revenue overview, adjust daily management, evaluate performance, monitor fish diseases as well as improve future plans (Pomeroy, 2003; Mwangi, 2008).

The barriers of aquaculture reported by respondents are consistent with findings of Nunoo et al. (2014) where main obstacles were lack of capital. According to Ugwumba and Chukwuji (2010) high capital investment for obtaining reasonable profit has to be made since aquaculture is a capital-intensive business. Lack of money was one of main obstacles for our respondent however according to responses we can assume that more serious constraint for interviewed farmers were fish diseases that negatively affect the production regardless aquaculture practice applied. Higher perception of fish disease is within intensive aquaculture farmers. This fact is supported by findings of Merican (2006) or Tan et al. (2006) that reported high prevalence of fish diseases among cage aquaculture farms. Correspondingly to our findings, fish diseases together with floods were problems rather for intensive fish farmers in Bangladesh (Ahmed et al., 2010). Interestingly to other studies (Ugwumba and Chukwuji, 2010; Hyuha et al., 2011), our respondents did not mention high cost of feed as serious problems. However it could be caused by the fact that interviewed farmers still used also non commercial feed like agricultural by-products, leaves and other plant parts that could reduce cost of feed or they covered this problem into the statement about lack of money. Even if intensive aquaculture farms were able to generate better profit, overstocking practised often in such system should not be underestimated since it could be one of the constraints leading to fish mortality, stress and fish disease. As obvious from our findings, in accord with study of fish disease in Asia (Tan et al., 2006), disease is undoubtedly recognized as one of the biggest constraints to the production, development and sustainability of aquaculture. Disease causes not only economic losses but improperly used treatment can lead to negative consequences concerning whole environment.

6.2 Limitations of the research

Our results have to be understood with certain limitations since certain factors might have affected respondent's answers and our results.

First of all, rapid appraisal method was applied on the research and thus smaller number of respondents (54) was interviewed within three communes, therefore the results might be different from results of the whole province and cannot be generalized for the whole region. Secondly, most of the farmers were not keeping the records regarding fish farming so it was very difficult for them to estimate their production, costs and to specify other information relating fish farming activities, and thus we had to rely only on information that farmer were able to remember. Further on certain days farmers were occupied with field work due to the harvest season and with local celebrations and thus were not willing to be interviewed. Furthermore, the research was conducted in the course of two months thus the whole fish production period was not included. Farmers could have more problems with fish farming in comparison to other months and thus there is possibility of influencing the responses. No possibility to compare our findings with previous years has been done due to short-term contact. The last but not least data were collected by third party and so some misinterpretations might have been caused by the language barrier.

6.3 Suggestion and recommendation for further research

Further research should more focus on costs structure and long-term sustainability of both aquaculture systems. The results have shown that intensive aquaculture was able to generate greater profit even if costs were higher than in case of extensive farms. Consequently it would be interesting to compare sustainability of each system, primarily extensive aquaculture which reported positive but low gross margin, net income and BCR. However due to limiting time for the research it was not possible to evaluate future potential of this system or compare with previous years. It is recommended to analyse different aquaculture system taking environmental impacts into consideration. Each aquaculture system has it pros and cons for farmer however not only economic benefits derived from fish production should be analysed.

Generally, more programmes should put young farmers into the centre of interest of agricultural extension services, policy makers and agribusiness to provide them with improved knowledge and practical skills, which could lead to higher awareness on how to deal with floods, fish diseases, biodiversity, economic performance as well as impact of each aquaculture system on environment. As aquaculture continues to grow, disease problem will threaten the sector unless key steps are taken. Research concerning disease should include implementation of disease control concept covering use of healthy fingerlings, optimized feeding, good husbandry techniques, monitoring of disease, sanitation and responsible use of chemicals (Tan et al., 2006). Since farmer will not be aware and trained in this field, there will be always problem with disease outbreaks affecting not only farmer's income but also their environment.

