ROLE OF SOCIAL CAPITAL IN CLIMATE ADAPTATION OF FISH-POND FARMERS IN NORTHERN REGION OF THAILAND

WEERAKAN KENGKAJ

MASTER OF ARTS
IN SOCIAL SCIENCE

GRADUATE SCHOOL

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A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN SOCIAL SCIENCE

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THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF
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LIST OF ABBREVIATIONS

RID	Royal Irrigation Department
DOF	Department of Fisheries
TMD	Thai Meteorological Department
TAO	Tambon (Subdistrict) Administrative Authority
BAAC	Bank of Agricultural Cooperatives

Thesis Title	Role of Social Capital in Climate Adaptation of Fish-Pond Farmers in Northern Region of Thailand	
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ABSTRACT

This thesis is about the adaptation of fish-pond farming households to climate-related and socio-economic risks in Northern Thailand. Successful fish farming depends on weather and climate conditions as well as supplies of sufficient water of adequate quality. In Northern Thailand, water is regulated by the *Muang Fai* (communal irrigation system) and state irrigation schemes managed by the Royal Irrigation Department (RID) with the latter now predominating. Pond-based aquaculture has benefited irrigation, but also suffered from uncertainty in water quality and quantity. As a result of rainfall pattern changes, fish farmers have experienced floods, drought, water pollution and resource conflicts. Therefore, the study explores (1) the vulnerability of fish farming households with small-, medium- and large-scale operations to climate-related and socio-economic risks; (2) the adaptive capacities of those fish farmers in coping with the risks and (3) the role of social capital articulated by various actors with bonding and bridging ties in both horizontal and vertical dimensions. Major findings in relation to this are as follows:

Fish-pond farming households are vulnerable to climate-related and socio-economic risks. They are exposed to the variations in weather, poor water quality and quantity, plus low quality materials, market forces and urbanization expansions, which lead to land use conversion to housing areas. As a result, people in the peri-urban places are most prone to floods, drought, water pollution and resource conflicts. Smaller scale-

operators, with low financial, social and human capital, are most vulnerable. They have less ability to access water and can barely deal with fish deaths or diseases.

Different fish farmers have different livelihood capitals, which relate to different adaptive capacities. Measured by the capacity to recover from stresses and the productivity, it is found that large-scale operators with higher financial assets are able to buy land with good water access and to develop farming system, and have more opportunities to gain knowledge from other external sources than the smaller operators. Moreover, the large operators can invest in high quality inputs such as fingerlings, feeds and more advanced technologies. Therefore, they can better prevent stress to fish and increase productivities. By contrast, the smaller fish farmers who have less lands must rely on poor quality water in the canals and have low fish production.

This study argues that kinship and neighborhood are constructed through bridging capital in fish farmer cooperatives and groups. In this way, social capital is mobilized by trust, exchange, regulation and collective action. The level of networking social capital has an impact on social innovations to prevent impacts from, and to cope with climate variability. Fish farmers with strong bonding capital in the community have access to knowledge and labor exchange, but less than the farmers with both high bonding and bridging ties. The latter farmers have greater trust with external organizations that help develop risk mitigation and fish productivity. Fish farmers across scale operations negotiate with the *Kae Muang* (the communal irrigation leader) in attempts to access to water resources. It contrasts with those fish farmers in the community that fully bridges with the state rather than bonding with kin and neighbors. Facilitating the information transfer from the state and university to local fish farmers is even found in the community with minimal levels of bonding social capital. Without trust, knowledge exchange and distribution among the group are uneven, thus increasing the possibility of fish death and losses. Above all, this kind of social capital exacerbates water shortage and competition among water users without voluntary help and solutions.

My recommendations are the micro and macro levels of adaptation policy. The adaptation from locality can voice out to the policy makers what is really happening and how to solve the problems. The state projects related to fish and water should be place-based. The external organizations with various kinds of fruitful and accurate researches should distribute their information and provide assistance to the fish farmers while taking local people into the participation for more trust and understanding. Moreover, those vulnerable fish farmers with low capitals should be supported technologically by the state and universities in order to improve the rearing system. To develop irrigation systems the state should develop the water allocation plan and its communication. It is also important not only to include public participation of the water allocation plan and management; but also to socially increase the *Kae Muang* role. Young people, who have more capacities to apply new technologies in irrigation systems and to effectively communicate with water users, should be encouraged to take part in the activities as a tactic to manage water systems more systematically and to increase local solidarity.

หัวข้อวิทยานิพนธ์	บทบาทของทุนทางสังคมในการปรับตัวต่อสภาพอากาศของเกษตรกร ผู้เลี้ยงปลาในบ่อดิน ในพื้นที่ภาคเหนือของประเทศไทย
ผู้เขียน	นางสาววีรากานต์ เก่งกาจ
ปริญญา	ศิลปศาสตรมหาบัณฑิต (สังคมศาสตร์)
คณะกรรมการที่ปรึกษา	อาจารย์ ดร. สัณฐิตา กาญจนพันธุ์ อาจารย์ที่ปรึกษาหลัก อาจารย์ ดร. มุกดาวรรรณ ศักดิ์บุญ อาจารย์ที่ปรึกษาร่วม

บทคัดย่อ

งานวิจัยชิ้นนี้ได้ศึกษาการปรับตัวของครัวเรือนเกษตรกรผู้เลี้ยงปลาในบ่อดินที่มีความเสี่ยงต่อการเปลี่ยนแปลงสภาพอากาศและสังคมเศรษฐกิจในพื้นที่ภาคเหนือของประเทศไทย ปัจจัยที่มีผลต่อการเลี้ยงปลาให้ประสบความสำเร็จคือสภาพอากาศ น้ำที่มีปริมาณเพียงพอและมีคุณภาพดี ระบบชลประทานในภาคเหนือเป็นทั้งระบบเหมืองฝาย (ระบบชลประทานส่วนรวม) และระบบที่อยู่ภายใต้ความดูแลของรัฐซึ่งมีบทบาทเหนือระบบเหมืองฝายในปัจจุบัน ระบบชลประทานที่ดีจึงส่งผลดีต่อการเลี้ยงปลา แต่ในความเป็นจริงปริมาณและคุณภาพน้ำมีความไม่แน่นอนประกอบกับการเปลี่ยนแปลงปริมาณฝน จึงเป็นปัจจัยที่ทำให้เกษตรกรผู้เลี้ยงปลามีความเสี่ยงต่อน้ำท่วม น้ำแล้ง มลพิษทางน้ำ และความขัดแย้งในการเข้าถึงทรัพยากร ดังนั้นงานวิจัยชิ้นนี้จึงมุ่งศึกษา (1) ความเปราะบางของครัวเรือนเกษตรกรผู้เลี้ยงปลาซึ่งมีทั้งรายเล็ก รายกลางและรายใหญ่ (2) ความสามารถในการปรับตัวของเกษตรกรในการรับมือต่อความเสี่ยง และ (3) บทบาทของทุนทางสังคมของคนหลายกลุ่มซึ่งมีทั้งความสัมพันธ์ที่เชื่อมโยงและเชื่อมประสานซึ่งกันและกันในรูปแบบความสัมพันธ์แบบแนวนอนและแนวตั้ง ข้อค้นพบหลักมีดังนี้

ครัวเรือนเกษตรกรผู้เลี้ยงปลาในบ่อดินมีความเปราะบางต่อความเสี่ยงด้านการเปลี่ยนแปลงสภาพอากาศและสังคมและเศรษฐกิจ นอกจากนี้ยังประสบปัญหาคุณภาพน้ำที่ไม่มีคุณภาพและการเปลี่ยนแปลงของปริมาณน้ำ รวมถึงปัจจัยการผลิตที่ไม่มีคุณภาพ แรงกดดันของตลาดและการขยายตัวของกระบวนการการกลายเป็นเมือง(urbanization) ซึ่งนำไปสู่การเปลี่ยนแปลงการใช้ที่ดินไปเป็นที่อยู่อาศัย ทำให้เกษตรกรที่อาศัยในเขตกึ่งเมืองกึ่งชนบทได้รับผลกระทบจากน้ำท่วม น้ำแล้ง มลพิษทางน้ำ และความขัดแย้งในการใช้ทรัพยากรมากที่สุด ยิ่งไปกว่านั้นกลุ่มที่มีความเปราะบางมากที่สุดคือ

เกษตรกรรายเล็กซึ่งมีทุนทางเศรษฐกิจ สังคมและมนุษย์น้อย จึงประสบปัญหาการเข้าถึงน้ำและขาดความสามารถในการแก้ปัญหาปลาตายและปลาเป็นโรค

เกษตรกรผู้เลี้ยงปลามีทุนการดำรงชีพที่มีต่างกันมีผลต่อความสามารถในการปรับตัวต่างกัน โดยวัดจากความสามารถในการฟื้นตัวจากภัยต่างๆและความสามารถในผลิต การศึกษาพบว่าเกษตรกรผู้เลี้ยงปลาขนาดใหญ่ที่มีทุนทางเศรษฐกิจสูงมีความสามารถในการซื้อที่ดินที่สามารถเข้าถึงน้ำได้ดีและมีความสามารถในการจัดการฟาร์มอย่างเป็นระบบ ประกอบกับมีความสามารถด้านการลงทุนสูงในปัจจัยการผลิตที่มีคุณภาพ เช่น ลูกปลา อาหาร และเทคโนโลยี ดังนั้นจึงมีความสามารถสูงในการป้องกันภัยและการผลิต รวมถึงมีโอกาสได้รับความรู้จากองค์กรภายนอกมากกว่าเกษตรกรที่มีขนาดประกอบการที่เล็กกว่า ซึ่งครอบครองที่ดินน้อยในพื้นที่ที่ได้รับน้ำไม่ดีนัก จึงมีโอกาสเผชิญกับปัญหาน้ำเสียและน้ำน้อยสูงและมีผลิตปลาได้น้อยกว่า

การศึกษาชิ้นนี้พบว่าเกษตรกรผู้เลี้ยงปลามีการสร้างความสัมพันธ์แบบเครือญาติและเพื่อนบ้านในรูปแบบใหม่ในลักษณะของการรวมกลุ่มเกษตรกรผู้เลี้ยงปลาด้วยการเชื่อมประสานทุนทางสังคมผ่านความไว้เนื้อเชื่อใจ การแลกเปลี่ยน กฎระเบียบและการทำงานเป็นหมู่คณะ จึงกล่าวได้ว่าระดับของทุนทางสังคมมีผลต่อการคิดค้นนวัตกรรมใหม่เพื่อหาแนวทางป้องกันและรับมือกับความเปลี่ยนแปลงสภาพอากาศ ชุมชนเกษตรกรผู้เลี้ยงปลาที่มีความสัมพันธ์ที่เข้มแข็งระหว่างเครือญาติและเพื่อนบ้านสามารถสร้างโอกาสการเรียนรู้ร่วมกันและการแลกเปลี่ยนแรงงาน แต่ยังน้อยกว่าชุมชมที่มีการเชื่อมสัมพันธ์ทั้งคนในระดับชุมชนกับองค์กรภายนอก ซึ่งช่วยพัฒนาความสามารถในป้องกันความเสี่ยงและการผลิตปลา รวมถึงความสามารถในการเข้าถึงน้ำ เกษตรกรผู้เลี้ยงปลาทุกขนาดประกอบการสามารถต่อรองน้ำกับแก่เหมือง (หัวหน้าระบบชลประทานส่วนรวมในระดับท้องถิ่น) ในทางตรงกันข้ามชุมชนที่มีการเชื่อมประสานกับภาครัฐมากกว่าความกลมเกลียวระหว่างญาติมิตรและเพื่อนบ้านเป็นอุปสรรคต่อการกระจายข้อมูลข่าวสารและความรู้จากองค์กรภายนอกเพราะขาดความไว้เนื้อเชื่อใจ ทำให้การแลกเปลี่ยนข้อมูลข่าวสารไม่ทั่วถึงซึ่งเป็นการลดทอนความสามารถในการปรับตัวและทำให้เกิดปัญหาปลาตายและความเสียหายอื่นๆมากขึ้น ยิ่งไปกว่านั้นยังส่งผลต่อปัญหาการขาดแคลนน้ำและการแย่งน้ำระหว่างผู้ใช้น้ำ โดยไม่มีใครอาสาเข้ามาช่วยเหลือและแก้ปัญหา

การศึกษาชิ้นนี้จึงเสนอนโยบายการปรับตัวทั้งระดับเล็กจนถึงระดับใหญ่ กล่าวคือ เนื่องจากการศึกษาการปรับตัวของท้องถิ่นในงานชิ้นนี้มุ่งสะท้อนปัญหาให้กับผู้ที่มีอำนาจกำหนดนโยบายถึงปัญหาที่เกิดขึ้นเพื่อหาแนวทางแก้ไข นโยบายรัฐจึงควรตั้งอยู่บนความแตกต่างและจำเพาะในแต่ละพื้นที่องค์กรภายนอกซึ่งมีงานวิจัยมากมายควรเผยแพร่ความรู้ที่ถูกต้องให้กับเกษตรกรผู้เลี้ยงปลาโดยเปิด

โอกาสให้คนในชุมชนมีส่วนร่วมเพื่อสร้างความไว้เนื้อเชื่อใจและความเข้าใจร่วมกันที่ดีขึ้น ในขณะเดียวกันทางภาครัฐควรสนับสนุนเทคโนโลยีให้กับกลุ่มเกษตรกรที่มีความเปราะบางสูงเพื่อปรับปรุงระบบการเลี้ยง ในด้านการจัดการน้ำเพื่อพัฒนาระบบชลประทาน ภาครัฐความเปิดโอกาสให้ผู้ใช้น้ำในชุมชนได้มีส่วนร่วมในการวางแผนจัดสรรและจัดการน้ำ ควรเพิ่มบทบาทของแก่เหมืองพร้อมทั้งกระตุ้นให้เยาวชนเข้ามามีส่วนร่วมในกิจกรรมเหมืองฝายซึ่งเป็นกลุ่มคนที่สามารถนำเทคโนโลยีมาปรับใช้ในระบบเหมืองฝายและมีความสามารถสื่อสารกับผู้ใช้น้ำได้อย่างมีประสิทธิภาพนับว่าเป็นกลยุทธ์หนึ่งที่ช่วยจัดระบบเหมืองฝายให้มีระบบมากขึ้นและเพิ่มความสามัคคีในหมู่คณะ

CHAPTER 1

Introduction

1.1 Rationale

Social capital is a comparatively new area of interest in climate adaptation among development and natural resources. The capital particularly encompasses norms and relationships among people that link them together within and into a community (Lin, 2001). To address climate-related risks, social capital strengthens people's abilities with the connection of their natural, human, physical, and financial capital. Climate variability has been changing and has become uncertain over the last decades. It has been observed that climate change has direct impact on natural and human systems across the continents. The phenomenon caused shrinking glaciers due to higher temperatures, warming permafrost, affected crop yields and coastal vulnerability (IPCC, 2013). A high potential of those capitals have been said to support both individual and collective adaptive capacity. Therefore, social capital is one of the capitals expected to reduce vulnerability to climate variability.

There has been plenty of literature-documenting the role of social capital in climate adaptation in many aspects. Cases studies in many countries, such as the UK, have found that strong constructive bonding networks play an important role toward decreasing vulnerability and improving health outcomes. Both the elderly and their social contacts can contribute to the knowledge and perception of heat effects and transmission of narrative about coping strategies. The state–civil society cooperation in the Republic of Trinidad and Tobago towards coastal resource management reduces resource conflicts. In Mexico, local farmers facing plantation failure are supported by government assistance in building up farmer associations with social security and healthcare. On the contrary, in Argentina, farmers lost their farming income without strong organization support. This is because of higher investment costs and increased environmental risks while they have less knowledge to deal with the problems.

In Asian countries like Nepal, the agriculture extension program is built and implemented through social capital for more sustainable farming. Although the country contains a high diversity of cultures, ethnicity and the caste system, higher levels of social capital are highlighted in adopting farming at household levels through collective action, ethical norms and reciprocity. In the case of Vietnam, local networks are emergently founded to replace the state hazard management and increase people's adaptive capacity. By contrast without a strong social network in Tonle Sap, Cambodia, small-scale operators of fisheries have different unequal and vertical social networks. Most large-scale operations get more benefits and influences than the small-scale ones that are excluded from access to resources.

Understanding the role of social capital on climate adaptation and many other agricultural activities and resource management are increasing, but is still limited in the arena of freshwater aquaculture particularly in the Asian region. Its production is also influenced by climate variability. According to IPCC (2014), large climate warming trends in the Asian sector is >2^{o}C per 50 years in the second half of the 20th century. Across Southeast Asia, temperatures have been rising (from 0.14^{o}C to 0.20^{o}C) per decade since the 1960s. A number of days, nights are hotter and warmer than before. Consequently, IPCC (2014) confirms that a large number of natural fish species are at high risk of extinction. This accounts for increases in the development of freshwater aquaculture.

Freshwater aquaculture is important for economic development and domestic consumption. The industry has grown steadily in the last five years due to a combination of increasing population growth, urbanization expansion, declining global capture fishery production; and more development of fish production and distribution channels. Inland aquaculture plays a great role in production as the fastest growing production sector. It is almost two times higher than marine aquaculture in 2011 and 2012. From 2007 to 2012, its production has risen from 29.9 to 41.9 million tons to serve the higher demands of the population which rises by 0.4 billion. The annual per capita fish consumption also increases by 1.6 million tons (FAO, 2014). A large part ofglobal aquaculture production is located in the tropical and subtropical region of Asia. Asia distributes 88.50 percentage of the world's aquaculture production of fish in 2011, higher than Americas and Europe respectively.

Previous ample studies on aquaculture adaptation conducted in Asian countries such as Vietnam, Thailand and the Philippines focused on the causes, effects and different forms of aquaculture development as well as physical and biological management. Few social relationships of fish operators were highlighted. It is noted that the ability of fish producers in Vietnam and Thailand with access to land and credit is mediated by relationships between individuals and the state and its associated institutions. Hence, technical knowledge transmission is more successful from informal channels than official attempts. In coastal Philippines, the local people are affected by the top-down policy of the conversion of mangrove forests to fishponds. They pursue collective struggle to negotiate through the state, since their common resources and the sources of local livelihood are threatened.

Thailand's contribution of total fisheries production rose up from below 20% in 2000 to over 41% in 2010 (Aquadapt, 2013). However, Thailand produced 1,286,122 tons in 2010 but reduced it to 1,008,049 in 2011 during the time of catastrophic natural disasters resulting in a great loss of aquaculture production (FAO, 2014). Fish-pond farming is an agroecosystem that relies on seasonal and unpredictable weather and climate. Cultured fish is also affected by extreme weather (hotter and colder than normal), excessive rainfall, prolonged cloud cover, floods and drought. These uncertainties directly results in the instability of salinity, dissolved oxygen, ammonia and nitrites, pH, photoperiod and water turbidity. In other words, these factors affect fish growth rate, food consumption, feed conversion, and other bodily functions of the fish that make it unavoidable for farmers to experience damage to physical materials, death of the fish and profit loss.

Successful fish farming depends on weather and climate conditions as well as supplies of sufficient water of adequate quality. Fish farming is promoted in areas in Northern provinces with access to water bodies (such as rivers, reservoirs and canals) and irrigated areas. In Northern Thailand, water is regulated by *Muang Fai* (the communal irrigation system) and state irrigation schemes managed by the Royal Irrigation

Department (RID) with the latter now predominating (Rigg, 1992; Tassanee, 2008). *Muang Fai* institutions that persisted have evolved; some became formal associations while others remained informal groups (Neef et al., 2004). It is obvious that water users especially fish farmers have less ability now to freely exercise their local power to claim and control water for individual benefit; instead they have to follow the new irrigation system. If flood and water shortage issues continuously increase without efficient water management mechanisms for overall aquaculture products, those fish farmer households will thus have to bear all the risks and uncertainties of climate related variability.

To achieve higher productivity, maintaining water quality and quantity in farming is also considerably affected by the capacity of fish farmers, the level of their community and the water management strategies. But the fish-related operators' social relationships embedded in fish production are still unmentioned. The key research issue is thus how fish farmers use social networks and exercise their power to improve their productivity and adaptive capacity in response to changing and uncertain climates. It situates the adaptation strategies that social relation within household and community levels are taken into consideration in fish farming and water management. Do good cooperation between fish farmers, other water users and water institutions potentially drive the efficiency of water flow and preserve its quality?

It is extremely challenging for the households and communities engaging in fish-pond farming. Chayanov (1996) (cited Sherbinin et al., 2008) observes that well-endowed households with many family workers have more land and more capacities than those constrained by labor shortages. The present changing structural households of fish farmers have impacts on labor availability, household livelihood options, and land use strategies. Rigg (2012) highlights the characteristic changes of the Asian countryside: (1) a delocalization of life and living, reflected high level of mobility; (2) a dis-embedding of households and families that stretches social and economic relations across spaces; and (3) a dissociation of the village-community. Again, the new community of fish-pond farmers has been founded with common economic interests to manage the cultured fish production and marketing system, under undesirable climate-related risks and the pressure of *Muang Fai* system decline. The strength of fish farmer cooperatives are dynamic and diversified, dependent on the connectedness of fish farmer members as well as technical production in terms of fish species, its density, chemical substances, supplementary feeds, rearing periods, size and weight of fish harvest in addition to marketing and distribution by mobile traders (Belton et al., 2008).

The vulnerability of fish farmers is hence examined in order to seek out how fish farmer households in different scales of operation (small, medium and large) can cope with and adapt their livelihood to climate-related and socio-economic risks. It would be necessary to justify that farm size matter as a key factor in their capacities in responding and adapting to the risks. But fish farmers in this study face resource conflicts while local people tend to look for more off-farm opportunities rather than farming. To face climate-related risks, do different fish operators have different responses to the risks upon different stocks of land, labor, money, water and knowledge? Do the livelihood capitals constitute vulnerability? One way of adaptation is possible with access to resources via social capital. It is skeptical the social capital can leverage climate uncertainty and vulnerability as well as social dynamic situations.

1.2 Research Questions

The primary research question focuses on how social capital contributes to livelihood adaptation in fish-pond farming households and the communities in which they operate. There are three secondary research questions that lead up to these main question as follows:

1.2.1 What are the main vulnerabilities to climate-related risks faced by fish-pond farming household with small- medium- and large scale operations?

1.2.2 To what extent does the size of operation of a fish farm influence adaptive capacities to cope with climate-related risks?

1.2.3 To what extent does social capital enhance adaptation to the changing climate of vulnerable pond-farming households and the communities in which they operate?

1.3 Research Objectives

The primary research objective is to study the role of social capital in building up the livelihood adaptation of fish-pond farmers. There are three secondary research objectives as follows:

1.3.1 Scrutinize vulnerability, resulting from climate-related and socio economic risks, faced by fish farming households of small- medium- and large-scale of operation

1.3.2 Evaluate the effects of scale of operation on adaptive capacities in coping with climate-related risks

1.3.3 Identify the role of social capital in relation to adaptation of vulnerable farmers at household and community levels

1.4 Operational Definitions

1.4.1 **Fish farmers** with diverse activities divided into four types. There are the farmers who (1) raise fish only; (2) raise fish and grow crops; (3) raise fish plus livestock plus cultivation, and (4) raise fish plus nonfarm activities.

1.4.2 **Community** of fish farmers means fish farmer cooperatives. The cooperatives are a self-organizations implemented by fish farmer members with trust, reciprocity, and exchange under accepted regulation and common interests. The organizations aim at achieving their common interests in accessing funds, knowledge, labor and so on; factors useful for fish productivity. In addition, the fish groups are related to water irrigation institutions. Here, water users including farmers, fish farmers and villagers are taken into account.

1.4.3 **Risks** define both natural extreme events and socio-economic contexts. Natural events become more hazardous to human life in various areas and to societies that result in disasters and loss of life and material wealth. Physical risks refer to climate-related risks (floods, droughts, and climate variability), location (up-, mid- and downstream), adjacent land use (the fish pond farms is surrounded by rice paddy fields, fish ponds and non-farm activities), and ecosystem (fishes are eaten by snakes and birds). The seasonal floods, droughts and climate variability will unexpectedly affect agricultural and aquaculture activities each year. Because of the rapidly changeable weather and temperatures, fish-pond growth is sensitive to fluctuating amounts of oxygen and plankton in the pond. Moreover, socio-economic risks are the structural institution that constraints human capacity and response to external hazards. In this sense, market uncertainty, weak irrigation systems, labor availability and wages, rice mortgage policies and urbanization affect vulnerability in leading to unequal access to resources, malnutrition, and poor health.

1.4.4 **Vulnerability** is a function of both climate risks and social construction. It is determined by physical capital, natural capital, financial capital, human capital as well as social capital. These capitals of individuals or households convey their abilities and diversities of- resource access. In this sense, the perception of risk based on culture and social norms and the lack of knowledge may limit decision-making about adaptation.

1.4.5 **Adaptation** means the adjustment of agencies that respond to, cope with, adapt to and recover from the stresses. Each agency's capacity to adapt is fundamentally based on their five capitals of livelihood strategy. Their capitals can be diversified, combined and transformed to increase ability of access profile, income opportunities and productivity.

1.4.6 **Scale of operation** is divided into three groups: small, medium, and large. It is defined by an aggregation of indicators such as the total sizes of fish-ponds. In Phan, one to four rais of fish pond are considered small scale; five to ten rais is medium-sized while more than 11 rais is large. In Sansai, small scale counts one to two rais, three to five rais is medium and more than six rais means large scale. Meanwhile, small scale in Phayao is about one to four rais, five to eight is medium and more than nine rais is counted as a large-scale of operation. Most large scale operations employ wage labors but this is hardly seen in medium and small ones. Productivity depends on the farm's size and investment costs.

1.5 Literature Review

The literature review mainly focuses on adaptation of fish farming households under the vulnerability of climate-related and socio-economic risks. Thus, I have organized the literature reviews in accordance with two major conceptualizations: (1) vulnerability and adaptation to climate-related and socio-economic risks and (2) social capital as a livelihood strategy.

1.5.1 Review of Theories and Concepts

The concept of vulnerability and adaptation of the study is chosen to explore the weaknesses and strengths of the fish-pond farming households prone to climate-related risk and socio-economic risks. In this regard, I divide the notion into two sub-conceptualizations: vulnerability as a result of climate-related risks, and adaptation as a response to climate-related risks.

1) Vulnerability as a result of climate-related and socio-economic risks

Climate-related risk results in vulnerability. Here, many schools of thought have their different concepts. Beginning with the natural hazards approach, Burton et al. (1978) from the pioneer study of "The Environment as Hazard" argue that risk as natural extreme events becomes more hazardous to human life in various areas and societies that result in disaster of life and material wealth (also see Lebel et al., 2010). Hazardous events are marked by six characteristics: (1) *magnitude* is the intensity of physical action; (2) *frequency* introduces the rate of events; (3) duration refers to how long the hazardous event persists; (4) *areal extent* identifies hazard-affected space; (5) *speed of onset* refers to the period of time between the first event appearance and its peak; (6) *spatial dispersion* shows the pattern of hazard distribution over an area that can determine the mitigation of its effects. Burton et al. (2005) also add seven key indicators of vulnerability not only resulted from climatic (magnitude, timing, persistence and reversibility of impacts and probability of occurrence), but non-climatic conditions (potential for adaptation; distribution to reduce vulnerability; and value of vulnerable system). More significantly, the rise of disasters is also forced by population growth and an increasing number of people moving to vulnerable places with many catastrophic hazards particularly in developing countries (Burton et al., 1978). It seems that the hazard school considerably highlights the hazards towards vulnerable groups of people settling down at risk areas. However, it does not address the social causes of vulnerability and talks less about how different kinds of people are differently vulnerable.

Next, the human ecology school explains vulnerability as the characteristic of a person or groups who cope with, and recover from, the natural hazards based on class, caste, ethnicity, gender, disability and age. Hewitt (1997) claims that vulnerability is a property or a circumstance of persons, activities and sites, seen in six basic forms: (1) exposure to dangerous agents which are determined by location of home, the structure of housing and workplace; (2) weakness of persons, communities, buildings or activities to stresses; (3) lack of risk protection; (4) lack of the resources that affect risks or response to danger; (5) lack of resilience and capability to avoid, endure, offset and recover from disasters; and (6) powerlessness to protect and relieve from loss. However, the weakness of actors remains unclear without influential context.

That is a good reason why political economists contest the vulnerability meaning coined by the human ecology school and political ecologists emphasize more on the social risk. The risk results from not only hazards but also structural institution. Blaikie et al.'s

“At Risk: Natural Hazards (1994)” emphasizes the “pressure and release” model (PAR) to understand how disasters happen when natural stresses affect vulnerable people. Dynamic pressure translates the effects of root cause into the vulnerability of unsafe conditions. The release idea is the reduction of disaster, the pressure and vulnerability. Global processes (population growth, rapid urbanization, land degradation and conversion, global environmental change and war) affect vulnerability in leading to unequal access to resources, malnutrition, and poor health.

Another aspect is geography. Many geographers perceive social vulnerability in terms of time and space. Cutter, Boruff, and Shirley (2003) quantitatively use social vulnerability in the United States on 1990 data to identify the individual characteristics of people comprising of age, race, health, income, type of housing unit and employment. Those social factors result partially in the social inequalities and influence the susceptibility and response of various groups to harm. Furthermore, place inequalities are influenced by the attributes of communities and the constructed factors such as urbanization and economic growth. Those affected people experience, respond to and adapt to hazards, but in turn they are influenced by economic, demographic, and housing characteristics. Nevertheless, this methodology works quite well by using the quantitative Social Vulnerability Index (SoVI), but it is not a perfect system yet since not all factors are equal. There is no analysis of the local sub-national conditions and social differentiation of vulnerability. Accordingly, the weighting is required for further development by integrating social, environment and the indicators of natural hazard to develop hazards assessments and mitigation.

On the contrary, the more qualitative livelihood approach put people at the center of the context of vulnerability from the external environment. The vulnerability of people is fundamentally increased by critical trends, shocks and seasonality. Trends may be predictable influence of population, resource use, economy, governance and technology on chosen livelihood strategies. Shocks of human health, nature, economy and conflict not only destroy those people's assets but also force them to leave their assets as a part of coping strategies. The uncertainties of the market, job availability and food make it difficult for the poor in developing countries (DFID, 2000). The study thus begins with an investigation of people's assets and their livelihood objectives or outcomes and the livelihood strategies.

In terms of assets, Sen (1981) identifies famine results from entitlement failures in the exchange or market mechanisms even in the fertile places. It is said that (1) vulnerability to famine is a direct cause of poverty; and (2) poverty directly results in a number of tangible assets owned by households. Therefore, vulnerability is dependent upon tangible assets. Still, Swift (1989) widens Sen's argument that famine can be triggered by indirect factors (eg. extreme climate events, disease, and war) and direct cause (assets). The assets can be invested, stored and claimed in the production, exchange and consumption process. Households are able to invest in, and store physical capitals (education or health), and claim their resource ownerships. With this notion, assets are basically correlated with access (Blaikie et al., 1994). The access model includes how individuals, groups, or communities use their resources to secure their livelihoods in a society. The resources comprise of information, money, rights to resources, tools and social networks.

