Small-scale Freshwater Aquaculture Practices in Indonesia: An application of Sustainable Livelihood Approach to Nile Tilapia Farmer in West Sumatera

(インドネシアの小規模淡水養殖：西スマトラ州のナイルテラピア養殖への
持続可能な生計アプローチの応用)

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2014

Small-scale Freshwater Aquaculture Practices in Indonesia: An application of Sustainable Livelihood Approach to Nile Tilapia Farmer in West Sumatera

A dissertation submitted to

The United Graduate School of Agricultural Sciences,

Kagoshima University, Japan,

in partial fulfillment of the requerements for the degree of

DOCTOR of PHILOSOPHY

By

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2014

Abstract

Indonesian aquaculture, which is dominated by small-scale farmers, has developed rapidly since 1990's. In West Sumatra Province of Sumatra Island, one of major site of freshwater aquaculture, Nile Tilapia was replaced by carp in 2005 because carp, with more small bones in edible portion than Tilapia, was sometimes seriously affected by koi herpes virus (KHV). This has lead to increase fish production for local markets, as well as to improve livelihood of local fish farmers. However, mass fish death has been observed since 2008 especially in floating net aquaculture in the lake due to water environmental change caused by intensive aquaculture. Fish farmers are required to make good culture practices for sustainable aquaculture, and to deal with issues such as water environmental problems, market uncertainty, consumers' health, as well as climate change while struggling with their limited capitals.

Four types of aquaculture, i.e., raceway, excavated pond, paddy field, and floating net, were practiced in West Sumatra Province, and this study examined 1) fish farmers' five capitals (human, natural, social, financial and physical capital), 2) impacts on the water environment (water quality), and 3) percentage and characteristics of the intensive farmers, by the type of aquaculture. Data were collected by snowball sampling from 216 fish farmers (households) using structured questionnaires. Water quality was analyzed with 15 outlet-water samples from three kinds of ponds, and data for floating net were referred to IIS (Indonesian Institute of Sciences), which has monitored water quality of Maninjau Lake since 2003.

The majority of farmers were young (average age 46.5), had completed junior high school, and had more than 4 household members. The average length of experience in aquaculture was different, with raceway farmers having longer experience (13 years) than others (6-10 years). The livelihood asset pentagon showed that raceway farmers had moderate livelihood capital, and excavated pond farmers were weak only in human capital. Paddy field farmers were weak in both natural and financial capitals, but floating net farmers were weak in natural capital. Some variables of water quality (COD and nitrite) in ponds exceeded the safety level for the environment, most probably due to using inorganic feeds and fertilizer to increase plankton to the ponds. Water quality of Maninjau Lake indicated eutrophic conditions and caused high fish mortality especially at the beginning of the rainy season. High price of feed was the most serious problem for all types of fish farmers, and additionally high pond construction cost for excavated pond farmers. Floating net farmers had high concerns with fish death and disease, and knowledge about aquaculture.

Input-output analysis detected 24% intensive farmers in raceway pond, 31% in excavated pond, and 0% in paddy field. While all (100%) the floating net farmers were intensive, and multivariate analysis were applied to classify them: Three sub-type of floating net farmers were identified; the first group (37%) included farmers with relatively poor access to aquaculture supplies but had another source of income. Farmers in this group had moderate capital and reported low fish mortality. Therefore, this group seemed to have a sustainable livelihood as fish farmers as long as donors or government paid attention to the distribution of aquaculture supplies. The second group (20%) was characterized by high accessibility to physical capital and financial aid, but limited access to natural capital and no other source of income. This group of farmers was seen to be highly vulnerable to production failure and price shock. The last group (43%) had higher capital than the other groups but often encountered massive fish mortality. Farmers in this over-culture group need to reduce the density of fish to avoid fish mortality. The findings of this study helped to identify farmers' capitals and problem faced by the farmers.

要旨

インドネシアの水産養殖は小規模漁家を中心に 1990 年代から急速に発展してきた。中でも淡水養殖が盛んなスマトラ島の西スマトラ州では、それまで主な魚種だった鯉よりも小骨が少なくウイルスに強いナイルテラピアが 2005 年に導入された。これにより、地方市場の魚生産量が増加するとともに地域の養殖業者の生活が向上してきた。しかし 2008 年頃から集約的養殖に伴う水環境の変化が原因ともいわれるテラピアの大量死が湖での網いけす養殖で見られ、漁家は淡水養殖を持続可能にするために、限られた資本をもとに、水環境への影響、市場の不確実性、消費者の健康や気候変動といった問題にも対処する必要が出てきた。本研究は、西スマトラ州で行われている淡水養殖の４つの方法（人工池による池中養殖、ため池養殖、水田養殖、網いけす養殖）ごとに、生計アプローチで言う漁家の 5 つの資本（人的資本、自然資本、物的資本、金融資本、社会資本）との関係を検討する一方、養殖方法による養殖環境（水）への影響を検討し、方法ごとに集約的養殖を行う漁家の割合と特徴を明らかにするために多変量分析を行った。小規模淡水養殖を行う漁家 216 世帯をスノーボールサンプリングで選んで対象とし、質問紙を用いた半構造化面接調査を行った。また池中養殖、ため池養殖、水田養殖の 3 方法の（出荷前の成魚がいる）池から 15（各方法 5 つの池）の排水サンプルを取り、現場と実験室で一般水質を測定した。なお、網いけす養殖の水質については現地のマニンジャウ湖を 2003 年以降モニターしているインドネシア科学研究所の資料を用いた。

その結果、漁家の多くが若く（平均年齢 46.5 歳）、世帯人数は 4 人以上だった。漁業経験年数は池中養殖漁家が 13 年と他の養殖方法漁家より有意に長かった。5 つの資本は、池中養殖漁家は平均的なのに対し、ため池養殖漁家は人的資本が弱く、水田養殖漁家は自然資本と金融資本が弱く、また網いけす養殖漁家は自然資本が弱

かった。水質では、すべての養殖池の COD と亜硝酸が安全基準を超えており、自家製鶏糞などではなく購入するエサやプランクトンを増やす肥料を養殖場に使うことが水質汚染を引き起こす可能性が示唆された。一方、網いけす養殖の湖は富栄養化しており、特に雨季の初めには水質変化による魚の大量死が見られた。最も深刻な問題として、全ての養殖漁家で魚の飼料代があげられ、ため池養殖漁家ではため池を作る費用が挙げられた。また、網いけす養殖漁家では魚の大量死や病気に対する関心に加えて、正しい養殖法の知識を得たいという人たちが多かった。

入出力変数を用いて漁家の特徴を多変量解析した結果、池中養殖の集約的漁家は 24％、ため池養殖の集約的漁家は 31％だったが、水田養殖ではすべて半粗放的/粗放的で集約的漁家は見られなかった。一方、全ての漁家（100％）が集約的養殖を行う網いけす養殖漁家の 5 つの資本に対して因子分析などの多変量解析を行った結果、網いけす養殖漁家は３つに分けられた。第１の「持続可能」グループ（37％)は養殖場へのアクセスが悪いが他の収入源があるため資本は適度にあり、魚が大量死することもほとんどなかった。彼らの生計活動を維持するためには、生産した魚の市場が拡大することが望まれた。第２の「失敗」グループ（20％)は物的資本と金融資本へのアクセスは良いが自然資本は限られ、他の収入源もなかった。このグループは魚生産の失敗や魚価の急落に弱かった。第３の「過養殖」グループ（43％）は他の２グループより良好な資本を持つが、しばしば魚の大量死に見舞われていた。これを抑えるために飼育時の魚密度を下げるなどの処置が不可欠と言える。

Acknowledgements

بِسْمِ اللّٰهِ الرَّحْمَنِ الرَّحِيْمِ,

الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ

Firstly I would like to express my sincere thanks to the Graduate School of Agriculture Sciences Kagoshima University— for supporting this research with Female Student Supporting Program 2012, and also to the Department of Aquaculture, Bung Hatta University, West Sumatera, Indonesia, for technical supports. I'm very grateful to the marine and fisheries officers of West Sumatera province and the regencies for guiding and accompanying me in the field survey and also for providing me with statistics data. Many thanks also go to Directorate General of Higher Education (DIKTI), Republic of Indonesia for the scholarship to undergo the PhD program.

I'm very thankful to Prof. Tsukasa Inaoka of Saga University, my principal supervisor for patient support of my PhD study. I would like to express my thanks to Dr. Daisuke Ueno (Saga University) and Prof. Jirou Koyama (Kagoshima University), my second and third supervisor for their appropriate advices. I am also indebted to Dr. Miho Fujimura (Saga University) for the excellent guidance during my study period and Prof. Masaaki Sano for the suggestions that enhance my dissertation. Thanks also go to all my friends in "Sangoukan" of Saga University, especially Dr. Anton Setyo Nugroho, Dr. Joweria Nambooze and Dr. Nasrin Nahar, for their friendships and constant listening ear.

Finally, special gratitude goes to my husband Tengku Zia Ulqodry and both of my lovely daughters T.S. Aisya Maulidia and T.S. Yasmine Fitria for the love and spirit that keep me stand in the worse time. Special thanks also go to my parents, parents in law and all of my big family in Indonesia and my entire friend in Sriwijaya University for supporting and believing me in this duty.

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CHAPTER I

Introduction

1.1 Aquaculture

Generally aquaculture is defined as "the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licences, are the harvest of fisheries" (FAO, 1988). Edward and Damaine (1998) brought up the common classification of aquaculture based on productive technology, especially feed and divided culture system into three, i.e.,

- *Extensive culture systems* receive no intentional nutritional inputs but depend on natural food in the culture facility, including that brought in by water flow e.g., currents and tidal exchange.
- *Semi-intensive culture systems* depend largely on natural food which is increased over baseline levels by fertilisation and/or use of supplementary feed to complement natural food.

- *Intensive culture systems* depend on nutritionally complete diets added to the system, either fresh, wild, marine or freshwater fish, or on formulated diets, usually in dry pellet form.

Aquaculture is one of the fastest growing food production sectors in the word. Global aquaculture production growth is likely jump by almost 12 times in the last three decades (1980–2010, at an average annual rate of 8.8 percent (FAO, 2012). Fish are less important than livestock as a source of animal protein, supplying only an average of 20% of the total for developing countries globally. However, in many developing countries, particularly in South and Southeast Asia, fish provide a higher percentage (30-50% higher) of animal protein and are important in food security (Edward and Damaine, 1998). The need for aquaculture to provide increased demands of fish should be considered in relation to capture fisheries production which remains rather stable at about 90 million tonnes (FAO, 2012). Such over exploitation of natural fish resources (overfishing) with continuously increasing human population have pushed the aquaculture sector to expand in order to fulfil fish demand.

Aquaculture is practiced in freshwater, brackish water and full-strength marine water. The average annual growth rate for freshwater aquaculture during 2000-2010 was 7.2 %, compared with 4.4 % for marine and 6-8 % for brackish water aquaculture. Freshwater aquaculture was overwhelmingly dominated by freshwater fishes (91.7 %) while brackish-water and marine water production was consisted of crustaceans (57.2 %) and marine mollusc (75.5 %) respectively (FAO, 2012).

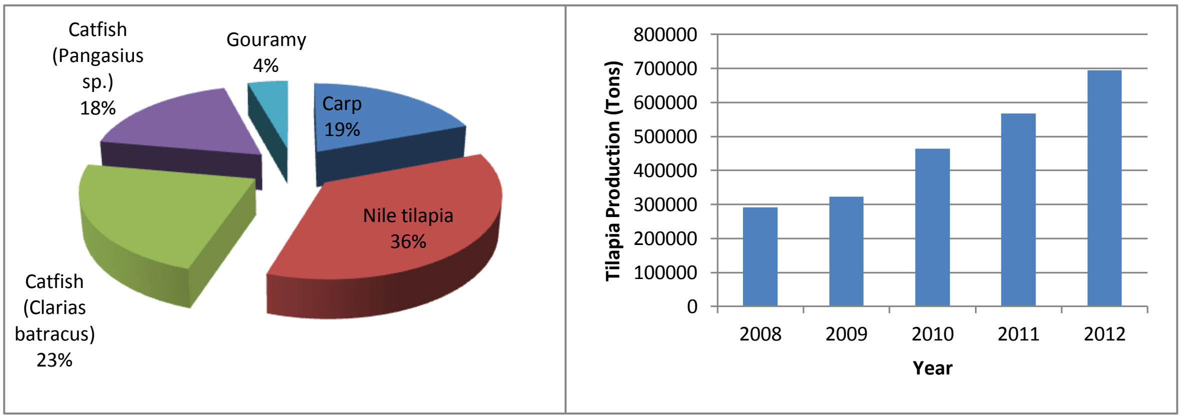
Aquaculture is expected to provide global fish security, nutritional well-being, poverty reduction, and economic development by meeting all of these demands.

However, it is true that aquaculture production is vulnerable to adverse impacts of natural, socioeconomic, environmental and technological conditions. As FAO (1998) have shown, aquaculture farmers have to deal with many issues relating to environment impact, such as effluent discharge, genetics, disease, pollutants, feed use, fairness, income distribution, equity, market uncertainty, political uncertainty, regulatory inconsistency, bureaucracy, profitability, consumer health, aesthetics, misinformation, and a plethora of competing and adversary groups.

1.2 Indonesian Freshwater Aquaculture

Aquaculture has been practised in parts of Indonesia since 1400 (Rimmer et al., 2013). Indonesian aquaculture continues to develop and currently became the 4th aquaculture producer in the world (FAO, 2014). Indonesian pro-active support for aquaculture is demonstrated by the government's policy. This policy of agriculture intensification is occurring in spite of the availability of large tracts of undeveloped land (Budiono, 2002). Aquaculture Intensification Program aims to increase the intensification of commercial species destined for foreign markets such as tilapia (*O. niloticus*), shrimp, seaweed and grouper (Hishamunda et. al., 2009b). Total aquaculture production increased by about 14 percent per year from 3,855,200 tons in 2008 to 9,675,553 tons in 2012 (MAFS, 2013). Aquaculture varies with the environment, i.e., marine, freshwater and brackish water. Based on the data from Indonesia Ministry of Fisheries and Marine Affairs in 2012, the highest number of fish farmers is freshwater pond farmers which count up to about 927,755 households, however, 65.81% of them have farm size less than 0.1 ha.

In the middle of 19th century, freshwater aquaculture started with common carp culture in backyard ponds in West Java and then spread out to other parts of Indonesia in the early 20th century. A great increase in freshwater aquaculture production was reported in the late 1970s as a result of successful introduction of new farming technologies relating to hatchery-produced seed and feed development (Nurdjana, 2006). Budhiman (2007) reported that 20 species of freshwater fish have been successful bred in hatcheries, with the most commonly species of tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*), catfish (*Clarias* sp., *Pangasius* sp) and gouramy (Osphronemus gouramy). Tilapia, which was introduced to Indonesia in 1969, is the most dominant freshwater species (36%) with production doubling from 323,389 tons in 2009 into 695,063 tons in 2012 (Figure 1).



(A) **(B)**

Figure 1.1 Freshwater fish production by species (A) and Nile tilapia production in 2008-2012 (B) (MAFS, 2013)

Freshwater aquaculture practices depend on the field condition. Various practices are carried out in fish pond (excavated and raceway pond), polyculture (paddy field) and cages in enclosure water body (river, reservoir, lake). The majority of freshwater production came from Sumatera and Java islands, but due to population growth and decrease of water supply in Java, Sumatera is likely to become a major frontier for freshwater aquaculture development (Edwards, 2010).

1.3 Small-scale Aquaculture practices

Most of freshwater aquaculture production in Indonesia is still from small-scale farms (Edwards, 2009). Weimin et. al. (2012) defined small-scale aquaculture as operations that are typically family-owned, rather vulnerable, not formalized into business operations and have small economic turn-over. Similar characterization, by highlighting the farmer motivation, are described by Bueno, (2009): One or more production units, family or communally run, low to moderate input levels, limited external labour, and farmers' goal can be both food supply and money from sale the fish.

Small-scale aquaculture is interpreted as low-input farming of aquatic plants and animals, with a large percentage of the labour usually provided by household members. Depending on access to resources and seasonality, farmers may be carried out on a part-time or full-time basis and integrated with other activities such as crop and livestock farming (Siar and Sajise, 2009).

The majority (98 %) of the world's small-scale fish farmers are in developing countries-mostly in rural area (Bhujel, et. al., 2012). In many communities, fish farming has been practiced as a tradition. Small-scale aquaculture also serves as an entry to commercial aquaculture. Being small and less risky, it can be adopted easily by resource-poor farmers. Upon learning the farming techniques, they can scale up it if they find it comparatively advantageous. The general aquaculture practices have the guiding principles based on ecosystem approach, which is often termed as Ecosystems Approach to Aquaculture (EAA) (Soto et. al., 2007). Based on AEE, the guiding principles of small-scale aquaculture proposed by Gurung et. al. (2012) are provided below.

- Small-scale aquaculture should be developed in the context of ecosystem function and services.
- Small-scale aquaculture should mainly be promoted for poverty alleviation, following the doctrine of social inclusion, equity and welfare to ensure equal opportunity and provide food security and safety to society, especially the poor.
- Small-scale aquaculture development should be in compliance with the other sectors, policies and goals.

1.4 Water quality

Water is limiting factor in commercial fish production. A site selection has to be made based on both the quality and quantity of water available. Water quality and quantity vary from place to place, and are affected by ecological factors such as soil and air quality. To accelerate growth of fish, fish are fed with commercial pellet or/and farm-made feed. Poor aquaculture practices, such as over fish density, over feeding, or over fertilizer, will increase the organic and inorganic matter in water, and will accumulate them on the pond bed. This situation will trigger the anoxic condition due to the decomposition of organic matter by bacteria which consumes a large amount of oxygen. If the culture environment continues to deteriorate, water quality may become poor that it is no longer suitable for fish culture and the water discharge can pollute the environment. The farmers should implement good aquaculture practices to prevent this condition for ensure the aquaculture sustainability.

In Indonesia, the important source of water for freshwater aquaculture especially pond culture and paddy field comes from an irrigation canal. The modern technical irrigation techniques in Indonesia were first introduced by the Dutch East Indies Government in early 1900s. At present, the total area of irrigation system in Indonesia amounted to 7.47 million ha or 33,210 systems (Arif and Murtiningrum, 2011). However, based on the rapid assessment in 2010 by Ministry of Public Works found that only 48 % of the irrigation network in good condition (Azdan, 2011). This condition will affect the agriculture and aquaculture activities.

1.5 Livelihood approach

The sustainability in rural development is issued by peoples' livelihood based on financial, natural, human, physical and social capitals (Little and Edward, 2003). By looking at the differences in access to the resources and assets used for various types of small-scale farmer, we are able to analyse what is needed to support their sustainability. To become a sufficient condition for promoting sustainability, access rights must go hand in hand with the build-up of the following livelihood capitals (DFID, 1999):

- Human capital represents the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives. At a household level human capital is a factor of the amount and quality of labour available; this varies according to household size, skill levels, leadership potential, health status, etc.