Majority of farmers did not keep records that make it difficult to have overview about production and overall costs. Therefore it would be good to include training about record keeping in extension services. Fish farming association then would require record keeping as a necessary condition for membership. Record keeping could not only help farmers to have an overview about revenues and expenses but also enable to follow overall situation and performance of fish farm.

Last but not least, it is recommended to focus further research also on recognition and consideration of context-specific preference of fish consumers, particularly cultural preferences, food habits and other needs. From the finding is obvious that most preferred farmed fish was grass carp however it would be appropriate to focus on consumers and to find out if current situation corresponds with consumer's preferences as well as nutritional needs. According to Kobayashi et al. (2015) consumer preferences play important role in analysing trends in demand and forecasting future fish supply.

7. Conclusion

The objective of the thesis was to document what are the main techniques and approaches applied in aquaculture production in Thua Thien Hue province, central Vietnam. From the results of research follows that aquaculture played significant role among fish farming households in term of increase of income rather than household consumption.

Specific objectives were analyzed and are concluded as follows:

(i) Three different fish farming practices were identified and according to initial cost grouped into two different systems in term of intensification. Pond and rice field aquaculture was determined as more extensive form while cage fish farming as intensive. More respondents practised intensive aquaculture. This type of aquaculture was observed in both rural and peri-urban areas whereas rice field aquaculture was observed only in peri-urban areas.

(ii) Our survey identified totally seven different fish species within both aquaculture systems. In term of fish species composition in particular fish farming techniques we observed that all seven fish species were common in extensive fish farming while intensive famers focused only on three species, namely grass carp, silver carp and nile tilapia. Generally, extensive farmers bred more fish species in average per farm than intensive farmers. Grass carp comprised majority of production within intensive farms while extensive farmers more diversified fish species composition. Grass carp belonged also among the most valuable fish species with the highest selling price reported. Thus intensive farms reported higher value of production in comparison to extensive farms.

(iii) Regarding to demographic profile of households involved in aquaculture our results showed that extensive farmers were generally older with more experiences and larger farm size than intensive farmers. Aquaculture comprised significant part of income indicating that it played key role in livelihood strategies of interviewed households.

(iv) Finding of cost-benefit analysis showed us huge differences between fish farming techniques. Generally, intensive farms reported higher total costs. But even if total costs were higher in intensive farms, they were able to generate greater profit. Both aquaculture systems were profitable however net profit from extensive farms was quite low and it would be appropriate to evaluate sustainable performance within further research.

It can be concluded that aquaculture play crucial role for certain part of Vietnamese society and the trend seems to be continued with respect to stagnating production of capture fisheries as well as increased demand due to population growth. Thus it is inevitable to manage aquaculture systems in sustainable way to provide livelihoods for local households as well as to preserve natural environment and the biodiversity in balance. There is necessity to evaluate not only the economic performance of aquaculture farms but also consequences of such activities on environment with respect to pollution, water quality or fish disease. As most of farmers complained about problem of fish disease it would be essential to involve extension services and government to take action and find proper solution how to cope with such problem and to secure safe environment and livelihood for future generations.

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ANNEX

List of Annexes

Annex 1. Semi-structured questionnaire

QUESTIONNAIRE

i. Name: ....
ii. Name of the village/commune: ..../............................
iii. District: ....

For how long do you run fish farming (years)? ....

Why did you start with fish farming? ....

Gender: ☐ male ☐ female Ethnicity ☐ Kinh ☐ other: ....

Age: ....

For how many years did you visit a school? ....

What is your annual income per household (thousand VND? ....

What are your annual cash expenditures (thousand VND)? Total:...................................

Farm (fertiliser, seed, fuel, fodder,equipment)	Household (electricity, food, water,land,house)	Health care	Education	Paying back for credit	Government taxes	Other

What is the area of your farm? Total:................ Rice field:............. Plantantion:...............