It is obvious that the livelihood approach rarely underlines natural hazards and the influence of structural institutions (state and market or organization). The hazard school puts too much weight on physical risk while human ecology considers human action without influential contexts. At the same time, political ecology too focuses on different actors who have unequal power relation towards natural resources.

Although the geographer has stratified on space and scale, it seems more quantitative without actor differentiation analysis. Thus, Adger (2006) concludes commonalities in vulnerability research that vulnerability includes exposure and sensitivity to external stresses, and the adaptive capacity. Exposure denotes the nature and degree of the system that experiences environmental (magnitude, frequency, duration, and degree of the hazard) or socio-political stress. Sensitivity is the degree that the system is affected by undesirable events (exposure and sensitivity defines risk). Adaptive capacity is the ability and response of a system to environmental threats or state policy.

To break down two dichotomies of physical and social risks, Brooks, Adger and Kelly (2004) views risk on social-ecological systems (SES). Physical climate hazard and socially constructed vulnerability are combined through the relationship, "risk= hazard x vulnerability." Vulnerability is measured by resource access and the diverse sources of income, as well as asset ownership of individuals or households (Adger, 1995). Brooks, Adger, and Kelly (2004) divide key indicators of vulnerability that limit adaptation into three broad categories: health (consumption, life expectancy and maternal mortality), governance (participation in political process) and education (access to skillful jobs and information). Adger et.al (2009) and Eiser et al. (2012) also add values and ethics, risk, knowledge and culture as limitations of adaptation. The perception of risk may also restrict decision-making about adaptation if the society is not concerned about the risks to kick off any action. In addition, those people who lack awareness about future climate hazards that can result in loss of place and culture often delay their adaptation actions. They lose their identity, power of decision-making and encouragement.

At this stage, I aim to employ the social-ecological systems (SES) idea that is a combination of both physical risks and socio-economic risks to vulnerability of agencies. Physical risks from the hazard school are the biophysical risks (e.g. droughts, floods) and their effects on production failures. Exposure, sensitivity and adaptive capacity will also be taken into account. Social risks include market uncertainty, weak irrigation systems, labor availability and wage, rice mortgage policy and urbanization. Furthermore, Adger's idea will be adopted to understand vulnerability covering exposure, sensitivity and adaptive capacity. It means an inability of an agency to cope with the stresses, to access resources and to diversify income sources. In this sense, being vulnerable or adaptable to hazards is dependent upon their five capitals (human, natural, physical, financial and social capital) elaborated further in the livelihood concept.

2) Adaptation as a response to climate-related risks

A vision for adaptation is specified by Pelling (2010) in order to build up the policy process and governance by linking adaptation and development into three pathways: resilience (maintaining the status quo), transition (incremental change by asserting full rights and responsibilities), and transformation (radical change by reform in political-economy regimes and cultural discourses on development, security and risk). Pelling's work inspired Bassett and Fogelman's 2013 idea on classifying adaptation into three literal types: adjustment, reformist, and transformative adaptation. They reviewed many papers talking about adaptation and found that 70% of the papers focused on adjustment adaptation approaches that see climate stress as the key cause of vulnerability. A smaller share (27%) refers to reformist adaptation to deal with both social risks and biophysical hazards. The lowest percentage (3%) relates to the social roots of vulnerability that urge the change of policy and economics to achieve transformative adaptation.

Beginning with the smallest share of transformative adaptation, the political ecology views transformation as adaptation in terms of winner and loser. O'Brien and Leichenko (2003) underline winners and losers as another idea of the transformative adaptation category. Winners and losers are naturally and socially constructed. Being a winner and a loser are determined by climate sensitivity and biophysical vulnerability and social and political construction. In terms of globalization, winners or losers may be measured by increased or reduced or losing income, gain or loss of employment and of productivity and so forth. With climate change, the nations that lose less are understood as the relative winners, while the nations losing more are the relative losers. Pelling (2010) underlines adaptations in the light of addressing root causes and forcing transformation. Radical changes must come from socio-political interventions designed to transform development and driven by industrialization, which is associated with climate change. In this way, human rights will also be reasserted to basic needs to balance the unequal world.

The second biggest share is reformist adaptation. Human ecology emphasizes that the contribution of economic development can build up adaptation and reduce vulnerability. The school also pays attention to socially exposed units such as household, farms and organizations (McLaughlin and Dietz, 2008). They hence have different degrees of adaptation upon fragile and defenseless persons, class structure, governance, economic dependency, property and communities (Hewitt, 1978). To lessen vulnerability, Bassett and Fogelman (2013) strongly propose the role of human agency and the change of institutions through political action. In this sense, the idea of access to and control of resources, entitlements, incorporative governance have been taken into account (Brooks, Adger and Kelly, 2004; Pelling, 2010). Moreover, the livelihood approach widens the access concept that poor people are supported to build up their assets to access and strengthen access to assets. The institutions and policies can influence access to assets by creating assets, determining access, and influencing rates of asset accumulation. Those with more assets tend to have a greater range of options and an ability to switch between multiple strategies to secure their livelihoods. In other words, different assets are required to achieve different livelihood outcomes (DFID, 1999).

The hazard school argues with the human ecology school that the increased economic activity seems unlikely to reduce vulnerability, but technology advancement can. The school draws a highly contribution to the IPCC and UNFCCC policies (2007) in terms of adjustment adaptation. It is a way a number of technical mechanisms illustrates how science and politics are mutually constructed and create top-down policies. Four types of national policy have been made: (1) disaster relief plan; (2) control of natural events plan by using engineering solutions; (3) plan to integrate technology, information, and monitoring system; and (4) combined multi-hazard management by establishing various kinds of administrative organizations (Burton, Kates and White, 1978). For instance, the New York City Panel on Climate Change (NPCC) promotes iterative or flexible adaptation pathways by using technological advancements and programs (Yohe and Leichenko, 2010). Thus, adaptation level can be checked from the state of acceptable levels of risks that maintains the status quo. On the other hand, human ecology argues that the discourse of hazard management through engineering and technology fails to engage with the political and structural causes of vulnerability within society.

To decrease vulnerability through technology, the hazard school believes that people living in prone areas have systematic rational decision-making analysis with four patterns of behaviors (Burton, Kates and White, 1978). People will deny and ignore the hazard exists; will tolerate the potential loss passively; will prevent impacts in their location; and will take significant action including abandoning the hazard zone. However, different people perceive hazards and adjustment differently depending upon the behavior of the individual unit, experience, material wealth, personality, and role of individual in a social group.

Since top-down solution sometimes fails to solve climate problems, Birkman (2007) argues that the state policy always ends up with conflicts because it isolates society, the economy and the environment from sustainable development. A paradigm shift is therefore highly required to link and keep the three factors balanced. Thus, Van et al. (2008) also propose bottom-up community risk assessments (CRAs) to engage participatory methods to deal with current climate risks and to reduce vulnerability to climate change. Furthermore, Cutter et al. (2012) voice out to policy makers that those managing risk or extreme events should consider local places and local actors. Adaptation would also be strengthened by using structural and technical responding mechanisms and proactive actions of local actors.

To build up human capacity of adaptation, the IPCC (2010) and Pelling (2010) underline the influence of socio-ecological systems (SES) theory to construct resilience of the interrelation between social learning and self-organization. Social learning is a property of social collectives with new values, ideas and practices. Self-organization, without direction from the state or other higher-level actors, refers to the tendency of the social collective to form new formal organizations. Moreover, Adger (1995) argues that coping strategies are counted as a kind of adaptation. But adaptation itself is a change of the institutional arrangements and the livelihood strategies. Coping may be defined as acting to survive within the existing rules falling into three categories: (1) initial use of assets (intra-household transfers and loans; and selling non-productive assets such as jewelry); (2) disposal of key productive assets including livestock; agriculture tools; and sale of land; and (3) destitution and suffering migration. Meanwhile, adaptation involves alternative income sources, migration or other significant changes as well as state interventions.

For my study, I cannot take each school of thought for granted in isolation because they are related to one another. Adaptation will not be achieved unless technical solution and human action are mutually constructed and work in cooperation. In my context, the fish farmer households attempt to maintain the status quo without the capacity to radically change the hazards and social structure. Therefore, the idea in the arena of adjustment is preferable in studying the process of adaptation. Social learning and self-organization (Pelling, 2010) will be embedded in human capital of livelihood strategy (DFID, 1999).

3) Role of Social Capital in Livelihood Strategy

The livelihood approach is an important actor-oriented perspective in development studies. The case studies for the research are centered on fish-pond farming households. How they cope with, resist, and recover from the environmental hazards depend upon their livelihood assets and their ability to access those assets.

> 'A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (Chambers and Conway, 1992).

The livelihoods framework developed by the Sustainable Rural Livelihoods Advisory Committee aims at improving our understanding of livelihoods, particularly those of the poor that are shaped by different shifting forces and factors (DFID, 2000). People-centered analysis begins with people's assets, their objectives (livelihood outcomes) and livelihood strategies to achieve these objectives. The strategies analysis begins with people's five assets which are human capital, natural capital, physical capital, financial capital and social capital (DFID, 2000). Human capital represents the skills, knowledge, as well as the ability to labor and good health. Natural capital is the natural resource stocks that provide resource flows and services. Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Financial capital denotes the financial resources that people use to achieve their livelihood objectives. Social capital means the social resources networks and connectedness, membership of more formalized groups and relationships of trust, reciprocity and exchanges.

The livelihood outcome will be achieved through the relative dynamics of those five asset capitals. An analytical framework of Bebbington (1999) claims that people's access to the five types of capital asset can combine and transform to build up livelihood viability and to reduce poverty. In addition, social capital (family, communities, the state, market and civil society) can widen their access to resources and other types of capital assets (produced, human, natural, social, and cultural). Moreover, their assets can be organized and enhanced to capabilities for better living and to change dominant rules to control, distribute and transform resources in society. Even though Bebbington's main focus on peasant viability and poverty is not consistent with my scope of study, asset capital transformation will be applicable to understanding vulnerability and climate adaptation.

Access has many dimensions as raised by many scholars. Sen (1981) points out access with conditions to gain resources and rights, the so-called entitlement. It is such a given right or what people should have. In contrast, Leach et al. (1999) argue that entitlement does not refer to people's rights in a normative sense; instead it is the range of possibilities that people can have. Entitlement is based on endowment which is defined as a person's initial ownership of land or labor power. Entitlement becomes endowment through negotiation. In other words, informal access can be negotiated to be institutional endowment as long as it can turn into formal rights of access and vice versa.

However, the concept of entitlement relied on initial capital assets might not give people ability or empowerment to claim their rights. Some community might have less capability to achieve or increase the level of access through institutional negotiation. In fact, access is better to start from individual ability in accessing to resources. Ribot and Peluso (2003) succeeded in expanding the idea of access beyond the fixed bundle of rights of property. Access embedded in property is hence based on the difference between ability and rights. The ability is akin to power in two senses: (1) as the capacity of some actors to affect the practices and ideas of others; and (2) as an emergent form that is- not always attached to people. Power has to be obviously seen as emerging and thus inherent in certain kinds of relationships.

Livelihood diversification is another way of access to resources. Hussein, Karim and Nelson (1998) claim that people construct their sustainable livelihood via three main interrelated strategies: agricultural intensification; livelihood diversification; and migration. Due to agricultural intensification failures, they not only diversify their livelihood but also migrate to access to higher income sources and other capitals through two factors. Push factors refer to environmental risk, falling incomes and pull factors means changing terms of trade, perceptions of improved opportunities.

Under the current transformations of global, national and local unstable economies, livelihood diversification is expected to be more complex and diverse. Family members tend to work both on-and off-farm activities to afford incomes and to reduce environmental risk (Stard and Johnson, 2004). Similar to de Sherbinin et al. (2008), they link environmental variables to the demographic variables that result in multiple pathways: fertility, migration, morbidity and mortality, and lifecycles. It is observed that households depend on natural resources intensification when human and social capital are lost through adult morbidity, and mortality. Moreover, environmental factors influence household decision making on fertility and migration. In fact, the idea cannot generalize all types of people because of differences faced by people who are poor, middle-class, or rich. They are all driven by institution and crucial market forces that determine their decisions on fertility, migration and lifecycles.

The research will use the five livelihood assets: human capital, natural capital, physical capital, financial capital and social capital (DFID, 2000) which are exposed to both climate and social risks. Meanwhile, some people diversify and other specialize their livelihood in response to the risks and to increase ability to combine, to transform the forms of assets (Bebbington, 1999) and to access to resources (Ribot and Peluso, 2003). In this way, access ability to resources conveys the level of access profile and income opportunities (Blaikie et al., 1994). Yet, the level of access will not increase unless social capital is taken into account.

Social capital can reduce vulnerability and build up livelihood adaptation within fish-pond farming households and among communities. Tracing back to historical social capital concepts, Field (2003) criticizes Bourdieu that (1970s-1980s) for focusing too much on material social capital since he adheres to Marxian unequal access and power to resources. People are able to use cultural symbols arising from habitus as determinant of the social status. Habitus means lifestyle, values, charterer of particular groups gained from every life experience. Some types of cultural taste enjoy more status and power than others. Years later, Colemen (1988) has had a much wider influence than Bourdieu. He argues that the individuality without social capital is a thread of distribution of skills.

Social capital is a key element to enhancing livelihood security, reducing environmental risk, and to solve economic instability, but social capital can also exclude certain groups etc. It is not necessarily a good then for everyone, but an empirical question. In sociology, social capital is defined as: (1) a social control source; (2) a benefit source of the family, and (3) a source of non-family networks, with the benefits of a material and informational collection (Adger, 2003). In this way, the relationships between individuals, households, intra-households, organizations, regional and macro economies can be incorporated to enhance wellbeing, sustainability of livelihoods and poverty alleviation (Bebbington, 1999). The economic point of view argues that social capital within household does not favor collusion. Thus, the non-family network is rather effective form to reduce transactions costs. Traders with better connections build up larger scales and more value is added than those with less (Fafchamps and Minten, 1998). However, the number of contacts is a measure of social capital output in this study, so it blinds us from the characteristics of actors and related social context.

To have a clearer scale of social capital, in contrast with Bourdieu, Coleman, and other economists, Putnam (1993) pays more attention to the resources. He introduces two basic forms of social capital: bridging (or inclusive) and bonding (or exclusive). Bridging social capital tends to involve diverse people whereas bonding social capital tends to reinforce exclusive identities and maintain homogeneity. However, Woolock (2001) writes that Putnam's argument on ties between different people in dissimilar situations, particularly that of outsiders, enable people to influence a wider range of resources than are available within the community. In reality, social ties are embedded in vertical and horizontal ties. Two types of relationships are based on the position of each group of people. The horizontal dimension represents the ties of those people who have similar positions or work at the similar level within the group. The vertical refers to the different levels of interaction between two groups of people in superior-subordinate relationships. Putnam argues that vertical bonds might be less helpful than horizontal ties that might undermine the capacity for collective action and the ability to access as well as influence over state and market (Bebbington, 1999). On the other hand, those areas based on horizontal social relationships (with trust and shared values), participation of people in social organizations and networks are high. It is seen that Putnam and Bebbington likewise highlight the importance of horizontal linkages, but neglect power inequalities from the vertical dimension mentioned in DFID (2000). It is noted that social capital means the social resources through both vertical or horizontal networks and connectedness. The network is able to increase people’s trust and collective action while expanding their access to wider connections.

However, Putnam’s bridging and bonding idea has influenced many scholars. Group progress is related to not only the locally availability of social capital but also the collaboration from government and voluntary agencies (Pretty and Ward, 2001). Adger (2003) also claims that collective action and social capital inform the nature of adaptive capacity and the direction of adaptation policies. He divides social capital into four extreme cases. First, a *“well-functioning state with low level of networking social capital”* can provide the necessary and social security for marginalized groups. Second, *a “well-functioning state with high levels of networking social capita*l” promotes social and policy learning through democratic participation and environmental governance. Moreover, *“a dysfunctional or absent state with low levels of networking social capital”* (coercive states) excludes or undermines social capital. Thus, conflict and marginalization are found. The last one is *“a dysfunctional or absent state with high levels of networking social capital”*. Networking social capital is built to replace some government roles.

Still, Bebbington and Perreault (1999) argue that social capital formation cannot be achieved without the state's help. It occurs at wider geographic scales achieved by the creation of organizations and networks. The vertical relationship from civil society and state actors plays an important role in widening the ability of household with horizontal connection and encourage the communities to access different types of capitals. The network can widen access resources, claim making, defend and transform assets. On the contrary, Pelling (1998) argues that vertical social capital distorts horizontal relationship since it shapes access and excludes local participation from national and international resources. For example, marginalized groups with limited capitals tend to be excluded from local participatory and decision-making in the environmental management. As a result, they are still struck in perennial vulnerability to climate risk. However, prior to relying on external ties, Ribot and Peluso (2003) claim that individuals or actors can build up emerging ability to access that is- not always attached to people and reliant on other helps. With this idea, people can develop their DIY ability as a way to strengthen their further bridging and bonding.

Social capital here is bound up with the reciprocity of the wider network, exchange through trust, shared value, common interests, common rules, norms and sanctions(Adger, 2003; Pretty and Ward, 2001). Granovetter (1985) cited in Tonkiss (2004); and Fu (2004) claim that trust is a social mechanism embodied in structures of personal relations and networks. Fu further elaborates that trust and social capital are interrelated. Social capital brings about trusting relationship and vice versa. Moreover, trust can be mobilized for financial capital and other resource accesses (Tonkiss, 2004). James Coleman (1988) cited in Tonkiss (2004) the example of the quasi-economic capital of the Jewish family and community. Up to the 1980s, the wholesale diamond traders in Brooklyn used their cultural, social and family ties and shared norms to operate the local trade. To alleviate economic risks, the relationship provides exchange security and reduces associated costs

There are two types of trust: trust in family relations and in non-family networks. Tonkiss (2004) argued that familial relations are bound up with trust, voluntary obligations and compelling norms. But trust in either networks or organizations, is more complex (Fu, 2004). Trust derives from regulations, rules and so called structured relations of the organization (McCauley & Kuhnert, 1992). Nevertheless, Granovetter (1985) cited in Tonkiss (2004) and Granovetter (1973) argue that social ties are more useful for people seeking work in communities with weak ties than in the strong ones. They have more potential to access information and enhance new contacts outside their usual circles.

Where is trust from? Prusak (2014) and Putnam (1993) cited in Fu (2004) proposes that people trust someone they know from repeated exchange, sharing and reciprocal relationships. Collective action of bounded solidarity can also be transformed into power as long as the group members selflessly sacrifice for the collective good. Collective action is also passed on by individuals through kinship or through interactions with the state, market, and the civil society (Pelling, 2010 cited in Portes, 2010). This kind of interaction becomes generalized and gets embedded in the norms. In addition, trust is developed from the transparency of the organization by means of meetings, weekly reports and working progress to keep the group members updated. Fu (2004) adds that trust indicates a willingness of persons to follow another party based on the belief in their skill and capability, their reliability and their openness (Nahapit and Ghoshal, 1998 cited in Fu, 2004). In this way, fair and just leaders in organizations create trust and high social capital between supervisor and subordinate relationships (Prusak, 2014).

To measure intangible social capital, Paldam (2000) reviews many means as follows. The first mean is to measure trust and ease of cooperation. Trust payoff can measure social capital as the amount of benefits persons can draw on the trust build. Ease of cooperation is the ability of people to voluntarily work together for a common purpose of the groups and organizations. Likewise, Fukuyama (1995) cited in Tonkiss (2004) distinguish 'high-trust' from 'low-trust' societies based on forms of voluntary association. Fu (2004) proposes that people with high trust are more willing to participate in social exchange and interactions. They have durable reciprocal labor relations to reduce transaction costs and increase the efficiency of work performance (Levine & Tyson, 1990). The outcome of the social interaction is innovation to solve the collective problems and to achieve common goals. Additionally, Putnam's instrument can be used to count the density of voluntary organizations, the frequency/intensity of the contacts. Also, the lines between voluntary and state organizations, as well as between voluntary organizations and private businesses, should be drawn. In terms of networks and the trust-cooperation-complex, network payoff refers to the social capital of a person. It is the total amount of benefits he/she can draw on his/her network. Furthermore, the measurement can be used to ask trust questions, particularly about money loans. Network density measures also helps map people's networks and weight each link of formed person.

In short, social capital is bound up with both the qualitative analysis and quantitative measurement. In this regard, Putnam's idea (1993) of social capital in terms of bridging (household) and bonding (community and fish farmer cooperatives) will be used to coincide with the DFID (2000) statement through networks and connectedness, either vertical or horizontal dimension (Adger, 2003). Moreover, individuals and the network are strengthened to expand access (Ribot and Peluso, 2003) to wider institutions with relationships of trust, reciprocity and exchanges. These elements will be measured by the scale of social capital (household, community and external institutions) and by the payoff of trust and network in terms of innovation, exchange and sharing as well as Putnam's instrument.

1.5.2 Review of empirical studies

The aim of this research is to examine social capital as a tool of vulnerability and adaptation to climate-related risks. Thus, I review two issues: vulnerability and adaptation to climate-related risks; and social capital under vulnerability.

Climate change seems to increase as a result of physical climate and human intervention. Eissa and Zaki (2011) emphasize that rising sea levels and climate change are predicted to affect a number of aquatic animals and those people who rely on the resources. Nowadays, dams cause dramatic changes in flow and fluctuations in water supply. As a result, increased flooding or water scarcities destroy ecosystems and humans. Weatherhead and Howden (2009) also highlight the interlinked problem between land use and limited water resources in United Kingdom. Competing water use becomes high in response to population growth, agriculture, industry, and infrastructure. This case reminds me of urbanization towards fish pond farming that negative impacts of water stress possibly degrade fish growth, thus generating less income for fish-pond farmers.

Moreover, the-socio economic context worsens the livelihood of a different kind of people prone to climate risks. Azga (2011) studies those people of Gaibandha District of Bangladesh who have adapted to live with perennial flood. Low-incomes people are found to be the most vulnerable groups because of their limited access to land and livelihoods. Many family members of the poor also rely on single income. Moreover, the vulnerability to flooding is increasing due to the pressure of increasing population and high cost of investment in intensive modern cultivation techniques, maltreatments of power, corruption, urban bias, gender disparity and existing religious practices. Similar to the changing weather braved by the rural mountain people in Nepal, the poor has faced crop failure and are vulnerable due to limited land ownership and limited support from the local organizations. The well off and middle-class, which own irrigated land, have better access to agriculture services provided by local organizations and state agencies. They then sell their labor force and seasonally migrate to India (Gentle and Maraseni, 2012).

Pond aquaculture ultimately maximizes local natural resources and total agricultural production by combining aquaculture, fruit, rice and livestock together. Phong et al. (2007) studies Integrated Agriculture Aquaculture (IAA) systems in the Mekong Delta of Vietnam. They argue that it is easier for the rich farmers who have good farming skills and capital to decide to intensify their farming systems. By contrast, the poorer farmers tend to diversify their livelihood. Some stop farming and become hired labor for rich farmers. Some do off farm in the city. Khin (2013) also argues that well-off farmers strategically manage the risk through various actions, such as substituting or trading-off or combining their available resources. Still, most poor farmers access the labor market through migration with the help of kinship or social networks.

In terms of the scale of aquaculture farmer operation, small, medium and large units have different strategies for survival under the pressure of climate and socio-economic risks. Chiep (2001) studies the excluded fisher farmers' responses for legitimacy in obtaining access to fishery resources in Tonle Sap, Cambodia. He explores the complexity of the social relations of each scale, either among the kinship group or with influential people in competing for gaining access to fish resources. His findings show that only a limited number of the large-scale of fish farmers benefits while the majority remains disadvantaged.

Even though doing small-scale fishing and fish farming face high risks of uncertain fish production and exposed location, migration or mobility might not be a solution for the fish farmer staying put in their farms. Thus, diversifying livelihood into more than one income source can diminish the possibility of risks (Allison and Ellis, 2001). Bosma and Verdegem (2011) mainly discuss that the intensification of aquaculture system is the most sustainable way to increase aquaculture production. All scholars agree that the poor producer can employ new technologies to make the financial and social factors more sustainable and more resource-efficient. Khondker and Diemuth (2011) add that the integrated aquaculture-agriculture (IAA) training helps increase food consumption and better nutrition of the small-scale farmers in Bangladesh. Longoni (2011) also introduces the education model, specifically semi-subsistence, to make small-scale fish farming both more environmentally and more economically sustainable.

Technology and knowledge utilization as a significantly worthwhile way for fish farmers' adjustment are led by the younger generation and social networks. Pickering et al. (2011) claim that the reproduction, growth and survival of the tilapia farming are expected to be sensitive to the increase of temperatures, salinity and oxygen level changes. Moreover, floods caused by cyclones and more extreme rainfall events are at risk to tilapia ponds constructed close to rivers. According to advice from social network, locating and constructing ponds are a way of adaptation to reduce any effects of warmer pond temperatures and to increase the mixing of water or turnover as the way to balance plankton blooms as natural food which helps minimize the cost of supplementary feeding. The claim coincides with what Ford and Smit (2004) have studied regarding the adaptability and resilience of indigenous Arctic groups. Owing to cultural and social changes, the young adopt new technology and distribute this to others with the help of strong social networks. They extend experience and knowledge for more flexible use of the environment (Fabricius and Cundill, 2010).

The adaptation concept here typically focuses on resistance, adjustment, mobility and diversification of vulnerable groups of the poor, but social networks are rarely found. To increase and improve the sharing of resources, cooperation and mutual interest can be a promising option for fish farmers. Social relation within household and community levels will be taken into consideration. Individuals and family members have different ability to cope with or adapt to climate change under socio economic dynamics.

The dichotomy of mobility and social capital has been raised by many scholars. It is noted that high mobility will be made in any place in which the degree of social capital is low (Kusakabe et al., 2003). Farmers tend to have access to the means of production and consumption in different places. On the contrary, without social connectedness construction, the rate of mobility is high in Ethiopia, Bangladesh and Mali. The poor migrate to earn remittance to relieve rural credit constraints. Social connectedness also reduces risk and maximizes household utility of rural investment (Dercon and Krishnan, 1996 cited in Hussein and Nelson, 1998).

In terms of vertical and horizontal ties, Belton (2012) provides a comparative analysis of knowledge transmission in Vietnam and Thailand. In both cases, informal channels are more successful than official attempts to extend technology in aquaculture. The transmission grows in interpersonal relationships such as local kinship, reciprocity, obligation implied in relationships in addition to location-specific historical contexts and the particular groups of institution. However, the horizontal relationship is not well successful without the vertical help like in the case of the Mozambique people vulnerable to low maize production because of low rainfall. Thus, the strategic formal agricultural associations in Nwadjahane have been working in cooperation with the local community, local government and international non-government organizations (NGOs). They aim at addressing local vulnerability to drought promoting food security and poverty reduction (Osbahr et al., 2008).

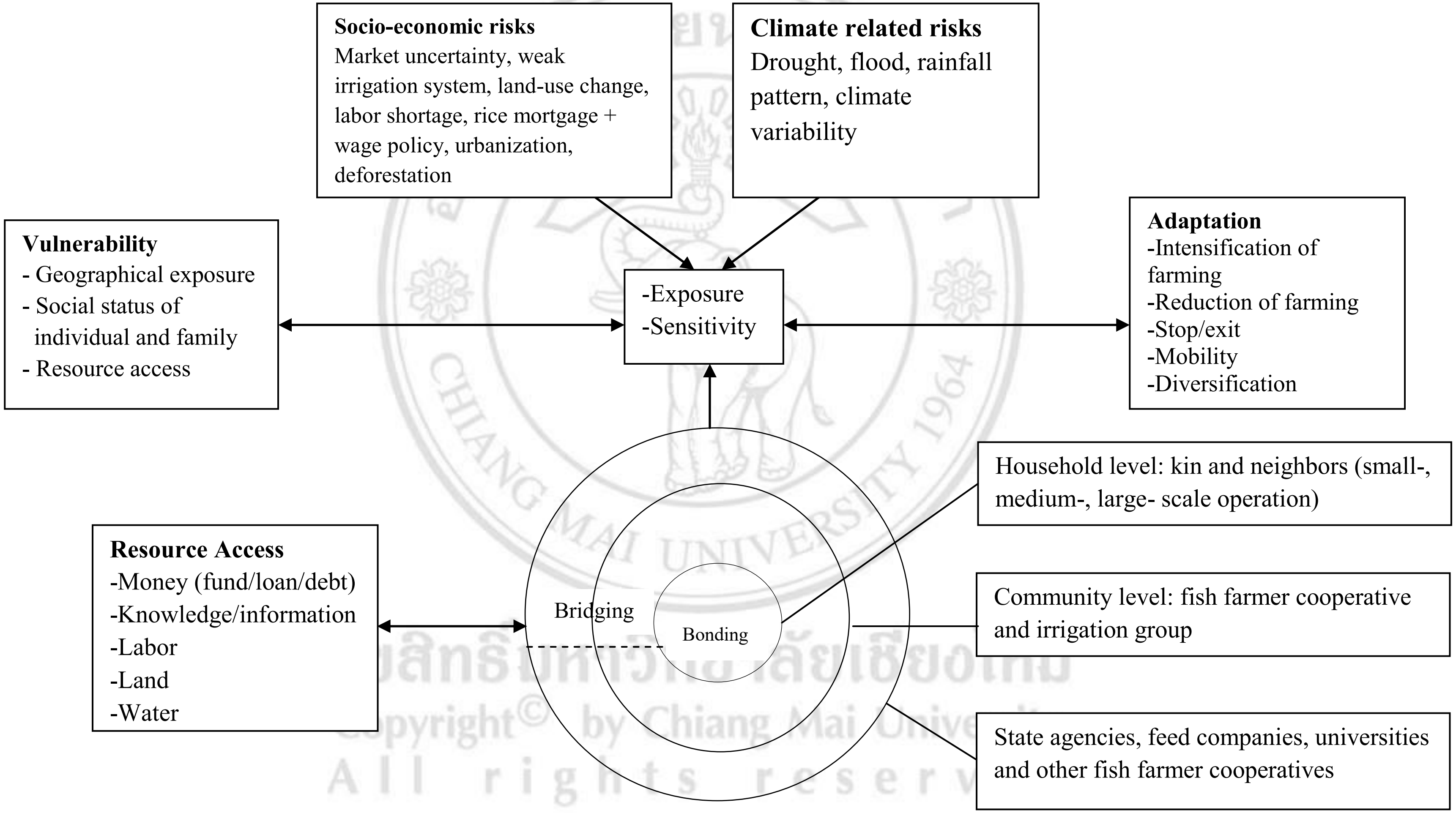
Nevertheless, social ties are different depending on place-based characteristics. Adger (2003) examines two case studies of social capital formation: (1) the collaborations between state and civil society in coastal resource management in Republic of Trinidad and Tobago; and (2) the state roles replaced by the networks towards hazard management in Vietnam. In Tobago, positive cooperation between the government and local communities to protect marine areas had been facilitated to solve conflicts and set up a new institution in the late 1990s. In contrast, in the mid-1990s, due to the decentralization and the collapse of agricultural cooperatives, local communities founded the planning and a system of coastal hazard prevention in Vietnam to substitute for the state. Both cases examine the nature of social capital from institution structures depending upon culture and place-specific characteristics. Additionally, Mexican farmers who suffered from coffee plantation failure have shifted to grow sugar-cane, which requires less labor and is supported by government programs. The programs also provide social security and healthcare through farmers' associations. In Argentina, without organization support, those farmers growing soy faced profit cuts due to higher investment costs and increased environmental risks. They had little ability to integrate local knowledge of environment and land management. Thus, most small- and medium-sized family farmers abandoned their farms, deciding to rent out their farmlands to larger-scale farmers or outside capitalists (Hallie et al., 2009). It is found that both vertical and horizontal ties in different contexts are important driving forces for the local people's decision-making about vulnerability to climate-related and socio-economic risks. For my study, both relationships are thus essential to determine the way social capital empowers people's ability to access resources at household and community levels.