- Social capital represents the social resources upon which people draw in pursuit of their livelihood objectives. These are developed through networks and connectedness, membership of more formalised groups, and relationships of trust, reciprocity and exchanges that facilitate co-operation, reduce transaction costs and may provide the basis for informal safety nets amongst the poor.
- Natural capital is the term used for the natural resource stocks from which resource flows and services (e.g. nutrient cycling, erosion protection) useful for livelihoods are derived. There is a wide variation in the resources that make up natural capital, from intangible public goods such as the atmosphere and biodiversity to divisible assets used directly for production (trees, land, etc.).
- Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Infrastructure consists of changes to the physical environment that help people to meet their basic needs and to be more productive. Producer goods are the tools and equipment that people use to function more productively.
- Financial capital denotes the financial resources that people use to achieve their livelihood objectives. The definition used here is not economically robust in that it includes flows as well as stocks and it can contribute to consumption as well as production. However, it has been adopted to try to capture an

important livelihood building block, namely the availability of cash or equivalent that enables people to adopt different livelihood strategies.

1.6 Sustainable Livelihood Framework

Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). Aquaculture is a system that is directly related to the environment. Frankic and Hershner (2003) defined sustainable aquaculture as an on-going system that continues functioning into the indefinite future without being forced into decline through exhaustion or overloading of key resources on which that system depends. A sustainable aquaculture development should ensure a quality of life for present and future generations by working within the limits of environment carrying capacity. On a small-scale case, Jolly at al. (2009) defined sustainability of small-scale aquaculture as the production of aquatic products in a given system over a long time period with minimal environmental effect.

Sustainable livelihood is a people-centred approach that aims to identify means to meet local needs and opportunities to support local capacity that are not dominated by individual sectors or disciplines. The sustainable livelihood approach (SLA) is prominent in recent development programs that aim to reduce poverty and vulnerability in communities engaged in small-scale fisheries and aquaculture (Ahmed et al., 2008). SLA centres on the links between individual or household assets, the activities in which households can engaged with a given asset profile, and the mediating processes that govern access to assets and to alternative activities.

At the core of SLA, as illustrated by DFID (Figure 1.2), there is the livelihood is built on a platform of capital assets that individuals or households can draw on. These assets are divided into five categories (the Asset Pentagon). Sustainability of livelihoods is threatened by external shocks, trends and seasonality of activities (the Vulnerability Context). The way that people are able to access and use assets is regulated by policies and institutions, both formal and informal (Transforming Structures and Processes). People put together a livelihood on the basis of their response to their vulnerability context, their available assets, and within the constraints or opportunities provided by the institutional environment (Livelihood Strategies). To be sustainable, livelihoods should improve the standard of living and reduce vulnerability while maintaining the natural resource base; in this case fish stocks (Livelihood Outcomes). One way of doing this is for households to build their capital asset base. The framework points to several possible means of intervention to support livelihoods: reducing vulnerability (e.g. through social service provision), creating enabling policies and institutions or building on households' or individuals' existing asset base or livelihood strategies.

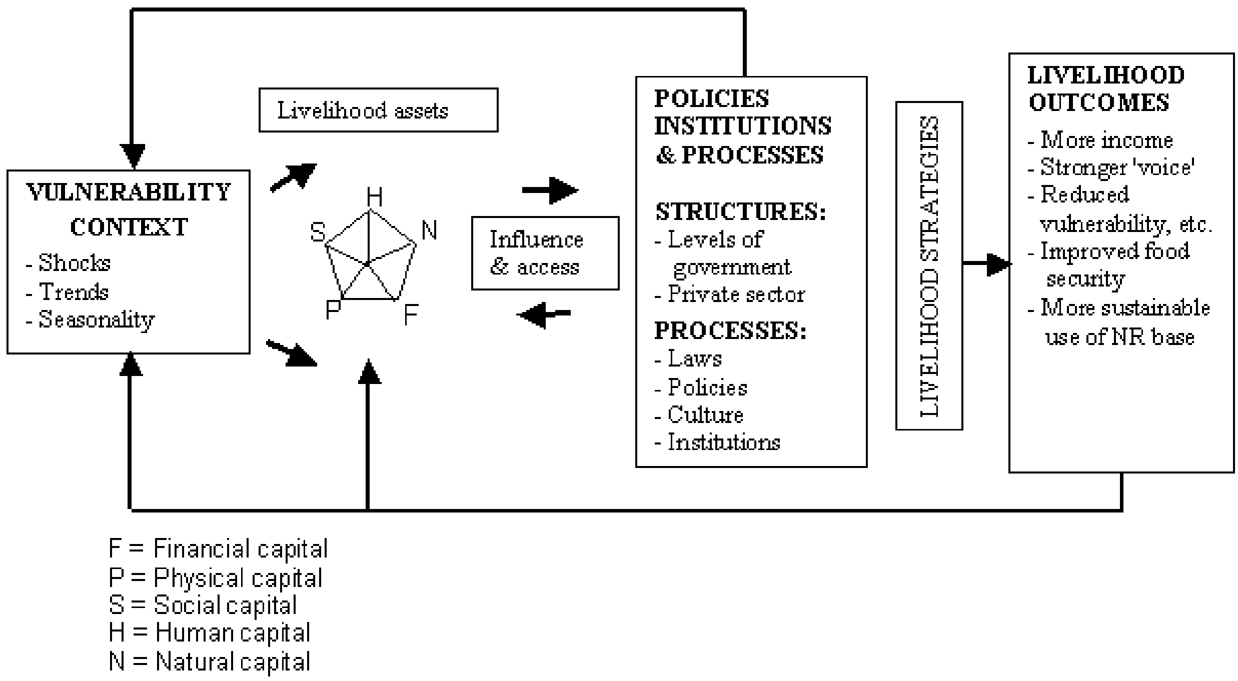


Figure 1.2 Sustainable livelihood framework (DFID, 1999)

1.7 The aims of study

The concept and methods of livelihood analysis have recently been applied to understanding the role those fisheries play in the rural economy in coastal, brackish water, and freshwater in developing countries (e.g. Armitage and Tam, 2007; Ahmed et al., 2008; Paul and Fogl, 2013). When applied to aquaculture, it was concluded that the holistic approach to sustainable aquaculture is the most appropriate with which to assess the multi-dimensional of sustainability. Within this approach to sustainability functional integrity, which draws on the system approach, was considered to be a useful tool with which to investigate the processes an interlinkages in the small-scale aquaculture and their potential to undermine the sustainability of small scale aquaculture in the long-term. The review reports that there is a lack of information regarding the livelihood capital, environment impact, and vulnerability context of small-scale freshwater aquaculture, as emphasis in the available literature is placed in practices of rural aquaculture.

The overall aims of the current study is therefore to assess to what extant small-scale freshwater aquaculture is sustainable and whether it has the potential to provide a sustainable livelihood option for rural community in Indonesia. The specific objectives of the study are:

1. To assess the key characteristics of small-scale freshwater aquaculture in raceway, excavated, paddy field and floating net systems.
2. To evaluate the role of small-scale freshwater aquaculture in farmers livelihood and the extent to which it contributes to a sustainable livelihood, by analysing livelihood capitals and vulnerability context.
3. To assess the environmental needs and impact of small-scale freshwater aquaculture to maintain the sustainability of aquaculture.
4. To establish a typology for the diversity of farmers involved in small-scale aquaculture in West Suamtera associated with their livelihood capitals and to analyze the differences between groups of farmers and determine the vulnerability of farmers.

CHAPTER II

Study Area

2.1 Selection of the study area

Indonesia is an archipelago and has a vast potential for aquaculture. Each island has the different potential of aquaculture. In 2010, the locations where major proportions of potential area were being used for freshwater pond aquaculture were in Sumatera (58 %) and Java (22 %). Similarly, the main areas for floating net were in Sumatera (58 %) and Java (29 %). Sulawesi (59 %) and Bali-NT (17 %) were potential in marine culture while Kalimantan (31 %) and Sulawesi (22 %) were potential in brackish water aquaculture (MAFS, 2011).

Sumatera is an island in western Indonesia. There are ten administrative provinces in this island. Sumatra is not particularly densely populated, with just over 100 people per km^2 – more than 50 million people in total. Sumatera Island accounted for 40% of freshwater aquaculture production in Indonesia. The major potential provinces in Sumatera for pond are West and South Sumatera, for floating net are West and North Sumatera, and for paddy field are Bengkulu and West Sumatera.

2.2 West Sumatera

Figure 2.1 West Sumatera map

(Sources: http://en.wikipedia.org/wiki/File:West_Sumatra_Map.png)

West Sumatera is located between 0°54' North Latitude, 3°30' South Latitude, 98°36' and 101°53 East Longitude. It is adjacent to North Sumatera Province in the north, Jambi Province in the south, Riau Province in the east and Indonesia Ocean in the west. Geographic features include plains, mountainous volcanic highlands formed by the Barisan mountain range that runs from north-west to south-east, and an offshore island archipelago called the Mentawai Islands.

The province covers a total area of 42,012 km^2, has numerous water bodies which include 5 lakes. The rivers of West Sumatra include: Kuranji, Anai, Ombilin, Suliki, Agam, Sinamar, Arau. According to 2013 census, the province has a total population of 5,133,988 with a population density of about 120 persons per sq km. West Sumatera consists of 12 regencies and 7 cities. Freshwater aquaculture is dominated by Agam, Pasaman, 50 Kota, Padang Pariaman regency and Padang city.

West Sumatera province was selected as a representative of small-scale operations because it has the highest number of fish farmers engaged in freshwater aquaculture, and the production of Nile tilapia is considerably high in the provinces of Sumatera Island (Figure 2.1). There are four types of freshwater aquaculture systems that most widely applied, i.e., raceway pond, excavated pond, paddy field (polyculture) pond, and floating net systems (Figure 2.2).

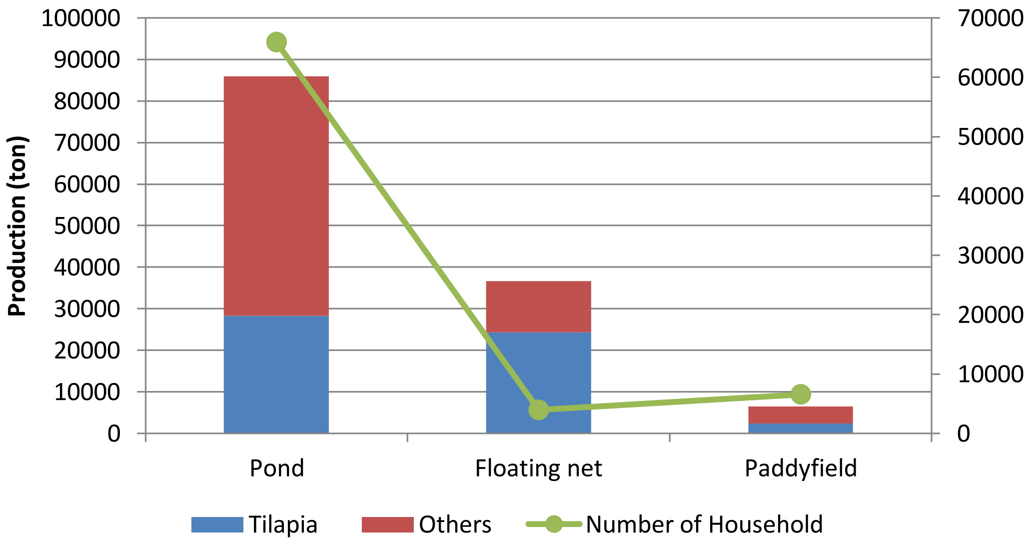


Figure 2.2 Fish production and number of household in West Sumatera (MAFS, 2012)

A. Raceway pond

B. Excavated pond

C. Paddy field pond

D. Floating net

Figure 2.2 Freshwater aquaculture practices in West Sumatera, Indonesia

CHAPTER 3

Methodology

3.1 Data Collection

An interview survey was conducted with owners of 216 household involved in raceway, excavated, paddy field and floating net cultures during 2012-2013 in West Sumatera, Indonesia. The statistics data of Nile tilapia farming was not available. The farmers were selected randomly from a list of tilapia farms in West Sumatera obtained from the Marine and Fisheries Office. But not all farmers in the list are still doing aquaculture. Therefore, we did the snowball sampling.

A questionnaire in Indonesian language (Appendix) was pre-tested and some changes were made. The questionnaire was modified from Asian Development Bank (ADB, 2005). The aim of pre-test was to ensure that questions and issues regarding the subject of the study were included in the questionnaires and the content can easily understood by respondents.

The interviews were made in co-operation with local extension officers of regency or city. Additional information was also collected at extension officers in the village. The questionnaire consisted of farmers' livelihood capitals (human, natural, social, financial and physical capital) and aquaculture practices. Aquaculture practices consisted of aquaculture activity, estimated annual production, market, future tilapia operation and the problem that farmers experienced on tilapia growth out operation.

3.2 Sustainable Livelihood Approach

Sustainable Livelihood Approach (SLA) contains the external and internal factors. The internal factors are the five capital assets: human, natural, physical, financial and social. Access to this internal factor is influenced by external factors (Mahdi, et al., 2009). The human capital is, generally, the amount and quality of labour available. As the small-scale of aquaculture, labour is the adult member of household and the quality is the aquaculture training attendance. The natural capital comprises the natural resources, from which the livelihood can be derived. In aquaculture practices, the natural resources are the land and water (quantity and quality). Social capital indicates the involvement the household/farmer in social activities and network for the livelihood activities. In the case of aquaculture, the social capitals are the member of aquaculture organization and the period of a member. Financial capital is the financial resources needed to support a livelihood. In this case, the financial capitals are the aquaculture aid and farmer’s another source of income. Physical capital contains the basic infrastructure that needed for a livelihood. Small-scale aquaculture usually located in a rural area, therefore the physical capitals are the access to road, transportation, communication, market and source of water (access to lake in floating net case).

External factors are the vulnerability refers to the shocks, trends, seasonality. In the context of aquaculture, the vulnerability consists of the problems that experience by the farmers in aquaculture activities. The problem consist of inputs problem (ex. Inadequate supply of feed, high price of feed, etc.), production problem (ex. Poor water, disease etc.), access problem (ex. Lack of access to land, credit, etc), and environment problem (flood, pollution, etc).

In order to integrate this framework into our research, we develop and apply a quantitative technique for livelihood capital. The farmers' responses in their livelihood capital were indexed (Shivakoti and Shrestha 2009) and plotted in the livelihood pentagon. The vulnerable context was calculated as the percentage of cases in all of farmers. The trend of internal and external factors was linked to livelihood sustainability (DFID, 1999).

3.3 Water Sampling

The water exchange during the cycle is used to assess water quality for both the dry and rainy seasons. There are many water quality variables in pond aquaculture, but only a few of these normally play an important role. The water quality variables used in the analysis were DO, BOD, COD, sulphate, nitrate, nitrite and total phosphor.

Dissolved oxygen (DO) is the most critical water quality variable in aquaculture. Determination of DO concentrations is a fundamental part of a water quality assessment since oxygen is involved in, or influences, nearly all chemical and biological processes within water bodies. Waste discharges high in organic matter and nutrients can lead to decreases in DO concentrations as a result of the increased microbial activity (respiration) occurring during the degradation of the organic matter. In severe cases of reduced oxygen concentrations (whether natural or man-made), anaerobic conditions can occur (i.e. 0 mg l^{-1} of oxygen), particularly close to the sediment-water interface as a result of decaying, sediment material. Concentrations below 5 mg l^{-1} may adversely affect the functioning and survival of biological communities and below 2 mg l-1 may lead to the death of most fish. The measurement of DO can be used to indicate the degree of pollution by organic matter, the destruction of organic substances and the level of self-purification of the water (Chapman and Kimstach, 1996).

Figure 3.1 DO measurements in pond

Portable electronic probes were used in each pond to measure DO (Figure 3.1). Fifteen outlet-water samples were taken from three pond types (five samples from each pond type) in rainy (February 2013) and dry (August 2013) season. The water samples were analyzed in the laboratory for water quality variables. All samples were analyzed according to the standard methods of water sampling and analysis (APHA, 1992).

The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate. The COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies. The biochemical oxygen demand (BOD) is an approximate measure of the amount of biochemically degradable organic matter present in a water sample. It is defined by the amount of oxygen required for the aerobic micro-organisms present in the sample to oxidise the organic matter to a stable inorganic form (Chapman and Kimstach, 1996).

Determination of nitrate plus nitrite in surface waters gives a general indication of the nutrient status and level of organic pollution. Consequently, these species are included in most basic water quality surveys and multipurpose or background monitoring programmes, and are specifically included in programmes monitoring the impact of organic or relevant industrial inputs. The nitrate ion ($NO3^-$) is the common form of combined nitrogen found in natural waters. It may be biochemically reduced to nitrite (NO^{2-}) by denitrification processes, usually under anaerobic conditions. The nitrite ion is rapidly oxidised to nitrate. Concentrations in excess of 5 mg $l^{-1}NO3^-N$ usually indicate pollution by human or animal waste, or fertiliser run-off. The World Health Organization (WHO) recommended maximum limit for $NO3^-$ in drinking water is 50 mg l^{-1}(or 11.3 mg l^{-1} as $NO^{3-}N$, and waters with higher concentrations can represent a significant health risk. In lakes, concentrations of nitrate in excess of 0.2 mg l^{-1} $NO^{3-}N$ tend to stimulate algal growth and indicate possible eutrophic conditions. Nitrite concentrations in freshwaters are usually very low, 0.001 mg l^{-1} $NO^{2-}N$, and rarely higher than 1 mg l^{-1} $NO^{2-}N$. High nitrite concentrations are generally indicative of industrial effluents and are often associated with unsatisfactory microbiological quality of water (Chapman and Kimstach, 1996).

Phosphorus is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. It is generally the limiting nutrient for algal growth and, therefore, controls the primary productivity of a water body. Artificial increases in concentrations due to human activities are the principal cause of eutrophication. As phosphorus is an essential component of the biological cycle in water bodies, it is often included in basic water quality surveys or background monitoring programmes. High concentrations of phosphates can indicate the presence of pollution and are largely responsible for eutrophic conditions. Sulphate is naturally present in surface waters as $SO4^{2-}$. Industrial discharges and atmospheric precipitation can also add significant amounts of sulphate to surface waters. Sulphate concentrations in natural waters are usually between 2 and 80 mg l^{-1} (Chapman and Kimstach, 1996).

3.4 Data analysis

Questionnaire interview data were coded and entered into a database using MS-Access. Data from questionnaires and laboratory analysis were entered into Statistic Package for Social Science, SPSS 17 for statistical analysis. A-one way ANOVA and a Duncan post hoc test were used to identify significant differences between the three kinds of pond ($P < 0.05$). Data were analysed in accordance with the sustainable livelihood framework that seeks to what factor impact farmers' livelihood.

The livelihood of farmers was analysed using an index to assess their capitals (Shivakoti and Shrestha 2009). Each individual asset was indexed across all respondents. The lowest 10% of values were indexed as 0.1; the next 10–20%, as 0.2; and the remaining 90–100%, as 1.0. The composite asset index for each farmers was calculated as the average of the relevant index indicators. The livelihood asset pentagon was plotted by using the average index of each group of farmers.

On typology, data from the interview were used for factor and cluster analysis. As first step, factor analysis was used to create a smaller set of composite variables to replace the original 13 variables. A range of variables was selected and their values calculated from the data. The adult member (labor) was calculated as the number of people above 18 years in the farmer household. The aquaculture training is the participation of farmers at least once in the aquaculture training organized by the government or NGOs. The cage area is the total area of cages owned by farmers. The mass death of fish represents the disaster that faced by farmer in last of 5 years. The farmer's answer was cross-checked with the fisheries office data. The organization is a membership of the aquaculture organization registered in the fisheries office. The member period was calculated as the years since the farmers joined the organization. The financial aid is the credit, loan or grant received by farmers related to aquaculture activity. The other source of income is a present or absence of the side job in the farmer household.