Homegarden:.................... Fish pond(s):........................ Field:............... Other:....................

Could you specify all people living in your household?

Specify other people living in your household (e.g. wife, son, daughter, parents, other relatives, friend)	Gender	Age	Years of schooling	Involvement in AQ design (management) (1 – very much, 4 – not at all)
	☐M ☐F			1 2 3 4
	☐M ☐F			1 2 3 4

Could you determine following situation during the year?

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Not enough money												
Not enough food												
Floods												
Drought												
Diseases												

How much money you are able to generate from particular activities (thousands VND) per year?

Rice	Field with annual crops (e.g. peanuts, corn, sugar cane etc.)	Perennial crops (trees) (e.g. rubber, acacia, bamboo etc.)	Home garden (vuon)	Aqua-culture (ao)	Livestock (e.g. meat, animals, eggs)	Salary	Small business (e.g. small shop, restaurant, tourist guide etc.)	Govern-ment support (e.g. pension)	Gifts money from relatives, friends, neighbours etc.	Other (specify)

Could you tell us what kind of fish species do you have and why?

Fish species	Reason for having this species					Annual production				Do you sell fingerlings?		
	Tradi-tion	Cheap inputs	Easy to grow	High demand on market	Other (specify)	Total in kg	Market (%)	House-hold (%)	Market price		Quantity sold	Market price
	☐	☐	☐	☐						☐No ☐Yes		
	☐	☐	☐	☐						☐No ☐Yes		

What are your main expenditures with fish farming per year (in thousand VND)?

Fingerlings	Feed	Fertilizer	Chemicals	Hired labour	Water (water fee)	Transport (fuel)	Damages (predator, thieves)	Other (taxes, association fee, market licences etc.)

How do you sell your fish? ☐ by my own ☐ via middlemen

Who from your household members work on your fish farm?

Household member	How many months per year?	How many days per month?	How many hours per day?	Other, notes

Could you describe us your equipment at your fish farm?

Equipment, tools etc.	How old is it? (years)	For how many years can you use it?	Money spent for equipment (thousand VND)	Owned vs rented

From where do you get water for the ponds?
☐ nearby stream ☐ reservoir ☐ ground water + rainfall ☐ other: ....

From where do you get fingerlings?
☐ commercial fingerlings producers ☐ own ☐ wild ☐ other: ....

Do you process fish? ☐ no ☐ yes

If NO, why: ....

If YES, why: ☐ not all yield is sold ☐ higher price ☐ other: ....

Types of processing:
☐ smoking ☐ salting ☐ fermenting ☐ frying ☐ drying ☐ other:................

Are you a member of any farmer association/cooperation (regarding to fish)?
☐ No ☐ Yes Which one: ....

What are main advantages which you can gain by association membership?
☐ market information ☐ input support ☐ extension services ☐ higher revenues
☐ other: ....

Do you use any extension service, advisory?
☐ No ☐ Yes From whom: ....

Do you make your own records on production, feeding, expenses, sales etc.?
☐ No ☐ Yes

Could you write down the most important barriers that hinder the efficiency and/or further development of your fish production?

Lack of money	☐No	☐Yes	
Difficulties in accessing loans	☐No	☐Yes	
Lack of water	☐No	☐Yes	
Floods	☐No	☐Yes	
Predators	☐No	☐Yes	specify:...........................
Poaching	☐No	☐Yes	
Diseases	☐No	☐Yes	
Market access	☐No	☐Yes	

Other ....

What is your perception of following issues?

a) Number of aquaculture farms in your commune in comparison with 5 years ago?
☐higher ☐identical ☐lower

b) Do you think your profit from aquaculture farm in comparison with 5 years ago is?
☐higher ☐identical ☐lower

c) Future expectation about profitability of your aquaculture production?
☐higher ☐identical ☐lower

d) What do you think would help you to increase your profit?
....