1.6 Conceptual Framework

In this research, my main objective is to understand how social capital builds up the livelihood adaptation of fish pond farmers. The secondary questions are firstly, how fish farming households of small-, medium- and large-scale operations face the vulnerabilities. The second question is how the scale of fish farm operations influences adaptive capacities to cope with vulnerability. Finally, social capital will be examined in relation to their adaptation at household and community levels.

Let's begin with risks. Households and communities are exposed and sensitive to both physical and socio-economic risks as drivers of vulnerability. The physical risks include droughts, floods, rainfall pattern and climate variability. The socio-economic risks comprise of market uncertainties, weak irrigation systems, labor availability and wages, rice mortgage policies and urbanization. With different abilities, the small-, medium- and large-scale fish farmers respond to these stresses in different ways. Being vulnerable to risks is indicated by the inability to cope/adapt as well as resource conflicts. To reduce vulnerability, the three groups of fish farmers can develop their abilities via social capital to differently resist, cope with, adapt to or recover from the risks. Their social connectedness also reinforces access profile, high income opportunities and high productivity.

The role of social capital will be essentially highlighted in climate adaptation. Social capital is inextricably entwined with money, labor, land, water and information/ knowledge. These capitals can be transformed to and combined with each other to increase ability of access. The social capital analysis is divided into family and non-family networks. The first network comprises households and neighbors while the latter means state agencies, agro-food companies, universities, irrigation groups and village-committees. Fish farmer cooperatives and *Muang Fai* members are reckoned in both types of networks. In addition, the levels of analysis are fish farming households and their communities. Thus, types of households are categorized based on scale of operation into small-, medium- and large scale. Furthermore, the fish farmer cooperatives fall within the community level.



Socio-economic risks
Market uncertainty, weak irrigation system, land-use change, labor shortage, rice mortgage + wage policy, urbanization, deforestation
Climate related risks
Drought, flood, rainfall pattern, climate variability
Vulnerability
- Geographical exposure
- Social status of individual and family
- Resource access
-Exposure
-Sensitivity
Adaptation
-Intensification of farming
-Reduction of farming
-Stop/exit
-Mobility
-Diversification
Resource Access
-Money (fund/loan/debt)
-Knowledge/information
-Labor
-Land
-Water
Bridging
Bonding
Household level: kin and neighbors (small-, medium-, large- scale operation)
Community level: fish farmer cooperative and irrigation group
State agencies, feed companies, universities and other fish farmer cooperatives

1.7 Research Methodology

17.1 Research Site

The number of sites varied among three villages in three provinces with the main idea of covering rural and peri-urban sites, density of intensive fish-pond farming and disaster experiences including conflicting access to water; and the pressure of socio-economic change on agricultural and aquaculture activities. From figure 1.1, the rural site is 1) Sanpakhee Village in Sanklang Sub-district, Phan District, Chiang Rai. The village is regulated by a Sub-district Administrative organization[1] that is considered as a small town. It has the highest commercial tilapia productivity in Northern Thailand under the Mae Lao and Mae Souy small irrigation system; 2) Maekaedluang Village in Nongchom Sub-district, Sansai District, Chiang Mai is under sub-district municipalities. The site is considered as the tilapia supplies are in a peri-urban area (a big city) and reliant on the Maefaek-Maengat Irrigation project and Mae Ngat Somboon Chol Dam. *Muang Fai* system is predominated by the Royal Irrigation Department. The last local site is 3) Tamphralae Village, Ban Tam Sub-district, Muang District, Phayao, under sub-district municipalities. The site in located in a medium town. The tilapia source is in the watershed areas in the small basin. Water users here consume water from Huay Hiek Catchment constructed in 1996, Champathong Waterfall, Mai Yang Weir, Champathong Waterfall and Khuntam Waterfall. Water allocation is regulated by Kae Muang (communal irrigation leader).

[1] The local government system in Thailand consists of
(1) municipalities which are divided into city municipalities (with at least 50,000 citizens), town municipalities (with at least 10,000 citizens) and sub-district municipalities in any other area.
(2) Administrative organizations that are divided into provincial administrative organizations and sub-district administrative organizations.

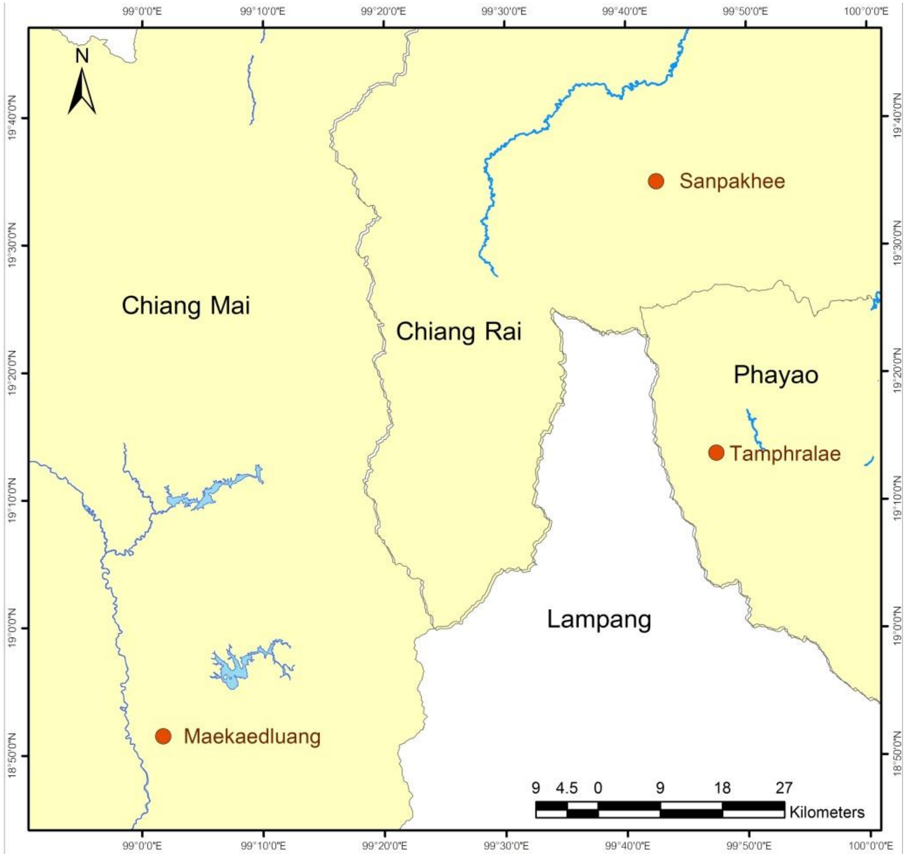


Figure 1.1 Research sites

Sanpakhee Village is located about 43 kilometers from Muang Chiang Rai district. It is also close to the Asian Highway, which connects it to other main markets in provinces such as Phayao, Lampang, Phrae, Nan and Uttaradit, including Chiang Mai. Moreover, the village is near Rajamangala University of Technology Lanna Chiang Rai which introduces sustainable energy particularly biogas to communities. From Muang Chiang Mai district to Maekadluang Village, it is about 13.5 kilometers to Maejo University, the oldest agricultural institution in the country. The institution has published research on freshwater aquaculture and agriculture while producing a large number of graduates who work in feed companies and in the fish trade. Tamphralae Village is 15 and 30 kilometers away from Muang Phayao district and Phayao University respectively. The university has launched projects and extensive research to address water pollution before flowing to the Ing River.

It is noted that both Maekadluang and Tamphralae are regulated by the municipal government.

1.7.2 Unit and Level of Analysis

Unit and level of analysis are based on Putnam's (1993) bonding and bridging idea. Bonding focuses on the household unit and level. Ties within a social group have been shown as bonding social capital. There are the homogeneous family, kinship and neighborhood. The household is a decision-making unit under one roof in lessening or raising the problems, based on the capacity of family members. Blaikie et al. (1994) also claim that a member of a household unit has a profile of assets that determine his/her certain ability of access related to income opportunities (cash, wages, gain and remittances), information, rights to the means of production, equipment or technologies and social networks. When faced with stresses such as drought, flood, fish diseases and death, some members decide to employ livelihood strategies and coping mechanisms.

Table 1.1 Thirty two selected households in three sites

Scales / Villages	Number of households		
	Sanpakhee	Maekaedluang	Tamphralae
Large	3	3	3
Medium	3	4	3
Small	3	4	3
Exit from fish pond culture	1	1	1
Total	10	12	10

Bridging of networking social capital is made up of economic and other external ties in the community unit and level. The network refers to fish farmer cooperatives and groups cooperating with state, agro-industrial companies, other fish-related sources and market channels. The groups aim to have access to funds, information/ knowledge, labor and water in order to maintain and increase fish productivity and distribution. From table 1.1, the total 32 case-studied households are categorized into four groups in each site: three households of large-, of medium-, and of small-scales as well as one farmer who completely exited from fish-pond farming. Fish farmers in the case studies include both commercial and integrated farming in order to examine the relation between the farming systems and risk management. The last case study is used to determine social capital impact whether or not it encourages fish farmers' decision to carry on fish farming over climate-related risks. To seek for more information in various aspects, 16 key informants from the government Department of Fisheries, Royal Irrigation Department, universities and feed companies were interviewed. In addition, fish farmers are a part of the *Muang Fai* group at the community level, in charge of water allocation and management. Based on the relationships of relatives and neighbors, they share water portions and collaborate in social activities. However, the strong local relationship has weakened nowadays through the changing water management system and more diversification of agriculture activities and land use.

Table 1.2 Number of farm types in three villages

Farming types / Villages	Number of farm		
	Sanpakhee	Maekaedluang	Tamphralae
Intensive	-	10	6
Integrated	10	2	3
Subsistence	-	1	1
Total	10	12	10

Besides size operation, the case studies are divided into the ones who implement integrated and intensive fish-pond farming (table 1.2). Both farms comprise of different farm characteristics on inputs, investment cost and exposure. Here you see that all the fish farmers in Sanpakhee adopt the integrated pig-fish farming system. The majority of fish farming is intensive (83%) in Maekaedluang. Two out of ten fish farmers implement integrated chicken-fish farming, whereas there is just one subsistence system from the ex-fish farmers who exited from the fish group and turned to work fulltime off-farm. Intensive fish farming in Tamphralae is 60 %, integrated system 30% and the rest is subsistence farming also implemented by the ex-fish farmers who are out of the fish group.

1.7.3 Data Collection

I used both primary and secondary data for the research. The first kind of data was gathered from the fieldworks. The field data collection duration was divided into three periods of time at the end of 2012 to the beginning of 2014: dry season (February- May), rainy season (May- October) and winter (October-February). The allocated period is a good time for studying the different climate impacts on pond-based aquaculture. This is because fish is sensitive to different climate variations and seasonal fluctuations throughout the year. Collecting data on their responses to risks is indicative of various fish farmers' coping capacity and adaptation. Qualitative studies were undertaken by thematic process research based on secondary data collection, participant observation, household dairy and in-depth interview of household and related key informants.

1.7.4 Researcher Identification

It was very important for me to position myself prior to and during the field visits. I was both insider and outsider in the three villages. The village where I live in Chiang Mai was near Maekaedluang Village, which made it easier for me to understand the contexts as well as historical and social movements. I also became very familiar with the villagers and quickly understood the nested linkage of the case studies that made the social capital issue more complex and accurate. However, my position was not viewed completely positively because I am a daughter of one fish groups out of the three with commercially competitive relationship to one another. Some of them naturally had bias against me. I therefore informed and explained to them my objectives and the scope of the work in order to clarify my position and ask for social acceptance.

Again being an outsider in Sanpakhee and Tamphralae obstructed me from gaining information. The villagers and fish farmer cooperatives and groups felt strange and difficult at the first because they were both commercial competitors with each other and with Chiang Mai traders. Thus, I tried to avoid approaching them with the topic about financial interest but via the cultural and social issue. For instance, when talking about family and the way of fish farming in Chiang Mai, I encouraged them to be open-minded and got them interested in exchanging information. This approach was beneficial for me in gaining new knowledge and experiences. Once I started visiting the fields more often, I became more familiar with them and kept them updated on my progress. To win the case studies over, I became like a coordinator who exchanged and shared available information from the communities to the others. Some fish farmers in the three sites asked me about the material uses in different places so that they could improve their farming. The more they shared and exchanged information from different contexts, the effective more I became and the more precise the data.

1.7.5 Secondary Data Collection

Prior to and during the fieldwork, I collected documents and articles related to the research content from various sources such as theses, statistics of water irrigation from the Statistical Forecasting Bureau of the National Statistical Office, Mae Lao Transmittal and Maintenance Project, Mae Faek Mae Ngad Operation and Management Project and Phayao Operation and Maintenance Project, the Royal Irrigation Department and Thai Meteorological Department. The information covered a timeline of about 30 years of both hazard events and the main events related to agriculture and freshwater aquaculture development. The source of the studies also included household demographics and farming and off-farming activities. The information was gained from the sub-district municipalities and the sub-district administrative organizations. Pond-based aquaculture policy was collected from the Department of Fisheries (DOF). The information on fish productivity data and group members of the fish group were also offered by fish farmer cooperatives and groups as well as related feed firms.

1.7.6 Participant Observation

The participant observation method was important for my data collection. The information needed was gathered from individual households in terms of their knowledge of fish feed, technology implementation and their geographical locations prone to risks in addition to their risk perception, their family members' profiles and their daily lifestyles as well as their social networks. In terms of social capital data, I observed how fish farmers with different scales of operation interact with each other and in community to explore their power relations and assistance. Moreover, in order to gather data on adaptation methods used by individuals and community, I spent time within the community to immerse myself in the situ and to observe the people's practices, while taking notes, recording and taking photos. I spent 3-4 days on each site collecting data each time. I visited Sanpakhee and Tamphralae 8 times each, and 14 times in Maekaedluang which was near my hometown. I often followed and helped them while working in the farms such as feeding fish, implementing aerators, feeding either pigs or chickens, making herbal feed and so on. While participating in their work, I took the opportunity to observe who played a role in farming; and their feelings and perception on what they had done in farming. This helped me immensely to understand the reasons behind their choosing to farm, whether it was a must in order to deal with household burdens or working hard just for accumulated wealth. It was useful to clearly understand how much experience they had which could determine the adaptive capacities. Above all, the empirical data was used to cross check with the secondary data about adverse weather events and hazards and with other villagers.

1.7.7 In-Depth Semi-Structured Interviews

In total, interviews with 16 external key informants and 32 case studied households were carried out. It was necessary to understand the background of the sites before selecting the 16 key fish farming informants. Firstly, this selection consisted of semi-structured interviews from the key informants including feed agencies, fish farmers and the agencies of the DOF and RID. Furthermore, village headman and village committee gave me the general village information, their livelihood and the impacts of climate-related risks as well as the state role on disaster prevention and solution. In terms of water irrigation management, *Kae Muang* and RID agencies were key informant. They were keen on the geographical waterway, flood and drought histories, water management problems as well as water management strategies. In addition, interviewing DOF agencies and feed agencies allowed me to understand government policies regarding flood insurance and new technological development used in the farming system. The policies propelled fish farmers to adopt either livelihood diversification or intensification to change farm resources and market opportunities.

Later on, total 32 households as the case study were selected. I basically followed ethnography which was rooted from the cultural anthropology and conveyed a cultural description and understood another way of life from the native point of view (Neuman, 2006). In this way, the information included their livelihood information and their capital assets. There were their livelihood profiles: knowledge, age, experience, household income and labor, a burden of household expenditure, investment cost, kinship, and friendship within household and external people, which offered the analysis of their adaptive capacity to climate related risks. In addition, since the social capital was an abstract concept, the quantitative questions were needed for more measurable analysis.

The social connections questions were hence asked with regard to the intensity and frequency in their circle of family members, neighbors, friends and other external organizations who offered help and whom they trusted. Then the trust questions were used to support the trust payoff, especially what kind of collective activities they were willing to do and share together. The questions were asked as follows. (1) Whom in your circle of networks do you trust with their advice and example? (2) Whom in your circle of networks do you think trusts you with your advice and knowledge? (3) How do you trust them and they trust you? (4) Are you willing to share, cooperate with and help the ones you trust? (5) Do you follow who you trust and the regulation of the fish group, and how? (6) If so, why do you change your action? (7) If not, why do not you change your action? Here, a recorder was necessary to record the implicit and explicit information emerging naturally without hesitation and bother from the key informants.

1.7.8 Data Analysis

This study was qualitatively based on key household and informant narratives. The recorded data were taped and transcribed from local Northern Thai dialect to the Central Thai language. Selected parts were then translated into English according to the main themes of the research. In this process, thematic analysis was implemented as a common form to pinpoint and examine the themes within the data in accordance with research questions. The data was concerned with the climate and socio-economic risks, the vulnerability of the fish farmers, their adaptive capacity and the role of social capital in their adaptation. Based on rapid appraisal, analysis was based on informality of collecting data; flexibility of field visit time and sites; data triangulation to compare data between sources to check its reliability. The method also enhances the relevance of the local people in verifying the findings. This process made the three essential techniques, which are semi-structured interviews, participant observation and secondary data, high potentialities for the purpose of this study and for validity and accuracy.

1.8 Organization of the Thesis

This thesis contains six chapters. This analysis is presented with reference to a series of qualitative empirical studies conducted in Chiang Rai, Chiang Mai and Phayao provinces, Thailand.

Chapter 1 describes the study, background, research questions and research objectives. Literature review is also related to (1) vulnerability to climate-related and socio-economic risks; (2) adaptation of fish farmers; and (3) the role of social capital in livelihood strategies. In addition, research methodology and data analysis methods are elaborated.

Chapter 2 identifies the contexts of aquaculture development from national level to northern level and to the study areas. The study also highlights the physical and socio-economic contexts of the three villages: Sanpakhee Village in Chiang Rai, Maekaedluang in Chiang Mai and Tamphralae in Phayao. The physical contexts comprise of location, topography and water management. Socio-economic contexts are population, production system, land use, fish pond system and fish production. In addition, the study explores the reasons for pond-based aquaculture implementation and fish farmer cooperative development.

Chapter 3 focuses on the main vulnerabilities of fish farming households with different scales of operations. In this regard, small, medium and large fish operators in each village have been differently exposed and sensitive to the incidents resulting from multiple climate-related and socio-economic risks. Access levels of water resources and degree of urbanization mediate site vulnerability. Household vulnerability is measured by aging, personal wealth, frail family member, labor availability, investment costs, fish death and fish weight; thus where and what kind of people are most vulnerable is also investigated.

Chapter 4 elaborates the adaptive capacity of households and communities in response to, to cope with, adapt to, and recover from hazards. The chapter identifies how fish farmers convert capitals to access as adaptive capacity; how they with different scale operations cope with climate variability; and how fish farmers adapt to climate-related and socio-economic risks. Many technologies and experience as well as much knowledge are highlighted as key tools to constitute their adaptive capacity.

Chapter 5 examines the role of social capital in climate adaptation. The social capital analysis is divided into kin, neighbor groups and external networks. Bonding networks comprise of households and neighbors while bridging networks refer to state agencies, agro-food companies, universities, irrigation groups and village committee. The study focuses on the reconstruction of bonding through bridging fish farmer cooperatives. By linking the relationship, social capital components are studied on how they increase level of adaptive capacity. How bonding and bridging network play an important role on water-related stresses is elaborated in the last chapter.

The last chapter concludes the thesis by elaborating upon the main research findings and results. It presents some theoretical reflections on academic distribution and further research as well as policy recommendations.

CHAPTER 2

Development of Freshwater Aquaculture

This chapter provides an analysis on how aquaculture development, moved from the global to regional, then to the local level until it is implemented in Thailand's upper northern provinces. Three villages are the main focus of the study. These are Maekaedluang Village in Chiang Mai, Sanpakhee Village in Chiang Rai and Tamphralae Village in Phayao according to the aquaculture initiative. The sites are characterized by their particular physical and socio economic contexts. For more information, the study takes into account the location, topology, irrigation system, population, production system, land use and the number of fish farms. The reasons for adopting pond-based aquaculture and fish farmer cooperation development are also taken into consideration.

2.1 Development of Aquaculture at National Level

Nile tilapia (*Oreochromis niloticus*) is considered in this study as this species of fish constitutes a large share in global production. Ranked third after carps and salmoinds, it is cultured in more than 100 countries around the world (El-Sayed 2006). Native to Africa, tilapia originally belongs to the family Cichlidae. It was introduced into many countries during the second half of the 20th century. The Nile tilapia became popular for aquaculture because they grow fast, are tolerant to stress and diseases, various environmental conditions such as salinity, dissolved oxygen (DO) and temperature as well as its taste (Falvey, 2000). In 2006, the total global fish production was about 1,988,726 tons of which more than half came from the Asian region. China produced around 1,111,461 tons during 1982-2006. Next was Egypt with 258,925 tons. The Food and Agriculture Organization (FAO) in the US reports that the tilapia consumption trend is obviously increasing around the globe including Thailand (DOF, 2014). The freshwater aquaculture initially developed in 1922 after the Chinese carp was imported to Bangkok for culture. In 1951 the Department of Fisheries (DOF) started promoting an aquaculture program of the following five species: Nile tilapia, hybrid catfish, silver barb, giant river prawn and snakeskin gourami (FAO, 2009). On March 25, 1965, Nile tilapia (*Oreochromis niloticus*) was introduced to Thailand as an official gift to the King (Abdel-Fattah, 2006). At that time Emperor Akihito, His Royal Highness, the Crown Prince of Japan, sent His Majesty the King 50 Nile-tilapias that were 9 centimeters in-length and 14 grams in-weight. His Majesty the King fed them in the Chitlada Palace garden for five months. He gave the fish a royal name, "black tilapia" or “Nile tilapia” (or called “*Pla Nile*” in Thai). To raise this fish for his population, on March 17, 1966, His Majesty the King allowed DOF to feed and breed 10,000 fish with 3-5 cm body length at the Experimental and Breeding Plan, Bangkhen campus and other 15 fishery stations throughout the country before distributing to the people nationwide (DOF, 2014).

From the mid- 1960s, since water supplies were not stabilized as a consequence of diminished harvest of wild fish, aquaculture became widespread and vital in alignment with the demands of an increasing population. During the decade, globalization had emerged and boosted economic activities and massive investments across the national level (Belton and Little, 2008). Significantly, between the 1940s and the 1970s, Thailand underwent rapid social and economic transformation from an agriculture-based economy to an export based industry as well as rapid urbanization through the Five-Year National Economic and Social Development Plan in 1961 (Phrek, 2002). Green Revolution technology was introduced to promote new commercial crops, infrastructure support, modern farming techniques, along with more inputs of labor, capital and pesticides. The more farmers invested, higher the return expectations, according to the intensive agriculture system. Higher inputs may maintain soil fertility and productivity that would otherwise be lost. However, their production might fall in the face of uncertain market prices and natural disasters like droughts and floods that unexpectedly affect their paddy fields. Thus, some farmers diversified themselves away from agriculture farming into more stable and higher income sources as a component of their portfolio of household activities (Bush, 2003). At that time, Bangkok also became the center of Thailand’s early industrialization and aquaculture development.

DOF played a significant role in distributing the fish species by introducing techniques, providing support and training aquaculture producers. Agro-industrial corporations especially the Charoen Pokphand Group (CP) were major in introducing aquaculture development in Thailand. CP introduced contract farming systems for integrated chicken/pig and fish-farming (Belton and Little, 2008). Since then, the fish farming practice shifted from the traditional semi-intensive system to more intensive production systems that required the employment of high-stocking densities of cultured species to maximize the production yield. Significant levels of integrated farming promoted in conjunction with pigs and chicken were introduced in many Northern provinces with access to water bodies and irrigated areas. The systems depended on artificial feeding, water reuse and/ or exchange, high levels of technology and management tools. Transportation and communications involving producers, wholesalers and retainer middlemen also helped expand aquaculture and made tilapia marketing more competitive. Nile-tilapias are now distributed throughout the country and have become popular. Production has risen to more than 200,000 tons per year (DOF, 2008). This provides various kinds of jobs and skillful careers associated with the fish nursery and fish feed industry, the production process, market trade and freezing storage (Belton and Little, 2008).

Freshwater aquaculture is greatly developed and cultured in an earthen pond and cage culture. It is noted that the male Nile-tilapia grows faster and are more cost-efficient than their female counterparts resulting in higher demand of male fish rather than for a mix of gender. Some breeders try to develop the gender changing process used around the world, where the female fry temporarily become male. The process has higher production costs of male hormones mixed with feed for the fry. Later on, transsexual Nile- and red hybrid tilapia (*Oreochromis mossambicus*, or "*Pla Tubtim*" in Thai) were raised particularly in cage cultures all over Thailand. Tilapia has 44 percent of the total number of fish production holding, followed by walking catfish (*Pla-Duk*) and the common silver barb (DOF, 2003). It is noted that fifty six percent of fish culture is for sale. Moreover, 339,887 Nile-tilapias are widely fed in earth ponds in a number of fish-pond holdings while 6,705 are in cage culture (Phum-Thai Farm, 2014).

Fish systems have become more specialized and commercialized in order to participate in the market. In the last few decades, the fish-pond culture was previously a traditional cheap protein source for household viability and generating extra income. Native fish species were favored such as cultured common carp, Nile tilapia and silver barb. They could be found in natural water resources or traditional ponds. Today, due to its high popularity the Nile tilapia fish-pond culture is characterized by its commercial aspect. With different purposes of the rearing practice, Pornpimon et al. (2013) state that Nile tilapia is raised in the three types of pond systems: (1) the commercial system using intensive pellet feed; (2) the integrated system using natural food through pond fertilization and supplementary feeding (with pigs or chickens); and (3) the subsistence system mainly for home consumption, which can be mixed with other kinds of fish and raised during unconditional period. The first two systems are run during the controlled period of the rearing practice.

To develop Thailand's fish quality, the DOF has launched the Good Aquaculture Practice (GAP) standard for export-led development since 2011. The main objectives are quality, safety, non-chemical contamination and non-use of prohibited drugs and chemical substances. For more livelihood security and sustainability, the fish farmers are required to learn how to rear fish to meet the GAP standard and produce safe fish for customers. According to the regulations, the rearing practices have to be improved and developed. Fish farmers are required to register for farming and follow the rules. The first rule is to locate the pond within easy access to clean water in order to avoid water pollution and to be able to change the water regularly. Secondly, fish farmers should follow the academic guidelines and make a farm map. Thirdly, the farm should be convenient for transportation and for releasing water that is under the standard control.

In case of fish diseases, urgent use of chemicals is prohibited, but rather changing water or running an aerator is allowed. If it is out of control, the registered fish chemical substances are preferable to avoid mistreatment as well as to prevent perennial diseases that might contaminate the food at risk for further consumption. In this way, the fish farmers have to report to the related DOF agencies. In terms of water management, polluted water and waste from households should be separated or avoided. Purifying water in the pond before discharging should be implemented. Furthermore, the fish farmers are required to record the use of feed and chemical substances from production to distribution. The process is beneficial for problem analysis and improvement. The GAP standard is implemented in fish farming nationwide by the DOF agencies. The actual standard is applied into various kinds of rearing practices (Freshwater Aquaculture Research and Development Center, 2011).

Nowadays, tilapia fillet under the GAP standard are exported by several big agro-industrial companies processing fish products to the US, European countries and Kingdom of Saudi Arabia. However, the number of the exported product is still low since many fish farms do not meet the GAP standard. The export price is also unfair compared to the domestic trade because the transportation distance, far from the US, makes it harder for Thailand to compete with other closer production countries. Thus, 89 percent of fresh tilapia production is mostly for domestic consumption, just 5 percent for fish processing, 3 percent for grilled fish and the rest for other forms of fish processing (DOF, 2014).

2.2 Development of Aquaculture in the Northern Region

The development of the economy and water supplies make widespread aquaculture viable. The freshwater aquaculture initially from Central Thailand has been introduced to other regions of the country. In the past, peasants in Northern Thailand aimed to achieve food production and food security (Yos, 2008). Villages relied mostly on (glutinous) rice cultivation subsistence during the rainy season, and practiced commercial irrigated crops during the dry season. However, subsistence agriculture started to diminish, while cash crops according to the market influence were increasing (Bruneau, 2012). According to A Siamese Tragedy (1998), rural farming in Thailand was declining. This showed the ongoing failure of development theory, policy and practice in the country (Rigg, 2001). Rural dwellers are now confronted with degraded environments, debts, widespread inequality and the decline of rural communities (Goss and Burch, 2001; Ben and Little, 2008). At the same time, aquaculture has become vital for livelihood income.

Various institutions such as DOF agencies, universities, overseas development agencies and NGOs have been driving the extension of pond farming in Northern Thailand

(Belton and little, 2008). The Bank for Agriculture and Agricultural Cooperatives (BAAC) offer credit for a large number of farmers (Belton and little, 2008). In other words, commercialization of aquaculture has been adopted nationwide and upper Thailand is one of the biggest bases of fish pond farming. From figure 2.1, measured by the number of farms, Chiang Rai is the biggest production base in upper Northern Thailand, followed by Lampang, Chiang Mai, Nan, Phayao, Phrae, Lamphun, Tak and Maehongson respectively in 2010 (DOF, 2014).