Following Milstein et al. (2005), all variables were normalized before the analysis. The factors rotated using VARIMAX method. The chosen component is the component that has eigenvalues above 1. The second step is cluster analysis. A hierarchical clustering technique by using the factors scores did to estimate the number of cluster. Next, a K-mean clustering technique procedure was used to obtain the cluster centers. A-one way ANOVA and a Duncan post hoc test were used to identify significant differences between the groups of farmers ($P < 0.05$).

CHAPTER IV

Farmers' Livelihood and the Impact on Environment

4.1 Introduction

In Indonesia, even though both capture fisheries and aquaculture are important, capture fisheries are almost fully exploited, and aquaculture still has high potential for growth (Rimmer et al., 2013). Indonesian aquaculture has developed rapidly, from 864.276 thousand tons (2001) to 2.304 million tons (2010), increasing at the rate of 14% per year, and now ranks fourth among the largest aquaculture producing countries (FAO, 2012). Currently, there are several aquaculture systems in Indonesia such as marine, brackish water, freshwater pond, cage, floating net and paddy field culture. The largest number of farmers is involved in freshwater pond and paddy field farming, 1725283 and 407230 households, respectively, and 80% are small-scale farmers (MAFS, 2011). Aquaculture in Asia is dominated by small-scale producers (ADB, 2004).

Freshwater aquaculture practices have been conducted in Indonesia since the early twentieth century, beginning with backyard ponds (Budhiman, 2007) and increased significantly. Based on data from the Indonesia Ministry of Fisheries and Marine Affairs in 2011, freshwater pond farmers represent the highest number of fish farmers at 1.725 million farmers; 65.81% of these farmers have less than 0.1 ha size farms though. Two main contributing factors are pointed to this increase (Edwards, 2010); first, a shift from low-intensity ‘traditional’ culture methods toward monoculture production systems and increasing intensification through the use of pelleted feeds and second, the introduction of new species like Tilapia (*Oreochromis* spp.) because carp, previous major species, was seriously affected by Koi Herpes Virus Diseases (KHVD) since the early 1990s, and because Nile tilapia (*Oreochromis niloticus*) has less bone than carp (Sunarto and Cameron, 2005; Edwards, 2009; Rimmer et al., 2013).

Previous studies have focused on small-scale fisheries in Indonesia (Armitaga and Tam, 2007; Alongi et al., 2009), Thailand (Lin, 2000), Latin America and the Caribbean (Salas et al., 2007), Namibia (Sawman and Cardoso, 2010), and Malaysia (Teh et al., 2011) that utilize marine and brackish water aquaculture. However, only a few studies have been reported about freshwater aquaculture, with a focus on large farms in Bangladesh (Ali et al., 2012), Vietnam (Phan et al., 2009), and Uganda (Bagumire et al., 2010).

Previous researches more reported on marine or brackish water, but less on freshwater aquaculture and very less among small-scale farmers. Small-scale aquaculture has a potential to increase food production for local markets, as well as to improve livelihood of local people; however, good culture practices are necessary for sustainable development. Fish farmers have to deal with issues such as environment problems, market uncertainty, consumers’ health, as well as climate change while struggling with their limited capital. There are limited studies available regarding the impact of small-scale fresh water aquaculture practices. This study investigated the Nile tilapia production system and its impact on water quality and fish farmers' livelihood.

4.2 Materials and Methods

A structured field survey was conducted twice during February and August 2013 in West Sumatera, Indonesia. West Sumatera province was selected for this study as a representative of small-scale operations because of the high number of fish farmers in freshwater aquaculture and the high production of Nile tilapia among the provinces in Sumatera Island. West Sumatera consists of 12 regencies and 7 cities. Freshwater aquaculture is dominated by Agam, Pasaman, 50 Kota, Padang Pariaman regency and Padang city. There are four types of aquaculture systems, i.e., raceway pond, excavated pond, paddy field (polyculture) pond, and floating net systems.

The statistics data of Nile tilapia farming was not available. The tilapia farmers were selected randomly from a list of tilapia farms in five areas from the marine and fisheries office. The livelihood data were collected from farmers using structured questionnaires and interviews conducted by the marine and fisheries officer. Final questionnaires were preceded by preparation and testing the draft questionnaire with a small number of farmers. In analyzing the livelihood of the farmers, an index was used to assess the assets of farmers (Shivakoti and Shrestha, 2009). Each asset was indexed across all 98 respondents. The lowest 10% of values were indexed as value 0.1, the next 10 to 20% as 0.2, and the last 90 to 100% as 1.0. The composite asset index for each type of farm was calculated as the average of the relevant indexes indicator. The livelihood asset pentagon was plotted by inserting the average indexes of each type of pond.

The water quality analysis was done in the excavated, raceway and paddy field pond. The water quality variables used in the analysis were DO, BOD, COD, sulfate, nitrate, nitrite and total phosphor. Dissolve oxygen (DO) is the oxygen content in natural water. Biology respiration, including that related to decomposition processes, reduces DO concentration. The chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate. The biochemical oxygen demand (BOD) is an approximate measure of the amount of biochemically degradable organic matter present in a water sample. It is defined by the amount of oxygen required for the aerobic micro-organisms present in the sample to oxidise the organic matter to a stable inorganic form.

Sulphate is naturally present in surface waters as SO_4^{2-}. Sulphate concentrations in natural waters are usually between 2 and 80 mg /l. Nitrite is an intermediate in the oxidation of ammonium to nitrate. The high concentration of nitrite in water may cause nitrification, which is harmful to fish. Phosphorus is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. Artificial increases in concentrations are the principal cause of eutrophication.

Portable electronic probes were used in each pond to measure DO. Fifteen outlet-water samples were taken from three pond types (five samples from each pond type) in rainy (February 2013) and dry (August 2013) season. The water samples were analyzed in the laboratory for water quality variables. All samples were analyzed according to the standard methods of water sampling and analysis (APHA, 1992). Data from questionnaires and laboratory analysis were entered into Statistic

Package for Social Science, SPSS 17 for statistical analysis. A-one way ANOVA and a Duncan post hoc test were used to identify significant differences between the three kinds of pond ($P < 0.05$).

4.3 Aquaculture practices in West Sumatera

The main aquaculture practices for freshwater in Indonesia, especially west Sumatera, are raceway, excavated, integrated farming in rice fields (polyculture) and floating net of Nile tilapia (*Oreochromis niloticus*). Table 4.1 shows the characteristics of them. Raceway ponds are constructed of concrete, mostly hexagon, and multiple raceways in a parallel system. Common sizes of individual units are 8- to 10 m long by 3- to 5 m wide by 1 to 1.5 m depth. The location has a large, consistent flow of water and sufficient slope that is available or can be created to allow gravity flow of water through and away from the system and the water must totally be changed within a period of 10-15 minutes. The principal water sources for pond are river and primary irrigation canal. In a parallel system, each unit receives water from the same source as independently. The advantage of this system is less of diseases transmission from others unit pond than another system. The farmers can growth high density of fish, about 300 fingerling /m^3 growths with intensive system. The most common fingerling size used for stocking was size 5-8 cm. With the intensification of aquaculture high amount of feed in the form of artificial and farm made pellets resulted high productivity in the short time (3.5-4 months) so that, the farmers have 2-3 cycle/year. The harvest size is around 200-500 g per fish. The one year average production is 1537.21 ton/ha.

Table 4.1 The characteristics of raceway, excavated ponds, paddy field and floating net in West Sumatera

Characteristics	Raceway pond	Excavated pond	Paddy field pond	Floating net
Source of water	River and Irrigation canal	Irrigation canal	Irrigation canal	Lake
Pond materials	Concrete	Concrete and Soil	Soil	Bamboo, wood, or steel; and net
Water flow (l/s)	100	48-60	0.6	-
Depth (m)	1 – 1.5	0.8 – 1	0.4 – 0.6	4-6
Stocking density (pcs/m^2)	256	150	13	328
Fingerling size (cm)	5-8	3-5	8-13	8-13
Length of culture (months)	3.5-4	5.5-6	2.5-3	3-4
Cycles (times/year)	3	2	3-4	3
Harvest size (g)	200-500	125-500	125-250	200-250
Production (ton/ha/ year)	1537	359	9	852

Results from the current research showed that the raceway system generated more production than excavated and paddy field systems. However, raceway ponds need concrete construction, which makes the initial cost for this effort higher. In addition, the need for a large, consistent flow of high-quality water makes this system only applicable in certain areas. According to Boyd et al. (2007), raceway culture uses a greater amount of water than the other systems. Raceway culture can only be carried out in a location with a large, consistent flow of water and sufficient slope or slope can be created to allow gravity flow of water through and away from the system.

The excavated pond are constructed of concrete and mostly soil, usually use stagnant water come from precipitation and regulated inflows of irrigation systems. The construction is very simple based on the area with an average of depth is 1 meter. The size and design of ponds are depending on land available, and some are arranged in series order. In series system, water flow along the ponds through a pipe that connected one pond to another. Water in the pond is almost stagnant because limited water exchange within the pond, around 0.5-1 l/s.

Nearly all respondent of excavated pond reared at least two cycles of tilapia per year. The most common fingerling size used was 3-5 cm with stocking density was around 150 pieces per m^2. After 5-6 months of growing time, farmer harvested the tilapia with size 120-500 g per pieces. For one year, the average of tilapia production was 359 t per hectare. Respondents used both commercial and natural feed. Organic (e.g., chicken manure) and/or inorganic fertilizer (e.g., urea) are applied to stimulate and maintain the growth of natural plankton.

The growth period of fish in excavated ponds is longer than the others because farmers are still using extensive and semi-intensive systems. In extensive and semi-intensive systems, natural or chemical fertilizers need to be used to grow plankton as natural food (Baluyut, 1989). Most of the excavated pond farmers (79%) used fertilizers in their ponds (Table 3). Farmers used both commercial and natural feed.

Organic (e.g., chicken manure) and/or inorganic fertilizer (e.g., urea) are applied to stimulate and maintain the growth of natural plankton.

The integrated farming in rice fields (polyculture) uses *tumpang sari* system that rearing fish as the same time as rice planting. Several physical modifications have been applied in order to make the rice field suited for fish culture. Some farmers dug some trenches longitudinally or peripheral way. The trench, approximately width is 40-50 cm and depth is 50 cm, is enough to accommodate all fish on drying and weeding time. It only removes two rows of rice and, according to farmers, does not significantly affect the production of the rice. The polyculture pond was stocked at 8-13 cm of fingerlings with the rate of 10-13 fries/m^2. Sometimes commercial pellet was needed. The time of rearing and cycle are the same with paddy, 2.5-3 months and 2-3 times per year respectively. The average of fish production was 9.2 t per hectare per year with harvest size 125-250 g per pieces.

The paddy field farmers used the *tumpang sari* (at the same time as paddy planting) system because fish add value to the paddy plantation. Although the fish production from paddy fields is low, it can still provide additional revenue to the farmer. This also supports earlier studies that showed that paddy fields aquaculture can lead to improved efficiency, productivity and higher income of farmers (Mohanty et al., 2009; Phong et al., 2010; Murshed-E-Jahan and Pemsl, 2011).

The community around Maninjau Lake is involved in FN farming for their livelihood. FN aquaculture involves growing aquatic organisms in an enclosed space that maintains the free exchange of water with the surrounding water body by using synthetic material that can resist decomposition in water for a long period (Das et al., 2009). It uses locally available resources such as bamboo or wood for cage construction and small ships for the operation. The size of cages are varies, with the dominant size is 5x5x4 m with bamboo frame, 5x10x4 m with wood frame and 6x7x4 m with steel frame. The floating net was stoked with high density of fry (328 pieces per m^2). The most common fingerling size used for stocking was size 8-13 cm. With the intensification of aquaculture, high amount of commercial resulted high productivity in the short time (3-4 months) and the farmers have 3 cycles /year. The harvest size is around 200-250 g per fish. The one year average production is 852 ton/ha.

The stocking density of floating net system was higher than the others because the floating net farmers considered the depth of floating net (4 m). However it can give bad effect when the up welling condition occurs. This can lead to massive fish mortality due to lack of oxygen in the water. According to Sulawesty et. al. (2010), the dissolve oxygen in the surface of water was very low (1mg/l) when the up welling condition happened on January 2009. This condition would be more severe in the deeper water. In this time, 15 thousand tons fish died and the floating net farmers suffered huge losses.

4.4 Fish farming communities

The farming communities are occupied by relatively young people ranging from 30-68 years old, and the majority (62%) was under 50 years old (Table 4.2). No significant variation ($P>0.05$) was noted in the age of the respondents among the aquaculture types. Additionally, no significant variations were found among different groups of farmers in terms of education level.

Table 4.2 Characteristics of respondents in West Sumatera by type of system

Respondents characteristics		Raceway (%; n=21)	Excavated (%; n=52)	Paddy field (%; n=25)	Floating net (%; n=118)
Age	30-39 years	19	25	24	23
	40-49 years	48	37	36	32
	50-59 years	24	27	20	25
	60-69 years	10	12	20	20
Education	ES	19	4	28	13
	JHS	5	11	8	25
	SHS	67	75	44	53
	UG	9	10	20	9
Household member	1-4	28	33	48	53
	5-8	67	58	48	39
	≥ 9	5	9	4	8
Adult member	<3	52	48	48	33
	3-5	29	33	24	59
	>5	19	19	28	8
Length of aquaculture	1-9 Years	27	81	52	62
	10-19 Years	61	13	32	34
	20-29 Years	12	6	16	4
Land for aquaculture	< 1000 m^2	77	55	48	100
	> 1000 m^2	23	45	52	0
Land acquired	Bought	33	30	16	100
	Inherited	57	70	80	0
	Others	10	0	4	0
Water sources	Irrigation	73	89	92	0
	River	27	11	8	0
	Lake	0	0	0	100
Use of fertilizer		0	79	28	0

Overall, the majority of farmers graduated from senior high school (65%). The household members of farmers varied from 2 to 11 people; most households (64%) were large (>4 people) and did not differ significantly ($P>0.05$) within the three types of ponds.The average length of experience in tilapia farming varied from 1 to 35 years and was significantly different ($P<0.05$) within farmer types. All of floating net farmers, the majority of raceway pond (77 %) and 55% of excavated pond farmers have less than one hectare of aquaculture area while 52 % of paddy field farmers have more than one hectare. Most farmers except floating net farmers (69%) acquired the land from their parents. Raceway and floating net farmers did not use fertilizer, while excavated (79%) and paddy field farmers (28%) used fertilizer.

4.5 Fish farmer livelihood

The livelihood asset pentagon (Figure 4.1) showed that the raceway farmers had moderate capital, excavated pond farmers were weak in human capital and strong in other capital, while paddy field farmers were weak in natural and financial capital and moderate in other capital. In the other hand, floating net farmers had low capital except financial capital. Human capital represents the adult member of the family (as labor) and aquaculture training (the skills, knowledge and labor ability). The adult members and the aquaculture training were significantly different among the four of systems ($p<0.05$) (Table 4.3). Floating net farmers had lower index in labor and aquaculture training. As small-scale system, household member act as labor in aquaculture practices. Most farmers had attended training in aquaculture practices (68%). There are many training opportunities provided by the government, university and NGOs in this area such as Good Aquaculture Practices, hatchery, farm-made feed and others for a period of between three days to one week. The training was attended by representatives of fish farmers in each regency and city in West Sumatera. The possibilities to be chosen as participant was low in Maninjau village because the farmers are concentrate in one regency (Agam regency). From the interview, farmers hope that government, NGOs or University can do aquaculture training special for Maninjau village.

Natural capital represents the land and water. From the ANOVA results, natural capital was significantly different among the four of systems ($p<0.05$). Higher access to natural capital was reflected by low water shortages in the excavated ponds. The floating net has a lower index area than the others. The floating net in Maninjau lake in 2012 (13,267) already exceed the carrying capacity of the lake (6,500) (IIS, 2009). This also reflected to the massive fish mortality that happened in the recent years. Therefore, the farmers are recommended not to extant their floating net. Paddy field and raceway ponds had low natural capital due to the high incidences of water shortages. The source of water in paddy fields and some of excavated pond is from the irrigation canal. Farmers reported that some of the irrigation canals are either clogged or broken causing limited water flow into paddy fields. The total area of irrigation system in Indonesia amounted to 7.47 million ha or 33,210 systems (Arif and Murtiningrum, 2011). However, based on the rapid assessment in 2010 by Ministry of Public Works found that only 48 % of the irrigation network in good condition (Azdan, 2011). This condition will affect the agriculture and aquaculture activities. It is needed attention from government to repair the irrigation canal immediately.

Table 4.3 The index of the livelihood capital and the results of ANOVA and Duncan post hoc

Index		Raceway	Excavated	Paddy field	Floating Net
Human Capital	Adult member (Labor)	0.67 b	0.57 b	0.57 b	0.37 a
	Aquaculture training	0.62 c	0.37 ab	0.48 bc	0.22 a
Natural Capital	Pond area (ha)	0.67 b	0.77 b	0.74 b	0.29 a
	Water shortage/ Fish mortality	0.52 b	0.85 c	0.12 a	0.19 a
Social capital	Organization	0.57 a	0.88 b	0.68 ab	0.58 a
	Member period	0.63 b	0.83 c	0.69 b	0.18 a
Financial Capital	Financial aid	0.38 a	0.77 b	0.36 a	0.32 a
	Other source of income	0.57 a	0.92 b	0.48 a	0.92 b
Physical Capital	Road Access	0.78 b	0.78 b	0.88 a	0.79 b
	Transport Access	0.78	0.79	0.71	0.74
	Communication access	0.83 b	0.85 b	0.80 b	0.72 a
	Market Access	0.82 b	0.84 b	0.77 b	0.64 a
	Water access	0.84 c	0.85 c	0.76 b	0.63 a

[1]a, b, …, values with different letters within the same row are significantly different ($P<0.05$)

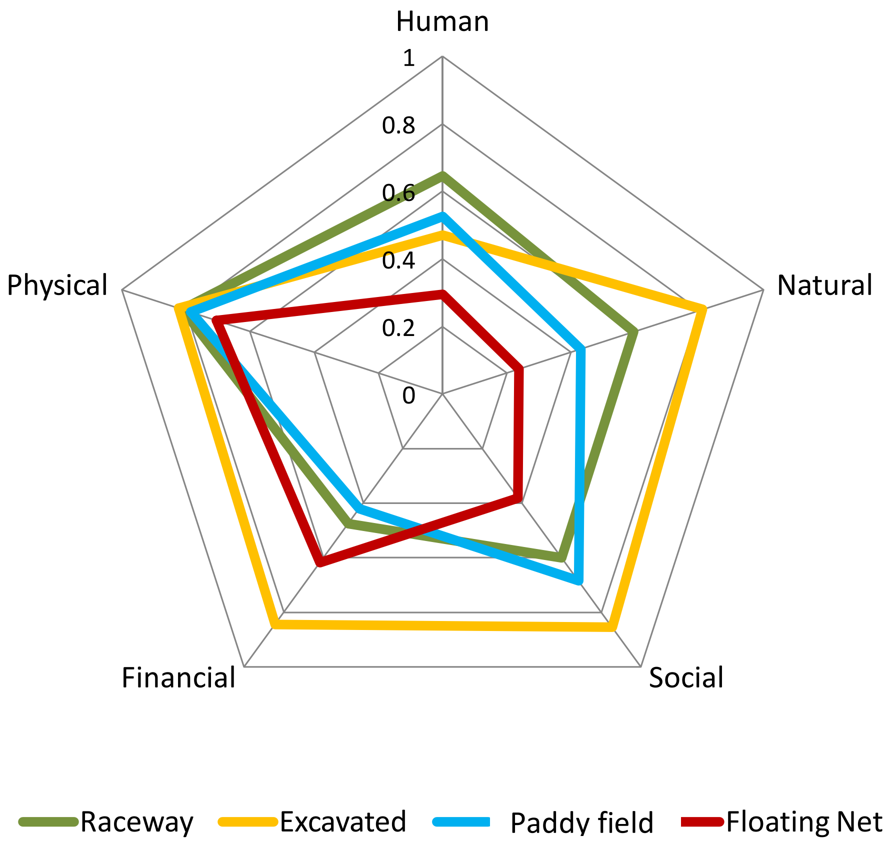


Figure 4.1 Livelihood asset pentagons by type of pond

In this study, social capital represents the social resources upon which farmers draw upon for their aquaculture production. Aquaculture organizations promote the exchange of knowledge, sharing of information, and cooperation among members. Excavated pond farmers had a significantly higher index ($p<0.01$) in social capital. Financial capital represents the incomes, credits, and financial aids. Most of all the excavated pond farmers are members of aquaculture organizations, which may be one of the reasons for higher social capital. Similarly, the higher financial capital index among excavated pond farmers was reflected in significantly higher financial aid from many sources due to the existence of aquaculture organizations. The Indonesian government, through the Ministry of Marine affairs and Fisheries (MMF), provides grants at group levels for helping small-scale farmers improve their aquaculture activity (Rimmer et al., 2013). During the interviews, we found that farmers face difficulties in acquiring loans from banks and financiers due to the large amount of documentation required for banks and the uncertainty of repayment to finances. One of the required documents is a certificate of land ownership. The majority of farmers have no certificate because the land is a legacy of the wife's parents. West Sumatera (Minangkabau tribe) is the largest matrilineal community in the world (Stark, 2013). Under tribal law, clan property including land and housing is held by the women and passed down from mother to daughter, though both men and women can own non-clan property.