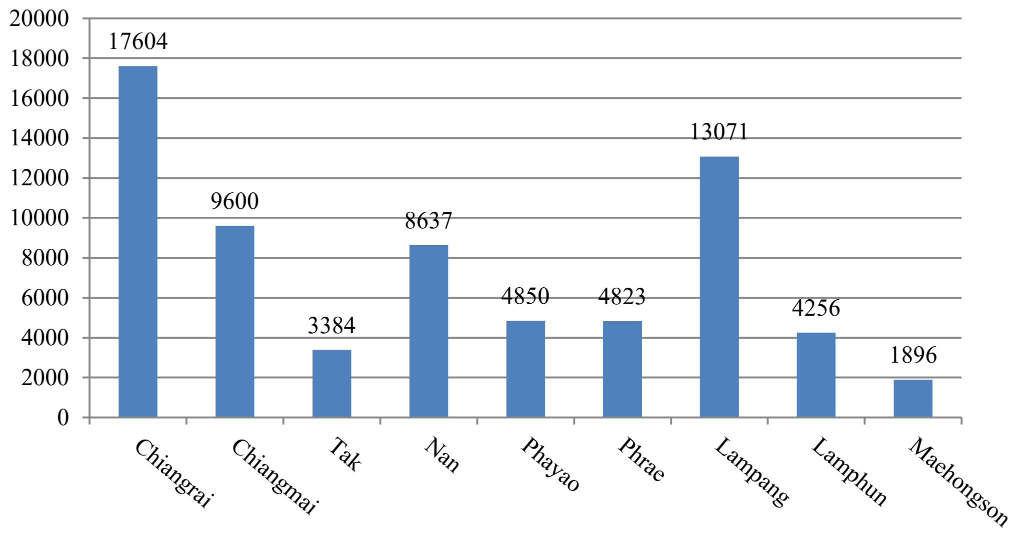


Figure 2.1 Fish production in 2010 in upper Northern Thailand (Kilogram)
(Source: Department of Fisheries, 2013)

Most fish cultures in earthen ponds in upper Northern Thailand are intensive and integrated. The use of artificial feed, drugs, hormones, fuels, etc., is unavoidable in intensive culture practices. To have high returns, it is mandatory to put in more massive investments than the integrated system. In terms of feed, the feed company agencies suggest using catfish feed these days to replace the tilapia feed for intensive and integrated farming in all sites. The catfish is a carnivore, but the tilapia is an herbivorous fish. If it is fed with catfish feed, the growth rate will be faster and the fish heavier. Nonetheless, reducing pellet feed and increasing pig and chicken manure instead can reduce the cost of investment. However, the system is in turn claimed to pose environmental and socio-economic impacts. Consequently, the GAP standard is not applicable to the integrated system that is mostly adopted in Phan District, Chiang

Rai and some in Sansai District, Chiang Mai and Bantam Sub-district, Phayao. Fish farmers raise pigs on top of fish ponds whereas a few of fish farmers especially in Chiang Mai, implement fish-chicken farms. The manure from pigs or chickens generates algae and plankton for fish feed. This system requires frequent changing of water; otherwise, the water quality in the pond will be poor with high ammonia that destroys the fish immune system. Fish farmers in Phan are resisting following the GAP standard, unlike most fish farmers in Bantam Sub-district and some in Sansai District.

2.3 Overview of Community Structure and Irrigation System

To respond to the aquaculture development, His Majesty the King paid attention to water sources, and issued the order to build up water catchment and weir to deal with either drought or flood. Since he realized that aquatic animals were a protein source beneficial for his subjects, fisheries and aquaculture were required to develop in line with the water sources (RID, 2014). The water systems had impacts on local water systems and the livelihood of water users.

Tracing back to the past, water users were united and bonded at both household and community levels. Kinship relations of fish farmers and other farmers had been a solid foundation of community unity. Most of the villagers were relatives while a few outsiders were found via marriages. They supported credit among social networks inside the villages (family, sister-brother and patron-client relations). They also relied on *Muang Fai* systems (communal irrigation systems) that were different in particular local places. With past keenness in water resources development, the self-reliant farmers in the *Muang Fai* system built irrigation systems to supply water to all the members in the community. In this way, Sanya *Muang Fai* was drafted under the agreement among all water members with the irrigation administrators such as the *Kae Muang* or local communal irrigation leader, *Rong Kae Muang* (deputy chair), *Phuchuai Kae Muang* (assistant) and the water users.

Water users, who identified themselves as *Muang Fai* members, honored the plan and participated in the collective activities or functions, particularly during the weir-repairing time around June (Tassanee, 2008; Vanpen, 1998). The system had long existed in the *Lanna Thai Kingdom* about 1,348-1,448 years ago. With local solidarity and public participation, communities were formed as an organization in charge of systematic water usage for cultivation to cope with unpredictable water levels at the beginning of the monsoon season, as well as to share water during the dry season (Vanpen, 2005). *Muang Fai* managers adhered to the principles that all members should be equally treated and that all management activities should be transparent and accountable to the members in the community (Tassanee, 2008).

2.4 Village Contexts

The national aquaculture development is driven at local and regional levels. This study is conducted in three villages in three provinces of the upper Northern Thailand. These are namely Maekaedluang Village in Chiang Mai, Sanpakhee Village in Chiang Rai and Tamphralae Village in Phayao. The three villages are located in the northern river basins with different historical backgrounds as well as physical and socio economic contexts. The sites are located in different degrees of urbanization and irrigated zones under the different water regulations. Chiang Mai, most influenced by urbanization, is one of the biggest fish market while Chiang Rai is a bigger core fish supplier than Phayao. Both of the production sites distribute to the upper Northern provinces including Chiang Mai. Prior to elaborating the chronological contexts of Northern aquaculture development, it is important to generate the overview of its irrigation systems. Then, the contexts of Maekaedluang Village as the first kicking off the fish-pond system are given, followed by Sanpakhee and Tamphralae respectively.

2.4.1 Maekaedluang Village

Maekaedluang's name does not appear in any evidences, but it literally means a small village. Mae means mother, Kaed is small but Luang is big creating a contrast between the last two words. Due to the density of population and household expansion, the village was separated into Maekaedluang and Maekaednoi (small). Thus, there are both big and small Maekaed Villages.

1) Physical contexts

Sansai, a district of Chiang Mai, is close to Mae Rim, Mae Taeng, Doi Saket, San Kamphaeng and Mueang Chiang Mai. The district is subdivided into 12 sub-districts (tambon). Maekaedluang is one of the villages in Nongchom Sub-district under the Sub-district municipality. Located in the low river plain, the villagers have experienced several flood events. Nowadays, the area is influenced by urbanization expansion. Large pieces of agricultural lands have been converted into residential estates while some have been left idle or are for sale.

The water flowing to Maekaedluang Village relies on the Maefaek-Mae Ngat Irrigation Project, which receives water from Mae Ngat Somboon Chol Dam. The water management system is mainly regulated by the Royal Irrigation Department (RID) that controls the *Muang F*ai system. In 1984, the RID in Chiang Mai built Mae Ngat Dam and completed Mae Kuang Dam in three years later. Maefaek-Mae Ngat Irrigation Project was developed from the *Muang Fai* system used for more than 700 years. The weir was built from local materials like bamboo, wood, pebble and sand. However, the local weir was often broken, so the RID was assigned by His Majesty the King Rama VII to construct a concrete one in Chiang Mai in 1928 on about 70,000 rai of agriculture lands.

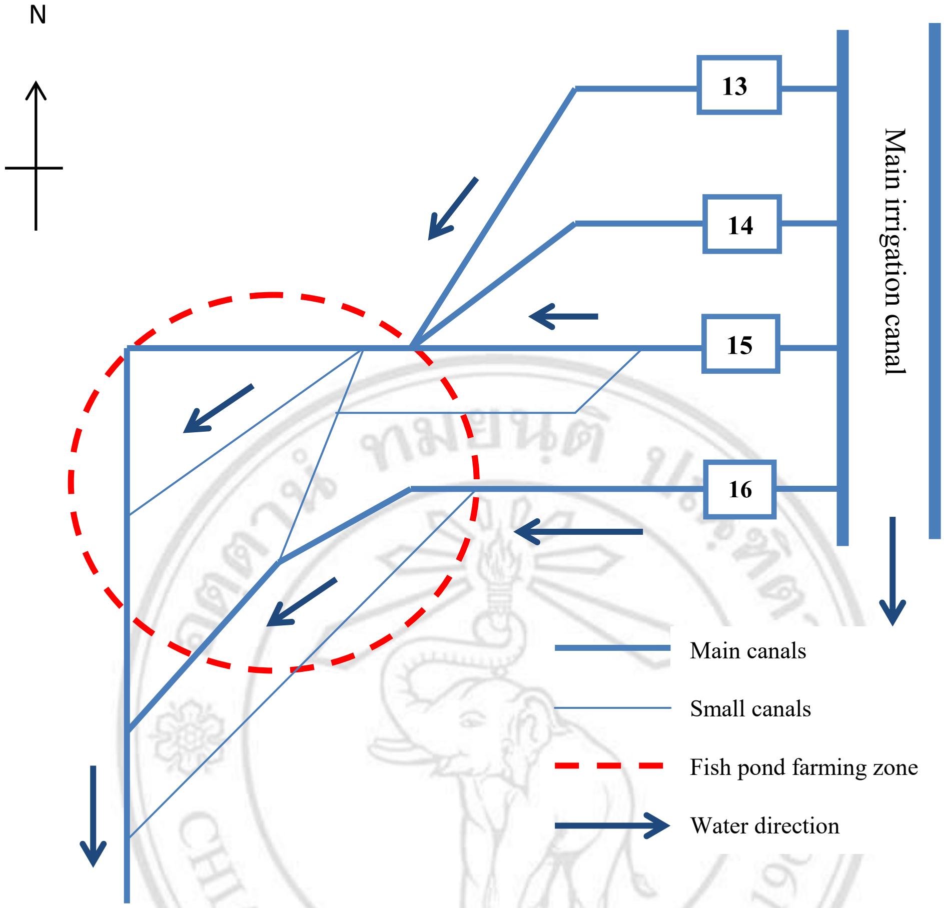


Figure 2.2 Irrigation canals in Maekaedluang Village

The Mae Ngat Somboon Chol Dam was built in 1952 and targeted to supply water to agricultural areas all year round for generating electricity as well as fisheries. To improve management and efficient water utilization, the Maefaek-Mae Ngat Irrigation Project and Mae Ngad Somboon Chol Dam were combined and controlled by the RID. The irrigated areas are divided into LMC (left main canal) and RMC (right main canal) for better management and distribution. The first part, which includes 1 to 8 smaller canals, receives water before the second comprising of 9 to 17 smaller canals. Maekaedluang Villager belongs to the RMC. The area not only receives water mainly from canals 15 and 16, out of a total of 16 canals, but also from canals, 13 and 14, which are released from the Maefaek-Mae Ngat Irrigation Project. In figure 2.2, water from the main irrigation canal is discharged to such small canals at the same time. The canals, 13 and 14, which are stocked by the local and state weirs, flow into canal 15. The water level of the last canal is therefore always slightly high, although it is out of the water allocation time. In addition, some fish ponds receive water from canal 16, which releases downstream to meet the water in canal 15.

Water allocation is systemized by RID while the *Kae Muang* as irrigation volunteer is assigned to regulate and freely design the allocation for more distribution and equality. He then assigns other local people, whose houses are settled at the irrigation doors, to open and close the water as much as the given amount of water and the restricted date controlled by the RID plan allowed. The water utility focuses mainly on agriculture activities that use water twice a year without affecting the pond-based aquaculture's need, which uses water all year long. In other words, fish farmers can get water for the rice production period.

Water allocation is different in different years. During the rainy season (the end of June - the end of November), the amount allocated each year is slightly different depending upon the agreement of RID and *Muang Fai* groups. Allocating water during the dry season takes turns between LMC and RMC, and between opening 3 days/closing 4 days and opening 4 days/closing 3 days. For instance, in 2013, water flows for the water users in the LMC was opened for 4 days and closed for 3, but the RMC part followed another system. In 2014, the turn of opening 4 days and closing 3 days was converted for water users in the RMC.

Water fees are also collected. Prior to the Mae Ngat Dam construction in 1985, water users in the past were required to pay a water fee via two bucket of rice. The water fee became a consented norm and sanction among the users. With the social commitment and punishment, all water users are required to pay this fee. Collected by the *Kae Muang* or his assistants, the fee now is 30 baht/ rai (Thai land measurement unit is equal to 0.64 hectares) for farmers and 50 baht/rai for fish farmers changed from 200 baht/pond. On the other hand, there is no standard rate of fish size. Some people have a lot of ponds but pay the same rate as those who have a smaller number of fish ponds. Breaking the rule will make it difficult for them to socialize with others who pay the water fee. In addition, the fee is used to be the *Kae Muang*'s yearly salary and partly for irrigation maintenance costs. All water users also have to participate in clearing canal activities around July or August every year. Anyone who misses the participation will be fined upon the *Kae Muang*'s judgment.

Water flow is abundant for both agriculture and aquaculture, but the resource conflicts remain. The top-down RID demand does not receive good cooperation from the local water users. For instance, the doors used to open and close the waterways are left uncared for, and have been broken into by farmers who illegally release water to their farms. In addition, farmers and fish farmers do not report the actual farm sizes to the RID that determines the water allocation schedule. The amount of water, as a result, is not enough to meet the real agricultural demand, thus leading to resource conflicts. At the local level, fish farmers upstream release poor water to other water users downstream, causing fish death and diseases as a consequence.

2) Socio-economic contexts

According to table 2.1, Maekaedluang Village contains 206 households with a total of 638 villagers, comprising of 295 men and 343 women. The average age of the farmers is 57.6 years old who are part of the aging generation. One hundred and ninety households earn a living from off-farm jobs, followed by 40 households operating fish farms and 20 households practicing agriculture farming. In the past, the majority of villagers essentially did farming. After finishing in-season rice, most farmers grew tobacco and commercial crops such as soy-bean, chili and tomato for agro-industrial factories. They used a large amount of pesticides to cope with reduced soil nutrients and pests. After the factories closed down, most farmers tended to grow in and off-season rice; some grew chili, maize and cabbage during the dry season.

Table 2.1 Summary of village profile
(Source: Nong Chom Sub-district Municipality, Sanklang Sub-district Administrative Organization and Bantam Sub-district Municipality)

Study areas	**Sansai District, Chiang Mai**	**Phan District, Chiang Rai**	**Muang District, Phayao**	
	Maekaedluang Village	Sanpakhee Village	M. 7 Tamphralae	M. 11 Tamphralae
Local government system	Nong Chom Sub-district Municipality	Sanklang Sub-district Administrative Organization (SAO)	Bantam Sub-district Municipality	
Number of Households	206	190	250	273
Male	295	337	473	459
Female	343	369	426	440
Total	638	706	899	899
Average age of household head	57.6	57	52.6	54.5
Agriculture farming household	20	130	202	250
Fish farming household	40	72	82	10
Off-farm household	190	20	16	70
Completely exit household from fish farming	3	2	1	4
Location of water	Midstream	Upstream	Upstream and midstream	
Irrigation system	RID and *Muang Fai*	RID	*Muang Fai*	

The agricultural production failure often occurs as a result of the environment variability and market price fluctuation. Due to urbanization influence over the village, most farmers then seek off-farm opportunities that offer a more stable income than farming. No longer is there crop intensification, but numerous villagers instead grow mango, garlic, papaya, coconut, lichi (lychee) and banana for household consumption, as well as longan and mushroom for sale. At the same time, many of the farmers who lost their profits from commercial crops, converted their lands to fish ponds- while five fish farmers raised chickens in addition to their ponds. Other animals like cows, catfish, frogs and fighting roosters are raised for sale.

Figure 2.3 The commercial system of fish farm in Maekaedluang

Figure 2.4 The integrated system of fish farm with chicken in Maekaedluang

The village lands were previously used as rice paddy fields surrounding the residential zone. But due to the low geographical lands, most farmers perennially experienced flooding. Their perpetual production failures motivated those farmers to shift this production type to the safer and more profitable fish farming. Fish farms were expected to block the uncontrollable, uncertain and excess water flow in the rainy season and to make more money than agriculture farming. As a result, more than half of overall lands were taken over by a large number of fish ponds along the canals while few paddy fields were seen. Since the urbanization area expansion, many rice paddy fields were filled up and sold to new comers or outsiders.

A large piece of land located upstream of canal 15 that has long been idle, was sold to build residential estates. Many agriculture lands have been filled up to build dormitories, rental houses and buildings. Furthermore, two vast filled lands downstream are also on sale. Undoubtedly, the land price has risen from 40,000-48,000 to 240,000-400,000 baht/ hectare (6.25 *rai*) within 5 years causing difficulties for fish farming investors. Investing in fish farming with high risks might not be worth it in the short run compared to selling or leasing the land to other landlords. Some fish farmers losing their profit decided to lease the ponds to other investors including migrants. Some leave the ponds idle for too long while collecting money for further investment. Meanwhile, other villagers also put aside a partial compound of their houses to build rented rooms for migrant workers who live together as a big community. The rental fee is usually about 1,000-2,000 baht/ room/ month.

In terms of labor, the average labor age is about 40-70 years old, none of the offspring is working in agriculture farming but there are a few in fish farming. The majority of villagers tend to work off-farm while supporting their children from farming. Since the last decade, due to the agriculture pattern development, many advanced agricultural machines have been adopted to reduce the hardship and time spent in the fields. Tractors, axial flow rice threshers and harvesters have become so popular that they have replaced a number of reciprocal and hired labors. The hire cost increased to 200 - 300 baht/ day regardless of the recent labor wage policy. Thus, labor costs in rice cultivation and harvesting are about 464 baht/ hectare excluding fertilizers and chemical costs of about 320 baht/hectare (6.25 *rai*).

By contrast, most fish farmers with limited lands rely on their labor forces as well as family members. Except for the small and large operators, they mainly hire migrant workers who can get through harder work than the local Thai people. In this way, the former migrant workers urge the new comers to seek for jobs in the area that expands the size of their community. The more migrant workers there are, the more local trade gain benefits. They work as independent employees in collecting chili, growing rice, and other works. In the fish industry, they are hired in the morning as fish harvesters with a daily wage (total daily fish weight divided by a number of fish harvesters). Most of them are not only fish harvesters, but also fish retailers which sometimes causes conflicts of market interest with some local Thai retailors. Their children also study nearby at the Thai school that includes a larger number of Taiyai (who predominantly live in the Shan State of North East Myanmar) children than local Thai.

3) Fish pond implementation

Chiang Mai Province has a huge growing population with high consumption demand. As a result, the aquaculture demand is higher since the urban dwellers are unable to find and capture natural fish like in the past (Belton and Little, 2008). The freshwater aquaculture here was initiated in 1982 before the Mae Ngat Somboon Chol Dam construction. Common carp with egg breeding was promoted in rice paddy fields. The fish was fed by paddy husk, cut glory morning vegetables, coconut residue, household leftover and boiled rice. Then, the DOF played an important role supporting feed and selling fish for farmers after harvest. In 1995, with cooperation from DOF, the agro-food industrial company (CP) arrived and urged farmers to raise chicken in addition to operating fish-ponds. It is fundamentally the initial stage of aquaculture development. A large number of farmers converted their rice paddy fields to semi-intensive fish and chicken farming. The BAAC also was also an essential driver offering loan for those farmers.

The chicken system was made through the contract farming system managed by the agro-food agencies that often gave advice to the farmers. The chicken manure would fall into the fish ponds, causing the fish to grow faster. Without pallet feed, fish raised for three months weighted only half a kilogram. During 2001- 2002, 90% of fish farmers stopped raising chickens after suffering from Avian Influenza and summer thunderstorms a year later. The coops were collapsed and a lot of chickens were drowned. Then, fish farmers gradually chicken farming but continued raising raising fish. There are now just 5 chicken farms left out of 32 farms.

> "No money from fish and chicken. Everything's gone. I have no money left and doubt what to do. Fish investment cost is dam high. Fish farmers have to adjust," said one fish farmers in Maekaedluang (12-06-2013).

2.4.2 Sanpakhee Village

Sanpakhee in Phan, Chiang Rai denotes the highlands (*San*) of local vegetable (*Pakhee*) plantations. 60 to 70 years ago, there were large numbers of both giant and tiny trees but these had died naturally; they were cut for house building and have virtually disappeared today. This village is the largest agricultural community compared to the other two in my study.

Here, the image of the village is presented as fertile, allowing many opportunities for agriculture and aquaculture activities throughout the year.

1) Physical contexts

Phan District is in the southern part of Chiang Rai Province, close to Wiang Pa Pao, Mae Suai, Mae Lao, Muang and Pa Daet of Chiang Rai Province, Mae Chai of Phayao Province and Wang Nuea of Lampang Province. The district is subdivided into 15 sub-districts (*tambon*). Sanpakhee Village belongs to the Sanklang Sub-district in Phan under the Tambon Administrative Organization (TAO). The area is high-land with access to upstream water.

Water runs from Mae Souy Weir, built between 1999 – 2002, in the Mae Souy Sub-district, Mae Souy District, Chiang Rai, and meets the Mae Lao Catchment located in Dongmada Sub-district, Mae Lao District and Thanthong Sub-district, Phan District. The catchment was completed in 1963, covering 23,734 hectares (148,337 *rai*) of irrigated area. It also receives water from Mae Fang River in Chiang Mai. The RID is responsible for water allocation to the area of around 29,449 hectares (184,000 *rai*) concluding in the Muang District, Mae Lao District, Phan District in Chiang Rai and partly, Mae Chai District, Phayao. The main canals, 4L, 5L and 6L, out of a total 8 canals, run through Sanklang Sub-district, which has the biggest fish supply in Phan. In figure 2.5, Sanpakhee Village relies on the canals, 5L and 6L, which divide the village into the left and right sides. The village is on the left of the river and has access to the upstream river from the main canal before it flows downstream. Moreover, there are natural water canals namely Rong Leuk and Mae Pond, which result from natural upstream source in the hill and receive water from the man irrigation canal. Rong Leuk canal meets 5L, which makes the water level enough for many activities. The largest number of fish ponds is located along the canal 5L. The second largest are those along Mae Pond flowing through the village. The smallest number of ponds is at the canal 6L, which comprises of fish farmers from the village and elsewhere.

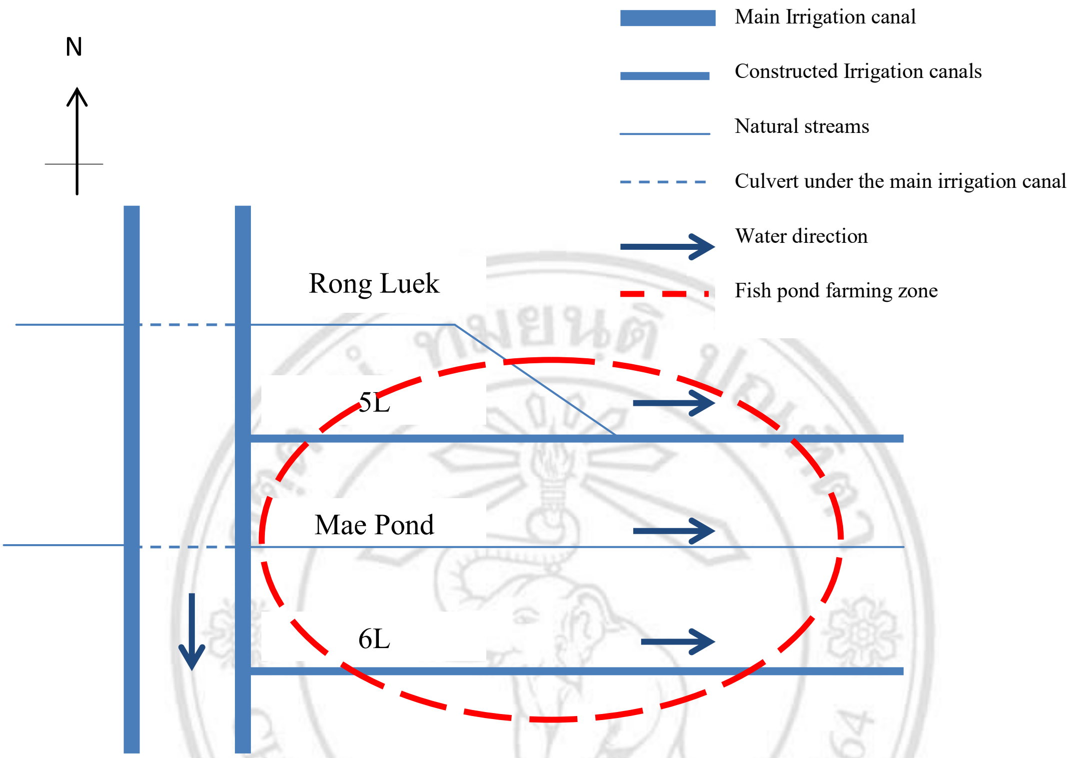


Figure 2.5 Irrigation canals in Sanpakhee Village

Water management is mainly by RID who turn to the *Kae Muang* to be an irrigation volunteer. The latter's salaries are 1,200 baht per month. They are required to control over 320 - 480 hectare (2,000 - 3,000 *rai*) of lands. The volunteers are selected mostly for their farm location, one from upstream and another one from downstream. They are supposed to be either the village headman or a respected person. Their work encompasses the distribution of irrigation news, dealing with local conflicts and clearing the canals. They mainly work to allocate water during the dry season but the allocation is based on the RID plan for the rainy season. If any conflict gets out of hand, RID agencies are required to take the role of mediators and conflict solvers.

In the past, the *Kae Muang* played a role on water management and rallied people to clear canals and make traditional weirs. People had access to water as much as possible and shared it with others. As time passed, the *Kae Muang* got older and few younger people voluntarily took that role. Once the local irrigation system in 1963 has been replaced with the modern Mae Lao Weir directly regulated by the RID, the traditional earthen canal was replaced with concrete. Thus, collective maintenance is now no longer required from the water users. The *Kae Muang* role has been transferred to a hired water volunteer or water leader in charge of each canal. In this way, the water allocation plan is scheduled by urging local water users to attend public meetings before the in- season rice period. They are required to declare their possession of farms and orchards so that the RID can calculate the amount of water use. The RID also mainly discharges water for five days a week to canals 5 and 6 and the other two streams in Sanpakhee Village. In fact, the information communication is not as widespread as before as the water volunteers do not fully play their roles. In addition, the RID allows the volunteers to independently manage water along the small canals and deal with resource conflicts. No water fee is imposed, but a water maintenance fee for each canal is collected among the local users.

"If there is a little problem, we will let them solve it by themselves because we have too few RID agencies to take care of all the people," said one RID agency (10-04-2014).

Water users can gain water as much as they want. The allocation organized by RID is used in the dry season. Table 2.2 gives an overview of water allocation during the dry season from January 1, 2013 to May 31, 2013. There are three rounds as shown by the numbers, 1, 2 and 3, which release water for 5 days per round in order. It is agreed that the water will be opened for 5 days and closed for 10. The canals, 15 and 16, belong to round number 2; then the village irrigation volunteers allocate water according to the local decision and agreement. For instance, at canal 5, before the water comes one day, all users have to first release their current water. After discharging the used water, those upstream will obtain the ‘new’ water first before those midstream and finally, the farmers downstream.

Table 2.2 Water allocation during dry season from January 1, 2013 to May 31, 2013

(Source: Royal Irrigation Department, Maelao District, 2013)

Month	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
January	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1
February	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3		
March	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3
April	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	
May	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	

Note: Number 2 in the table means a period of water allocation in Sanpakhee Village, the number 1 and 3 belong to other villages.

1) Socio-economic contexts

Sanpakhee Village has 190 households and 706 people comprising of 337 men and 369 women. The average age of the farmers is 57 years old, which is slightly lower than that of the Maekaedluang's villagers. A majority of villagers (130) are agriculture farmers, followed by 72 fish farmers and 20 farmers doing off-farm respectively. Agriculture practices have changed after the irrigation construction was completed in 1963. In the past, due to inefficient irrigation systems, farmers could only plant several crops such as cucumber, garlic, shallot and tomato. Once the irrigation system was developed with abundant water, fish farmers basically used water as much as available. 5 years ago, farmers increased their production frequency and changed the crop type. Most of them grew Thai rice both in- and off-seasons. Then several farmers decided to grow Japanese rice, after the Japanese rice company "Thanagrain" set up in nearby the village- and started selling their production at a higher price than ordinary-Thai rice. Through the contract farming system, farmers have to buy seed, fertilizers, and chemicals and hire agricultural machines with the payment regulated by the company.

After the pioneering farmers gained more income than those with Thai rice, the latter started to follow suit one by one via word of mouth until a larger number of farmers decided to grow Japanese rice. It happened during the implementation of the Thai mortgage policy when the Puea Thai Party pledged to pay rice farmers above market prices at 15,000 baht/ ton. Unfortunately, the program has run into the long-overdue payment problems and some farmers have not been paid for months. It is no doubt a large number of farmers shifted to Japanese rice for it is commonly seen that large areas of agricultural lands have been used for intensive Thai rice and Japanese rice as well as earthen ponds. Seventy-two fish farm households (38%), which include 9 fish farm case studies, basically raise pigs in addition to operating earthen ponds as shown in the figure 2.6. One-fifth of them raise fighting roosters for sale and leisure while others grow Chinese cabbage around the pond during the off-rice or rainy seasons.

Figure 2.6 The integrated system of fish farm in Sanpakhee Village

The related state organizations support agriculture production development through different means such as the association led by the village headman who formally gathered farmers together with some funds provided by the state for 6-7 years. The fund is divided up to invest in fertilizers and in housewife groups. The members are allowed to borrow fertilizers with interest, at 30-40 baht/ bag while the housewives invest in pork processing. The income generated is then used for further investment. Moreover, the village-related associations with the state money can give loans to both farmers and fish farmers who meet their criteria and are able to repay. To make use of a large amount of pig manure besides fish feed, the village headman decided to consult with the Rajamangala University of Technology Lanna Chiang Rai with TAO cooperation. Thus, the biogas project was implemented initially on 24 fish farms where the manure and other waste can be recycled into the liquid gas that can be used for household consumption.

In response to a labor wage policy, wages of laborers in construction and agriculture are similarly aligned at 300 - 350 baht per day. However, these laborers are rarely found among their offspring generation who tend to study and work off-farm in the city. Some send remittances to their parents but others do not. A few return home to help their parents with fish farming and its related activities such as working as fish farm employees, fish wholesalers and checkers. Most fish farmers have to rely on their aging labor force while a few big farms hire local labor and migrant workers from Laos and Burma. In terms of farming, exchange labors have been declining noticeably the last two years and have been replaced with mechanization. Most farmers have to pay for many things from seedlings to harvesting cars. Prior to starting agriculture farming, the decision whether farmers and fish farmers are allowed to run their activities is supposed to be passed by public hearing and agreement from all the water users. Although the community structure has loosened due to the mobility, villagers significantly still participate in social activities. Agriculture and fish farmers labor as well as off-farm employees continue to help hold important social events, especially religious ceremonies. They often find spare time to help prepare things and set up the location for these ceremonies. Often the fish farmer cooperative with its large number of farmers in the village not only assists the organizers but also donates money.

Sanpakhee is an important agriculture and aquaculture base with sufficient water sources. Most of the huge areas undoubtedly contain rice paddy fields and fish-pig farms. Due to low urbanization influence, the land price is as about 80,000 baht/hectare lower than that in Maekaedluang Village. The price has risen up between 40,000 to 48,000 baht in the last three years. The land prices are now highly speculated on by many outsiders but the local villagers seem uninterested in meet their demands; instead, they are likely allocate their land to their heirs.