Physical capital is the basic infrastructure in the location that is needed to support aquaculture activity. The physical capital was significantly different among the systems ($p<0.01$). The physical capital index in composed of five indicators: road, public transportation, communication, market and water access.

3.6 Vulnerability

Nile tilapia farmers identified several problems that influenced the vulnerability of their aquaculture activity in past years (Table 4.4). Within the three pond types, there were significant differences in the vulnerability. Raceway pond farmers identified the high price of feed as the most important problem (100%), followed by pond construction cost (86%) and difficulty obtaining credit as the third problem (48%). The raceway system is carried out intensively and is dependent on commercial feed. Most farmers reported that the price of feed increases rapidly while fish prices remained stagnant.

Table 4.4 The common problems faced by farmers by type of pond (percentage of respondents)

	Raceway	Excavated	Paddy field	Floating net
Feed prices	100.0%	76.9%	92.0%	98%
Pond/floating net constructing cost	85.7%	78.8%	40.0%	93%
Credit access	47.6%	28.8%	36.0%	75%
Low of aquaculture knowledge	38.1%	28.8%	44.0%	82%
Disease	33.3%	50.0%		87%
Fingerling/fry price		30.8%	40.0%	78%
Internal pollution		19.2%		88%
Predators		21.2%	24.0%	
Labour cost	47.6%		20.0%	
Parasite	33.3%	46.2%		
Fertilizer price	33.3%			
Labour	23.8%			
Water supply	23.8%			
Road quality		11.5%		
Lack of attention from the government			48.0%	
Floods			20.0%	
Water quality			20.0%	
Fish price is low				89%
High mortality				75%
Fingerling/Fry supply				72%

For excavated pond farmers, the cost of pond construction was the main problem (79%), while the second was the high price of feed (77%) and the third was fish disease (50%). Similar to raceway pond farmers, the high price of feed was identified as the major problem for paddy field farmers (92%). The next problem was a lack of government attention (48%) followed by low aquaculture knowledge (44%). The excavated pond farmers also faced problems with pond construction cost and the price of feed. Even though the excavated ponds can be constructed by soil, concrete ponds reduce water shortage due to no water infiltration into the soil. The paddy field farmers experienced problems with the price of feed and lack of government attention. Paddy field farmers reported the irrigation canal problem to the government but have not yet received any response.

The same condition was also faced by floating net farmers. The main problems were feed price and cost of floating net. Special problem that faced by floating net farmers are low of fish price and high fish mortality. Floating net farmers has passive market, which most of buyers come directly to lake for harvesting the fish. In one side is good for farmers no need for looking the market. In the other side, farmers got the lower prices than the market price. The high of fish mortality was caused by the decrease of lake water quality. According to Lukman (2013), the water quality of Maninjau Lake indicated eutrophic conditions on the basis of chlorophyll content, secchi depth, and total phosphorous and nitrogen levels. Further, anoxic conditions were found at a depth of 15 m. Henny (2009) found that the concentration of chemical oxygen demand (COD) in water was slightly higher; organic compound (C-organic and volatile solids) could extend the anoxic layer of water and enhance hydrogen sulfide production. This condition can trigger upwelling by drastic changes in weather (temperature) such as in the beginning of the rainy season.

4.7 Water quality

Table 4.5 Water quality of three pond types during dry and rainy seasons in West Sumatera

Type of Pond	Season	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Total P (mg/L)
Raceway	Dry	6.6±0.3	4.1±0.5	70.1±3.1	64.7±4.0	0.3±0.2	0.1±0.0	0.4±0.1
	Rainy	5.5±0.3	3.6±0.1	67.0±2.6	77.2±1.8	0.1±0.0	0.1±0.0	0.2±0.0
Excavated	Dry	6.4±0.9	2.6±0.4	89.1±7.6	78.3±3.5	1.2±0.3	0.2±0.1	0.6±0.1
	Rainy	4.4±0.3	1.4±0.2	103.4±8.5	108.0±10.1	1.8±0.2	0.3±0.0	0.7±0.1
Polyculture	Dry	5.2±0.2	2.1±0.1	108.1±4.6	97.0±5.0	1.7±0.2	0.3±0.0	0.8±0.0
	Rainy	4.8±0.2	1.7±0.2	79.2±16.3	90.5±13.1	0.7±0.7	0.2±0.1	0.4±0.2
Standard (GAP & SNI)*		≥ 5	≤ 30	≤ 50	≤ 400	≤ 10	≤ 0.06	≤ 0.5

*GAP (Good Aquaculture Practices) from Global Aquaculture Alliance, 2008. SNI (Indonesian Standard) 7550, 2009)

The water exchange during the cycle is used to assess water quality for both the dry and rainy seasons. The water quality variables used in the analysis were summarized in Table 3.4. It was found that the average values of water quality variables were significantly different among the three types of ponds ($p<0.01$). COD and Nitrite of all kind of ponds in the both season exceed the safety level standards for the environment. DO of excavated pond and paddy field in rainy season was lower than the standard. The total phosphor of excavated pond in both of season and paddy field in dry season were higher than the standard. DO and total phosphor of raceway pond in dry season were significantly higher than rainy season, while the sulfate was lower ($p<0.01$). DO and BOD of excavated pond in rainy season were significantly lower than dry season, while the other variables were significantly higher ($p<0.01$). Almost all of water quality variables of paddy field pond in dry season were significantly higher than rainy season ($p<0.05$).

Many variables of water quality in excavated and paddy field ponds were not up to the good aquaculture practices (GAP) standards (GAA, 2008) because of limited water exchange within these ponds. Stagnant water can increase biological respiration, including that related to decomposition processes and also reduce DO concentrations (Chapman and Kimstach, 1996). A similar result was also reported for the integrated pond systems in Mekong Delta, Vietnam (Nhan et al., 2006; Anh et al., 2010); the main variability in pond water quality and sediment nutrients was related to food input and water exchange rates (Alongi et al., 2009). DO concentrations below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish (Chapman and Kimstach, 1996). The total phosphor in excavated and paddy field ponds was high. An increase in phosphor concentration can cause of eutrophication. Phosphorus in these ponds was mainly from the decomposition of organic matter from feed and faces.

Another important finding was the high COD and concentration of nitrite. Similar conditions were also reported by Anh et al., (2010). COD is a measure of the total quantity of oxygen required to oxidize all organic material. A COD test indirectly measures the amount of organic and inorganic pollutants in the water. The COD of excavated and paddy field ponds was significantly higher than that of raceway ponds. Common contaminants contributing to COD in excavated and paddy field ponds came from fertilizers and feed applied in the both of ponds while the COD in raceway ponds came from commercial feed.

Nitrite is an intermediate in the oxidation of ammonium to nitrate. The high concentration of nitrite in water may cause the nitrification, which is harmful to fish. One main effect of nitrification is the oxidation of hemoglobin to methemoglobin in fish, compromising blood oxygen transport (Kroupova et al., 2005). In human body, nitrite and nitrate can produce nitrosamine that one of the most potent groups of known carcinogens (Yurchenko and Molder, 2006). The concentration of Nitrite in excavated and paddy field ponds was significantly higher than that in raceway ponds. High protein diets and wastes derived from the feed are either directly or indirectly released into the surrounding pond. Limited water exchange, in such cases, can increase the concentration of nitrite. Many studies have been conducted using probiotics in aquaculture to improve water quality. Zokaeifar et al. (2014) studied the use of two *Bacillus subtilis* strains in the rearing water of shrimp (*Litopenaeus vannamei*) and noted a significant reduction of ammonia, nitrite and nitrate ions under in vitro and in vivo conditions for eight weeks. These results are consistent with those of other studies (Zhou et al., 2009; Talpur et al., 2013). In addition of using probiotics, water quality can be improved by using floating feed. Frimpong et al. (2014) concluded that floating feed was associated with higher water quality, especially dissolve oxygen, and higher growth of Nile tilapia. Floating feed will also improve the efficiency of feed which will effect on cost reduction.

CHAPTER V

The Typology

5.1 The typology of Pond

5.1.1 Introduction

The previous chapter shows that some parameters of water quality of raceway, excavated and paddy field pond exceed the safety level standards for the environment. The level of intensification in aquaculture is quietly related to the environmental concerns particularly for high-input high-output intensive systems (Nhan, et. al., 2006). To identify the intensification degree for each of pond, we decided to carry out a study to assess the pond clustering among the three kinds of pond.

Several studies have highlighted the complexity and dynamics of the different variables across farming activities. The typology of the Asian carp farming system conducted by Michielsens et al. (2002) was based on resource use efficiency, whereas Joffre and Bosma (2009) investigated the typology of shrimp farms in Mekong Delta on the basis of technical and economic characteristics. The other typology studies have been performed on dairy goat production system of Spain (Caste et al. 2011), farm diversification of mountain areas (Lopez-Gelats et al. 2011), and dairy sheep production of Spain (Milan et al. 2011). The present study aims to evaluate the intensification of the raceway, excavated and paddy field with particular reference to the input-output systems.

5.1.2 Materials and Methods

Questionnaire interview data were coded and entered into a database using MS-Access. The Statistical Package for Social Science, SPSS 17 was used to produce descriptive statistics. The input-output component that used were fry density (pcs/m^2), pond area (ha), feed cost (MRp./ha/year), fertilizer cost (MRp./ha/year), and gross return of aquaculture (MRp./ha/year). A hierarchical clustering technique by using the five components did to estimate the number of cluster. Next, a K-mean clustering technique procedure was used to obtain the cluster centers. A-one way ANOVA and a Duncan post hoc test were used to identify significant differences between the groups of farmers ($P < 0.05$).

5.1.3 The raceway pond intensity level

Cluster analysis based on the five components was used to identify principal farm types. Hierarchical cluster analysis indicate the presence of two clusters. K-mean cluster analysis was used to obtain the two cluster centres (Table 5.1 and 5.2). Clustering was influenced mainly by the feed cost, fry density, pond area, and gross return. The both of identified cases can be characterized as intensive and super intensive. The intensive raceway pond takes up most of the farmer (table 5.1). Nile tilapia is cultivated at a moderate density and production is based primarily on commercial feed and also used farm made feed. The gross return was better and the pond area was larger than the super-intensive (Table 5.2). The second, super-intensive system, are only a fraction of farmers. Nile tilapia is cultivated at a very high stocking density using a high amount of commercial feed, but less of gross return. The super intensive system is thought to be polluting the environment with residual feed because not all feed can be consumed by fish. This is exacerbated by the use of sinking feed. From the study done by Frimpong et. al. (2014), the floating feed was associated with higher water quality.

Table 5.1 Number of cases in each cluster of raceway pond

Cluster	1	16
	2	5
Valid		21
Missing		0

Table 5.2 Final cluster center of raceway pond

Component	Cluster	
	1 (Intensive)	2 (super intensive)
Gross return of aquaculture (MRp./ha/year)	5,155	2,624
Fertilizer cost (MRp./ha/year)	0	0
Feed cost (MRp./ha/year)	7,486	53,656
Fry density (pcs/m^2)	211	400
Pond area (ha)	.008	.002

5.1.4 The excavated pond intensity level

Table 5.3 Number of cases in each cluster of excavated pond

Cluster	1	16
	2	36
Valid		52
Missing		0

Table 5.4 Final cluster center of excavated pond

Component	Cluster	
	1 (Intensive)	2 (semi-intensive)
Gross return of aquaculture (MRp./ha/year)	3,743	940
Purchased of fertilizer (MRp./ha/year)	22.51	7.7
Purchased of feed (MRp./ha/year)	9,475	1,573
Fry density (pcs/m^2)	346	63
Pond area (ha)	.0034	.02

Cluster analysis based on the five components was used to identify principal farm types. Hierarchical cluster analysis indicates the presence of two clusters. K-mean cluster analysis was used to obtain the two cluster centers (Table 5.3 and 5.4). Clustering was influenced mainly by the all component: feed cost, fertilizer cost, fry density, pond area, and gross return. The both of identified cases can be characterized as intensive and semi intensive. The intensive excavated pond takes small amount of the farmer. Nile tilapia was cultivated at a high density and production is based primarily on commercial feed and also used natural feed. The gross return was better than the semi intensive. The intensive system in excavated pond seems to be the source of water degradation. High cost fertilizer and feed showed that farmers used inorganic fertilizer and commercial feed.

The second, semi intensive system, are the majority of farmers. Nile tilapia was cultivated at a low stocking density using a small amount of commercial feed. The pond area was bigger than intensive system. The semi intensive system used the organic fertilizer such us cow dunk or chicken manure that can freely they get or cheaper than inorganic fertilizer.

4.1.5 The paddy field pond intensity level

Cluster analysis based on the five components was used to identify principal farm types. Hierarchical cluster analysis indicated the presence of two clusters. K-mean cluster analysis was used to obtain the two cluster centres (Table 5.5 and 5.6). Clustering was influenced mainly by the feed cost, fry density, pond area, and gross return. The both of identified cases can be characterized as extensive and semi extensive system. The extensive paddy field (traditional) pond takes up half of the farmer. Nile tilapia are cultivated at a very low density and production is based primarily on natural feed and small amount of commercial feed. The gross return was lower but the pond area was larger than the semi extensive. The second, semi extensive system, are also the half of farmers. Nile tilapia is cultivated at a low stocking density using a natural feed and commercial feed. This affected on the lower of fertilizer cost.

Table 4.5 Number of cases in each cluster of paddy field pond

Cluster	1	13
	2	12
Valid		25
Missing		0

Table 4.6 Final cluster center of paddy field pond

Component	Cluster	
	1 (extensive)	2 (Semi extensive)
Gross return of aquaculture (MRp./ha/year)	59	349
Purchased of fertilizer (MRp./ha/year)	2.1	1.7
Purchased of feed (MRp./ha/year)	45	84
Fry density (pcs/m^2)	10	17
Pond area (ha)	.075	.0397

In the principle, paddy field aquaculture can be integrated using crops and crop residues as feeds and fertilizers for fish and pond sediments and water can be used as crop fertilizers and irrigation water, respectively (Murshad-E-Jahan and Pemsl, 2011). The paddy field farmers still believe that fish in paddy field still need commercial feed for their growth. Therefore, it is needed the aquaculture training about application of polyculture aquaculture especially paddy field.

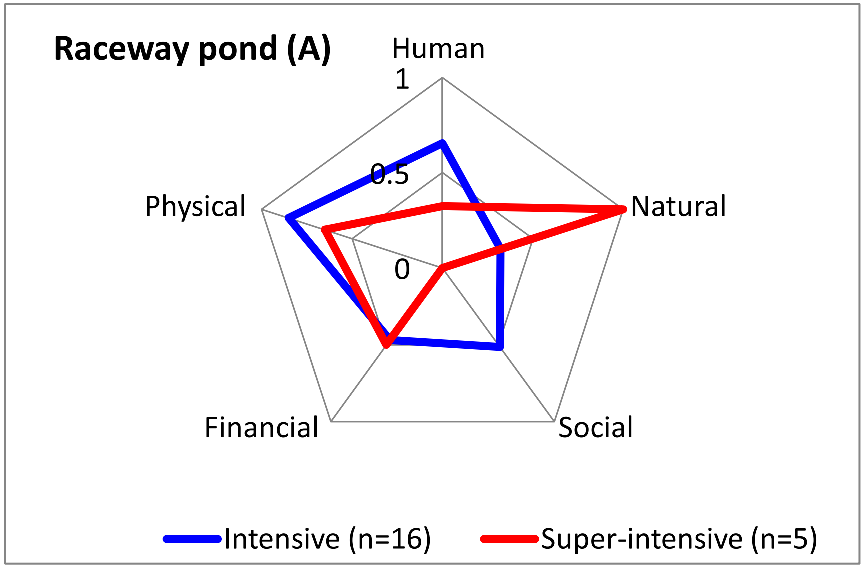
4.1.6 The livelihood pentagon

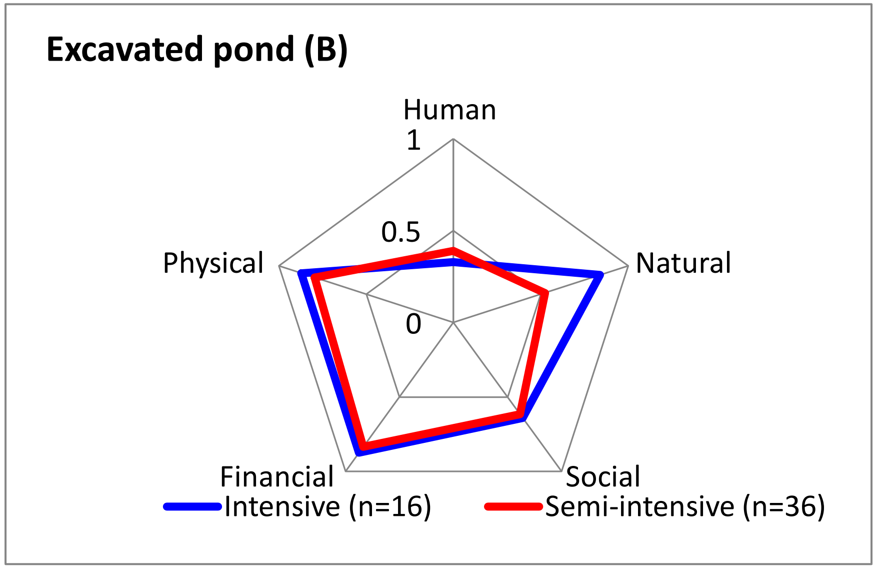
Table 4.7 Index of livelihood capital

Index		Raceway		Excavated		Paddy field	
		Super-intensive (n=5)	Intensive (n=16)	Intensive (n=16)	Semi-intensive (n=36)	Semi-extensive (n=12)	Extensive (n=13)
Human Capital	Adult member (Labor)	0.65	0.5	0.47	0.34	0.47	0.43
	Aquaculture training	0***	0.81***	0.19	0.44	0.5	0.46
Natural Capital	Pond area (ha)	1	0.27	0.68***	0.27***	0.34	0.3
	Water shortage	1**	0.37**	1**	0.78**	0	0.24
Social Capital	Organisation	0***	0.75***	0.94	0.86	0.42***	0.92***
	Years of member	0*	0.28*	0.34	0.37	0.32	0.34
Financial Capital	Financial aid	0*	0.5*	0.81	0.75	0.25	0.46
	Other source of income	1*	0.44*	0.94	0.92	0.17***	0.77***