2) Fish pond implementation

Pond-based aquaculture kicked off in 1995. According to the Royal Project of Joint Plantation, farmers were encouraged to grow either hog plums or longans. But the soil is unqualified with few nutrients and unsuited for these kinds of plants. So one farmer initially converted the farm owned by his mother, into a fish pond instead. At that time, his mother disagreed and was angry with him, but he tried to overcome her objections. He fed 4,000 breeding fish bought from the local fish hatchery while raising fish in the pond, but they died. Then he bought 2 pigs with 7,500 baht each, but one pig died, resulting in worsening the relationship between his mother and him. However, he did not give up and decided to sell the fish. He initially earned 30,000 baht, his mother relented, allowing him to increase the number of fish ponds, which were originally paddy fields. He fed the fish with low- cost feed such as duck manure and mixed rice bran and boiled rice. Since then he has not suffered any losses but now gains 2-300,000 baht per crop of fish, which is higher than farming.

At that time, few markets were available, so fish farmers asked their neighbors who were unemployed or free to sell fish in the morning. Then, the markets started to expand naturally, but they had to avoid selling to the same market as other traders. Most of them put the fish into the basket at the back of their motorcycles. To meet the increasing demands of the expanded markets, they adapted to use a sidecar with more carrying capacity. Still, the sidecar was not enough for a large amount of fish and for travelling longer distances to markets. They eventually decided to buy pickups for large tons of fish. It was noted that fish farmers used to gain high profits, but after the number of farmers started increasing, the profit margins fell.

The fish farmers here independently decided to be a part of any fish groups. Some followed their kin and neighbors while others chose the group they liked. Phan comprises of 20 fish groups that exited from the Pha Thong group founded 20 years ago. In Sanpakhee Village, most fish farmers belonged to the A group (pseudonym); several farmers were in the B group (pseudonym) and the rest was with other groups. Each fish group did not cooperate with the other. Fish products are harvested in the early morning since between 5 to 10 o'clock. Farms can hire fish harvesters from their fish group for 250 baht each and the owners were expected to serve breakfast to their stakeholders.

2.4.3 Tamphralae Village

Muang Phayao is the capital district of Phayao about 40 kilometers from Chiang Rai. The neighboring districts are Mae Chai Phukamyao and Dok Khamtai of Phayao Province, Pa Daet of Chiang Rai Province, and Ngao and Wang Nuea of Lampang Province. The district comprises of 15 sub-districts. Tamphralae is one of the villages in the Bantam Sub-district under the sub-district municipality. This study takes place in both Tamphralae Mu[1] 7 and Mu 11, which used to be part of the same village. Because Tamphralae Village previously contained a dense population of around 523 households; dividing it into two smaller villages made the development project and administration fund more efficient and widespread

1) Physical contexts

Tamphralae is located in between outside villages and inside villages with the same name "*Tam*" which represents river flow. The outside villages are Tamdonmoon (high land of sediment), Tampalan (forest land), Tamnamlom (surrounded by amount of water) and Tammon (high hill) respectively. The inside villages are foothill Tamklang (the middle) and uphill Tamnai (the furthest inside) respectively. Thus, these villages rely on related common water flow. Tamphralae's river flow areas can be easily recognized by the beautiful Buddha image with the turned head. The village landscape is made up of foothills that were previously safe from floods and droughts due to the efficient water upstream. However, the villagers recently faced flash floods and recurrent drought. Similar to farmers in Tammon, Tamnamlom, Tampalan and Tamdonmoon, they often suffer from flooding and low flow.

[1] Thai Village (muban) represents the actual settlements of the village. It can be called mu, often abbreviated "M."

The villagers thus only do in-season rice a year and leave the land idle for the rest of the time. So fish pond farming is rarely seen downstream.

There are six main natural water sources shown in the Figure 2.7: (1) Huay Hiek Reservoir constructed in 1996. The reservoir was developed by the Phayao Irrigation Department in response to the Royal Project edict. The aim of the project is to reserve water for agriculture and consumption. The reservoir has a capacity of 595,000 cubic meters that is distributed to the 256 hectares (1,600 *rai*) of land during the rainy season and 64 hectares (400 *rai*) during the dry season (RID, 2014). The water is also supplied for daily use in the Tamphralae Village. However, the water level is low from deforestation without serious control from the National Park officials and polluted from pesticides and upstream fish-pond farms. As a result, the villagers no longer use and drink the water; buying water bottle has become a new way for survival.

The rest of the water sources are naturally constructed; (2) Mai Yang Weir gains water from Champathong Waterfall and then releases it (3) Thung Klong Catchment (built in 1983) before flowing to (4) Tontakhienkhu Weir and agricultural lands. The irrigation system nowadays has higher capacity to support water for widespread agriculture; (5) Champathong Waterfall, a source of water from Doi Luang National Park. Here a big organic-related product company has established itself upstream for rubber plantation. Finally, (6) Khuntam Waterfall, an important natural water source with fertile forest but it has been deforested for growing numerous commercial crops and intensive fish-pond expansion.

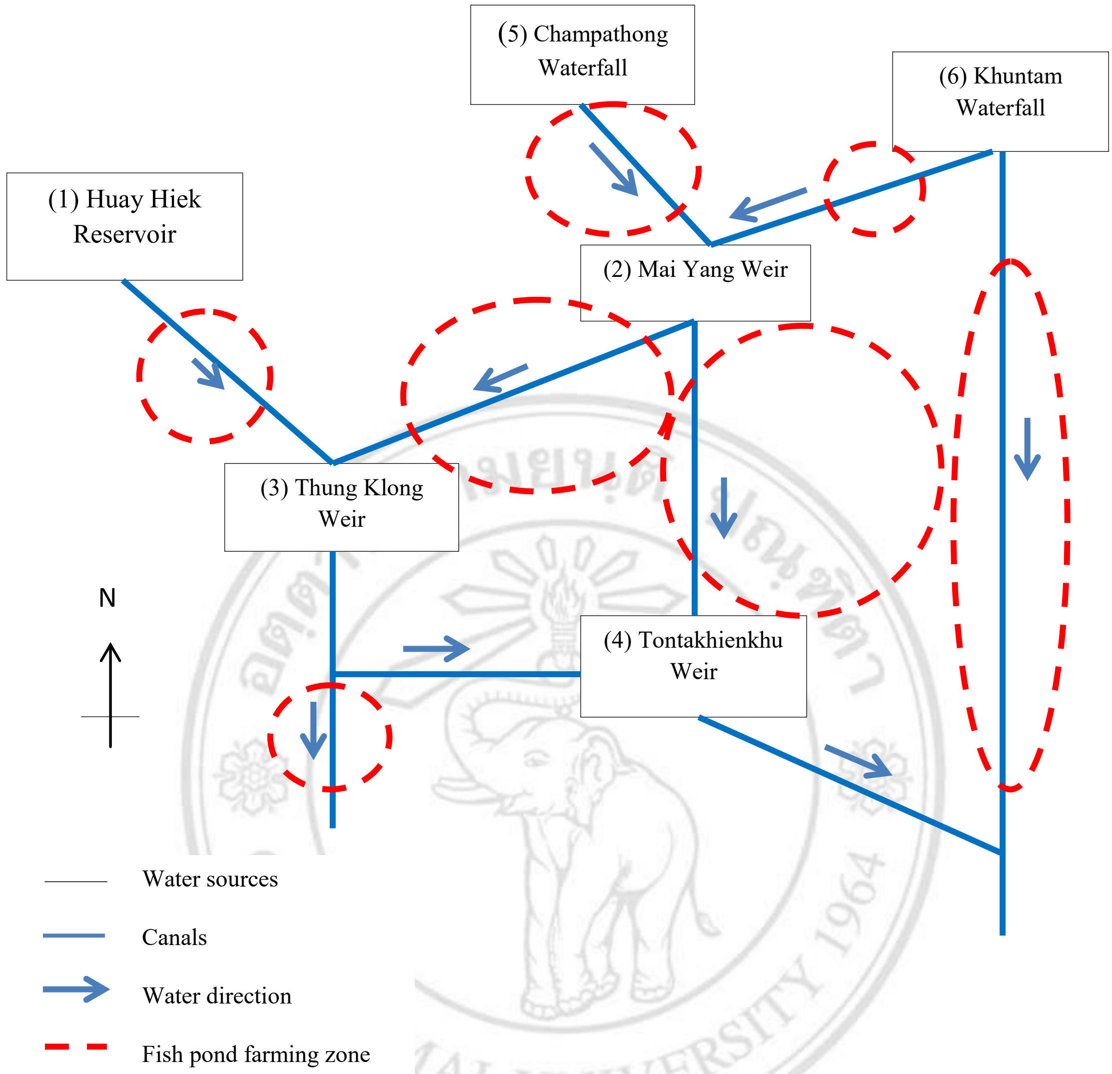


Figure 2.7 Irrigation canals in Tamphralae Village

The irrigation system in Bantam Subdistrict, Phayao District is under the subdistrict municipality control of overall water management and construction. RID role partly offers knowledge and academic information to support water allocation. In fact, *Muang Fai* groups are assigned to run the system. The *Kae Muang* adopts the discursive water management plan, allocates water and clears the resource conflicts. Moreover, he is a representative to attend meetings and to voice out the local problems for all water users. In the past, the *Kae Muang* role was once significantly important in managing earthen water ways and maintaining natural wooden weirs. But the Royal Irrigation Department cooperated with the municipality to replace the earthen canals and the traditional weirs with concrete that is beneficial in preventing the absorption of water in soil and secure the water flow for more than five meters. As a result, the common activity of clearing the water-ways is less necessary than ever.

In terms of *Muang Fai* activities and its role, one communal irrigation leader is responsible for each irrigation zone during the duration of in-season rice planting. Furthermore, either farming or fish farming has to pay water fee at the same rate of 100 or 200 baht per pipe depending upon the agreement of each *Muang Fai* group. Every water user is asked to clear the waterways. The one who takes too much water will be fined 100 - 300 baht. In this regard, the *Kae Muang* is required to transparently inform all water users the overall expense' plan which is divided into two parts, namely, (1) the *Kae Muang*'s salary; and (2) irrigation maintenance fund. If it is not enough for maintenance, he will raise new funds from the users. The common activity of cleaning the waterways basically begins in May. For example, if the weirs collapse, the *Kae Muang* will encourage water users to solve the problems by hiring a backhoe car to fix the canals or fixing it themselves. Anyone who does not participate in the activities or breaks the rule will also be fined. If there is any conflict during the off-rice season, water users are asked to solve the problems by themselves. In some *Muang Fai* group, led by the local irrigation head, water will be allowed for farmers in daytime and for fish farmers at nighttime.

2) Socio-economic contexts

The two Tamphralae villages have a total of 523 households. M.7 contains 250 households with 899 people comprising of 473 men and 426 women. There are 273 households in M.11with a total of 899 people covering 459 men and 440 women. The average age of the farmers who are family leaders is 52.6 years old in M.7 and 54.5 in M.11, which are roughly similar to the other two previous villages. The largest number of people in both villages is in agriculture farming. In M.7, 202 households are farmers; 82 are fish farmers (including 9 fish farmer case studies); 16 are off-farm workers as well as 1 household exiting from fish farming. M.11 has 250 households of farmers, 10 fish farm households, 70 employee households and 4 households exiting from fish farming. It is noted that a number of people are overlapping across careers because some are not only employers, but also farmers and/ or fish farmers as well. However, the way to study here is combining the two villages into one community that share the common diversification occupations, household structure and land and water use.

The villagers rely chiefly on agricultural activities. The villagers who are mostly farmers have their agricultural lands outside the village. With sufficient natural water sources, their previous main occupation was agriculture growing in-season rice and crops in the dry season. These days, based on figure 2.8 and 2.9, many farmers converted their land into commercial fish ponds. Some large fish operators essentially have chicken and pig farms on top of the pond or on the land. Smaller scale operators raise fish and other animals such as cows, pigs, chickens and ducks. Since there is a lot of agricultural land, crop varieties are so diverse including in-season rice, maize, bean, longan, pumpkin and rubber trees, influentially promoted by the state 3 to 4 years ago. For the last 3 years, most farmers, who could access water particularly under the Thung Klong Weir throughout the year, could do both in- and off-season rice. The rest of the farmers just leave their land idle; some grow garlic mainly for household consumption, and for sale. Furthermore, it is noticeable that most villagers tend to grow vegetables in the front and backyards of their house for household consumption and for sale. Each early morning, women will sell their products in the central market of the community to their neighbors and the middle women who have their own shops in the villages.

Figure 2.8 Commercial system of fish ponds in Tamphralae Village

Figure 2.9 Integrated system of fish ponds in Tamphralae Village

The labor shortage situation is similar to the earlier villages in that few of the young generation work in the farm. But labor exchange remains practical here. Several local villagers basically help each other do some agriculture activities such as seedling, growing and harvesting. Nevertheless, the number of laborers is still so rare that it has forced some poor farmers to involuntarily use their own work force. Some with enough money can hire people and machine. Therefore, this image of mechanization has become a normal part of agriculture activities. Most fish farmers meanwhile use their own labor to feed fish but large-scale operators have decided to hire local people.

Even though the village is located in the capital district of Phayao Province, it can be said that the village is situated between local and urban areas. It is observed that there is a high number of shifting land ownership. Large pieces of land in the village and at the hill are leased and sold to outsiders. Most land titles are SPK4-01 which is the temporary land right title for smallholders or the landless to do agricultural activities and are not allowed to buy, sell or lease. In fact, the local owners illegally lease to landlords or outsiders including local politician, businessmen and policemen. The land price is now 80,000 - 112,000 baht/ hectare (6.25 *rai*). This is more expensive than the SPK4-01 which is an upland area priced between 16,000-48,000 baht/ hectare. Most of them invest in rubber plantations and fish farming. It is seen that many villagers claim the land over the national park after which they later ask to transfer the land title into SPK4-01. As a result, the number of forest lands is reducing.

In terms of land use, most fish ponds and agriculture lands are settled upstream along those water sources. In other words, the poor used water releases downstream that impact villagers in Tamphralae, Tammon, Tamnamlom, Tampalan and Tamdonmoon orderly. Apparently, most dense fish ponds are located upstream under the water sources especially Mai Yang Wei. There are a lot of commercial crops such as rubber, maize, bean and pumpkin upstream with intensive use of chemical substance that affects the water users and villagers downstream. Moreover, several rice paddy fields are taking place downstream under the fish ponds and the reservoir. Some fish ponds are located along the canals and even in places with no water flow. It is because even though fish ponds use up a larger amount of water than rice, there is efficient water with more opportunities to get higher investment returns than rice. They prefer relying on underground water. Rice paddy fields as a result, surrounded by the pond expansion that indirectly pressures the conversion of the rice fields to fish ponds.

3) Fish pond implementation

In Phayao, most fish farming in Bantam started with the fish-chicken integrated system implementation surrounded by rice paddy fields. Four to five years later, local farmers founded a chicken cooperative. Unfortunately those farmers experienced fly impacts while the central market hit the northern chicken that made many farmers difficult to continuously run their business. Then the cooperative relatively stopped. They also could not continue the rice paddy fields because it was flooded from the fish pond water. Thus, many fish farmers tended to convert their farming into fish farming completely.

The Phayao fish product was started after they were given support from the state. It is because the number of natural fish in Phayao Lake was reducing from time to time because fishermen caught fish during its egg laying period and other environmental factors. DOF fully took action to conserve the Giant snakehead and Sand Gody, which increases the supply of pond-based aquaculture. The fish-pond farming was booming after the district and provincial authorities drew attention to the success of Mr. A (pseudonym) who was rewarded as a fish expert and an excellent fish farmer in 1993. This reward also inspired other farmers to do fish farming. At the first time, 8 fish farmers gained financial support from DOF, which then expanded to others.

2.5 Reasons for Adopting Pond-Based Aquaculture

Many fish farmers not only work in farming but also seek off-farm employment. Thus, with the differentiation, those fish farmers adopt pond-based aquaculture for the following reasons. Firstly, it is to escape from natural disasters and agricultural losses because Maekaedluang is lowland that is prone to perennial flood. In the rainy season, the rice paddy fields are sometimes flooded with the increasing level of water without releasing the waterways. Pests also sometimes attack their agriculture production. As a result, many farmers have lost their benefits. They have to pay for higher-cost chemical substance, but in turn, their products are as unstable and uncontrollable as their incomes.

Secondly, it is to maximize the return of investment since they have been promised that fish-pond farming has more commercial value than other cash crops. Even if it has higher risks, there is still an opportunity to gain more returns. In this way, gaining profit between rice paddy fields and fish farming is different depending on the geographical landscape and water access. It is evident that Bantam Sub-district with its more limited water supply can grow just in-season rice. Thus, it would be more cost effective to raise fish for 2-3 crops a year. The fish price is also higher than rice per crop and the fish farmers have more income opportunities from off-farm. By contrast, some farmers in Sanpakhee refuse to adopt the fish system because they are concerned that fish is riskier than rice and has a higher cost of investment. They can basically produce rice twice a year while some can do three times a year with a higher return of income but with less risk than culturing fish.

The third reason is to follow other neighbors who have gained profit from fish-pond productivity. Due to good word of mouth, most of them are convinced that fish farming does generate more income. Even though they have little knowledge and experience in rearing fish, they decide to take a risk. In addition, some of the fish farmers inherited the farms from their fish farmer parents. Others were pressured by the fact that their rice paddy fields were increasingly surrounded by large numbers of fish ponds. Therefore, the farmers decided to join in the fish pond farming.

2.6 Fish Farmer Cooperation Development

It is noted that fish farmer cooperatives everywhere are set up to manage production and marketing. The three provinces are interrelated in terms of marketing and sometimes knowledge sharing.

The first fish farmer cooperative named “Pla Thong” was initiated in 1995 by about 550 fish middle men. Later, due to financial conflicts, many members quit to set up more than 10 new groups. Most large operators today set up groups because they have enough skills, experience, knowledge, market bases and funds to afford expensive materials. Most members were medium and small operators. Each group in Phan runs their business independently from processing applications from fish farmers, employing staff, dealing with the harvest process and managing to marketing. A fish farmer is allowed to apply to join more than one group. Some are members of a group because of their personal relationship with their kin groups or have patronage relationship.

Some are private groups while others have set up a kind of fish farmer cooperative. The private group management works faster than the cooperative. Their aims are mainly for increasing the owners' business. The private group is advantageous when fish shortages occur because they can speculate on the price. Conversely, the cooperative is more reliable under the enactment of fish cooperatives while enhancing the relationship of the members with trust through meetings and regulations "*the cooperative is for all your benefit, not for the individual.*" However, such collective activities are rarely seen in the private groups. The cooperative provides feed at reasonable prices but the private group will sell these for profit.

Fish farmer groups in Maekaedluang Village are developed at the village level. In the past, middlemen harvested fish once a year with their provided equipment. The fish price was cheap around 20-30 baht/ kilogram with the weight of 4 grams. From 1999 - 2000, without queue management, fish harvesting became more competitive. Thus, those fish farmers decided to form a cooperative. They managed a sequential queue of harvest and negotiated the fish price with their members. A member quit from the cooperative due to a difference of ideas. He felt he was not heard at meetings since the majority of the members were relatives and did not trust others. Several years later, the old group was broken up two small groups due to a conflict of financial interests. No member gained any collective money from the group. Then, each group started seeking for new members, developing and expanding the marketing with their own abilities and expertise. Today, the number of ponds is increasing and is quickly expanding to other nearby districts.

"Union is a kind of strength. Getting together we live; separating we die. We grow up, we connect and we survive," claimed one leader of a fish farmer group in Maekaedluang (02-02-2014).

There are three big groups of fish farmer cooperatives. The organized production is taken into account. Fish production has become more commercialized and farmers have shortened the rearing duration to meet the faster and higher consumer demands. The market also demands a bigger size of fish. Hence, the rearing practice duration has reduced to 3 - 6 months and organized teams now do the harvesting. The fish farmers have also learned to examine how to choose and use fingerlings, feed and use chemicals wisely. Some farmers started to compare different types of feed for their protein level and price. If the price were slightly different, they would choose the one with high protein. But, investment cost is higher nowadays because they use a lot of machines, technology and chemicals to help sustain the survival rate of fish. Furthermore, most large-scale operators in each particular fish group were the ones who strongly implemented the GAP standard.

In Tamphralae, the local cooperatives in 1996 had started with more than 30 fish farmers. Fish marketing was not as effective then. There were few fish wholesalers and natural fish was only enough for domestic consumption. At first, it was necessary to ask harvesters and traders from Phan who could provide fish materials and marketing, for help because the cooperative was not really organized and methodical yet. Fish price then was quite cheap, fluctuating at around 35 baht/ kg. At that time, Mr. A (pseudonym), the leader of the fish cooperative, got to know the chairman of the Phayao Chamber of Commerce who aimed to make Phayao fish more famous than others. Fish sold in Phayao was not actually from Phayao. Although there was the big Phayao Lake, natural fish unfortunately were rare. Worse still, the customers misunderstood that fish sold in Phayao was from Phan.

The chairman therefore wanted to develop the pond-based culture to increase the mass fish productivity. He then suggested that Mr. A met the provincial governor who was interested in how Mr. A could harvest fish three times a year, surprisingly more than other areas. In 2006, the provincial governor in 2006 decided to fund 1,000,000 baht for the fish cooperative before he was assigned to take the same role in other provinces. That same year the Department of Fisheries also provided funds and formally named the group "Bantam Phayao fish cooperatives". The group was registered as a formal cooperative. The membership doubled from 100 to 200 people. After that, the DOF, Phayao and Maejo universities often showed up and offered assistance. The networks such as Maechai Group and Dokkhamtai Group also expanded to other districts nearby. Later, however, the cooperative decided to limit its network scope to just Bantam in order to control the fish quality and standard (clean and not fishy- because of good quality upstream water sources). It is clear that the increasing number of fish farmers was already expanding up the water source of Tamnai Village.

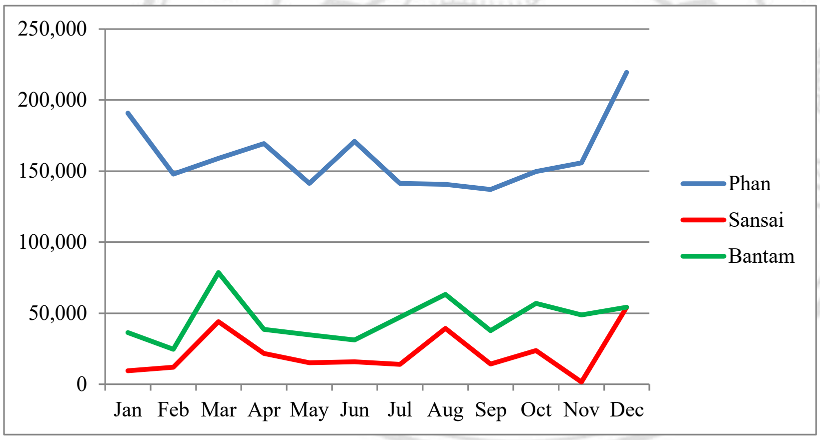


Figure 2.10 Fish production information in 2013 given by the biggest fish cooperative in each province (in kilograms).

(Source: Major fish farmer cooperatives and groups in the three sites by Santita, 2014a).

According to figure 2.10, it is seen in 2003 that Phan District has the highest production with a total of 1,923,517 kilograms, followed by Bantam with 552,447 and Sansai with 236,999. To examine the productivity of each community, the data was collected from the biggest representative fish farmer groups and cooperatives as provincial representatives. The production results from a largest number of fish farmers, most of whom are located in the studied villages. There are 235 fish farmers in the big cooperative in Chiang Rai, 80 in Maekaedluang, Chiang Mai, and 190 fish farmers in Bantam Sub-distict, Phayao. Still, the number amount of producers does not include the more than 20 smaller fish groups in Phan and individual fish groups who extend fish chains in Bantam as well as other 2 smaller groups in Sansai.

It is evident that there are different freshwater aquaculture adoptions and development with different opportunities. Phan, Chiang Rai, not only has the highest capacity of fish production due to sufficient water. The transportation system is well-developed offering opportunities for Phan traders to expand their products to numerous main provincial markets such as Chiang Mai, Nan, Phayao, Phrae and Lampang and Lamphun. They hire local people to harvest fish, sometimes fish farmer members and sometimes their children during school break. Most fish traders are Phan big wholesalers. Meanwhile, Bantam, Phayao, is well supported by the state attempts to increase their fish production capacity and produce their own brand since it is known as a fertile province with Phayao Lake. The harvest teams are made up of local people who are either farmers or fish farmers. Fish are distributed to other provinces like Phan's community chain but in smaller amounts. Fish traders are from Phan, other neighboring provinces and Bantam itself. However, Sansai in Chiang Mai has the lowest capacity due to resource competition and limited land regardless of urbanization domination. Fish farmers thus hardly expand their production base. The fish is harvested by migrant workers who are hired by the fish farmer cooperatives. The farmers are also retailers with sidecars like other local people who are either farmers or do off-farm work. Most big wholesalers are from local communities and from fish-cage culture. Some of Phan traders who are based in Chiang Mai market often buy fish from Sansai and sometimes from Phan.

2.7 Summary

Apart from agricultural loss resulting from climate disturbances and market fluctuations, pond-based aquaculture has become an alternative choice with the belief that fish pond farming increases economic value. The pond-based aquaculture development is variously dependent upon geographical locations, water management, production system, land-use and labor availability. In addition, the initial stage of fish farming is quite similar to agricultural systems that the fish systems are developed from the mixed system among agriculture, livestock and poultry. Maekaedluang in Chiang Mai is the first adoption, followed by Tamphralae in Phayao and Sanpakhee in Chiang Rai.

The Department of Fisheries together with agro-industrial companies widely promotes rearing practices. The evidence drives farmers to adopt two kinds of systems: commercial and integrate. In this way, fish farmers in different areas are given differ income and knowledge opportunities as well financial supports from external organizations. Phayao is fully reinforced by the state to build up the fish farmer groups in order to develop their production. Meanwhile, Chiang Rai and Chiang Mai have to develop on their own. At that time, fish farmers in different sites have formed fish groups or fish farmer cooperatives to manage production and marketing. In this way, income opportunities from related fish farming are generated for many fish-related people such as fish farmers, fish group staff, fish retailers, wholesalers and harvesters. All of them are one of the factors of such productivity in each site.

It is found that at the association level, Phan has the highest production and market base coinciding with the market share of Bantam and Sansai District. Fish production is yet uncertain and sensitive to climate related risks including extreme temperatures (hot and cold), excessive rainfall, prolonged cloud cover, floods and droughts. At this stage, risk and vulnerability are taken into consideration. It is interesting and useful to study the fish farmers and how they are vulnerable to uncontrolled and uncertain climate related risks. More details are presented in Chapter 3.

CHAPTER 3

Vulnerabilities of Fish-Pond Farming Households with Scale Operations

This chapter identifies the main vulnerabilities of fish farmers with different farm sizes in order to find out how they deal with variability in climate. The climate impacts result from not only from nature itself but also from socio-economic processes particularly urbanization, which in turn impacts land title, labor availability and local resources. This analysis is guided by the social-ecological system (SES) and livelihood framework. The SES idea is a combination of both physical and socio-economic risks that make an agency vulnerable. To understand risk and vulnerability, I adopt Adger (2006)'s idea that vulnerability includes exposure and sensitivity and adaptive capacity. Exposure is the degree to which a system experiences physical or socio-economic stresses. Sensitivity is the degree to which a system is affected by undesirable events (exposure and sensitivity define risk). Adaptive capacity is the ability with which a system responds to environmental hazards or market changes. In this chapter, the degree of exposure and sensitivity is used as the main focus to study place and household vulnerability.

The studies are differentiated into household and community levels. In each village, the households are categorized into 4 groups: large-, medium- and small-scale as well as the ex-fish farmers who stopped (commercial) fish farming. Household vulnerability depends on their five capitals elaborated in the livelihood framework. It includes human capital, natural capital, physical capital, financial capital and social capital. The community level comprises of wider networks of fish farmers who have relationships with the government department of fisheries, universities and feed companies. The first three groups are members of fish farmer groups but the last is not. The ties with water users at the community level are also highlighted under the local irrigation system and the state authority. The small, medium and large fish operators in each village, whether they take part in both groups or not, have different response to the risks. Having different hazard experiences and effects result in the differentiation of high, medium and low risks. Some fish farmers might survive while some give up. This chapter highlights (1) the incidents resulting from multiple climate-related and socio-economic risks; and (2) the identification of that people is vulnerable to hazards.

3.1 Incidents Resulting from Multiple Climate-related and Socio-Economic Risks

According to IPCC (2014), warming trends and increasing temperature extremes have been observed across most of the Asian region over the past century. The climate change impacts on food production and food security in Asia also cause a decline in productivity. This is evident in the case of freshwater aquaculture, which is exposed to both socio-economic and physical risks. The social risks are market demands, state policies of cash crops and the influence of urbanization. These factors intensify the impacts of climate-related stresses that comprise of extreme temperatures (too hot or too cold), excessive rainfall, prolonged cloud cover, floods and droughts. To respond to the stresses, sensitivity is the degree to which the capitals of fish pond farmers (human, natural, physical, financial and social) are affected by undesirable events. Fish farm operators with unbalanced or low capitals have high possibilities of suffering from production failures (fish deaths, diseases and loss). The results influence their decisions on further adaptation. Hence, the chapter aims to identify how multiple climate-related and socio-economic risks influence the livelihoods of those fish farmers with small-, medium- and large-scale operations. My discussion draws on data from the last 30 years during the time of fish-pond initiation, which corresponds with my exploration from the end of 2012 to the beginning of 2014. Before moving to discuss the climate-related risks, I would like to elaborate the relationship among temperature, rainfall and human intervention process in fish-pond farming in the section that follows.

3.1.1 Temperature

The first point to be considered is the extreme hot and cold weather[1] interplaying in water temperatures, which has an impact on water quality. Water temperature is affected by sunlight and air temperature. The difference between the water temperature and the cooler weather, from the absorption of solar radiation through the surface and bottom level of the water, causes stratification in the pond (AQUADAPT, 2013).

Tilapia is sensitive to de-stratification or water turnover which leads to low dissolved oxygen (DO) and high concentrations of ammonia. Warm surface water has a higher DO level from photosynthesis than cool surface water (Patcharawalai et al., 2013). Cooler bottom water lowers DO levels and accumulates nitrogenous waste from uneaten feed and feces. In turn, when the temperatures drop, de-stratification or remixing of thermocline occurs. The surface layer is cooler and denser than water in the bottom layers. It then sinks and forces the water at the bottom to rise up to replace the surface layers. As a consequence, DO level drops and nitrogenous waste like ammonia that affects fish survival in the ponds, increases. Ammonia is the first form of nitrogen discharged when organic matter decomposes. It becomes toxic when water temperature and pH increases, and it is dangerous to fish blood and tissues (Patcharawalai et al., 2013). Hence, different temperatures resulting from sunlight and rainfall patterns stimulate de-stratification.