Physical Capital	Road Access	0.6***	0.82***	0.83	0.76	0.76***	0.66***
	Transport Access	0.6***	0.82***	0.85*	0.76*	0.8***	0.63***
	Communication access	0.68***	0.87***	0.88	0.83	0.81	0.78
	Market Access	0.68***	0.86***	0.9	0.81	0.85	0.69
	Water access	0.68***	0.88***	0.9**	0.82**	0.81	0.7

ANOVA results, significantly difference: * P<0.05, ** P<0.01, *** P<0.001





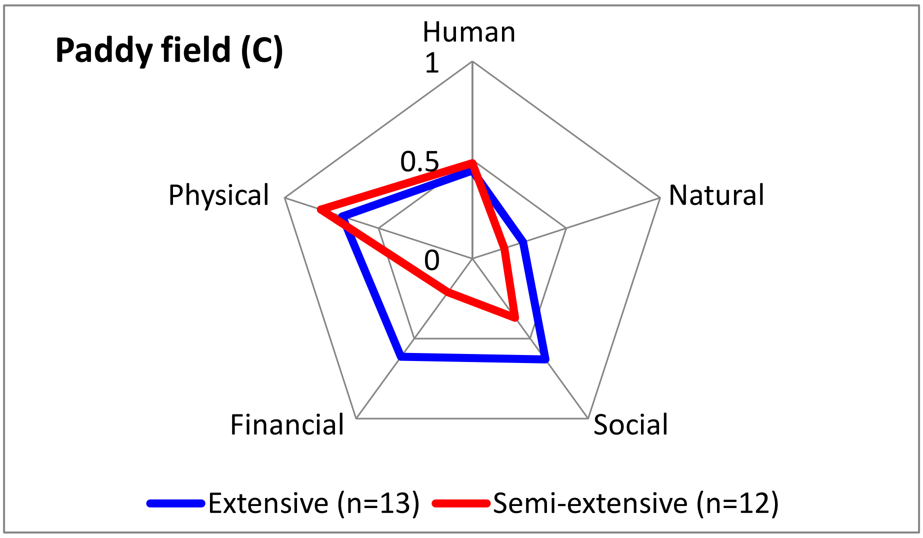


Figure 5.1 The livelihood pentagon of raceway pond (A), excavated pond (B), and paddy field pond (C)

The livelihood indexes of each type of pond were shown on table 5.7 and the index mapping on livelihood pentagon was shown in the figure 5.1. On the raceway type, there are two type of system: intensive and super intensive. The farmer of super intensive system had higher natural capital, but the human, social and physical capitals were lower than the intensive system. The super intensive farmers had another source of income and had enough financial capital. On the other hand, they were not belonging to one aquaculture organization and never attend the aquaculture training. Farmer organizations are needed by small-scale farmers because they face major challenges to remain competitive and participate in modern practices (Kassam et al., 2011). The organization provides a place for discussing and exchanging information among the members. Further, some organizations form a cooperative institution that provides production, supply, and market links for the members. There are many training opportunities provided by the government, university and NGOs in this area such as

Good Aquaculture Practices, hatchery, farm-made feed and others for a period of between three days to one week. The super intensive farmers seem not socialize with other farmers so that the lack of information regarding good aquaculture practices.

The excavated type has two systems: intensive and semi intensive. The farmers of intensive system had better natural capital than the semi intensive farmers. The semi intensive farmers had the small aquaculture area and faced the water shortage. This is also shown in the physical capital, the semi intensive farmers has lower water access index than intensive farmers. The water shortage was caused by the damage of irrigation canals. The rapid assessment in 2010 by Ministry of Public Works found that only 48 % of the irrigation network in good condition (Azdan, 2011). This condition will affect the agriculture and aquaculture activities. It is needed attention from government to repair the irrigation canal immediately.

The paddy field type had two systems: extensive and semi extensive. There were no significant different in the human and natural capital between them. The social and financial capital of extensive farmers significantly higher, but the physical capital was lower than semi extensive system.

5.2 The typology of the farmers involved in floating Net Culture in Maninjau Lake

5.2.1 Introduction

Maninjau Lake is a caldera lake, which has an area for almost 10,000 ha, and is approximately 16.5 km long and 7.5 km wide and located at an altitude of 461.5 m above sea level. The average depth is 105 m, with a maximum depth of 165 m. About 88 streams flow into Maninjau Lake, but only 36% flow year-around, and the only outlet is Antokan River, which is used for hydroelectric power generation for West Sumatra and the surrounding regions. Besides this, the lake has been used for aquaculture activity by using floating net cages.

Floating net (FN) culture is the rearing of aquatic species within enclosures in natural waterways (oceans, lakes, reservoirs, or rivers). FN aquaculture was introduced in 1992 by 17 fishermen households and has developed rapidly. In 2013, around 1,882 households were engaged in FN aquaculture with a total of 13,627 FN units (MAFS, 2013). Fish production increased from 4,401 tons in 2002 to 36,664 tons in 2011 (MAFS, 2012). FN culture is an intensive aquaculture system that yields a high input of feed and a high density of fish. Most farmers are engaged in small-scale aquaculture, defined as systems in which aquaculture is performed on small land and water areas with family-scale operations business, mostly involving the contribution of family members and often restricted to family land; this type of aquaculture is rather vulnerable (Bueno, 2009). This activity has indeed increased economic benefits to the community.

According to Alston et al. (2006), open cage culture has benefited from large volumes of water and strong water currents passing through the site. However, Maninjau Lake is a volcanic lake used for hydroelectric power generation, with a retention time of about 23 years (IIS, 2009). Intensive aquaculture activity can cause high accumulation of nutrition and lead to eutrophication because of the reduced water replacement. This effect has been reported by farmers several times in the form of massive fish mortality since 2009. Such a situation could also threaten the income of households engaged in FN culture. Thus, identifying constraints as well as providing areas for development are necessary.

The fish commonly cultured using FN is Nile tilapia after Koi Herpes virus diseases (KHVD) destroyed almost all carp cultures in 2005. However, since 2009, massive fish mortality has been reported by farmers. Henny (2009) reported that the accumulation of organic matter in the deepest part of the lake and shifts in oxygen content over the 4-year observation period could be one of the major factors for fish mortality. Further, climate change might be another factor that influences the fish mortality rate since most fish die during the rainy season (IIS, 2009). The farmers' characteristics, aquaculture activities, and their impacts can influence the livelihood of farmers. In this dynamic environment, few studies have recently analyzed the effects of the diversity of FN aquaculture practices on farmers' livelihood.

An in-depth study involving the use of multivariate analysis to determine the typology of farmers engaged in aquaculture activities and the association with their livelihood seems useful. The livelihood approach has been widely used to achieve a better understanding of a particular component of an individual or family livelihood strategies associated with the environment. This study aimed to establish a typology for the diversity of farmers involved in FN aquaculture in Maninjau Lake associated with their livelihood capitals and to analyze the differences between groups of farmers and determine the vulnerability of farmers.

5.2.2 Materials and Methods

An interview survey was conducted with owners of 118 families involved in FN cultures twice during August and December 2013 around Maninjau Lake, West Sumatera, Indonesia (Figure 5.1). West Sumatera province was selected as a representative of small-scale operations because it has the highest number of fish farmers engaged in freshwater aquaculture, and the production of Nile tilapia is considerably high in the provinces of Sumatera Island. The farmers were selected randomly from a list of tilapia farms in West Sumatera obtained from the Marine and Fisheries Office.

A questionnaire in Indonesian language was pre-tested and some changes were made. The questionnaire consisted of farmers' livelihood capitals (human, natural, social, financial and physical capital) and aquaculture activities. The interviews were made in co-operation with local extension officers of Maninjau village. Additional information was also collected from extension officers in the village. Data from the interview were used for factor and cluster analysis. A range of variables was selected and their values calculated from the data. The adult member (labor) was calculated as the number of people above 18 years in the farmer household.

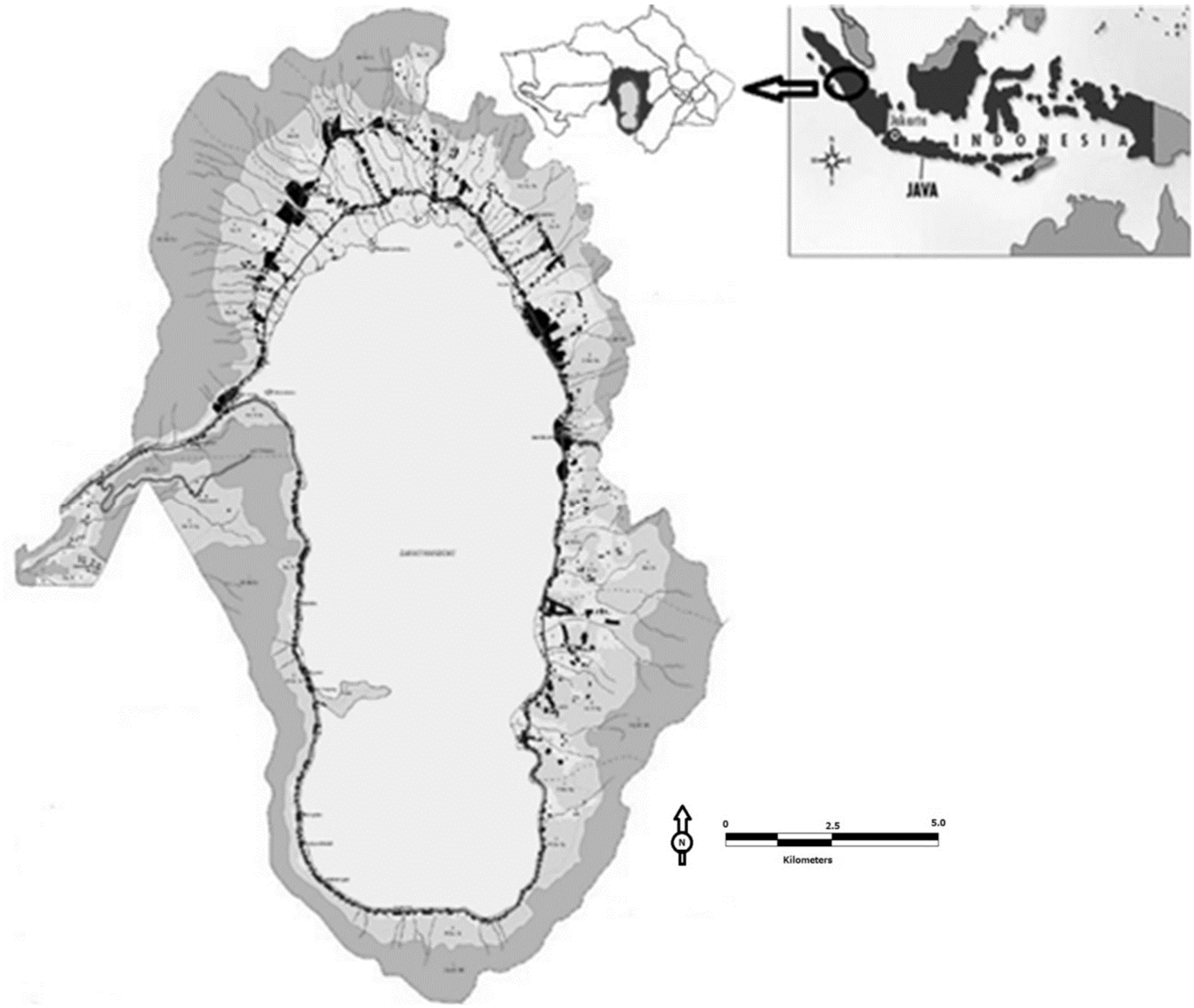


Figure 5.2 The Maninjau Lake's map

(Source: http://www.agamkab.go.id/?agam=profil&se=peta&j=kec&id=5)

The aquaculture training is the participation of farmers at least once in the aquaculture training organized by the government or NGOs. The cage area is the total area of cages owned by farmers. The mass death of fish represents the disaster that faced by farmer in last of 5 years. The farmer's answer was cross-checked with the fisheries office data. The organization is a membership of the aquaculture organization registered in the fisheries office. The member period was calculated as the years since the farmers joined the organization. The financial aid is the credit, loan or grant received by farmers related to aquaculture activity. The other source of income is a present or absence of the side job in the farmer household. The farmer was asked to evaluate the physical capitals (road, transport, communication, market, and lake access) in his area by using a five-point rating scale with an ascending value of 1 (very difficult), 2 (difficult), 3 (neither difficult nor easy), 4 (easy), and 5 (very easy).

Questionnaire interview data were coded and entered into a database using MS-Access. The Statistical Package for Social Science, SPSS 17 was used to produce descriptive statistics. As first step, factor analysis was used to create a smaller set of composite variables to replace the original 13 variables. Following Milstein et al. (2005), all variables were normalized before the analysis. The factors rotated using VARIMAX method. The chosen component is the component that has eigenvalues above 1. The second step is cluster analysis. A hierarchical clustering technique by using the factors scores did to estimate the number of cluster. Next, a K-mean clustering technique procedure was used to obtain the cluster centers. A-one way ANOVA and a Duncan post hoc test were used to identify significant differences between the groups of farmers ($P < 0.05$).

The livelihood of farmers was analyzed using an index to assess their capitals (Shivakoti and Shrestha 2009). Each individual asset was indexed across all 118 respondents. The lowest 10% of values were indexed as 0.1; the next 10–20%, as 0.2; and the remaining 90–100%, as 1.0. The composite asset index for each farmers was calculated as the average of the relevant index indicators. The livelihood asset pentagon was plotted by using the average index of each group of farmers.

The vulnerability context refers to the shocks, trends and seasonality that have affected livelihood of farmers in floating net farming communities. There were many problems that related to aquaculture practices that have been experienced by farmer. The vulnerable data was collected by multiple respond questionnaire of the problem that faced by farmers. The problems consist of input, production, facilities, access and environment section. The results were presented as the percentage of cases.

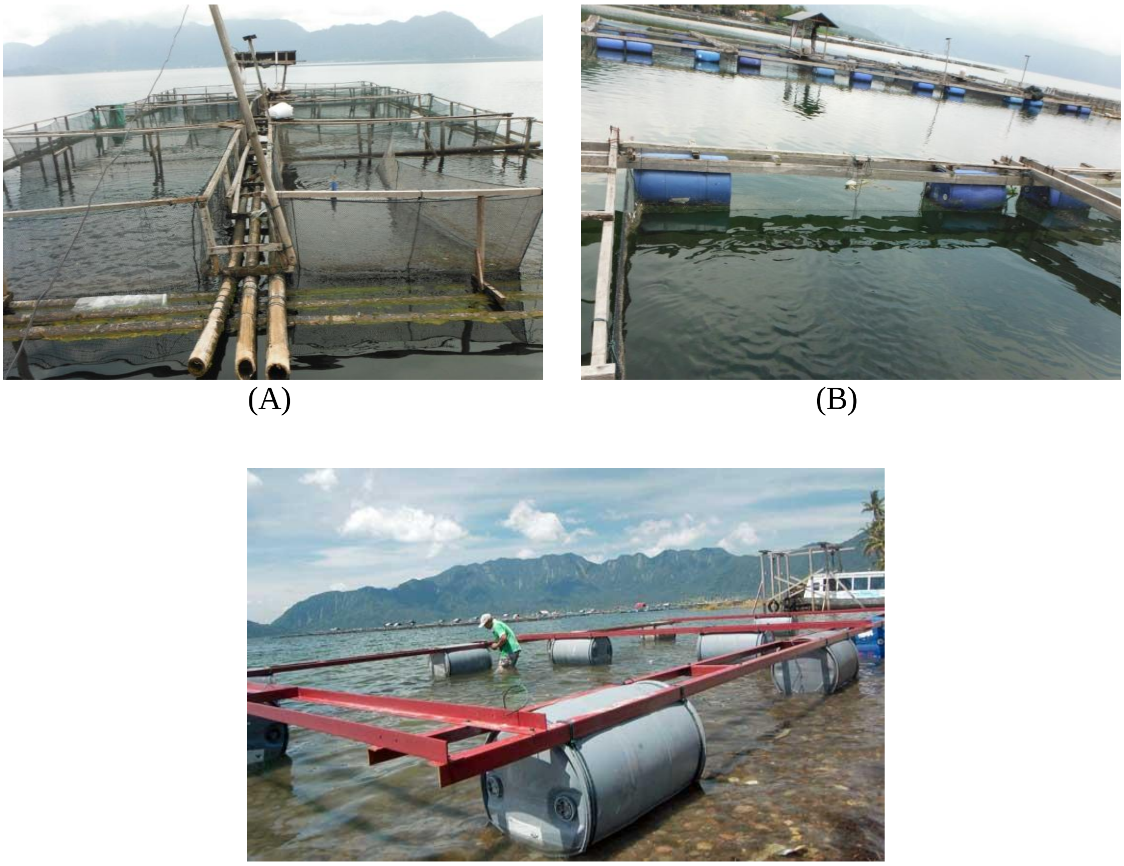
5.2.3 The livelihood capital indicator

The community around Maninjau Lake is involved in FN farming for their livelihood. FN aquaculture involves growing aquatic organisms in an enclosed space that maintains the free exchange of water with the surrounding water body by using synthetic material that can resist decomposition in water for a long period (Das et al., 2009). It uses locally available resources such as bamboo or wood for cage construction and small ships for the operation (Figure 5.3).

Cage farming in Asia (including FN culture in Maninjau Lake) is considered to be a small-scale practice, but can contribute to a significant level of production (De Silva and Phillips, 2007). It has numerous important benefits for Maninjau lake community livelihood, including increased food supply and availability, better employment opportunities, and improved rural economics (Munzir and Heidhues, 2002). Since 1992, a rural population surrounding Maninjau Lake has utilized FN culture as one of their livelihoods. The FN aquaculture has been growing rapidly in Maninjau Lake because of the high profits it yields.

The livelihood capital identifies five main capital categories: human, natural, social, financial, and physical (Table 5.8). The analysis of livelihood capitals has revealed that FN farmers in Maninjau Lake have moderate capitals. The farmers have their own cages and engage in aquaculture by themselves. This condition is different from FN farmers in Lake Taal, Philippines, which is dominated by caretakers (ADB, 2005). In Saguling Dam, Indonesia, FN culture is presently mostly owned by non-residents who have capital and hire labor from outside the Saguling area (Sunardi et al., 2013). Even though FN culture does not need land, it requires high initial capitals for developing FN cages, supplying fingering, and feeding the fish.