1) High temperature

Starting from high temperature, the strong sunlight shining into the bottom of the pond also reduces the level of dissolved oxygen in the fish ponds (Pornpimol et al., 2013). However, the hot and cold weather that

[1] Thai weather is divided into three periods of time: dry season (February - May), rainy season (May - October) and winter (October - February) (TMD, 2014).

affects fish health and survival is uncertain and unpredictable. Consequently, fish death will be found in almost every single pond in every village if the fish farmers are not well prepared for risk prevention.

In 2013 and 2014, Northern Thailand had higher yearly and monthly average temperatures than normal, particularly during the dry season. As shown in figure 3.1, the bars represent the monthly average temperature. The temperature in February went up sharply from the normal average by 1.3 ^{0}C; dropped dramatically by 0.6 ^{0}C in March and 0.5 ^{0}C in April. Summer starting at the end of February, was later than usual by about 2 weeks and ended by 18 May, which was normal. As a result, the northern part of the country was successively hot throughout the season. Although the weather was cool in the mornings, it was hot in the daytime. In 2014, during late February and almost the whole of March, the upper Northern Thailand was affected by hot conditions. Monthly mean temperatures were around 0.8 - 1.8 ^{0}C above average and it was the same in April (TMD, 2004).

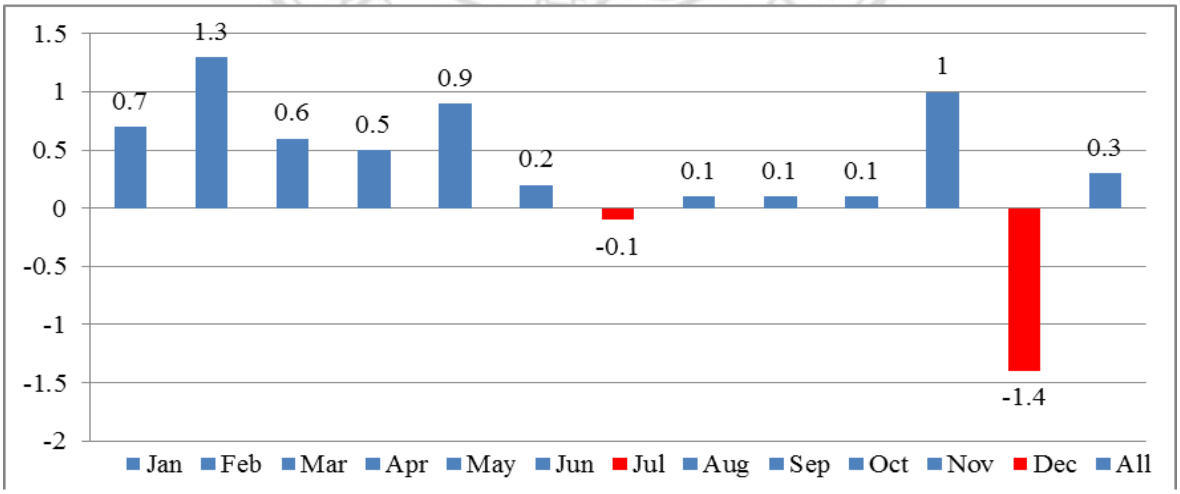


Figure 3.1 Monthly average temperature (Degree Celsius) in 2013 (Source: Thai Meteorological Department, 2014 by Santita, 2014a)

In the dry season with stronger solar radiation than in other seasons, integrated systems are more sensitive to water turnover than commercial systems (Patcharawalai et al., 2013). It is because the high load of nutrients and fertilizers causes phytoplankton blooms that consume a lot of oxygen at night and in the day when there is no light. Most integrated culture is in Chiang Rai; others are in Phayao and Chiang Mai.

2) Low temperature

Low temperatures especially in winter reduces fish feeding capacity. It is because fish digestion systems work ineffectively and slower than normal during this time (AQUADAPT, 2013). During my field visits from the end of October in 2013 to the beginning of February 2014, the cold weather was different from the previous years. The rearing duration had to be postponed for more than one month.

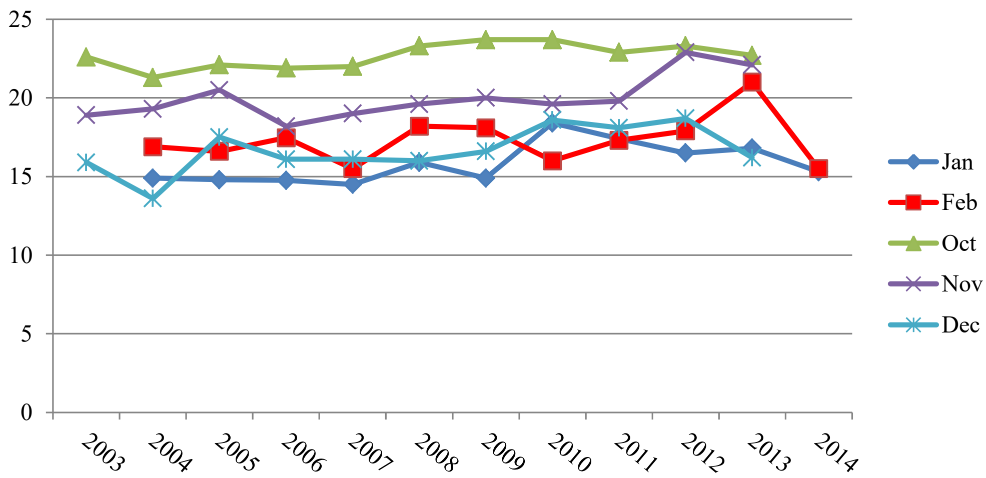


Figure 3.2 Minimum average daily temperatures in Northern Thailand during 2003 - 2014 (Degree Celsius) (Source: Thai Meteorological Department, 2014 by Santita, 2014a)

From figure 3.2, January generally had the lowest minimum temperature, followed by December, February, November and October respectively, which marked the end of the rainy season. Even though it was winter, the minimum temperature trend during the last 12 years has been gently increasing. The temperature in December 2004 was significantly the lowest among the following years. Similar to the trend in January, it was slightly lower than the year after 2009. More focus in 2014, the temperature in January and February was lower than the previous years. The upper part of Thailand in particular was covered by the influence of a dry condition with cool and cold weather from November 2013 to the beginning months of 2014. In December, the average temperature in Northern Thailand was below normal by 1 - 2 ^{0}C. Furthermore, the mean temperature was around 15 ^{0}C below normal in January and February 2014 (TMD, 2014).

In 2014, the weather turned colder than the last 5 years. Upper Thailand and places in the upper south were covered by cold weather from the extended China ridge during most of January. The minimum temperature broke the record cold that occurred mostly in mountains areas and mountaintops. During the first half of February, the weather condition was periodically dominated by the high-pressure area from China. These led to cool weather that was below normal of 0.2 ^{0}C (TMD, 2014).

It is found that temperature and tilapia interacts significantly. Tilapia can tolerate temperatures as low as 7 - 10 ^{0}C for a short time. Longer exposure to low temperatures of about 16 ^{0}C will certainly lead the fish to mass mortality and reducing or stopping feeding (El-Sayed, 2006). In other words, the cold weather retards fish growth and causes a longer rearing period. During my fieldwork in January, the temperature was cold at about 13.3 - 25.8 ^{0}C in Chiang Rai and 14.8 - 32.17 ^{0}C in Phayao and 16.7 - 35.9 ^{0}C in Chiang Mai respectively (TMD, 2014). Fish farmers in the three sites encountered similar problems of fish disease disperse (Trichodina infestation), feeding reduction ratios, slow fish growth, seed shortages as well as prey such as snakes and migrant birds which escaped earlier than the previous years. Yet, the fish death level was at the lowest compared to other weathers.

3.1.2 Climate-related risks towards livestock and poultry

A large number of fish farms in Sanpakhee and some in Tamphralae face another risk in raising pigs which is mostly sensitive to dry and rainy seasons. In summer, the pigs are at risk of cholera and get stressed while some bite each other. So the fish farmers have to provide small water containers at the corner of the pigsty to release their stresses. Though the fish pond lacks water exchange, the pond water is enough for cleaning the pigsty. During rainy seasons, the pigs also contract diarrhea, pneumonia and uncertain Porcine Reproductive and Respiratory Syndrome (PRRS); and may catch colds. However, all the symptoms can be prevented early by injecting vaccines and providing the pigs with a safe and convenient farming environment. Some medium and small fish farmers in Maekaedluang who raise chickens are also prone to the different season changes. Chickens are likely to catch colds during the rainy season, but do not have any diseases in winter. Still, the possibility of chicken death is high during the dry season. The hotter the weather, the more the chickens crowd to get some wind and air. Consequently, fish farmers have to turn on fans and set up water springers on top of the chicken coops to reduce the heat. Above all, the chickens risk diseases such as Influenza A virus subtype H5N1 known as Avian Influenza ("bird flu"). It was widespread once in the 2000s and forced people to kill their chickens. Most of the fish farmers suffered huge losses and ran into debt, which eventually made them reluctantly decide to exit from chicken farming.

3.1.3 Rainfall pattern

Moving from temperature variation to rainfall pattern, it is evident that rainfall that is physically fluctuating and uncertain through several years increases the possibility of floods and droughts as well as changes in weather that these hazards bring about. In addition, during a week of cloudy and rainy days, de-stratification reduces dissolved oxygen levels (El-Sayed, 2006). Integrated and commercial systems are highly exposed to this consequence because such farms contain high fish-stocking densities and organic matter inputs in livestock wastes. Even more severe, this is an important feature that the level of flood, water shortage and remixing of thermocline are relatively ameliorated by irrigation management, geographical landscape and land use.

All case studies similarly agree that the first rain is most dangerous because it is not within the fish's capacity to adjust itself to the changeable temperatures. Pickering et al. (2011) claim that the reproduction, growth and survival of the tilapia are expected to be sensitive to the increase of temperature, and salinity and oxygen change. Temperature affects the physiology, growth, reproduction and metabolism of the tilapia. Salinity determines the ability of most tilapia species to tolerate a wide range of water salinity. DO fluctuation is affected by photosynthesis, respiration and diet fluctuation. Nile tilapia exposed to ammonia has a lower number of red bloods cells and hemolytic anemia, leading to a reduction in blood oxygen control. High levels of nitrates may weaken its immune system and increase the possibility of mortality. Conversely, photoperiod promotes fish growth, metabolic rates, body pigmentation, sexual maturation and reproduction (El-Sayed, 2006).

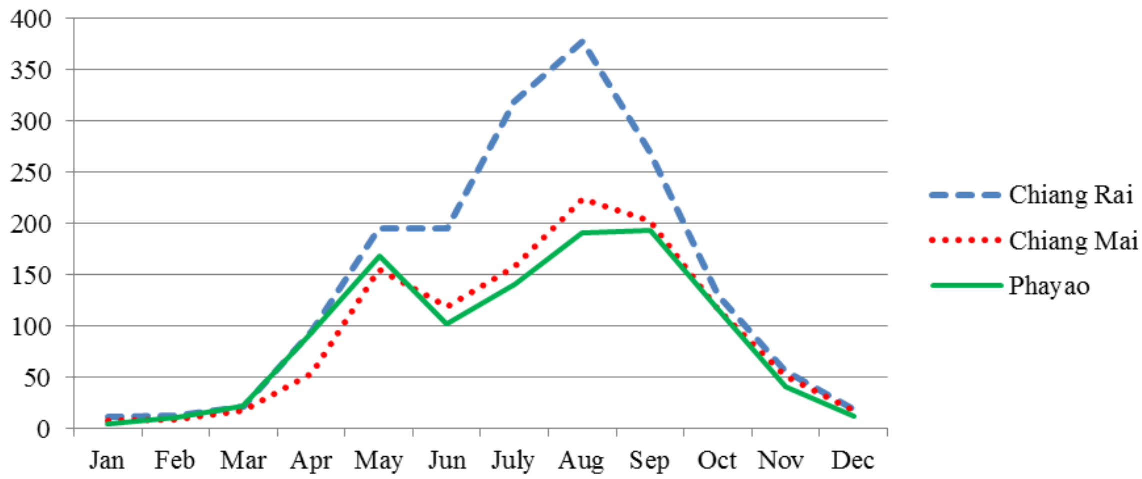


Figure 3.3 Average monthly rainfall in last 30 years (1971-2000) in Northern Thailand (Millimeter) (Source: Statistical Forecasting Bureau, National Statistical Office, 2014, by Santita, 2014a)

This section traces back to the 1990s when pond-based aquaculture was initiated. Figure 3.3 showed the rainy season pattern in Northern Thailand over the last 30 years (1971 -2000). The average rainfall was different in the three provinces. Chiang Rai had the highest rainfall, followed by Chiang Mai and Phayao respectively. According to TMD (2013), the rainy season was from May to October. The rainfall generally started by the end of April and dropped a little in June under the weak influence of the Southwest monsoon. The rainfall pattern increased again in July and gradually again due to tropical storms in August and September. Then, it declined by the end of October at the beginning of winter.

3.1.2 Drought

Rearing practices during the dry season is the most severe and are highly risky to fish aged over 4 - 6 months. A water shortage worsens water quality and quantity. It is a threat to fish-pond culture because it reduces the possibility of water exchange. Due to low water quantity in the canals, fish farmers hardly change water in the ponds. Low water exchange directly results in the instability of water temperature, salinity, dissolved oxygen, ammonia and nitrites, pH, photoperiod and water turbidity (Pimolrat, 2013).

For that reason, poor water quality and quantity during low flow periods result in increasing the plankton boom, the weakening of fish disease resistance and increase in its mortality rates (El-Sayed, 2006). Based on the Thai Meteorological Department (2014), figure 3.4, in fact, indicates the rainfall pattern fluctuation and uncertainty from 2005 to 2012 including the period of the study from the end of 2012 to the beginning of 2014. It can be seen that the rainfall pattern had changed and became uncertain. In fact, the rainfall in 2005 and 2012 did not meet the normal dry season period (February-May). It rose during summer in February and dropped slightly before the beginning of the rainy season in May.

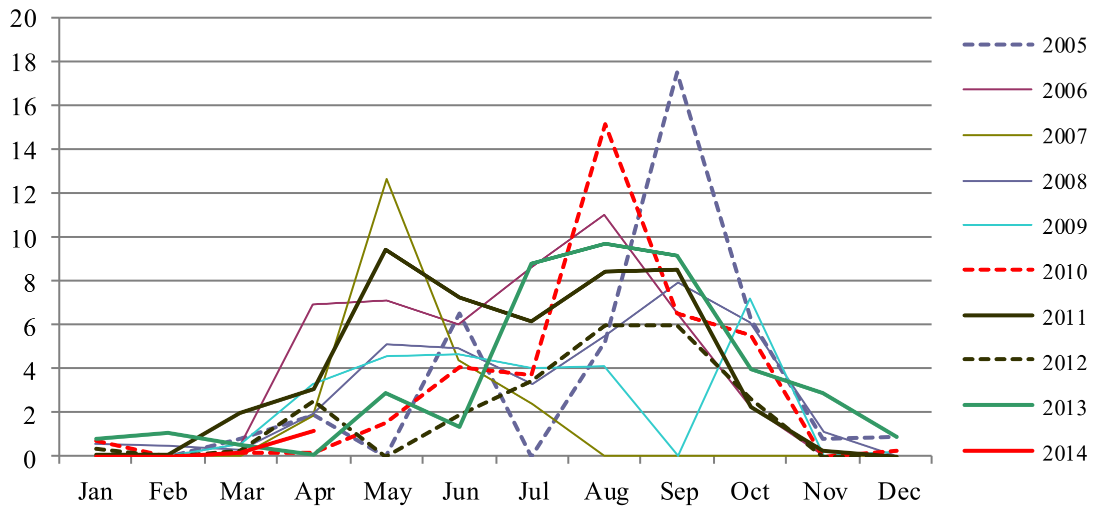


Figure 3.4 Rainfall pattern in from 2005 to 2014 in Northern Thailand (Millimeter) (Source: Statistical Forecasting Bureau, National Statistical Office, 2014 by Santita, 2014a)

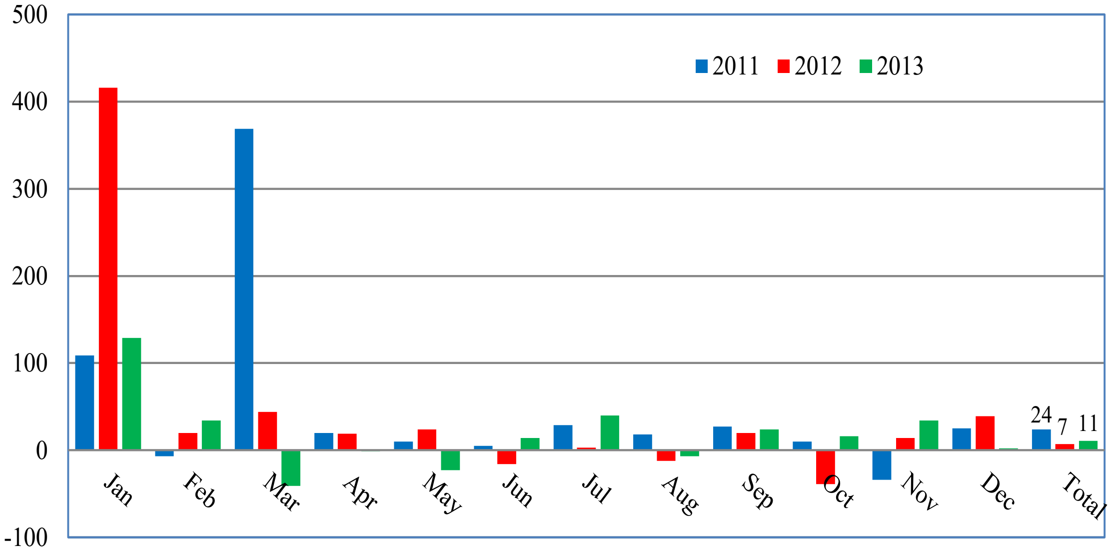


Figure 3.5 Monthly rainfall patterns in Northern Thailand during 2011- 2013 (%)
(Source: Thai Meteorological Department, 2014 by Santita, 2014a)

The decreasing rainfall in 2012 and 2013 resulted in drought over the last decade. To clarify the point, figure 3.5 demonstrates the comparison among the rainfall pattern during 2011 - 2013 to explain the rainfall level change. It is found that drought was most severe in 2012, followed by 2013 and 2011. The total of 7 percent rainfall in the 2012 was lower than in 2013 by 4 percent, and more than 3 times lower than in 2011. In terms of quantity, the rainfall in 2012 was steadily low (figure 3.5), but increased slightly before the rainy season. On April 18, 2013, Northern Thailand encountered long low flows of the water level at Mae Ngad Somboon Chol Dam; Chiang Mai was reduced to 36 percent from the full water storage capacity of the dam. Chiang Rai and Phayao were also affected by severe drought (Office of the National Water and Flood Management Policy, 2013).

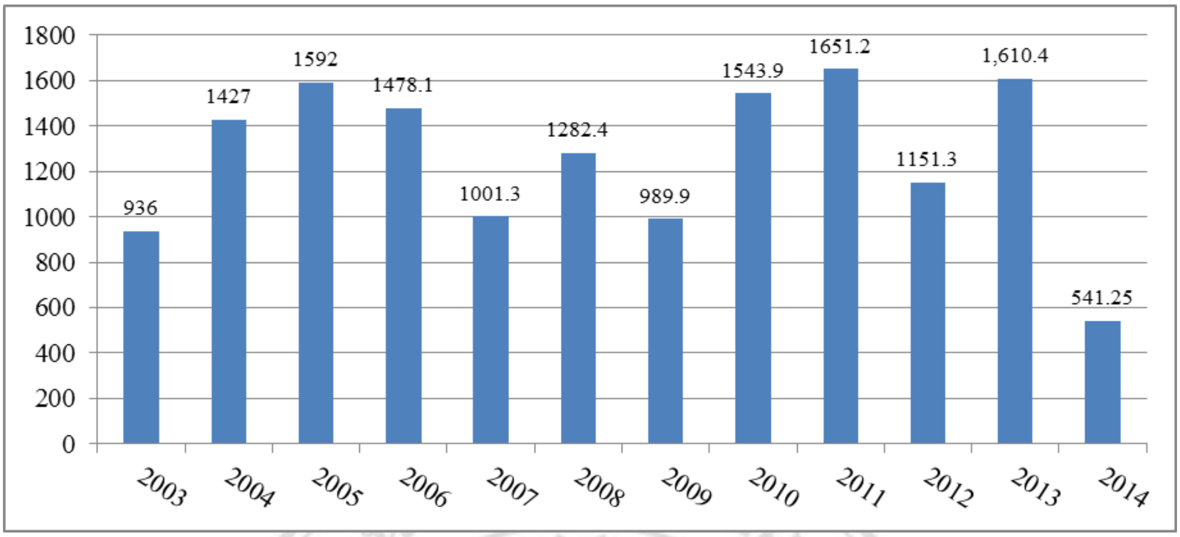


Figure 3.6 Rainfall units in Mae Lao Weir during 2003-2014 (Millimeter) (Some incomplete data in 2014 in collecting.) (Source: Mae Lao Transmittal and Maintenance Project, 2014 by Santita, 2014a)

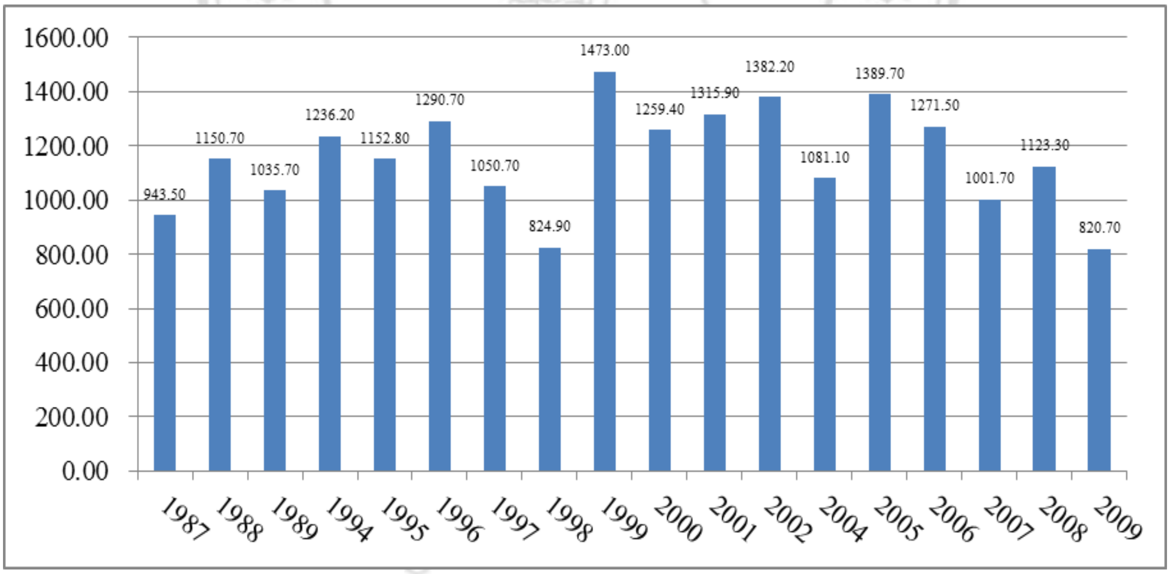


Figure 3.7 Rainfall units in Mae Ngad Somboon Chol Dam (Millimeter) (Source: Mae Faek Mae Ngad Operation and Management Project, 2014 by Santita, 2014a)

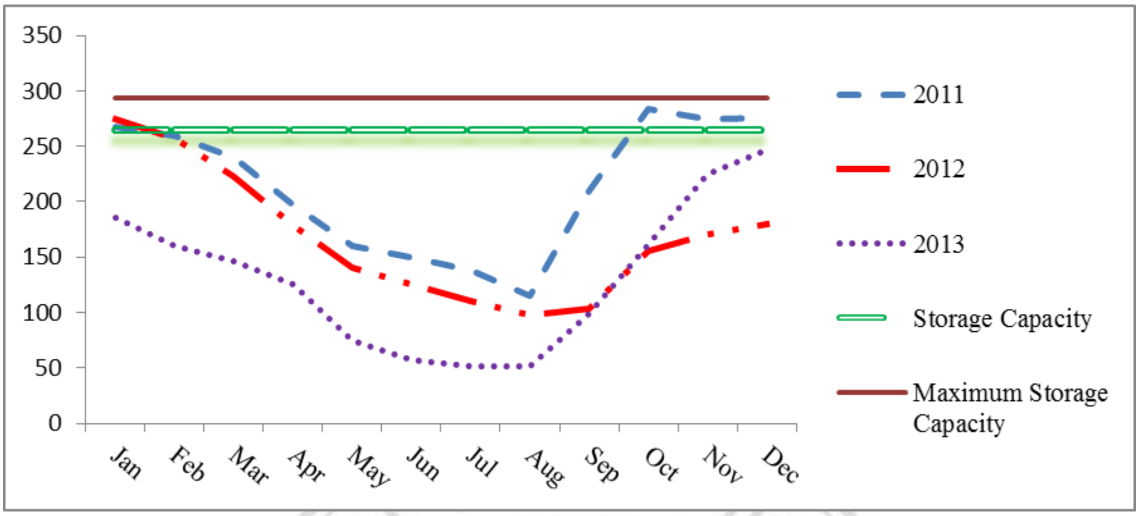


Figure 3.8 Monthly water storage in Mae Ngad Somboon Chol Dam during 2011 - 2013 (Million cubic meter) (Source: Mae Faek Mae Ngad Operation and Management Project, 2014 Santita 2014a)

At the local level, Sanpakhee Village has fewer impacts from long low flow since it gains water from Mae Lao Weir. From figure 3.6, rainfall units in the Mae Lao Weir in 2012 sharply dropped, but it grew steeply in 2013. The total high amount of water could be allocated for widespread use in farming and fish farming. The water supply was different in Chiang Mai. Figure 3.7 emphasizes the fluctuation of water and rainfall in the Mae Faek Mae Ngad Operation and Management Project (2014). The trend of rainfall after 2005 was steadily reducing. Figure 3.8 shows the level of water corresponded with the water storage capacity in Mae Ngad Dam in 2012 and 2013. It was lower than the level in 2011 that caused the local Maekaedluang fish farmers' difficulty in accessing the water.

The water shortage issue became drastic in some areas especially Tamphralae in 2014. Since the site was regulated by local communal irrigation system; there was no data record of monthly and yearly water storage and its flow. In turn, the *Kae Muang*, as a representative of each weir, made a plan for common water allocation during the wet season rice and off-season rice while the sub-district municipality kept records and sometimes supported with equipment to maintain the weirs and canals. In fact, the *Muang Fai* system managed water allocation unevenly and not extensively. In other words, the majority of mostly midstream and downstream farmers no longer received water in last 2 to 3 years. They could not do off-season rice, so a low water use-crop such as garlic, onion, pumpkin and marigold was more preferable. Furthermore, the villagers encountered water conflicts and polluted water.

"The water level has been reducing the last ten years until now. I am so worried about the situation in the next five years. The water will probably dry out if the forest is replaced with rubber and cash crop plantations as well as fish ponds. The state makes the villagers misunderstand that growing rubber means replenishing the forest. Actually, that kind of tree needs a large amount of water. People selfishly connect water pipes and pump only into their plantations. There are more than 16 hectares (100 *rai*) of rubber plantation and less than 16 hectares of maize plantation up there. As a result the water pollution and shortage affect villagers downstream. I never thought that we would have to compete with each other for water access," explained one affected villager in Tamphralae (07-05-2013).

We could say that water scarcity was expected to become a big issue due to increased demand and lack of the good management. Tamphralae in particular was most affected by the stresses because the *Kae Muang* was absent from managing the water during the low flow period and the regulation was temporarily implemented but was not active enough. The water users broke the law that stipulates that farmers were allowed to access water in the daytime and fish farmers at night. In fact, fish farmers got as much water as possible all the time. They were careless about the *Muang Fai* punishment and sought out ways to access water as much as they could. As a result, they competed for access with one another; some stocked a lot of water whereas others lacked the resource. Sanpakhee and Maekaedluang also faced similar problems, only less drastic. For this reason, the role of the

RID agencies and *Kae Muang* in water allocation throughout the year is important.

3.1.3 Flood

Floods caused by cyclones and extreme rainfall events are risks to tilapia ponds constructed close to rivers. According to figures 3.6 and 3.9, it was obvious that the total monthly rainfall in 2011 was higher than in 2012 by 17 % and in 2013 by 13% (TMD, 2014). The excessive rainfall led to floods in 2005 and 2011. The rainfall in the first year dramatically rose from August to September and inundated 25 districts such as Muang Chiang Mai, Sankhampaeng, Doi Saket, Prao, Maetaneng and Sansai. In particular fish farmers in Maekaedluang Village, Sansai District, were vulnerable to such a great and unpredictable flood. Moreover, although the rainfall pattern in 2011 was lower than 2005, flooding still occurred and caused a lot of damage to fish farms and agriculture lands. In late June, Thailand was dominated by the remnants of the tropical depression, "Haima." By the end of last July to last August, the country was affected once again by the tropical storm, “Nok Ten.” It induced very heavy rainfalls and resulted in widespread flooding in the north and northeast (TMD, 2014). Thus, the water collecting in the Mae Ngad Somboon Chol Dam had been increasing since May and when discharged, it raised the water level of the canals higher than normal.

The flood was worsened by ineffective water management and urbanization influence in relation to human intervention. It is agreed by Cutter et al. (2003) that the density of the commercial establishments and housing units probably caused the exposure of this hazard situation. Areas packed with households and residential estates increase the possibility of flooding or higher levels of water. Land use has rapidly changed and local land ownership has declined whilst the rate of land speculation for housing and residential estates is increasing. The villagers agree that once there were vast paddy fields and agricultural lands, but now outsiders have converted them to residential areas. Some filled their lands for residential estates while others left theirs idle for sale. Consequently, some waterways have become narrower and blocked full with waste from households and agricultural activities. Many suffered losses, some stayed safe while others gained. At that time, several fish ponds, especially catfish farms upstream were flooded at the natural canals and the water also flooded other neighboring fish ponds.

Tamphralae faced floods in 2005 and flash floods in 2013. In October, 2013, flash floods rose rapidly during 1 - 3 days of heavy rain. The flood was also stimulated by a reducing number of trees that could have helped absorb water and reduce the massive magnitude of flood. Fortunately, most fish farmers were safe because a large amount of water was released downstream before it caused any damage. Only a few fish farmers and households suffered from the flood. Walker (2002) mentions the role of farmers in forest conservation, but in fact there is less public attention on their role in maintaining forest functions. Tamphralae villagers do not seem to maintain the forest, but only take its advantages instead. This phenomenon is one of the factors that increase the possibility of natural hazards.

> "Look! There is a crack in the mountain. Over there is maize and rubber plantation owned by a big company. Indeed, those areas belong to the forest conservation and SPK4-01 agricultural lands, but no one protects the forest. I'm so afraid of landslides in the future," said a medium-scale fish farmer in Tamphralae (18-08-2013).