Human capitals include labor and the knowledge or skill of aquaculture practices. In the FN systems, the adult members of a family with around 1–9 members were average 3 people, and only 20% obtained aquaculture training provided by the government. Since it is a small-scale aquaculture practice, most activities were performed by all members of the household, especially adult members. Family labors are mostly used for preparing cages and feeding the fish. All harvesting activities are performed by buyers. Fishery officers of the province or regency often provide aquaculture training about good aquaculture practices, but most farmers do not have the opportunity to participate in these training programs because of the lack of information and, occasionally, because the venue of these programs was Padang city (Provincial capital of West Sumatera; about 140 km from Maninjau Lake).



(A) (B)

(C)

Figure 5.3 Floating net from bamboo (A), wood (B), and steel (C)

Natural capitals are water area, and fish mortality reported by farmers has an impact on water quality. On average, FN farmers own 203.3 m^2 wide area, with an average depth of 4 m, and 80% of farmers report high fish mortality. Majority of the cages are single-net systems with a variety of sizes and depths. Generally, the size is 5 × 5 with a depth of 4 m. Massive fish mortality has been occurring almost every year since 2009. The highest mortality rate was reported in 2009, with death of more than 15 thousand tons of fish. Most farmers attributed this to climate change, whereas the Indonesia Institute of Science recorded that the water quality of Maninjau Lake was decreasing, especially the oxygen demand was extremely low (IIS, 2009).

Table 5.8 The farmers' livelihood capitals that used as variable for factor analysis (FA)

Livelihood capitals		Parameter	Average	Std Dev.
Human Capital	Adult member (Labour)	People	3.3	1.4
	Aquaculture training	Binary (Yes (1) No (0)	0.2	0.4
Natural Capital	Cage area	m^2	203.3	137.6
	Mass death of fish	Binary (No (1) Yes (0)	0.2	0.4
Social Capital	Organization	Binary (Yes (1) No (0)	0.6	0.5
	Member period	years	5	2.6
Financial capital	Financial aid	Binary (Yes (1) No (0)	0.3	0.5
	Other source of income	Binary (Yes (1) No (0)	0.9	0.3
Physical capital	Road access	Scale (Very difficult (1)- Very easy (5)	3.2	0.5
	Transport access	Scale (Very difficult (1)- Very easy (5)	3	0.8
	Communication access	Scale (Very difficult (1)- Very easy (5)	3.6	0.6
	Market access	Scale (Very difficult (1)- Very easy (5)	3.2	0.7
	Lake access	Scale (Very difficult (1)- Very easy (5)	3.1	0.8

Source: Field survey, 2013

Social capital refers to the social resources using which farmers increase their aquaculture production. Aquaculture organization is a group of farmers that can exchange knowledge, share information, and cooperate. More than half of the farmers (60%) are members of an aquaculture organization with a range of period of 1–16 years (average, 5 years). Farmer organizations are needed by small-scale farmers because they face major challenges to remain competitive and participate in modern practices (Kassam et al., 2011). The organization provides a place for discussing and exchanging information among the members. Further, some organizations form a cooperative institution that provides production, supply, and market links for the members. The aquaculture organization is common and strong among farmers in Maninjau Lake. It serves as a channel for information exchange among the farmers, fishery officers, and suppliers, as well as a link to the market. This organization also helps farmers obtain financial aids.

Financial capital represents access to income and formal or informal aid and credit. About 90% of the FN farmers have another source of income, such as paddy farming, civil service, carpentry, and services in public transportation. Most of the farmers (70%) did not use credit or aid in their activity; the remaining 30% received credit or aid from banks, government, and financiers. Because FN culture is an intensive technique, it requires a high start-up cost. The Indonesian Government through the Ministry of Marine Affairs and Fisheries (MMF) provides a grant at group levels for helping small-scale farmers to improve their aquaculture activity (Rimmer et al., 2013). Our interview survey revealed that respondents face difficulties acquiring loans from banks and financiers due to excessive documentation required for banks and uncertainty of repayment for financiers.

Accesses to road and the lake, transportation, communication, and marketing are needed to facilitate FN culture. A five-point rating scale with an ascending value of 1 (very difficult) to 5 (very easy) was used for rating the quality of physical capitals. The majority of physical capitals were average (3, neither difficult nor easy). The Maninjau Lake is located in Agam regency, which is 140 km from the provincial capital. Usually, the suppliers and buyers meet at the lake. This limits production supply and markets for farmers. Similarly, for accessing the lake, farmers who do not have land in the beach area of the lake have to rent land for mooring cages and ships or rafts.

5.4 Typology

There are various criteria that have been used to classify aquaculture communities, such as technical and economic factors (Joffree & Bosma, 2009), water quality (Milstein et al., 2005), intensity, and diversity (Michielsens et al., 2002). For sustainable aquaculture practices, we selected livelihood capitals as variables because FN aquaculture needs a high start-up capital. Five components were extracted from 13 variables by using factor analysis (Table 5.9).

The first component had five significant loadings with positive signs on access to markets, transportation, roads, lake, and aquaculture aid. This component represented “accessibility” of FN culture activity. Component two was linked positively with organization period, aquaculture organization, and training, thus representing “association” among the farmers. The third component had one positive loading—access to communication—and one negative loading—another source of income. This component represented “original” because FN culture is the only source of income.

Table 5.9 The rotated factor matrix, result from FA based on 13 variables of 118 floating net farmers

	Variable	Component				
		Accessibility	Association	Original	Intensification	Low mortality
Zscore	Access to market	**.892**	.056	-.007	.012	-.024
	Access to transport	**.811**	.114	.146	.292	.071
	Access to road	**.585**	.458	.464	.110	.079
	Access to cage	**.550**	-.190	-.113	.024	-.513
	Aquaculture aid	.429	.370	.048	-.313	-.114
	Length of organization	.028	**.903**	-.084	.034	-.019
	Aquaculture organization	-.006	**.879**	-.062	.095	-.148
	Aquaculture training	.116	**.592**	.071	-.044	.008
	Access to communication	.281	-.078	**.766**	-.262	.026
	Another source of income	.223	.012	**-.649**	-.417	.135
	Adult number	.152	.047	-.129	**.767**	-.155
	Total area	.090	.009	.160	**.501**	.315
	Massive fish mortality	.017	-.199	-.109	.005	**.837**
Eigenvalues		2.2	1.5	1.4	1.1	1.0
% of variance		17.9	12.2	11.4	9.3	8.7

Component four is "intensification" component that was positively linked with labor (the adult member) and the total area. The last component is characterized by a single variable—massive fish mortality. Positive loading means "low mortality."

Table 5.10 Final cluster centres

Factor	Cluster		
	1	2	3
Accessibility	-.695	.516	.367
Association	-.545	-.473	.683
Original	.298	-.965	.178
Intensification	.030	-1.093	.467
Low mortality	.499	-.132	-.371

A hierarchical cluster analysis was performed using the factor scores of five components over 118 farmers; this analysis indicated the presence of three clusters. Table 5.10 shows the cluster centers for each cluster by using the K-means cluster analysis. The first cluster is farmers dominated by three components: "original," "intensification," and "low mortality," The second cluster is dominated by "accessibility," and the last cluster is dominated by all components except "low mortality."

5.2.5 Farmers' community and aquaculture practices.

Table 5.11 Farmers' characteristics and aquaculture practices identified by groups

Variables	**Group 1 (n=44) 'Sustainable'**	**Group 2 (n=23) 'Failure'**	**Group 3 (n=51) 'Over culture'**
Household number (People)	4.4 (a)[1]	4.2 (a)	5.6 (b)
Age (Years)	47.6	45.35	50.9
Education	2.6	2.7	2.5
Number of net	7.4 (b)	4.9 (a)	7.2 (b)
Total area (m^2)	214.6 (b)	136.4 (a)	223.8 (b)
Period of practicing aquaculture (Years)	8.0 (a)	10.5 (b)	8.6 (ab)
Market (1-in village; 2-around province; 3 other province)	2.4 (ab)	2.2 (a)	2.6 (b)
Harvest (1-selective; 2-partial; 3-total)	1.2	1.2	1.3
FCR	1.3 (b)	1.26 (a)	1.27 (a)
Fish density (pcs/m^2)	314.1 (a)	325.9 (ab)	341.2 (b)
Net Profit (million Rp./cage)[2]	6.2 (c)	5.6 (b)	3.4 (a)
Future (1-continue; 2-expand)	1.3 (a)	2.0 (b)	1.2 (a)

[1)] a, b, …, values with different letters within the same row are significantly different

[2)] million Rp. = US$ 86.63

Cage farming in Asia (including FN culture in Maninjau Lake) is considered to be a small-scale practice, but can contribute to a significant level of production (De Silva and Phillips, 2007). It has numerous important benefits for Maninjau lake community livelihood, including increased food supply and availability, better employment opportunities, and improved rural economics (Munzir and Heidhues, 2002). Since 1992, a rural population surrounding Maninjau Lake has utilized FN culture as one of their livelihoods. The FN aquaculture has been growing rapidly in Maninjau Lake because of the high profits in yields

By using household livelihood capital as indicators, the typology of farmers was established, and the farmers were classified into three groups. Table 5.11 shows the characteristics of farmers and the FN culture system used by each group. The household members of farmers varied from 2–11 people, and group 3 had significantly higher members than the other groups. The farming communities were occupied by relatively young people, with the average age being 48 years, and no significant variation ($P > 0.05$) was noted for the age of respondents among the three groups of farmer. As with the age of farmers, no significant variations were found between different groups of farmers in terms of education level. Overall, the majority of farmers graduated from senior high school (53%). There were various numbers of FN sets, from 2 to 20 sets in each household.

Group 2 had significantly lower FN sets than groups 1 and 3. This result was associated with the difference in the total area owned by the farmers. The average period of farmers practicing FN culture varied from 2–20 years and was significantly different ($P < 0.05$) within the groups of farmers, i.e., the average period was longer for group 2 than for the other groups. The differences in harvesting type among the groups were not significant ($P > 0.05$). The majority of farmers used the selective system (selection of desired tilapia size for sale and harvesting is performed more than once) for harvesting. The results also showed that the market of group 2 was significantly different from that of group 3. The majority of farmers in group 2 had a market around the province, whereas the majority of farmers in group 3 sold their fish in others provinces. The farthest markets were outside West Sumatera province, such as Riau, Jambi, or Bengkulu Provinces. Market competition played a significant role for determining competitive prices, not only for FN culture, but also for other aquaculture practices such as pond and polyculture. The feed conversion ratio (FCR), fish density, and net profit were calculated for farms when no massive fish mortality occurred. FCR is the amount of feed required to produce one kilogram of fish. There was no significant variation in FCR among the groups of farmers ($P > 0.05$), whereas group 3 had higher density of fish than the other groups, which correlated with a higher net profit ($P < 0.05$).

5.2.6 Livelihood pentagon

The livelihood asset pentagon (Figure 5.4) showed that group 1 farmers had strong natural capital; moderate human capital; and low social, physical, and financial capitals. Strong natural capital was attributed to wider farming area and lower fish mortality. This group had relatively low access to aquaculture supply and less association, had another source of income because of which they were not keen on FN culture, had moderate capitals, and reported low fish mortality rates. This group of farmers had lower fish density and net profit than the farmers of the other group.

However, this practice was beneficial since it was associated with low massive fish mortality. The Indonesian Institute of Science (IIS, 2009) suggested reducing fish density for preventing massive mortality. When the fish density is reduced, the feed added to the water reduces. FN culture is fed with high protein diets, and wastes derived from the feed are either directly or indirectly released into the surrounding environment, causing eutrophication and reduced lake water quality (Effendie et al., 2005; Henny, 2009).

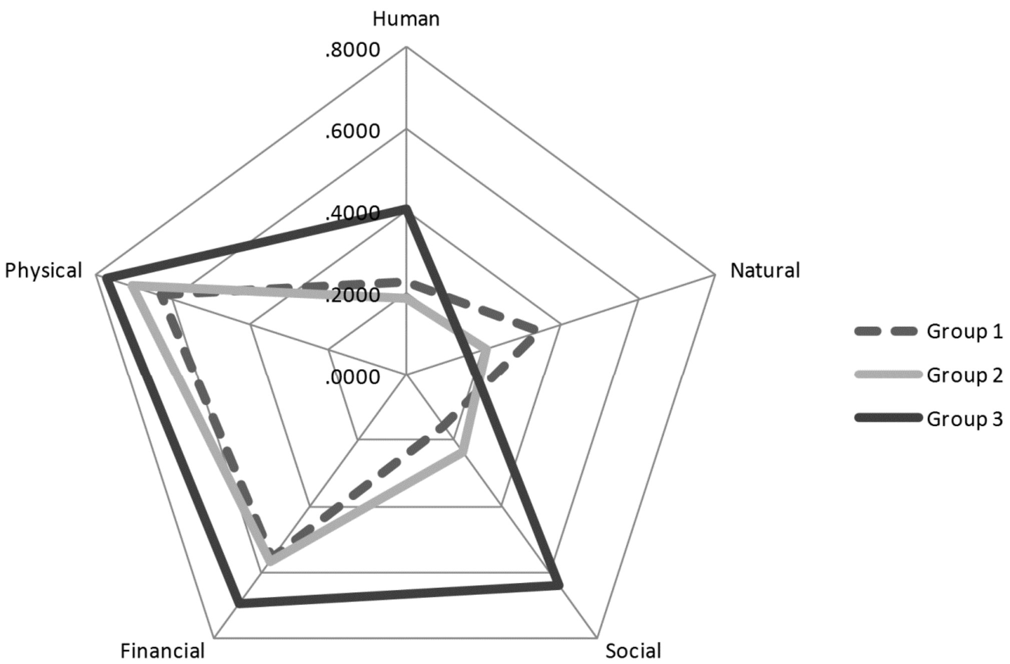


Figure 5.4. Livelihood capitals pentagon by groups

Table 5.12 Livelihood index of farmers identified by groups

Livelihood capitals		Group 1 (n=44)	Group 2 (n=23)	Group 3 (n=51)
Human Capital	Adult member (Labour)	1.7 (a)	1.4 (a)	2.2 (b)
	Aquaculture training	0.6 (a)	0.4 (a)	1.9 (b)
Natural Capital	Cage area	1.6 (b)	1.0 (a)	1.5 (b)
	Mass death of fish	1.8 (b)	1.1 (b)	0.1 (a)
Social Capital	Organization	1.3 (a)	1.7 (a)	4.8 (b)
	Member period	0.3 (a)	0.6 (a)	1.6 (b)
Financial capital	Financial aid	0.6 (a)	2.8 (b)	2.0 (b)
	Other source of income	5.0 (b)	2.8 (a)	5.0 (b)
Physical capital	Road access	2.9 (a)	2.9 (a)	3.5 (b)
	Transport access	2.5 (a)	2.7 (a)	3.5 (b)
	Communication access	3.6 (ns)	3.5 (ns)	3.6 (ns)
	Market access	2.7 (a)	3.6 (b)	3.5 (b)
	Lake access	2.6 (a)	3.6 (b)	3.4 (b)

Group 2 farmers had moderate natural, physical, and social capitals, and low human and financial capitals. They had higher accessibility because of physical capital and financial aid than the other groups (Table 5.12). However, it had limited natural capital and other sources of income. Most of the farmers of this group depended only on FN culture for their livelihood. Thus, this group was vulnerable to disasters, failures, or price shock. According to Paul and Fogl (2013), multiple livelihood activities provide a safety net for farmers to cope with production failure and price shock. Similar results have also been reported by Gunawan et al. (2004); 70.3% of FN farmers in Saguling reservoir, Indonesia, have no agricultural land and rely solely on FN culture.

The last group had higher capital than the other groups, but often encountered massive fish mortality. After Nile tilapia was being used for FN culture due to the KHVD in carps in 2005, farmers still reported massive fish mortality. This has been a special concern for the central and local government which led to the establishment of a research centre in Maninjau village. According to Lukman (2013), the water quality of Maninjau Lake indicated eutrophic conditions on the basis of chlorophyll content, secchi depth, and total phosphorous and nitrogen levels. Further, anoxic conditions were found at a depth of 15 m. Henny (2009) found that the concentration of chemical oxygen demand (COD) in water was slightly higher; organic compound (C-organic and volatile solids) could extend the anoxic layer of water and enhance hydrogen sulfide production. This condition can trigger upwelling by drastic changes in weather (temperature) such as in the beginning of the rainy season. Abery et al. (2005) reported that cage culture operations in Cirata and Saguling reservoirs (Indonesia) already exceed the reservoirs' carrying capacity and became the major contributors of large inputs of nutrients into the reservoirs and could have resulted in fish mortality. This condition also usually occurs during the rainy season.

5.2.7 Vulnerability

Table 5.13 The common problems faced by farmers by groups (percent of cases)

Problems	Group 1 (n=44)	Group 2 (n=23)	Group 3 (n=51)
Feed prices	100%	100%	96%
Pond constructing cost	92%	91%	96%
Internal pollution	89%	91%	85%
Fingerling/fry price	86%	91%	-
Low of aquaculture knowledge	86%	82%	79%
Fish price is low	86%	86%	92%
Disease	81%	91%	90%
Fingerling/Fry supply	78%	-	-
Feed supply	72%	-	-
Transport facilities	72%	-	-
Vitamin/drug price	-	86%	-
High mortality	-	86%	75%
Parasite	-	82%	73%
Credit access	-	-	81%
Fingerling/Fry supply	-	-	75%

Source: Field survey, 2013

FN culture farmers identified several issues that influenced their aquaculture activity in the past years (Table 5.13). There were significant differences in the issues faced by the three groups of farmers. Most farmers identified feed prices as the most critical issue, followed by FN constructing cost, which was reported by groups 1 and 3 farmers, whereas fingering price was an issue for group 2 farmers.

There were some specific issues faced by each group of farmers besides the common issues faced by all farmers. Group 1 had specific issues on fingering supply, feed supply, and public transport facilities. This was because most of the farmers in group 1 lived on the south side of Maninjau Lake, which is a disaster prone area close to the hills. The road access in this part was disrupted by an earthquake in 2009, and hill eruption still happens in this area (Danida, 2009). The road conditions also influence the production supply of FN culture.Group 2 reported issues related to vitamin or drug prices, and group 3 reported issues associated with access to credit and fingerling supply.

CHAPTER VI

Conclusions and Recommendations

The main freshwater aquaculture practices in Indonesia, especially West Sumatera, are raceway, excavated, integrated farming in paddy fields (polyculture) and floating net of Nile tilapia (*Oreochromis niloticus*). The livelihood analysis concluded that the excavated pond farmers had better livelihood capitals than the other types of pond farmers. The fish production in raceway ponds was generally higher than the others, but many limitations were observed in the raceway-culture. The main problem among raceway pond and paddy field and floating net farmers was high price of feed, while that of excavated pond farmers was a high cost of pond construction.

Based on water quality analysis on raceway, excavated, and paddy field pond, almost all of water quality variables of three kinds of pond in the dry season were significantly different than the rainy season. Some variables of water quality (COD and nitrite, in particular) from all types of ponds exceeded the safety level of the good aquaculture practices and this may pull public concern in near future. Generally water quality of raceway pond was better than the others.

The intensity level of each pond was analyzed. The raceway intensive system was better than the super intensive. The super intensive raceway pond should reduce the feeding amount or use the floating feed in order to increase the water quality. The semi intensive excavated pond was better than the intensive pond. The intensive excavated pond was recommended to reduce inorganic fertilizer to maintain the water quality. The extensive paddy field system was better than semi extensive system. The paddy field aquaculture farmers need the polyculture training to enhance their aquaculture knowledge.

The floating net culture is a major aquaculture activity in Maninjau village. As the result, the farmers were classified into three groups. Group one included farmers with relatively poor access to aquaculture supplies and had another source of income. Farmers in this group had moderate capital and reported low fish mortality. This group seemed to have a sustainable livelihood as fish farmers as long as donors or government paid attention to the distribution of aquaculture supplies. The second group was characterized by high accessibility to physical capital and financial aid, but limited access to natural capital and no other source of income. The second group of farmers was seen to be highly vulnerable to production failure and price shock. The last group had higher capital than the other groups but often encountered massive fish mortality. Farmers in the last group need to reduce the density of fish to avoid fish mortality. Typology created from this study will help in prioritizing intervention needs.

The outcomes of this study further strengthen the argument and suggestions put forward by policy makers and the scientific community in showing that the small-scale aquaculture can be worth for rural livelihood. In addition to reduce the environmental impacts, the aquaculture of excavated and paddy field ponds should be able to apply the good aquaculture practices in all of the aquaculture activities. It is also needed the attention from national until local government to facilitate the farmer on good aquaculture practices. To obtain a positive impact on freshwater aquaculture practices, this study also suggests that future research should focus on small-scale farmers, on improving aquaculture practices, and on reinforcement of technology and research in aquaculture.

The other findings of this study help identify farmers' capitals and the problems faced by farmers, to prioritize intervention needs and enhance targeting. Moreover, in the absence of relevant capital, many reasonable issues were faced in relation to small-scale aquaculture practices. Despite this limitation, our analysis might provide substantial and useful information for stakeholders to solve local problems by implicating farmers in preserving the pond and lake environment. The government and the aquaculture authorities should intensively monitor the good aquaculture practices and monitor the floating net accretion to maintain the capacity of the lake. Furthermore, the lake's management regulations need to be implemented.

References

Abery, N.W., F. Sukadi, A.A. Budhiman, E.S. Kartamiharja, S. Koeshendrajana, Buddhiman and S.S DeSilva. (2005) Fisheries and cage culture of three reservoirs in west Java, Indonesia; a case study of ambitious development and resulting interactions. *Fisheries Management and Ecology* 12: 315-330.

Ahmed N., E. H. Allison, and J. F. Muir (2008) Using the sustainable livelihood framework to identify constraints and opportunities to the development of freshwater prown farming in southwest Bangladesh. *J of the World Aquaculture Society* 39 (5): 598-611.

Ali, H., M. M. Haque, and B. Belton (2013) Striped catfish (Pangasianodon hypophthalmus, Sauvage 1878) aquaculture in Bangladesh: an overview. *Aquaculture Research* 44 (6): 950-965.

Alongi, D.M., A.D. McKinnon, R. Brinkman, L.A. Trott, M.C. Undu, Muawanah, and Rachmansyah (2009) The fate of organic matter derived from small-scale fish cage aquaculture in coastal waters of Sulawesi and Sumatra, Indonesia. *Aquaculture* 295: 60–75.

Alston, D.E., A. Cabarcas-Nunez, C.E. Helsley, C. Bridger, and D. Benetti. (2006) Standardized environmental monitoring of open ocean cage sites: Basic consideration. *World Aquaculture* 37: 24-26.

Anh, P.T., C. Kroeze, S.R. Bush, and A.P.J. Mol (2010) Water pollution by Pangasius production in the Mekong Delta, Vietnam: causes and options for control. *Aquaculture Research* 42(1): 108–128.

APHA (1992) *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association. Washington, D.C. USA.

Arif, S. S and Murtiningrum. (2011) Challenges and future needs for irrigation management in Indonesia. In: Sustainable Water Management for Food Security: An international policy dialogue on progressing water policy reform in agriculture, with focus on Indonesia. GOI/ADB/OECD International Workshop: Bogor Indonesia.

Armitage, D. and C.L. Tam (2007) A Political Ecology of Sustainable Livelihoods in Coastal Sulawesi, Indonesia. *Canadian Journal of Development Studies/Revue canadienne d'études du développement* 28 (1): 39-57.

ADB (Asian Development Bank) (2005) An evaluation of small-scale freshwater rural aquaculture development for poverty reduction. http://www.adb.org/publications.

Azdan, D. (2011) Overview of Indonesia water system and policies. In: Sustainable Water Management for Food Security: An international policy dialogue on progressing water policy reform in agriculture, with focus on Indonesia. GOI/ADB/OECD International Workshop: Bogor Indonesia.

Bagumire, A., E.C.D. Todd, G.W. Nasinyama, and C. Muyanja (2010) Food safety regulatory requirements with potential effect on exports of aquaculture products from developing countries to the EU and US. *African Journal of Food Science and Technology* 1(2): 031-050.

Baluyut, E.A. (1989) Aquaculture systems and practices: A selected review. ADCP/ REP/ 89 /43. Rome: FAO. http://www.fao.org/docrep/t8598e/t8598e00.htm

Bhujel, R. C. (2012) Small-scale aquaculture: Global and national perspectives. In Shrestha M.K. and J. Pant (Eds). Symposium Prosiding; *Small-scale Aquaculture for Rural Livelihoods*. Kathmandu, Nepal.

Boyd, C. E., C Tucker, A. Mcnevin, K. Bostick and J. Clay (2007) Indicators of resource use efficiency and environmental performance in fish and crustacean aquaculture. *Reviews in Fisheries Science* 15(4): 327-360.

Budhiman, A. (2007) Freshwater fish seed resources in Indonesia. In M.G. Bondad-Reantaso (ed.), *Assessment of Freshwater Fish Seed Resources for Sustainable Aquaculture*, pp. 329–341. FAO Fisheries Technical Paper No. 501. Rome: FAO.

Budiono, A. (2002) Country report: Indonesia. In Review of the State of World Aquaculture. pp. 176-188. FAO Fisheries Circular No. 886. Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Department, Rome, Italy.

Bueno, P.B. (2009) Indicators of sustainable small-scale aquaculture development. In M.G. Bondad-Reantaso and M. Prein (eds.) *Measuring the Contribution of Small-scale Aquaculture: an Assessment,* pp. 145-160. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome: FAO.

Castel, J. M., W. Madry, D. Gozdowski, B. Roszkowska-Madra, M. Dabrowski, W. Lupa, and Y. Mena. (2010) Family dairy farms in the Podlasie province, Polland: farm typology according to farming system. *Spain Journal Agriculture Science* 8: 946-961.

Chapman D. and V. Kimstach (1996) Selection of water quality variables. In Chapman D (ed). *Water Quality Assessments - A Guide to Use of Biota, Sediments and Water inEnvironmental Monitoring - Second Edition.* NESCO/WHO/UNEP.

Danida. (2009) *Strategic Environmental Assessment of Maninjau lake, Agam Regency, West Sumatera.* ESP (Environmental Support Programme) Report. GFI Agendi, Jakarta.

Das, A.K., K.K. Vass, N.P. Shrivastava, and P.K. Katiha. (2009) *Cage culture in reservoirs in India. (A Handbook)* WorldFish Center Technical Manual no. 1948. The WorldFish Cener, Penang, Malaysia.

De Silva, S.S. and M.J. Phillips. (2007) A review of cage aquaculture: Asia (excluding China). In M. Halwart, D. Soto and J.R. Arthur (eds). *Cage aquaculture – Regional reviews and global overview,* pp. 18–48. FAO Fisheries Technical Paper. No. 498. Rome, FAO.

DFID (1999) Sustainable livelihoods guidance sheets. Department for International Development, United Kingdom. www.dfid.gov.uk/

Edwards, P. (2009) Changes in traditional inland aquaculture in West Java, Indonesia. *Aquaculture Asia Magazine vol. XIV* 4: 3–8.

Edwards P (2010) The development of 'modern' aquaculture in Java, Indonesia. *Aquaculture Asia Magazine vol. XV* 1: 3–9.

Edwards, P and H. Demaine. (1998) Rural Aquaculture: Overview and Framework for Country Reviews. Regional office for Asia and the Pacific food and agriculture organization of the United Nations, Bangkok, Thailand.

Effendie, I., K. Nirmala, U.H. Saputra, A.O. Sudrajat, M. Zairin Jr, and H. Kurokura. (2005) Water quality fluctuations under floating net cages for fish culture in Lake Cirata and its impact on fish survival. *Fisheries Science* 71: 972-977.

FAO (Food Agriculture Organization) (1988). Definition of aquaculture, *Seventh Session of the IPFC Working Party of Expects on Aquaculture*, IPFC/WPA/WPZ, p.1-3, RAPA/FAO, Bangkok.

FAO (Food Agriculture Organization) (1998). Rural Aquaculture: Overview and Framework for Country Reviews. Regional office for Asia and the Pacific Food and Agriculture Organization of the United Nations. Bangkok, Thailand.

FAO (Food Agriculture Organization) (2005) National aquaculture sector overview; Indonesia. FAO Fisheries and Aquaculture Department. Rome. www.fao.org/icatalog/inter-e.htm.

FAO (Food Agriculture Organization) (2012) World fisheries and aquaculture. FAO Fisheries and Aquaculture Department. Rome. www.fao.org/icatalog/inter-e.htm.

FAO (Food Agriculture Organization). (2014) FAO Global Aquaculture Production Volume and Value Statistics Database Updated to 2012. FAO Fisheries and

Aquaculture Department. ftp://ftp.fao.org/FI/STAT/Overviews/Aquaculture Statistics2012.pdf

Frankic A., and C. Hershner (2003) Sustainable aquaculture: developing the promise of aquaculture. *Aquaculture International* 11: 517–530.

Frimpong, E. A., Y. B. Ansah, S. Amisah, D. Adjei-Boateng, N. W. Agbo, and H. Egna (2014) Effects of two environmental best management practices on pond water and effluent quality and growth of Nile tilapia, Oreochhromis niloticus. *Sustainability* 6: 652-675.

GAA (2008) Aquaculture Facility Certification. Tilapia Farms, Best Aquaculture Practices, Certification Standards, Guidelines, Sample Application/Audit. Global Aquaculture Alliance. www.gaalliance.org.

Gunawan, B., K. Takeuchi, and O.S. Abdoellah. (2004) Challenges to community participation in watershed management: an analysis of fish farming activities at Saguling Reservoir, West Java-Indonesia. *Water Policy* 6: 319-334.

Gurung T. B., S. R. Basnet, A. B. Thapa, A. Raymajhi, and N. Pradhan (2012) Small-scale aquaculture in Nepal: Principles and practices. In Shrestha M.K. and J. Pant (Eds). Symposium Prosiding; *Small-scale Aquaculture for Rural Livelihoods*. Kathmandu, Nepal.

Henny, C. (2009) Dynamics of biogeochemistry of sulphur in Lake Maninjau. *Limnotek* 16 (2): 74-87.

Hishamunda N., N. Ridler, P.B. .Bueno, and W.G. Yap (2009a) Commercial aquaculture in Southeast Asia: Some policy lessons. *Food Policy* 34(1): 102–107.

Hishamunda, N., P. B. Bueno,, N. Ridler, W.G. Yap (2009b) Analysis of aquaculture development in Southeast Asia: a policy perspective. *FAO Fisheries and Aquaculture Technical Paper.* No. 509. Rome, FAO. 69p.

IIS (Indonesian Institute of Science). (2009) *Program penyehatan danau Maninjau dan pemberdayaan masyarakat disekitar danau*. Limnology Research Centre – Indonesian Institute of Science, Cibinong. Indonesia.

Joffre, O.M., and R.H. Bosma. (2009) Typology of shrimp farming in Bac Lieu Province, Mekong Delta, using multivariate statistics. *Agriculture, Ecosystem and Environment* 132: 153-159.

Jolly, C.M., Umali-Maceina, G. and Hishamunda, N. (2009) Small-scale aquaculture: a fantasy or economic opportunity, pp. 73-86. In M.G. Bondad-Reantaso and M. Prein (eds). *Measuring the contribution of small-scale aquaculture: an assessment.* FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180p.

Kassam, L., R. Subasinghe, and M. Phillips. (2011) *Aquaculture farmer organizations and cluster management: concepts and experiences.* FAO Fisheries and Aquaculture Technical Paper. No. 563. FAO, Rome.

Kroupova H., J. Machova, and Z. Svobodova (2005) Nitrite influence on fish: a review. *Vet. Med. – Czech* 50 (11): 461–471.

Lin C.K. (2000) Development of shrimp farming and environmental sustainability in Thailand. *Aquaculture Science* 48 (2): 267-272.

Little, D.C. and P. Edwards. (2003) Integrated livestock-fish farming systems. inland water resources and aquaculture service animal production service. FAO. Romae.

Lopez-Galats, F., M.J. Milan, and J. Bartolome. (2011) Is farming enough in mountain areas? Farm diversification in the Pyrenees. *Land Use Policy* 28: 783-791.

Lukman. (2013) Pola stratifikasi sebagai indikasi tubo belerang di Danau Maninjau. *Limnotek,* 20 (2): 16-27.

MAFS (Marine Affair and Fisheries Services). (2011) Working Group of Marine and Fisheries Data Arrangement. Centre of Data Statistics and Information. Indonesian Ministry of Fisheries and Marine affair. Jakarta, Indonesia.

MAFS (Marine Affair and Fisheries Services). (2012) *Aquaculture Statistics of West Sumatera*. Marine Affair and Fisheries Services of West Sumatera province, Indonesia.

MAFS (Marine Affair and Fisheries Services). (2013) *Aquaculture Statistics of West Sumatera*. Marine Affair and Fisheries Services of West Sumatera province, Indonesia.

Mahdi, Ganesh P. S., and Dietrich S. V. (2009) Livelihood change and livelihood sustainability of Lembang subwatershed, West Sumatera, Indonesia, in a changing natural resource management context. *Environmental Management* 43: 84-99.

Michielsens, C.G.J., K. Lorenzen, M.J. Phillips, and R. Gauthier. (2002) Asian carp farming system: towards a typology and increased resource use efficiency. *Aquaculture Research* 33: 403-413.

Milán M.J., G. Caja, R. González-González, A.M. Fernández-Pérez, and X. Such. (2011) Structure and performance of Awassi and Assaf dairy farms in northwestern Spain. *J Dairy Sci* 94: 771-784

Milstein, A., M.S. Islam, M.A. Wahab, A.H.M. Kamal, and S. Dewan. (2005) Characterization of water quality in shrimp ponds of different sizes and with different management regimes using multivariate statistics analysis. *Aquaculture International* 13: 501-518.

Mohanty, R.K., S. K. Jena, A.K. Thakur, and D.U. Patil (2009) Impact of high-density stocking and selective harvesting on yield and water productivity of deep water rice–fish systems. *Agricultural Water Management* 96(12): 1844–1850.

Munzir, A., and F. Heidhues. (2002) Towards a technical efficient production in rural aquaculture case study at Lake Maninjau, Indonesia. International Symposium of Sustainable Food Security and Managing Natural Resources in Southeast Asia. Chiang Mai, Thailand.

Murshed-E-Jahan, K., and D.E. Pemsl (2011) The impact of integrated aquaculture–agriculture on small-scale farm sustainability and farmers' livelihoods: Experience from Bangladesh. *Agricultural Systems* 104 (5): 392–402.

Nurdjana, M.L., 2006. Indonesian aquaculture development. Delivered on RCA International Workshop on Innovative Technologies for Eco-Friendly Fish Farm Management and Production of Safe Aquaculture Foods, Bali, Dec. 4-8.

Nhan, D.K., A. Milstein, M.C.J. Verdegem, and J.A.V. Verreth (2006) Food inputs, water quality and nutrient accumulation in integrated pond systems: a multivariate approach. *Aquaculture* 261: 160–173.

Paul, B.G., and C.R. Fogl. (2013) Organic shrimp aquaculture for sustainable household livelihoods in Bangladesh. *Ocean and Coastal Management* 71: 1-12.

Phan, L.T., T.M. Bui, T.T.T. Nguyen, G.J. Gooley, B. A. Ingram, H.V. Nguyen, and S.S. De Silva (2009) Current status of farming practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. *Aquaculture* 296(3-4): 227–236.

Phong, L.T., A.A. van Damd, H.M.J. Udob, M.E.F. van Mensvoort, L.Q.Tri, F.A. Steenstra, and A.J. van der Zijpp (2010) An agro-ecological evaluation of aquaculture integration into farming systems of the Mekong Delta. *Agriculture, Ecosystems and Environment* 138: 232–241.

Rimmer, M.A., K. Sugama, D. Rakhmawati, R. Rofiq, and R.H. Habgood (2013) A review and SWOT analysis of aquaculture development in Indonesia. *Reviews in Aquaculture* 5: 1-25.

Salas, S., R. Chuenpagdee, J.C. Seijo, and A. Charles (2007) Challenges in the assessment and management of small-scale fisheries in Latin America and the Caribbean. *Fisheries Research* 87(1): 5–16.

Shivakoti, G., and S. Shrestha (2009) Analysis of Livelihood Asset Pentagon to Assess the Performance of Irrigation Systems Part 2 – Application of Analytical Framework. *Water International* 30 (3): 363-371.

Siar, S.V. and P.E. Sajise. (2009) Access rights for sustainable small-scale aquaculture and rural development, pp. 87-94. In M.G. Bondad-Reantaso and M. Prein (eds). *Measuring the contribution of small-scale aquaculture: an assessment*. FAO Fisheries and Aquaculture.Technical Paper. No. 534. Rome, 180p.

SNI (2009) Standard National Indonesia 7550: Produksi ikan nila (*Oreochromis niloticus*) kelas pembesaran di kolam air tenang. Indoneian Standarization Organization. Jakarta. 12pp.

Soto D., Aguilar-Monjarrez, and N. Hishamunda (2007) Building an ecosystem approach to Aquaculture. FAO/Universitat de les Illes Balears Expert Workshop.

Sowman, M., and P. Cardoso (2010) Small-scale fisheries and food security strategies in countries in the Benguela Current Large Marine Ecosystem (BCLME) region: Angola, Namibia and South Africa. *Marine Policy* 34(6): 1163–1170.

Stark, A, (2013) The matrilineal system of the Minangkabau and its persistence throughout history: a structural perspective. *Southeast Asia: A Multidisciplinary Journal* vol. 13: 1–13.

Sulawesty F., Sutrisno, A. Hamdani and Triyanto (2010) Kondisi kualitas air beberapa daerah pemeliharaan ikan karamba jarring apung di danau Maninjau. Prosiding Seminar Nasional Lymnology V. LIP (Indonesian Institute of Science), Jakarta.

Sunardi, B. Gunawan, J. Manatunge, and F.D. Pratiwi. (2013) Livelihood status of resettles affected by the Saguling Dam project, 25 years after inundation. *International Journal of Water Resources Development* 29 (1): 22-31.

Sunarto, A. & Cameron, A. (2005) Response to mass mortality of carp: an Indonesian experience. *In* R.P. Subasinghe & J.R. Arthur, (eds.) *Preparedness and response to aquatic animal health emergencies.* FAO Fisheries Proceedings No. 4.

Sunarto, A., A. Rukyani, and T. Itami (2005) Indonesian Experience on the Outbreak of Koi Herpesvirus in Koi and Carp (*Cyprinus carpio*). *Bull. Fish. Res. Agen. Supplement* 2: 15–21.

Talpur, A.D., M. Ikhwanuddin, M.D.D. Abdullah, and A.M. Ambok-Bolong, (2013). Indigenous *Lactobacillus plantarum* as probiotic for larviculture of blue swimming crab, *Portunus pelagicus* (Linnaeus, 1758): Effects on survival, digestive enzyme activities and water quality. *Aquaculture* 416-417: 173–178.