All in all, table 3.1 shows the summary of the impacts from climate-related and socio-economic risks in the three sites. It is clear that the damages to fish farms result from not only hydrological and meteorological cycles towards changes in climate but also the process of human intervention. High market demand and irrigation systems influence water quantity and quality, resource exhaustion and resource conflict as well as land title changes. More details are discussed below.

Table 3.1 Summary of the impacts from climate-related and socio-economic risks

Village	Sanpakhee	Maekaedluang	Tamphralae
Flood	No	2005, 2011 resulted from monsoon + weak irrigation system + land-use change from urbanization	2005, 2013(flash flood) resulted from excessive rainfall + land-use change from deforestation
Drought	2008 stopped waterway for weir construction for three months, 2013 faced water conflict	2012,2013 experienced low flow, overused water and lands from in and off season rice; and water conflict	2012, 2013, 2014 experienced low flow and water conflict

3.1.4 Water pollution from used water upstream, toxic and fish diseases

Pollution from poor water quality and quantity reduces fish survival and weakens its resistance to diseases. According to figure 3.9, water pollution results from both climate-related risks and socio-economic risks. Low and late rainfall plus hot temperatures cause drought, which increases the level of water pollution issues. High levels of water in the canal from raining also lead to the release of polluted water to downstream users.

On the other hand, commercial plantations and urbanization not only require high amounts of water but also increase water pollution issues. In this sense, farmers and fish farmers who use intensive systems nowadays tend to use chemicals to increase their production. Farmers also use pesticides to kill pests while fish famers use chemical medications to treat fish diseases. All the chemicals are mixed with water and released to common irrigation canals for water users. Therefore, the fish production process risks facing the polluted water from maize and rubber plantations, chilli farming and rice paddy fields.

Water pollution mostly occurs during the low flow period. Low water exchange directly results in the instability of water temperature, salinity in addition to dissolved oxygen, ammonia, nitrites, pH and water turbidity. With these factors, high ammonia and nitrite levels signal that there are high fish density and many wastes in the ponds (Patcharawalai et al., 2013).

Moreover, during the rainy season or in places with highly intensive agricultural plantations, fertilizers or pesticides and waste are likely to get into the pond water, unqualifying and worsening its water quality. Since the location of a large number of rice paddy fields and fish ponds are close to one another, the use of poor water relatively increases the level of pollution upstream, midstream and downstream. Consequently, the poor water conditions result in the weakening of fish disease resistance and the increase in its mortality rates. Fish diseases spreading among several ponds are hardly solved and eradicated. Chemical use and other technologies are solutions that also add to the problems.

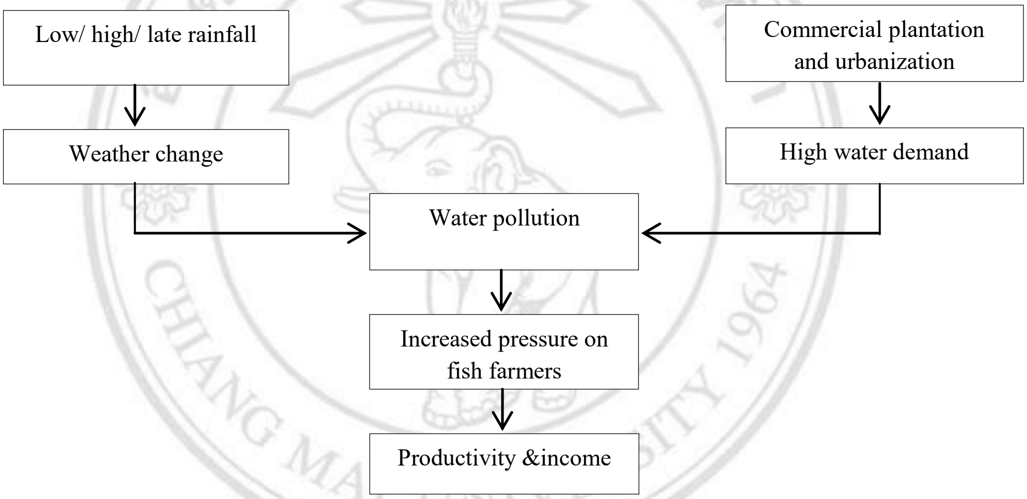


Figure 3.9 Effects of multiple climate and socio-economic risks on fish farmers

Water pollution causes different impacts in the three villages. Low levels of water intensify water pollution. In other words, low flows of water in the pond reduce dissolved oxygen and worsen its quality; this poor water is then released downstream. In Sanpakhee, a place with highly intensive rice and fish-pig production, too much poor water has serious impact on the farmers' production. The rice growth is unnaturally faster and taller than normal but is too weak to resist the heavy winds in summer. Many fish farmers with medium- and small-scale operations and the one who left the fish group in Maekaedluang also face poor water quality. They are agreed that the intensive catfish farming in the last two years has made water too low in quality for use. Thus, fish farmers downstream have found it difficult to change the water in the pond, which affects the fish growth and production system. Then, the polluted water flows into three smaller canals. It is found that one canal stocking water in a high wooden weir increases the level of poor water quality and causes the most trouble to downstream water users.

> "From what I notice, water quality in Maekaedluang is poor; the water surface is dim and oiled unlike that in my Sanpakhee Village. The water quality might be in trouble and contaminated with waste and chemical substances. I understand that it is so in places located in peri-urban areas. Even if the water is purified, I am not sure if it will be clean and safe for rearing practice. The water in my hometown is from the highland, which is also polluted with chemical substances," one fish farmer from Sanpakhee said after visiting one of the fish groups in Maekaedluang (11-01-2014).

Tamphralae fish farmers with medium and small farm sizes as well as the one who left also encountered the highest rate of fish deaths because of the high level of poor and polluted water. During the rainy season, the public stream is at high risks from the fertilizers and chemical substances from intensive farming activities. Even if the chemical substances are supposed to maintain soil quality and pesticides kill pests, they destroy natural aquatic animals and contaminate water, soil and plants. Moreover, in the rainy season, the three sites probably experience sediment from heavy rain flow. Water passing through agricultural fields is contaminated and mixed with polluted soil and mud. Such water possibly fills up the fish gill and causes difficulty in breathing. It is more problematic if there is no filter in the pond or if fish farmers cannot identify whether the water is polluted with pesticide or safe. This is why most fish farmers try to avoid the water by closing their pipes. These stresses mostly affect the fish ponds in Tamphralae. It is because most fish farm systems are automatically changing water all the time in order to increase the oxygen rate in the pond. But unfortunately, the system is prone to polluted water without proper prevention and control. For instance, during one rainy season, polluted and toxic water from the medium fish operators upstream got into the pond of a large operator downstream. This water linkage led to the death of about 4,000 kilograms of fish.

3.1.5 Non-climate risks

1) Resource demand as a result of market forces and urbanization

The consumption of agriculture and aquaculture production is highly boosted by the market demand of fish resulting from increasing populations and urbanization expansion (Belton, 2008). The pressures forced an increase in the number of people moving from rural to urban areas. Those local people shifted from farming to off-farm employment in urban areas. Thus, the local agriculture-based economy changed to a more intensive system to respond to the market expansion. The phenomenon coincides with what Phrek (2002) wrote about numerous agricultural land tenures becoming insecure and speculated on by external landlords and capitalists. Many agricultural lands are undoubtedly now converted for housing development.

The demand is a crucial pressure on the fish farmers' resource access, which is related to their productivity. Water competition among agricultural intensification and fish-pond farming is increasing. According to the rice mortgage policy (2012 - 2013), the price of ordinary rice has risen to 15,000 baht a ton. Many farmers tend to grow wet and off-season rice around two to three times a year to benefit from the policy. Farmers in Sanpakhee Village settled down near the Japanese rice company, preferring to grow its rice variety because of its attractive price at 15.30 baht/ kilogram for normal moderators and 17 baht for seed producers. They shift between growing Japanese rice and Thai rice all year round even during the dry season.

In Maekaedluang, a few farmers who left their paddy fields idle also returned to grow rice to benefit from the rice mortgage policy. Farmers (92 percent of village households) in Tamphralae moreover responded to not only the policy but also commercial plantations drives by mainly the state and agro-industrial companies. Consequently, an increasing amount of water is being used for agricultural farming expansion such as chilli, maize, longan and rubber trees. In this regard, the water demand has been rising the last 2 - 3 years after the DOF launched fish-based production in the area. Since then, both villagers (28 percent of households) and outsiders have converted their farms into fish farming. We can see that about 64 hectares (400 *rai*) of land upstream have been expanded for those activities. It is skeptical in what way the soaring water demands plus climate-related risks affect fish pond farms.

2) High cost of investment

Fish farmers are dominated by higher and higher costs of investment. Most input factors including seed, feed and the harvest fish process are produced and provided by the fish- related enterprises (Table 3.2). The price of the production factors collected in 2013 was slightly lower than the price in 2014, except feed prices which increased by 5 baht/ bag in the three sites. According to the farming standard system agreed upon from meetings between feed companies and fish groups, 480 fish in intensive farm should fit into one 0.16 hectare of the pond and requires a maximum 150 bags of feed. The data is mixed up from both 14 integrated (9 in Sanpakhee, 2 in Maekaedluang and 3 in Tamphralae) and 17 non-integrated fish farmers (1 in Sanpakhee, 10 in Maekaedluang and 6 in Tamphralae). Land used for pond-based aquaculture is also a very important cost in which its price naturally rises through time whether the land ownership is either bought, leased or inherited. Showing its rental cost is counted as a cost of land use. Based on one 0.16 hectare (1 *rai*) of land, the calculations below are briefly made to prove the differences of the production cost per crop in each site.

Table 3.2 Average unit cost of key inputs in the three villages

Factors	Sanpakhee	Maekaedluang	Tamphralae
Seed price	0.4-0.5 bht/ fry or 1.80 bht/ fingerling		
Average feed price*	540 bht/bag**	470	530
Average number of feed bags	100	150	270
Water fee	Free	200 bht/ pond	100 bht/ pipe
Rental land price	5,000 bht/ *rai*/ year	20,000 bht/ *rai*/ year	10,000 bht/ *rai*

* Average feed price is calculated by collecting different prices from many brands and divided by a number of the feed brand (Collected on 16-09-2013).

** 20 kilograms/ feed bag

In reality, fish farmers in the three villages use varying portions of feed with different prices and farm systems. Feed agencies play an important role in fish groups. Each feed agency in Sanpakhee chooses a few feed brands whose price is controlled by the particular feed companies. Buying feed with cash is cheaper than with credit as a surplus of interest. In fact, some large- and smaller-scale operations, decide to borrow feed that makes the price higher (540 baht/ a feed bag) than reality. The system is like that of the Tamphralae fish farmer cooperatives. They prefer using only one type of feed while the fish committee negotiates with the feed companies to keep the price low. Thus, the feed price (530 baht/a feed bag) is slightly lower than the feed price in Sanpakhee by 10 baht.

On the other hand, Maekaedluang fish groups allow various brands of feeds with different prices and quality. The feed companies are required to compete with each other which automatically force the price (470 baht/ a feed bag) to reduce to entice the farmers to buy. Moreover, the fish farmer members are encouraged to buy feed with its actual price and allowed to pay with credit just for one month before harvesting in order to reduce the groups' debt and the obstacle of money circulation. Sanpakhee uses the smallest number of feed because the majority of them rely on not only fish feed but also plankton from pig manure. But they pay the most expensive feed price while Maekaedluang and Tamphralae buy cheaper but the latter fish farmers have to pay for the water fee. Fish farmers in Tamphralae use a larger number of feed than Maekaedluang and Sanpakhee respectively. Yet, the ones who are out of the groups in the three villages were previously required to buy the feed with the given price from the feed companies and middlemen. Their cost of investment therefore was hardly negotiable and higher than the ones in the fish farmer group. That is an important reason why they decided to leave fish farming.

Table 3.3 Calculation of cost of investment in the three villages

Price	Sanpakhee	Maekaedluang	Tamphralae
Seed price (fry)		0.5* x 3,000 = 1,500	
Average feed**	540 x100 = 54,000	470 x 150 = 70,500	530 x 270 = 143,100
Water fee	Free	200	100
Rental land /crop	5,000 / 2 crops = 2,500	20,000 / 3 crops = 6,600	10,000 / 2 crops = 5,000
Total expense (bht) ***	58,000	78,800	149,700

* Use 0.5 baht/ fry

** Maximum - minimum. price of various brands of fish feed / 2 is an average feed price.

*** Labor is out of the calculation because most fish farmers rely on their own labor, just a harvest fish cost.

It is significantly seen in the table 3.3 that Tamphralae has the highest cost of investment (149,700 baht), 3 times of Sanpakhee (58,000 baht) and 2 times of Maekaedluang (78,800 baht). Fish farmers use the highest number of expensive feed with an average of 2 crops a year like Sanpakhee. At the same time, even if the land title in Maekaedluang is the most expensive, the fish farmers can increase frequencies of crops as much as they increase their incomes. However, this cost is a brief number which is different upon scale operation in different places. In addition, the policy of a minimum of 300 baht of daily labor wage increases all employment wages including harvesting costs and other employments. As a result, fish farmers here have much more financial burden from production to harvest process. Harvest labor wage in Sanpakhee and Tamphralae rises to 250 baht/ person/ day. The owners of the fish farms are required to provide breakfast around 1,000 baht/ day. The more they harvest, the more they pay. Sometimes fish harvests takes longer than usual because of excess fish supply. So fish traders skip the queues for the new farms and return to the previous one. Consequently, all fish farmers have higher investment costs and hardly negotiate with the invisible market uncertainty.

Fish sale is dependent upon the market price and related actors. The fish farmers' incomes are determined by the price regulated by fish networks and traders based on demand and supply. Fish networks are able set the price based on other groups in other provinces. The price of the biggest fish size is hence not that much different at around 55 - 59 baht/ kg during 2012 - 2014. However, the price fluctuation caused by excess demand or supply in the market impacts production process. For example, the excess supply from other fish sources and low demand of consumers in 2011 delayed harvest queues. This lowered prices and pressured the farmers to continue to rear fish while waiting for lower supply. Those fish farmers had no choice but to pay for extra feed, materials, electricity and other additional costs. Unfortunately, oversized fishes with longer rearing duration did not meet market demand which possibly forced the price lower. Above all, those fish farmers without groups are more vulnerable because they are out of the harvest queue and controlled price regulation.

Most fish farms (90% of the case studies) in Sanpakhee and some (3 out of 9) in Tamphralae have another problem with pig prices. The price of pig feed and vaccines increase, but the pig price is not regulated by the state and not predictable. For example, selling a pig of over 100 kilograms at 52 baht was reduced from 65 last month. The fish farmers lost about 1,300 baht/ pig.

"This year, the price of pigs rose up to 75 baht/ kg, then dropped by 13 baht. Even at 65 baht/ kg, it is difficult to get a profit and is not worth investing in. When the price of pigs is low, pork retailers do not reduce the price; but when it is higher, they increase their prices naturally. Whether the price is high or low, we have to sell pigs for the middleman; otherwise they will be overweight, which does not meet the market demand. Again, if the price is soaring too high, some agro-industrial companies will lower it. Farmers like us are barely surviving," one fish farmer in Sanpakhee said (01-06-2013).

3) Low quality fingerlings and pest

Some fingerling varieties are not strong enough to withstand the different weathers. Hence they die after being reared for a week. In addition, the low quality fingerlings results from the process of converting female fingerlings to males in the northern part of Thailand, the coldest in the country. Transforming the gender might not be successful because fish eat fewer hormones under the cold weather. Thus, the fish is still female and breeding, so such so that it is too thin to meet the market demand. Additionally, intensive agriculture has an impact on the loss of aquatic animal. After implementing agricultural intensification, natural fish are disappearing because lots of chemical substances and fertilizers destroy a number of aquatic animals. Therefore, natural fish such as the climbing perch and eel naturally surviving in paddy fields adapt themselves to live in fish ponds. But unfortunately, they eat fingerlings between 4 - 5 mm. and this reduces the fish farmers' income.

Members of the fish farmer groups in the three sites are allowed to buy the selected fingerlings suggested by the feed agencies and other fish networks. The source of supplies is different upon the consideration of fish farmer groups and locations close to them. Maekaedluang mostly use the fingerlings from the supplier in Chiang Mai while Sanpakhee and Tamphralae buy from sources in the central and eastern provinces of Thailand. However, choosing the wrong supplier probably causes worse fish productivity and reduces income. The members might unfortunately get the breeding fingerlings which have slow growth and weight. Slightly similar to some fish farmers who do not belong to the groups, they have to get the fingerlings from the available sources themselves. Some medium and small fish farmers buy the seed from known persons who might lack enough related information and knowledge.

4) Fish snatching and weighing process

Some fish pond compounds are not fenced and located far away from home, presenting opportunities for fish snatchers or thieves who enter the pond at night or when there are no owners. For instance, the situation often appears in Tamphralae since most fish-pond farming is settled outside of the village community. Some fish farmers have to carefully watch out for the fish for a few months before harvesting time. Conversely, the situation is rarely found in Sanpakhee and Maekaedluang because the ponds are close to the houses of the fish owners. The weighing process is another problem mostly found in Sanpakhee. Harvesting fish periods are run systematically by the groups. Some fish farmer brokers cooperate with traders to cheat on the fish's weight and size. For example, the checker writes down the weight of a fish as 200 kilograms when it is in fact 240 - 250 kilograms. That is how the fish farmers lose their profits or earn less than they are entitled to. Yet some passively accept the corruption.

"The pond owners have to check the harvest staff and checker because they skillfully and quickly run a process that is likely to cause mistakes. For example, a harvest man weighs fish quickly but does not communicate properly with the checkers. So they don't actually record the real weight or some just pretend to do so. Some might write the fake weight. However, if the fish owners have such experiences they will deal with the situation. But I decided to keep silent," one fish farmer in Sanpakhee explains (03-07-2013).

3.2 Vulnerability of Pond-Based Aquaculture

Which site is most vulnerable to physical and socio-economic risks? The study explores where and what kind of fish farmers are most sensitive to the multiples risks, and the conditions that affect their response to hazards.

3.2.1 Site vulnerability

The sites that are vulnerable are measured by different levels of access to water resources and degree of urbanization. These conditions increase the stresses and create greater impacts on fish farmers. Types and density of infrastructure and water management at community levels determine household capacity in response to the stresses. Furthermore, building effective canals running far and wide for agriculture and aquaculture farms to assess can resolve resource conflicts among water users. The concrete water canals, which reduce the frequency of clearing canals, are mostly built in Sanpakhee, except for some downstream canals that are still earthen and covered by weed. In Maekaedluang, most canals are concrete; some are earthen but not well taken care of by the *Kae Muang* and water users. In the first two villages, whether they are up-, mid- or downstream, the water users have high chances of gaining a lot of water. By contrast, most canals in Tamphralae are earthen with slow-flowing water; some of it is absorbed by streams running alongside the canals, thus lowering the water level. As a result, water users do not have enough supply for their farms.

Water access is related to the relationship between irrigation institutions and water user groups including farmers and fish farmers. It also affects the collaboration of the *Muang Fai* system and the rate of water competition. Loose water user networks reduce the efficiency of water allocation and management. In this way, after the RID has played its role in the existing *Muang Fai* system, the main responsibility of the *Kae Muang* in managing water has been changed and replaced. The collective action of all water users in maintaining the *Muang Fai* has also likely disappeared. Local people rarely take care of common water and public activities. It can be said that the three villages lack solidarity and participation among water users, but the situation is different in various contexts.

In the past, the users helped clear the earthen canal together. After the state development of the irrigation system, the earthen canal was replaced with concrete ones. The collective action has disappeared whereas the role of machines like backhoes has become more significant. The *Muang Fai* system in Sanpakhee Village is completely controlled by RID, while the *Kae Muang* continues playing a few roles in water maintenance. But some canal has no collective activities. The Maekaedluang irrigation has also declined. Few *Kae Muang* take on the responsibilities of water management under the top-down RID policy. Water users are asked to pay for the water fee and to help clear the waterway. The level of the villagers' collaboration in irrigation activities is declining. Some claim that they will not pay the fee anymore, but they continue to use the water for agriculture and aquaculture activities.

> "I work hard alone and there is no young generation taking part in my work. Now, my assistant does not help me, not even to attend the meetings and maintain the canals. But he collects the water fee without letting me know. You know, I am given a monthly salary of 1,200 baht together with the small partial amount of water fee. I also have to report the updated situation and activities monthly to the RID meeting," one local *Kae Muang* in Maekaedluang explained (10-01-2014).

Figure 3.10 The canal construction by filling the gap between the actual canals and the constructed dyke.

Anyway, many canals in Maekaedluang are designed and developed by RID without any public hearing. The RID does not ask for public agreement or participation from the local water users in developing the waterway. For instance, to prevent soil erosion, they recently built a concrete dyke that was narrower than the actual canal width (figure 3.10). On April 2014, the RID filled the water gap area between the canal with its actual width and the constructed dyke. Besides the irrigation construction increasing the flood probability, filling lands and converting them for housing also impede the waterways and slow down the water flow. Therefore, the locals' concerns about the higher water level during the rainy seasons are not always unfounded, like the flooding that happened in 2005 and 2011.

> "We can't even tell whether the RID aims to solve or increase the problems. Without good communication, we don't know what they use to fill some parts of the canals. We cannot stop the project because it is run by the RID. The canals cannot revert to the normal state. It is now narrower and at risk of floods," said one fish farmers in Maekaedluang (28-03-2014).

Land titles are highly likely to be transferred to the one with more purchasing power. Many farmers lease or sell their lands to outsiders while they move to work off-farm. For example, a large fish operator sold his fish pond land to a rich lady from the city (figure 3.11). After she raised fish for a year, she sold the land nearby to foreigners and converted the rest of the land to soil mining. A lot of big trucks started driving back and forth many times a day, carrying a ton of soil dug from more than 10 meters deep. The villagers were annoyed by the activities and afraid of landslides, so they asked the lady to stop.

Figure 3.11 Soil mining done by outsider in Maekaedluang

Due to higher water demand from agriculture and aquaculture production expansion in the upland area, resource conflicts in Tamphralae are something beyond the control of the farmers. Some agriculture farmers and fish farmers upstream undoubtedly gain a good quantity and quality of water. The downstream water users consequently suffer from the inert and poor overused water. Without collective action, some people break the rules by using big pumps and stock water without sharing with others. The local irrigation leader position is no longer valued nowadays. Few people voluntarily take the role of *Kae Muang* with low salary and many responsibilities. In addition, the system of water allocation is not well managed and planned for a vast land of waterways. Hence, some agricultural lands lack water, some gain less while others overuse.

"The *Kae Muang*'s role is reducing. I am too old to walk back and forth to check how far the water is distributed and to deal with conflicts. Because of low flow, water conflicts are more severe. It is because the authorities upstream stock water in a big pipe intake, how can it flow? I ask for the water to be shared. I'm *Kae Muang*, I actually have rights to take the big pipe out, but I can't. I'm too weak to have a say like other villagers who are scared of the influential people. They are rich and authoritative," one old *Kae Muang* in Tamphralae said (08-05-2013).

"*Kae Muang* is no longer prestigious. No one is scared or cares about their punishment. The existing *Muang Fai* law is not active. As long as anyone has opportunity, they will access more and more, using a big water pipe. Thus, the *Kae Muang* should be younger. They can understand easily, make a project and report to the municipality," explained a medium fish farmer in Tamphralae (07-05-2013).

In terms of market demand over land titles in Tamphralae, the lands there are either left idle or forest areas that are villagers and outsiders use for economic benefits. Around 64 hectares (400 *rai)* of forestlands under the national park are illegally occupied by local people who are relatives of national park officials. Some farmers converted their farms to grow rubber trees, pineapple, pumpkin, corn and soybean in the highland while some illegally stake the partial upper watershed areas in the national park compound. Most upland areas are SPK4-01 and the lowland village is titled. The upland areas have been transformed to SPK4-01, which does not allow them to be sold. In fact, large pieces of lands are illegally leased, speculated upon, and sold to other farmers and wealthy outsiders. Unquestionably, the forestlands have been replaced with housing and agricultural lands.

All in all, with a high potential of water allocation, Sanpakhee has fewer problems of such land ownership change. Maekaedluang is mostly affected by urbanization that makes water management and allocation more difficult. The fish farmers there are mainly plagued by floods, droughts and water pollution. Tamphralae, a medium-sized town, faces the highest rate of resource conflict. This issue increases the probability of drought and water pollution whist reducing the capacity of fish farmer households' response.

3.2.2 Household vulnerability

The weather changes, flooding and droughts can affect annual incomes and resource base. How much impact the climate and weather leaves on the pond culture depends not only on where the area is geographically situated but also on how the people respond to the adverse situations. Here I classify the capitals embedded in families of fish farmers with different scale operations and see how they are affected by the stresses. The information is analyzed from the case studies representative from each community, as follows:

1) Aging farmers over rearing practice

The aim of classifying the different ages here is to see how those fish farmers can apply new knowledge and technology in rearing practices. Does age matter in response to the multiple risks? If so, which of the age groups are more vulnerable to the risks? The average age of the fish farmers of all scale operations in the 3 sites is 54 - 57 years old who are naturally getting older and weaker for such hard farm work. In fact, there are also a number of people older than the average age, whilst a few young people around 25 - 40 years old work in fish farming.

It is necessary to rely on new technology, scientific knowledge and economic understanding when practicing earthen pond-based aquaculture. Fish farmers basically learn or experience first-hand how to choose the factors of production and to calculate the feed ratios and productivity. But, it has been found that age is an obstacle to the old people's learning and practice. As a result, the younger and older generations have different fish productivity outcomes. The young know how to seek for knowledge wider and more modern than the older generation. In other words, the elderly who lack support from their children or other younger family members have slowed down their learning or learned as much as they could on their own.

Based on table 3.4, compared to the other sizes, most large-scale fish farmers are younger and have higher education from high school to graduate degrees. Thus, they have more capacities to develop the fish business and to maximize productivity. Exchanging information in fish groups encourages the 22 fish farmers who are group members in the three sites to use a high feed conversion ratio (a measurement of the animal's efficiency in converting feed portion into fish meat or FCR); and 13 fish farmers to use fingerlings. All of them, mostly in Maekaedluang, are able to reduce the risks during rearing and produce good fish weight within a short period. Fish farmers who implement the ideas are 77% large-scale and 30% medium-scale operators in all sites who are approximately below 60 years old. Significantly, all three large fish operators in Maekaedluang are the youngest (average age of 45 years old) and would rather choose feed with high FCR and fingerlings. As a consequence, they have less likelihood of fish death than smaller fish farmers in other villages. On the other hand, not only some small-scale elderly fish farmers (average age of 63 years old) but also the one who exited from fish farming and the fish group (62 years old) in Maekaedluang always encounter slow fish growth and low weight (less than 400 grams per fish) and a high rate of fish death. They can barely cope with the stresses when dealing with urgent matters. The impacts are also found among some medium-scale, many small-scale fish farmers and the ex-fish farmers who are non-group members in all sites. It is likely that they prefer using production inputs different from the larger scale operators.

The enthusiastic younger generation with high education can reduce their vulnerability by putting in more long-term management strategies and investments. In Maekaedluang, for instance, two large fish farmers apply their knowledge from geography and another from economics into their farm practice. Some large-scale fish farmers use their own geographical knowledge and zoning to foresee what will happen in the area and whether it is fit for agriculture and aquaculture. They also formulate their farming systems with maximization and utilization. Furthermore, in Tamphralae, one large operator applies knowledge from agriculture of which he is a university graduate, into farming management. He runs the business in terms of hybrid farming including agriculture, aquaculture and livestock as well as marketing.

Standard Feed Conversion Ratio (FCR) Calculation

Formula: FCR= Total feed (kg)/total fish production (kg)

(1) A number of feed = 730 bags
(2) Weight per feed bag = 20 kg.
(3) Total production = 11,330 kg.

Calculation: FCR = (730x 20)/11,330 = **1.3**

Figure 3.12 Standard FCR calculation

Local Feed Conversion Ratio (FCR) Calculation Example

Conditions:

(1) Present fish price = 56 bht/kilogram
(2) Feed price = 490 bht/ bag
(3) A number of feed= 730 bags
(4) Total production = 11,330 kg.

Calculation:

(1) Total production/a number of total feed: 11,330/730 = **15.52 (FCR)**
(2) FCR x fish price: 15.52x 56 = 869.12 baht
(3) Total fish price with FCR – feed price (profit/bag): 869.12-490 = **379.12 baht**

Result: a bag of feed can return 379.12 bht/bag. Thus, the higher protein feed is (more expensive), the higher FCR is. (Collected on 01-07-2014)

Figure 3.13 Local FCR calculation in Maekaedluang

Conversely, the aging and smaller fish farmers with lower education and rare knowledge exchange with their counterparts have less ability to understand and develop rearing techniques and processes. FCR is one example of knowledge management. I explore the comparison of different FCR calculations in figures 3.12 and 3.13, one is academic and the other is the local pattern. The collected number in Maekaedluang is used as an example that can be applied to different feed ratios and sites. Beginning with figure 3.13, FCR is made by total feed (kg) divided by total fish production (kg). One shows the best conversion from feed to fish protein, so the closer the number is to 1, the better the FCR. Still, the calculation system has changed a little after local fish famers adopted it in their farming.

FCR and profit per feed bag are measures of good rearing practice. FCR in the local version is supposed to be 20. It means the closer the number is to 20, the higher the FCR. The higher the FCR, the more fish farmers gain high fish weight that returns high profit per feed bag. Based on figure 3.14, the number 15.52 FCR means high protein conversion. Using high FCR increases the fish weight, makes it grow faster and reduces the rearing period. The profit per feed bag represents a return of investment. In figure 3.14, the farmers will gain 379.12 baht as profit/ feed bag in return. In other words, the way to get more profit is using a feed with high FCR. The higher the number, the higher the profit per feed bag.

With less understanding of the technical and economic terms, most fish farmers of mostly aging medium-, small- and some large-scale operations experience slower fish growth and more deaths. Since the feed brand with high premium protein is expensive, those farmers try to minimize the cost as much as possible. No matter how much the FCR is worth in the long term, they prefer using cheaper feed as a way to save money in the short term. The fish, in turn, have lower weights and smaller sizes than those fed with high FCR. Therefore, the farmers need extended rearing periods and require more investment in order to respond to the market demand with big and heavier fish. Above all they cannot notice and clarify fish diseases, which makes it difficult for them to choose the chemical treatment.