Teh, L.S.L., L.C.L. Teh, and U.R. Sumaila (2011) Quantifying the overlooked socio-economic contribution of small-scale fisheries in Sabah, Malaysia. *Fisheries Research* 110(3): 450–458

WCED (World Commission on Environment and Development). (1987) *Our common future*. Oxford: Oxford University Press, p. 43.

Weimin M., J. Clausen, and S. Funge-Smith (2012) Development of small-scale aquaculture in highland and remote areas: An opportunity for aquaculture development in Nepal. In Shrestha M.K. and J. Pant (Eds). Symposium Prosiding; *Small-scale Aquaculture for Rural Livelihoods*. Kathmandu, Nepal.

Yurchenko, S., and U. Molder (2006) Volatile N-nitrosamines in various fish products. *Food Chemistry* 96 (2): 325-333.

Zhou, X., Y. Wang, and W. Li (2009) Effect of probiotic on larvae shrimp (*Penaeus vannamei*) based on water quality, survival rate and digestive enzyme activities. *Aquaculture* 287(3-4): 349–353.

Zokaeifar, H., N. Babaei, C.R. Saad, M.S. Kamarudin, K. Sijam, and J.L. Balcazar (2014) Administration of *Bacillus subtilis* strains in the rearing water enhances the water quality, growth performance, immune response, and resistance against Vibrio harveyi infection in juvenile white shrimp, *Litopenaeus vannamei*. *Fish & shellfish immunology* 36 (1): 68-74.

APPENDIX

Questionnaire (in Indonesian language)

Kuisioner untuk pembudidaya Nila

Kami sedang melakukan studi tentang budidaya ikan air tawar, terutama pada ikan nila. Kami sangat tertarik untuk memahami situasi petani ikan nila di daerah Anda dan bagaimana budidaya ikan nila telah mempengaruhi kehidupan masyarakat umumnya. Partisipasi Anda dalam penelitian ini akan sangat berguna dalam menghasilkan wawasan yang berharga. Kami ingin meyakinkan Anda bahwa semua jawaban individu akan dijaga kerahasiaannya. Tidak ada jawaban Anda yang akan dikutip atau disebarluaskan kepada orang lain atau organisasi untuk menjaga identitas Anda.

Nama responden: …………………………………

	Desa	Kabupaten/Kota	Kode
Lokasi			

A. Sumberdaya manusia

1. Berapa orang tinggal satu rumah dengan anda?
   a. Laki laki ………… orang
   b. Perempuan …………orang
   c. 18 tahun keatas …………orang
   d. Yang masih sekolah …………orang
2. Informasi kepala rumah tangga dan ibu

	Status pernikahan	Umur	Pendidikan formal	Pekerjaan utama	Pekerjaan sampingan (jika ada waktu lebih)
Bapak					
Ibu					

3. Tiga buah pendapatan yang paling penting dalam rumah tangga anda

Tingkat pentingnya	Sumber pendapatan	% pendapatan RT
a. Sumber yang paling penting		
b. Sumber kedua yang paling penting		
c. Sumber ketiga yang paling penting		

4. Lama waktu di pekerjaan sekarang dan sebelumnya

	Respon
a. Lamanya di budidaya ikan nila	……… tahun
b. Pekerjaan sebelumnya, jika ada	………………………………………………….
c. Lamanya di pekerjaan sebelumnya	……… tahun

5. Apakah budidaya ikan nila membahayakan kesehatan anda? 1-Yes 2-No

   Jika iya, apa bahayanya? …………………………

6. Berdasarkan jenis kelamin, apakah pekerjaan utama yang dilakukan pada budidaya ikan?

Aktivitas	1=hanya laki laki yang mengerjakan	2=hanya perempuan yang mengerjakan	3=keduanya bs mengerjakan	99=tidak dilakukan
a. Persiapan kolam				
b. Pengadaan benih				

c. Pengadaan pakan				
d. Pengadaan pupuk				
e. Memupuk				
f. Memberi makan ikan				
g. Menghubungi pembeli				
h. Memanen				
i. Menyeleksi ikan				
j. Pemasaran				
k. Penanganan				
l. Pencatatan				
m. ……………..				

B. Sumberdaya alam

1. Akses ke lahan

Kepemilikan lahan	Ukuran (m^2/ha)	Digunakan untuk	Ket.
a. Lahan milik sendiri - Kegiatan pertanian 1. Budidaya ikan			
2. Diluar budidaya ikan			
- Diluar pertanian			
Total wilayah			
b. Lahan yang disewa/ pinjam dari orang lain			
c. Lahan yang disewakan/dipinjamkan ke orang			

lain			

Ket.: 1=Dibeli 2=Warisan/hibah 3=Reformasi lahan 4=lain lain ……..

2. Akses ke air

a. Apa sumber air yang tersedia untuk membudidayakan ikan?

1=air tanah 2=air hujan 3=saluran irigasi 4=sungai

5=danau 6=lain-lain

b. Untuk setiap sumber air, Berapa biaya untuk penggunaannya?

Sumber air	Jumlah yang dibayarkan
1. Saluran irigasi	Rp……………….. per ………………
2. ……	Rp……………….. per ………………

c. Apakah air menjadi suatu pembatas pada budidaya ikan? 1= iya 2=tidak

Jika iya, bagaimana? 1= musiman 2=kualitas air 3=Kuantitas

4= lainnya ………………………………..

d. Apakah **biaya** untuk air bersih menjadi pembatas untuk budidaya ikan? 1=iya 2=tidak , Jika ya, bagaimana? …………………….

3. Akses ke kolam ikan

a. Apakah kolam yang anda gunakan milik anda?

1=iya (ke nomor 4) 2=tidak (ke poin b)

b. Apakah anda memerlukan izin untuk membudidayakan ikan dikolam? 1=iya 2= tidak

Yang mengeluarkan	Jangka waktu	Persyaratan	Keuntungan

4. Kontrol lahan dan sumberdaya air

a. Apakah ada kelompok yang dominan mengatur akses ke sumberdaya lahan? 1=iya 2=tidak

b. Apakah ada kelompok yang dominan mengatur akses ke sumberdaya air? 1=iya 2=tidak

c. Pernahkah terjadi konflik dalam pengaturan sumberdaya ini? 1=iya 2=tidak

d. Bagaimana konflik dapat dipecahkan? …………………………………………………

e. Apakah anda menyadari adanya ancaman lingkungan bagi keberlanjutan budidaya ikan di daerah anda? …………………………………………………………

f. Apa yang anda lakukan terhadap isu ini? ……………………………………………..

C. Sumberdaya sosial

1. Sumber informasi dan saran

<table>
<tr><th>Tipe informasi</th><th>Respon</th><th>Kode</th></tr>
<tr><td>a. Asal ikan nila yang dibudidayakan</td><td>1=local (di dalam provinsi) 2= dari luar (luar provinsi) 3= keduanya</td><td></td></tr>
<tr><td>b. Sumber informasi awal tentang budidaya ikan nila (boleh jawab lebih dari satu)</td><td rowspan="2">1=pembudidaya yang lain 2=Teman 3=keluarga 4=pemerintah 5=universitas 6=LSM 7=pembenihan 8=pengalaman pribadi 9=media elektronik 10=buku/majalah 11=pemasok pakan 12=lain-lain</td><td></td></tr>
<tr><td>c. Sumber masukan/teknologi pada proses budidaya ikan nila (boleh jawab lebih dari satu)</td><td></td></tr>
</table>

2. Apakah anda pernah mengikuti pelatihan pada budidaya perikanan? 1=pernah 2=belum

   a. Jika pernah, Pelatihan apa? Berapa hari? Dan diselenggarakan oleh siapa? (diisikan pada table berikut)

Topik pelatihan	Lamanya (Hari)	Diselenggarakan oleh

b. Jika belum pernah, kenapa?

…………………………………………………………………….

3. Apakah anda anggota dari perkumpulan/organisasi/koperasi dibidang budidaya ikan?

   1=iya 2=tidak

4. Jika ya, apakah namanya? Apa keuntungannya dan sudah berapa tahun anda menjadi anggota?

Nama organisasi/koperasi	Keuntungan	Lama menjadi anggota

D. Sumberdaya keuangan

1. Apakah anda menerima bantuan/pinjaman keuangan untuk operasional budidaya ikan ini? 1=Iya 2=tidak, karena

   …………………………………………………………………………

2. Jika ya, siapa yang memberikan bantuan/pinjaman tersebut?

Tahun	Jumlah	Diberikan oleh*	Penggunaan	Persyaratan		
				Bunga (%)	Jangka waktu	lainnya

(*) 1=penjual 2=tengkulak 3=pemasok pakan 4=keluarga 5=lembaga keuangan 6=Bank 7=koperasi 8=pemerintah 9=lainnya

3. Apakah anda dapat mengembalikan pinjaman tersebut?

   1=dapat 2=tidak,

   karena……………………………………………………………………………….

4. Berapakah biaya awal untuk pembuatan 1 unit kolam? Rp. ………………./……… m^2(satuan luasan)

E. Sumberdaya fisik

1. Tempat tinggal; 1=milik pribadi 2=sewa 3=tanpa sewa
2. Kualitas rumah tinggal (hal ini tidak ditanyakan, interviewer yang menyimpulkan dari keadaan di lapangan). 1=minimal (terbuat dari bahan alami, seperti kayu, bamboo,atap rumbia dll)

   2=low (terbuat dari bahan alami dengan atap seng)

   3=medium (terbuat dari campuran semen dan bahan alami)

   4=high (terbuat dari semen dan atap seng/genteng)
3. Bagaimana keadaan fasilitas umum di lingkungan anda?

Fasilitas	1=sangat sulit	2=sulit	3=biasa	4=bagus	5=sangat bagus
a. Akses jalan					
b. Akses ke transpor umum					
c. Akses komunikasi					
d. Akses pasar					
e. Akses ke sumber air untuk aktivitas budidaya					

F. Proses Budidaya dan Teknologi

1. Apa keuntungan bagi anda menjalankan usaha budidaya ini? (Jawaban boleh lebih dari satu) 1=menguntungkan

2=dapat mengkonsumsi ikan dari kolam sendiri

3=sebagai usaha ujicoba

4=dapat berdiskusi dengan petani lainnya

5=lainnya………………………………………………………………………………
….

2. Apakah anda menggunakan system mono-sex?

   1=iya, karena……………………………………………………………………………..

   2=tidak, karena…………………………………………………………………………...

3. Apakah anda memijahkan ikan nila di kolam?

   1=iya, seberapa banyak? ………………….   2=tidak

4. Apakah memijahkan ikan di kolam mempengaruhi:

   a. Pertumbuhan rata-rata dari ikan   1=Iya 2=tidak 3=tidak tahu

   b. Jumlah ikan yang dipanen 1=Iya 2=tidak 3=tidak tahu

   c. Ukuran ikan ketika panen   1=Iya 2=tidak 3=tidak tahu

5. Apakah pertimbangan anda memilih ikan nila untuk dibudidayakan? (setelah responden memilih jawaban, tanyakan 3 urutan tertinggi dari pilihannya)

Pertimbangan	ceklis	urutan
a. Harga benih murah		
b. Tidak membutuhkan waktu lama		
c. Kemampuan ikan nila untuk mereproduksi/menyediakan bibit untuk budidaya berikutnya		
d. Tempat Pembenihan/pembibitan dekat dari kolam anda		
e. Saran dari pembenih/sales/penjual pakan		
f. Ikan ini tidak membutuhkan pakan yang banyak		
g. Saran dari pembudidaya lain		

h. Membudidayakan jenis apa saja (tidak ada alasan khusus)		
i. Lainnya ………………………………………………………..		

6. Apakah anda akan membeli/menggunakan benih ikan nila yang jenisnya tidak pernah anda coba sebelumnya, hanya berdasarkan klaim keunggulannya?

   1=Iya 2=tidak

7. Seberapa penting menurut anda spesies atau jenis dari ikan nila yang akan anda budidayakan? 1=sangat penting 2=penting 3=agak penting

   4=tidak penting samasekali

8. Perkiraan produksi ikan nila dalam setahun: 2012

Siklus	Jenis ikan	Lama budidaya (bulan)	Ukuran kolam (pxl)	Kedalaman air (m)	Ukuran benih	Tingkat kelangsungan hidup (%)	Total panen (kg)	Ukuran panen (ekor/kg)
1								
2								
3								

9. Total pengeluaran produksi: 2012

Siklus	Pakan (harga; banyaknya)	Benih (harga; banyaknya)	Upah pekerja	Penyubur dan bahan kimia	Lainnya (transport, diesel dll)	Pengeluaran total
1						
2						
3						

10. Penjualan Ikan nila:2012

Siklus	Total panen (kg) a=b+f+g+h	Penjualan				Dikonsumsi sendiri (kg) (g)	Lainnya (kg) (h)
		Penjualan (kg) (b)	Diskon (%) (c)	Harga di kolam	Total nilai penjualan		

				(Rp/kg) (d)	E=b(1-c)x(d)		
1							
2							
3							

11. Sistem pembayaran untuk hasil panen:

    1=tunai saat itu juga

    2=tunai dengan jangka waktu (…… har/minggu)

    3=dicicil (………………………………….)

12. Apakah jenis pakan yang digunakan?

    a. Hanya pakan komersil

    b. Hanya pakan buatan

    c. Hanya plankton

    d. Kombinasi dari semua

Pakan buatan

Komposisi bahan	harga

13. Cara pemberian pakan

Umur ikan	Cara pemberian pakan	Berapa kali

14. Jumlah pakan yang dikonsumsi dan FCR: 2012

Siklus	Total pakan yang dikonsumsi			Total panen (kg)	FCR
	Jumlah karung	Berat (kg) per karung	Total (kg)		
1					
2					
3					

15. Apakah anda menggunakan suplemen pakan/vitamin/perangsang nafsu makan?

Jenis Suplemen	Merek	Dosis	Sumber

16. Apakah anda menggunakan penyubur (fertilizer)

Jenis penyubur	Digunakan	Tidak	Merek penyubur	Sumber
Alami (organic)				
Non alami (inorganic)				

17. Jika tidak menggunakan penyubur,, alasannya ……………………………………

    a. Apakah anda berniat untuk menggunakan penyubur untuk memperkecil biaya pakan?

       1=Iya 2=Tidak

    b. Jika tidak, kenapa? ………………………………………………………………

18. Apakah anda pernah mengalami kematian massal pada kolam anda? 1=pernah 2=tidak

    a. Jika pernah, kapan terjadi? (bulan dan tahun) ………………………………….

    b. Apakah kemungkinan penyebab dari kejadian tersebut? (boleh pilih lebih dari satu jawaban)

    1=kualitas benih yang rendah 2=air tercemar 3=kekurangan oksigen

    4=kualitas pakan yang rendah 5=penyakit/parasite ……..……………………

    6=lainnya …………………

19. Jenis penyakit apa sajakah yang pernah dialami ikan di kolam anda? ....

20. Bagaimana menanganinya? ……………………………………………………………………………….

21. Apakah yang anda gunakan untuk mencegah penyakit? …………………………………………………

22. Dari mana asal benih ikan nila yang anda gunakan? (2012) ………………………………………….

G. Masa depan Budidaya ikan Nila

1. Apa rencana anda terhadap budidaya ikan nila untuk lima tahun kedepan?

   1=melanjutkan 2=memperluas 3=mengurangi 4=menghentikan 5=belum diputuskan, karena …………………………………………………

2. Selama lima tahun ke depan, apa yang Anda lihat sebagai ancaman utama terhadap usaha budidaya ikan nila secara umum? ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………

H. Pasar

1. Kemanakah umumnya anda pasarkan ikan ini? 1=di sekitar desa 2=di sekitar provinsi 3=di luar provinsi …………………..

2. Kepada siapa anda umumnya menjual ikan anda?

   1=agen 2=tengkulak 3=grosir 4=langsung ke pasar

3. Apa alasan anda menjual kepada mereka? (Jawaban boleh lebih dari satu)

   1=adanya perjanjian jual beli 2=kenyamanan (kedekatan / pedagang yang datang)

   3=menawarkan harga yang lebih baik 4=dibayar tunai

   5=lainnya ………………………………………………….

4. Siapa yang memutuskan harga akhir dari produk anda?

   1=anda sendiri 2=pembeli 3=pasar

   4=lainnya ……………………………………………………..

5. Apa yang membatasi Anda dari mencari pasar lainnya, jika ada?

   …………………………………………………………………………………………

………………………………………………………………………

6. Apa metode panen yang anda gunakan?

   1=selektif (menyeleksi ukuran ikan yang akan dipanen, sehingga panen dilakukan lebih dari sekali untuk satu kolam)

   2=parsial (tidak melakukan seleksi ukuran, panen dilakukan lebih dari sekali untuk setiap kolam)

   3=panen total (semua isi kolam dipanen dalam satu kali waktu)

I. Spesies asing

1. Apakah ikan yang anda pelihara dapat lepas dari kolam? 1=dapat 2=tidak
   a. Apakah Anda berpikir bahwa ikan yang lolos berpengaruh pada lingkungan alam? 1=Iya 2=tidak 3=tidak tahu
   b. Jika iya, apakah pengaruhnya? ………………………………………………….

J. Keamanan pangan

Menurut anda, apa yang menentukan mutu ikan nila?	Ceklis	Urutan
a. Kualitas air		
b. Jenis benih		
c. Pakan		
d. Metode panen		
e. Penanganan setelah panen		
f. Lainnya ……………………………………………………		

Apakah anda pernah mengalami masalah ini pada ikan yang anda hasilkan?

a. Rasa lumpur 1=pernah 0=tidak

b. Keamanan 1=pernah 0=tidak

c. Kualitas 1=pernah 0=tidak

Masalah apa yang sering anda jumpai pada proses budidaya ikan nila ini?

Masalah	1=Iya	2=tidak
a. Pemasukan		
1. Pasokan benih yang tidak memadai		
2. Pasokan pakan yang tidak memadai		
3. Pasokan penyubur yang tidak memadai		
4. Harga benih yang mahal		
5. Harga pakan yang mahal		
6. Harga penyubur yang mahal		
7. Pasokan/pemasukan air yang kurang		
8. Kesulitan dalam mencari pekerja		
9. Upah pekerja yang tinggi		
10. Keterbatasan teknologi budidaya		
11. Lainnya ………………………………..		
b. Produksi		
1. Kualitas air yang buruk/tidak baik untuk ikan nila		
2. Adanya penyakit …………………………..		
3. Adanya parasite ……………………………		
4. Adanya predator ………………………………		
5. Rata-rata kematian ikan tinggi		
6. Pencurian		
7. Konflik dengan orang lain		
8. Kurangnya perhatian dari pemerintah		
9. Lainnya ……………………………………………….		
c. Fasilitas		

1. Biaya yang besar untuk membangun kolam		
2. Keterbatasan fasilitas transport		
3. Kualitas jalan yang buruk		
4. Lainnya ………………………………………………….		
d. Akses		
1. Keterbatasan akses lahan		
2. Keterbatasan akses air		
3. Keterbatasan akses ke kolam		
4. Keterbatasan akses ke pasar/pembeli		
5. Keterbatasan akses kredit/pinjaman		
6. Keterbatasan akses ke penyuluh		
7. Lainnya ………………………………….		
e. Keuntungan		
1. Keuntungan yang menurun		
2. Lainnya ………………………………………		
f. Lingkungan		
1. Polusi dari luar (pabrik, industry dll)		
2. Polusi dari dalam (sisa pakan atau buangan ikan)		
3. Banjir		
4. Adanya ikan jenis asing		
5. Lainnya ………………………………….		

-Terimakasih atas kerjasamanya-