Table 3.4 Summary of fish farmers' capitals on fish material selection and the results

Villages	Scale operations	A number of individuals at education levels			Average age	Fish group	A number of individuals using farm input		Results
		<High school	High school	>High school			Feed with high FCR	Fingerling	
Sanpakhee (rural area)	Large (n=3)	3	-	-	55	3	3	1	High fish weight in a short rearing duration and low rate of fish death
	Medium (n=3)	2	1	-	59	3	3	-	
	Small (n=3)	3	-	-	57	3	3	-	Low fish weight in long rearing duration and high rate of fish death
	Exit (n=1)	1	-	-	58	-	-	-	
Maekaedluang (Peri-urban area)	Large (n=3)	1	1	1	45	3	3	3	High fish weight in a short rearing duration and low rate of fish death
	Medium (n=4)	4	-	-	53	4	3	3	
	Small (n=4)	3	1	-	63	4	3	3	Low fish weight in long rearing duration and high rate of fish death
	Exit (n=1)	1	-	-	62	-	-	-	
Tamphralae (rural area)	Large (n=3)	1	1	1	56	3	3	3	High fish weight in a short rearing duration and low rate of fish death
	Medium (n=3)	3	-	-	51	2	1	-	Low fish weight in long rearing duration and high rate of fish death
	Small (n=3)	3	-	-	60	3	-	-	
	Exit (n=1)	1	-	-	50	-	-	-	
Total	n=32	26	4	2	56	28	22	13	

Table 3.5 Summary of fish farmers' capitals on fish material selection and the results (continued)

Village	**Scale operation**	**Labor availability**			**Family members**	**Land title**			**Land price (bht/hectare)**	**Results**
		Hired	Family	Exchange		Rental	Inherited	Bought		
Sanpakhee (rural area)	Large (n=3)	1	3(A)	3	< elderly	-	3	1	50,000-80,000	Investment expansion
	Medium (n=3)	-	3(A)	3	> elderly / children and grand children	-	2	1		Limited investment cost
	Small (n=3)	-	3(A)	3		-	3	-		
	Exit (n=1)	-	1	-	-	-	1	-		
Maekaedluang (peri-urban area)	Large (n=3)	2 (M)	3	-	< elderly	-	2	3	240,000-400,000	Investment expansion and maintenance
	Medium (n=4)	-	4	-		-	4	1		
	Small (n=4)	1(A)	4(A)	-	> elderly	-	4	-		Limited investment cost
	Exit (n=1)	-	1	-	> children and grand children	-	1	-		
Tamphralae (rural area)	Large (n=3)	3	3	-	-	1	3	2	80,000-112,000	Investment expansion
	Medium (n=3)	-	3	-	-	-	3	-		Limited investment cost
	Small (n=3)	-	3(A)	-	> children	-	3	-		
	Exit (n=1)	-	1	-	> elderly and many children	-	1	-		
Total	n=32	7	32	9		1	32	8		

M= migrant worker, A= aging generation

2) Personal wealth, weak family members and labor availability

Wealth enables people to quickly prevent and recover from losses. Other income sources and accumulated wealth can be fast diverted to mitigate or recover from stresses. Using other safer income is a good indicator of its ability to offset the loss in time. However, family member's burden is necessarily taken into account as a key factor of income allocation in the households. In this way, farming stock, tenancy and family members can produce the social vulnerability.

Labor is an important factor of fish farming as a measure of the farmers' capacity in rearing practice. Non-farm jobs are seen as new income opportunities for the young generation while the reciprocal and young laborers working in farming diminish. However, found in some parts of Tamphralae Village, even under the commercial pressure on agriculture, labor exchange (*ao mu ao wan*) remains operating in particular during the rainy rice season, except in fish farming. Also seen in Sanpakhee, fish farmers help one another harvest fish in the morning.

From the table 3.5, in the other two villages, they have to hire labor, which increases the cost of investment. Hired labor roles become important for both large and aging fish operators. Seven out of nine large-scale operators hire labor since they have various businesses such as land speculation, fish trade and expanding agricultural farming. Those large fish farmers in Maekaedluang, Chiang Mai hire migrant workers, who mostly work in the big city, and neighboring laborers to support a large amount of farming work. One aging fish farmer with less help from his family but has enough money, also hires labor for temporary work.

The rest of the medium and small fish farmers in Maekaedluang and Tamphralae, and operations of all scales in Sanpakhee, rely on their own labor (husband and wife) and family members. For instance, one large-scale operator in Sanpakhee takes care of the pig and fish farming alone while his wife takes care of their grandson. Her daughter and son-in- law are working off-farm in other provinces. Without hiring any labor, he has to work from sunrise to sunset every day and seldom participates in social activities in the villages. Similar to other two medium and two small fish operators, their children sometimes send remittance as a cost of looking after a grandson and a granddaughter. Therefore, their fund is too limited to pay for hired labor costs.

Two demographic groups most affected by disasters are children and the elderly (Cutter et al., 2003). The more children and elderly people they have, the more their capitals are reducing. In the three sites, it is clearly seen that the large fish operators have fewer children than the smaller operators. They have to share affordable income among family members especially the elderly and children who have less ability to earn, help with the farming and take care of themselves. In other words, all available income is exhausted for the necessities of daily life and life cycles that cause the limitation of the smaller fish farmers to invest in fish farming.

Table 3.6 Land holdings comparison of each scale operator in each site

Villages	Sanpakhee	Maekaedluang	Tamphralae
Scale of fish pond (Hectares)	S = 1.6-3.2 M = 4.8-8 L = > 9.6	S = 1.6-6.4 M = 8-12.8 L = > 14.4	S = 1.6-6.4 M = 8-16 L = > 17.6

Land ownership is dependent upon farm sizes. Do large-scale operators have more capacity to own more lands than the smaller ones? It is found that larger-scale operators have more land holdings than smaller fish farmers in all sites. From the table 3.6, all fish farmers are given inherited lands. The land ownerships across scale operations are not vastly different like in Tamphralae and Maekaedluang. Large fish farmers in Tamphralae own approximately 17.6 hectares (110 *rai*), the highest land ownership;

followed by the large-scale farmers in Maekaedluang and in Sanpakhee. The small- and medium-scales are slightly different among the three sites. Tamphralae land types in Phayao, a medium town, comprises of land titles and SPK4-01, based on the table 3.5. The land price is 80,000 - 112,000 baht/ hectare (6.25 *rai*) which is more expensive than the upland SPK4-01 by 16,000 - 48,000 baht/ hectare (6.25 *rai*). Most large fish farmers, except for the small and medium, are able to buy and lease the lands. The lands owned by the smaller-scale farmers are mostly inherited from their ancestors. Besides their inheritance, those with more wealth are also better able to choose the right location and buy or lease the lands than most small operators who are inherited the lands. Meanwhile, the large-scale operators have more opportunities to intensify fish farming and other farming over the land utilization.

The land price in Maekaedluang, Chiang Mai (a large city) is most expensive at about 240,000 - 400,000 baht/ hectare (6.25 *rai*). That is the reason why the small fish farmers cannot buy the lands while those who exited from fish farming decide to rent out their lands. Six out of nine large and 2 out of 9 medium fish farmers in all sites both buy and lease the lands. One large operator in Maekaedluang buys land outside the village with better quality of water and away from urbanization. Meanwhile, he has more opportunities to intensify fish farming and other farming and expand income availabilities. He is hence safe from the hazards unlike others in the village. Sanpakhee lands in Chiang Rai, a small town, cost about 80,000 baht/ hectare (6.25 *rai*).

3.2.3 The most vulnerable households prone to the multiple risks

Site vulnerability coincides with the level of household vulnerability. The peri-urban Maekaedluang, followed by Tamphralae and Sanpakhee respectively, is most prone to the multiple risks between climate-related and socio-economic stresses. The vulnerability level is mediated by aging, which affects the understanding ability, non-working household members, lack of social networks and lack of massive investment as well as the likelihood of fish death. Thus, high household vulnerability is assessed by frequency of fish death in every season and the slow fish growth and low weight (the largest amount is less than 500-600 grams). Such households also have a very small amount of money for the existing and future investment. Moderate level is assessed by some amount of fish death in some seasons, the fish weight around 500 - 600 grams and enough investment funds. The fish farmers with low vulnerability levels have some fish death in some seasons, produce fish weighing mostly 700 grams up and have the ability to intensively invest in the fish ponds.

Most small-scale operators are likely exposed and sensitive to risks. It is found that the small aging fish operators and the one who has left fish farming in Maekaedluang are most vulnerable (table 3.7). They not only face disasters and natural stresses but also massive urbanization influences on landlessness, land conversion and labor shortage. This group of people also undergoes ineffective farm management from the lack of help from family members and their low level of understanding the new information and technology. As a result, they can hardly avoid the fish diseases and fish death from the fluctuating water quality and quantity released by the water users and the residents. Taking the long rearing duration is undoubtedly not suitable for them. They have to harvest the fish earlier during the stresses that return the low fish weight and low income.

Table 3.7 Level of household vulnerability (Source: Santita, 2014a)

Villages	Level of vulnerability	Scale operation	Level of vulnerability
Sanpakhee	Low	Large	Low
		Medium	Low
		Small	Moderate
		Exit	High
Maekaedluang	High	Large	Low
		Medium	Moderate
		Small	High
		Exit	High
Tamphralae	Moderate	Large	Low
		Medium	High
		Small	High
		Exit	High

Two cases are elaborated to see who is most vulnerable and how affected they are. Both of them are members of fish groups. Firstly, Mrs. A (pseudonym) in figure 3.14 is a small aging fish farmer in Maekaedluang. She encountered fish loss from floods in 2008 and 2011 as well as fish diseases and death from rapid changes between hot and cold temperatures in the following year. In addition, the water level was not stable during the dry season in 2013 due to its demand upstream for residential estates, households, agriculture and aquaculture farming. Furthermore, her productivity was uncertain due to the pressure from unqualified fingerlings and climbing feed prices. Moreover, she raised the fish alone such as feeding, circulating the pond and cleaning its compound. With little help from her family members, getting older was her obstacle and deepened her growing desire to exit from fish farming. But no one seemed interested in continuing with the farm at the moment. Thus, she reluctantly remains on the farm as long as she is not too weak to work.

Furthermore, a small divorced fish farmer woman Mrs. B (pseudonym) in the same village lost 30,000 baht from fish death due to the multiple water pollution and rapid weather change. Located downstream, she allowed water upstream into the pond without realizing how poor and polluted the water was during the raining period. Her fish were affected by severe diseases through relatively used water and suffered from rapid water turnover. Barely able to cope with the situation, what she could do was to just let the fish group harvest earlier and freeze dying fish for sale with hopes of getting as much returns as possible. To make matters worse, her brother sold the fish pond she was allowed to use, which belonged to her dead parents. The land was filled and a house was built in its place. She then used the idle pond near her brother's house, but still lacked investment money. It was because she had to save the small amount of accumulated money for her two school-going sons. Thus, she had to stop rearing fish for almost a year as a way to reduce risks during the rainy season. She also worked hard off-farm to accumulate money to offset the previous fish loss and kept it for the next investment.

Figure 3.14 Mrs. A (pseudonym) rafting to feed fish alone

Second is the medium-scale operation with non-group, the small and the exited one who often faced water competition, drought and high levels of water pollution. They try hard to maintain the productivity at the existing fish farm landscape by using the available water, whether it is safe for the fish or not. Some ex-fish farmers also had household burdens from a lot of non-working generations. The most affected case is also found in Tamphralae. The medium-scale operator Mr. C (pseudonym) is a newcomer who is neither a part of a fish farmer cooperative nor the *Muang Fai* system. His pond is located in the lowland downstream, which is prone to low flow and stocked water upstream. During the dry season in 2013, lower levels of underground water and hot weather led to tons of fish death. There was no help from any social partners and even the state's compensation since he did not register in the fish farmer list of RID. A year later, he set up an aerator and reduced fish density to reduce risks but vulnerably still faced lower flow period. To keep water quantity, he sometimes had to reluctantly utilize overused poor water from other ponds upstream.

Sanpakhee Village is less prone to the multiple risks but there is still the vulnerable person who left fish farming because he was independent of any fish farmers' organization. That was why he had minimal opportunity to exchange information and knowledge with other fish farmer friends. Therefore, he had a low coping strategy and no network to help him during the harsh stresses. The four cases ensured the vulnerability of fish farmers as a result of weak human capital, problematic financial capital, inefficient natural capital and lack of social capital in households and social networks. The problems are made more critical by the high degree of urbanization due to increasing resource demands. Indeed, the capacity of water allocation at the community level is neither well managed to respond to the uncontrollable influences nor able to support the fish farmer business. Consequently, those vulnerable fish farmers have to individually struggle for survival to make their capitals balanced as much as possible.

3.3 Summary

Findings indicate that not only climate-related risks but also socio-economic risks have impacts on pond-based aquaculture. Location, social and financial status capital, knowledge and social networks have constituted the vulnerability of different sized operators.

The most vulnerable places are (1) Maekaedluang and (2) Tamphralae based on the criteria of the degree of urbanization and water access. Due to the high urbanization influences, poor infrastructure of water management and allocation lead to the low capacity of water users to access water. Earthen canals result in ineffective distribution of water that causes different capacity of access. Moreover, the lack of collaboration in *Muang Fai* activities reduces the solidarity of water allocation and increase resource conflicts between those upstream and downstream. In addition, the degree of urbanization increases pressure on land ownership/ titles and the cost of investment in the fish farming. Some smaller-scale operators cannot own the land rights and better location with easy access to efficient water. It is noted that all these factors multiply the severity of climate-related risks. Maekaedluang was dominated by floods in 2008, 2011 and 2013 while Tamphralae flooded in 2013 and suffered droughts in 2013 and 2014. The least vulnerable is Sanpakhee because it has sufficient water sources with low levels of urbanization.

In terms of household vulnerability, the most vulnerable households are mostly small-scale and some medium-scale operators in Tamphralae because of the loose collaboration among fish farmers and villagers. Furthermore, the lack of family labor, support and social networks makes it difficult for the fish farmers to cope with the problems and increases the possibility of reducing or exiting from fish farming. In addition, aging is an obstacle to learning new scientific and economic knowledge on how to rear fish effectively. Limited wealth resulting from weak family members also reduces the capacity of intensive investment. However, the differences among smaller and larger operators can be resolved through social connections across the scale operations, collective action, and the exchange of information and knowledge with external organizations. In this regard, different scale fish farmers with diverse livelihood capitals are differently exposed and sensitive to the multiple risks. It is skeptical how they use their capitals to respond to, cope with, recover from, and adapt to the stresses. More details are explored and elaborated in Chapter 4.

CHAPTER 4

Farm Sizes and Adaptive Capacities

Households and community vary their abilities to respond to, cope with, recover from, and adapt to hazards. Adaptive capacity is determined by ability to access: information and technology; natural resources; labor; money; lands; and, social networks. The chapter outlines (1) the rationale to examine the different abilities of small, medium and large scale operators over the capital convertibility in order to maintain fish productivity and to generate income; (2) the impacts of climate-related variability towards fish farm households and communities and their coping capacities; and (3) their adaptation to different scale operations. To elaborate the different adaptive capacity, the fish farm households with small, medium and large scale operations are divided into the ones participating in fish farmer groups and those not.

4.1 Converting Capitals to Access as Adaptive Capacity

Successful pond-based aquaculture depends on site selection, good quality and quantity of production factors and good rearing management. Any fish farmer who has more assets tends to have a greater range of options and an ability to switch between multiple strategies to secure their livelihood (DFID, 2000). In other words, water, information, labor, money, land and social networks can be utilized, mobilized and converted among themselves in order to access to resources. It is necessary to study how that small, medium and large fish farmers who are both in and out of the groups have different adaptive capacities.

4.1.1 Water access

Water is an important factor for rearing practice. But each scale of operation in the three villages has different abilities to access to water. Most fish farmers

(90%) in all sites are members of fish groups that work in isolation with the *Muang Fai* group. Eighty four percent of all case studies take part in the *Muang Fai* system. One medium fish operators in Tamphralae and those who exited from fish farming in all sites decided not to undertake the irrigation system, but prefer using the nearby available water sources instead. Water use in Sanpakhee is more efficient than the other two villages. Regulated by the RID, the water allocation plan is made based on rice seasons and will be closed during rice harvesting period. However, in reality, the water allocation plan together with natural water sources provide sufficient water that allow farmers and fish farmers to do agriculture and aquaculture activities widespread throughout the year round. That is the reason why they hardly make a direct contact or negotiation with the irrigation agencies because of the low level of water conflicts, shortages and access difficulties. They can use enough water during rainy season and just slightly have difficulties in accessing to water during low flow periods.

All scale operations in Sanpakhee can use and change water in the pond whenever the water is released, but they are different in terms of their pond location and their different capacities. It is also found that no matter they have different scale operations, their pond location is scattered along upstream to downstream canals. Fish farmers in general are hence able to not only change water in the ponds at least once a month but also to use water even during the dry season. Downstream fish farms of any size can change water later than 2 - 3 days compared to up- and midstream fish farmers. Since there is low level of water downstream, some fish farmers (30% of them) are willing to share water with other water users who both do agriculture and aquaculture. In terms of farm sizes, large fish operators with a larger number of lands than smaller scale ones can allocate at least one fish pond in order to stock water and to purify polluted water before using in their fish farm. One out of two medium-scale fish farmers also allocate small pieces of their lands to stock water. Small-scale farmers with limited lands primarily rely on the irrigated canals. But this is not a big problem since the water is mostly widespread, allowing them to change water during the summertime. If there is totally no water, some large-, medium- and small-scale fish farmers basically put the probiotics to maintain the quality of water as long as possible. In contrast, the farmer who exited completely from fish farming due to the poor water downstream and replaced his lands with rice paddy fields also access to water like other fish farmers. Since he lacks participating with fish groups and fish farmers friends, he mainly relies on the poor used water from upstream fish ponds. If getting excessive water enriched with too much nutrient, rice growth will be negatively fastened with low weight of grain.

In terms of widespread water allocation, the water users in Sanpakhee face less water problems than those in Maekaedluang. Regulated by the cooperation between RID and the *Muang Fai* system, water users experience the uncertain water level and its poor quality especially during the dry season. They have difficulty maintaining the existing pond water and their productivity. Except for the one who stops fish farming, every fish farmers belong to the fish farmer groups and the *Muang Fai* system. The two organizations sometimes cooperate with each other particularly during the time of water crisis. Depending on scale operations, fish farmers can differently access to water. In other words, whether the fish farmers include in the fish group or *Muang Fai* group, they actively try to access to water by their ways. All farm sizes are located around the areas from upstream to downstream.

Starting from large size, fish farmers upstream can easily access to water. Since pumping water to the ponds requires extra cost of investment, the larger-scale operators take the condition into consideration and decide to reduce the expense permanently. The first large fish farmer with high financial capital moves his fish-based production to the better location with efficient water access upstream. The new place allows a water flowing system into and out of the pond autonomously that can reduce long-term water pumping costs. Another large operator downstream also rents a big idle pond at 10,000 baht a year for stocking water to prevent water shortage. Then, he sets up the water circulation in the ponds in order to keep the existing water qualified and long utilized rather than using the poor water in the canal. It is obviously seen that the most wealthy fish farmers face a lower level of water constraint than the smaller-scale operations.

On the other hand, the smaller fish farmers with fewer choices have to adjust their ways of water access in the existing areas. They can get enough water in general but usually face problems during the low flow period. Six out of eight fish farmers can rely on the irrigation water while one small operator has to access to water in other different ways. To solve the water shortage crisis, one medium fish farmers can temporarily rent a small idle pond for 5,000 baht a year but unfortunately the owner of the pond decides to build houses on the property. Then the fish farmers have no choice but to look for alternative water sources. The small fish farmers located downstream struggle from long low flow owing to the water use for farming upstream. One out of three small fish farmers use accumulated wealth to invest in ground water. They mix the ground water from 30 % of pond water with 60 % of the irrigation water. Lastly, the fish farmer who exited from commercial fish farming did not participate in any kinds of group investments in the ground water and seldom used irrigation water. He did not pay for the water fee, which limited his negotiation rights in accessing to water unlike others in the *Muang Fai* group.

The role of water irrigation systems in Tamphralae under the *Muang Fai* system is declining nowadays. However, water allocation is mainly taken care by the communal irrigation leader who does not enforce the irrigation regulation towards water users. There are many natural streams and some canals from Mai Yang Weir around the farming and fish farming areas. Some of the landscape is low, which makes underground water available. Most fish farmers (80% of all case studies) are members of fish farmer cooperatives and *Muang Fai* groups in which their works do not coincide with one another. Thus, fish farmers try to access to water by their own ways. Two out of these who does not belong to both fish group and the *Muang Fai* group are excluded from any given benefits. On the other hand, some, mostly outsiders who practice farming and fish farming, get benefits from water, but do not live up to the irrigation rule, which causes problems for the other water users. Most of them use and stock good quality water and large quantities upstream before releasing the poor water, which impacts on most water users mid- and downstream.

In terms of scale operation, all farm sizes rely on water from the streams and some canals without spared ponds for stocking the water. The farms upstream mostly use automatic water circulation systems in the pond that require a larger amount of water than the normal pond water system. Fish farmers with more money are able to buy or lease the additional lands with good access to water. On the contrary, the medium and small scales have fewer abilities to buy land in suitable locations. They possibly face water problems depending on their farm location. The ones in the local irrigation groups generally use the irrigation canals and face fewer problems than the one out of the *Muang Fai* group. For instance, one medium fish farmer who is excluded from the *Muang Fai* group has no rights to negotiate with the communal irrigation leader for access to water. He independently relies on the uncontrolled rain, natural underground water and used water from aquaculture and agriculture activities upstream. Sometimes, he has to clear the canal by himself with his own funds. Thus, he can feed fish in particular rainy season but his production is inconsistent. Furthermore the ground water is sometimes too low to use for the pig farm, which leaves him with no choice but to transport large amounts of water from his home.

In addition, all three small fish farmers downstream in the *Muang Fai* area use a little water from natural streams since a large amount of water is stocked upstream. They prefer using the underground water from which their ponds located in low land generates water through year round. The water is always available even in dry season but it is difficult for them to change poor water in the pond and allow the pond to dry out for cleaning after harvesting. The waste and toxic-residue left in the pond create risks of fish diseases in the next crop. In addition, one large fish farmer neighbor built canals to release his used water from his farm for the smaller fish farmers who also need water. They thus utilize the used water that is poor and polluted especially during low flow periods. Because of poor water, one out of three small fish farmers decided to invest in ground water for pig farming. Additionally, the ex-fish farmer who is out of the fish group but still in the *Muang Fai* group had most difficulty in accessing to water and help. She left because she had no help from the fish cooperative during the time of fish stresses. To make things worse, her pond located downstream gained poor and polluted water from upstream. She sometimes had to use piped and underground water instead.

4.1.1 Access to money and earned income-generating activities

Different places with different rearing fish systems depend upon various systems of water availability. In particular, the integrated pig-fish farming system is widely implemented by every fish scale operator in Sanpakhee and two large fish operators in Tamphralae. Additionally, chicken-fish farming is implemented by one medium and small fish operators in Maekaedluang. However, fish farmers in the places with less efficient water such as Maekaedluang and Tamphralae tend to do intensive farming without pigs or chickens since they do not have enough water to change and maintain the fish production.

1) Sources of investment

The sources of income are generated from loans and accumulated income. Loan sources comprise of banks, village loans (1,000,000 baht per village), cooperatives as well as social networks (kin, neighbors and friends). Smaller scale fish farmers in the three sites borrow money from the Bank of Agricultural Cooperatives (BAAC) with a small amount of interest. The village loan generally allows farmers to borrow money around 10,000-20,000 baht per year. It is required to refund and re-borrowed yearly. Furthermore, most of fish farmers who belong to the fish group are allowed to borrow feed with interest at the beginning of the rearing practice. Some groups allow farmers to borrow feed just a few months before harvesting. More or less available income can be used to invest in fish farming and households depending on the farming system and their scale of operations. It is chiefly found that all farm sizes have access to all investment sources but in differing amounts. Most large operators get money from inherited family wealth and from wealth accumulation from farming and other businesses. Some also manage to get large loans from the BAAC and other private banks plus their accumulated money. They use the loan to pay for the high investment of commercial feed and expand their businesses. Many of them divide part of the profit to refund and keep the rest of money for the next investment. However, without a loan, some smaller-scale operators decide to use their own small amount of money from off-farm income to invest in their small fish farming. More details are elaborated below in different villages.

In Sanpakhee Village, large fish farmers borrow money from the BAAC and other private banks for investment plus their accumulated incomes. Paying back the banks' loan is cheaper than the higher extra expenses of the related materials. For instance, they use the borrowed money to pay cash for the expensive feed and seed in order to reduce its interest. They think that borrowing 100,000 baht from the bank with 6-700 baht for its interest a year is better than paying for the additional and higher feed interest set by the fish groups. Moreover, some of them borrowed money from the BAAC as an initial cost of investment and paid it off before using their accumulated wealth for present and further investment. However, they decide to borrow the feed from the fish group instead of paying cash. The other large fish farmers who belong to a feed agency borrow a large amount of money (around millions) from the BAAC and other banks to pay cash for a large amount of feed. Income from the profit of retail feed and fish sale is used to pay their monthly debts.

For medium and small fish farmers, they borrow money from the bank and village fund. With limited accumulated wealth, some of them use about one hundred thousand baht in cash to pay for feed while a few people would rather keep the money for the rearing payments and daily consumption. That is why they cannot pay cash for feed, which forces some of them to borrow feed with high interest from the fish group. To save the interest cost of about 5-15 baht per feed, some decide to pay in the first 4 - 5 months and borrow the feed a few months before harvesting time. Some of them use are given financial support for initial investments from their kin who are large fish farmers. Then, the loan is required to be repaid in kind through assistance as well as money.

In Maekaedluang, since, all of the fish groups do not allow every single fish member to borrow feed to prevent the debt constraints. But the systems of some fish farmer are compromised by allowing the members to borrow feed for 1 - 2 months with a high interest of about 5 - 30 baht/feed bag before harvesting. Thus, each fish farmers have to try their best to access to money sources. Most large fish farmers borrow money from the BAAC and private banks and use accumulated wealth. Most then repay the borrowed money and use their main incomes from fish farm and other sources of income. They usually pay cash for the rearing materials. Without the bank loan, for instance, one large operator firstly invests in fish farming with his pocket money. After harvesting the fish, he keeps two-thirds of the profit for the next investment in buying fingerlings and feed. If the investment cost is not enough when fish-harvesting time comes around, he uses the additional profit from other fish crops to invest in the present crop. Thus, his investment cost is systemized by allocating and circulating money. Some furthermore get the private bank loan for further wealth speculation as shown in the speech below.

> "I just borrow money from the bank as a supplement fund for urgent matters, but I have the existing investment money. Imagine I use that amount of money with 3% interest to buy other stocks or deposit the money. I get divided 7% that mean I thus get 4% profit. See there are many ways to get profit from a bank loan," explain the large fish farmer in Maekaedluang (8-07-2013).

With limited money, medium- and small fish farmer rely on the loan from the BAAC bank and kinship's assistance. The bank loan is usually used for fish farming investment and house construction. Some of them are still in the process of refund while some continue borrowing. Some use the village loan mostly for daily expenses. Few medium and small fish farmers use their own income, which is for household consumption. Some medium-scale farmers borrow money from relatives; one farmer borrowed from his son who works off-farm in the big city. They also ask the large fish farmers who are their clans to pay in advance for the feed and the money will be returned. Some use the winning lottery reward to invest in materials such as aerators. In terms of paying for feed, they tend to use their rights borrowing feed a few months before harvesting by paying extra interest for 30 baht/ feed bag. It has been found that a few small fish farmers whose family contains working people and a low number of aging adults and children add their own off-farm income with the bank loan and the profit from the existing fish farm to invest in further fish crops. For the person who was out of the fish group and exited from fish farming later on previously paid for expensive feed costs regulated by the contract farming. He had to work in more off-farm employments for the investment cost used in the fish farm, but in reality he hardly keeps the profit for the next investment. This was because there is high financial demand from his family members who are still studying and over-spending.

In Tamphralae, fish farmers generally get a bank loan, village funds and other sources depending on their abilities. Two out of three large fish farmers do not borrow money from the bank, but rely on the feed loan from the feed shops or the fish cooperatives and circulated profit from livestock such as pig and chicken. One of them get a large amount of BAAC bank loan of more than 1,000,000 baht and the Agriculture Cooperative to pay cash for feed and other materials and equipment. Meanwhile, two out of three medium- and three small-scale fish farmers borrow a small amount of money from the BAAC. They also get the feed loan from the fish farmer group with less credit than the large fish farmers. One small fish farmer is given money mainly from the Agriculture Cooperative of about hundred thousand baht with 5 baht interest per year. Another two small fish operator are supported by their children to invest in the farm. They prefer to borrow feed with some surplus interest because they do not have enough remaining money. Similarly, one medium-scale fish farmer out of fish group does not receive any feed credit. He decides not to borrow a loan from the bank, but to use his circulating income from livestock and fish farming profit to borrow feed. Thus, his income is allocated for investment, which limits his business expansion. The one who stopped fish farming use the bank loan and his small amount of income. This limited his capacity to invest in fish farming which requires high costs of investment. All in all, it is noticeable the small fish farmers in all sites rarely use accumulated wealth.

Two types of rearing practices which are intensive and integrated farming require different investment management. Intensive farming relies very much on commercial feeding; even though pellet feeds are more costly than pig/ chicken manure. The systems are mostly found in all farm sizes in Maekaedluang and Tamphralae. Fish farmers with all scale operations invest in the business with loans and available incomes. But, circulating money between aquaculture and livestock can help reduce the cost of investment. Fish and pig income can be circulated for all farm sizes in Sanpakhee and large sizes in Tamphralae. According to the table 4.2, raising pigs for 3 - 4 months is faster than fish for 5 - 7 months. The income from pig with 10,000 baht per pig is used to invest in fish, and fish income is used for pig investment in return. Thus, their income affordability can reinforce production and household security throughout the year.

"Income from fish and pig is circulated. That is why we raise pigs. After getting money from this pig crop, we will keep it for fish investment. So we never lack money because it is saved from both fish and pig," one medium-scale Sanpakhee fish farmer explained (18-01-2014).

Table 4.1 Non fish products

Sanpakhee	Maekaedluang	Tamphralae
Pig: 10,000 bht / pig (on sale every month)	Chicken: 6 - 10,000 bht/ crop (6 - 8 crops a year)	Pig: 10,000 bht/ pig (on sale every month)

Raising chickens on top of fish in Maekaedluang minimizes the cost of investment. For instance, a small- scale fish farmer tries to maximize her small piece of land by raising chicken and reducing the feed use. Her tactics are feeding fish with plankton from chicken manure, but it decelerates fish growth and causes low weight. Therefore, after raising 4 crops of chicken (20 - 28 days for one crop), which is matched to 5 months old of fish, commercial feeding will be started for another month before harvesting. Then, the fish will get higher protein and good weight. Fish and chicken crop will start at the same time again then. From the table 4.1, raising chickens in summertime returns little income, but the winter can produce 3 crops a year with high income of about at least 6,000 – 10,000 baht/ crop. The income is circulated to invest in interrelated fish and chickens. Moreover, income from her husband as a van driver is used for household consumptions.

2) Farming investment

To invest in fish-pond farming, many costs, which are available in the fish farmer groups, are taken into account such as that of fingerlings, feed, chemical substance and water system as well as other equipment. The fish farmers who participate in the fish farmer groups have opportunities to get reduced prices and loans. On the contrary, non-group fish farmers are naturally required to pay as much as the real costs of inputs. Although the groups can take the extra financial burden, most small- and medium- scale operators basically with limited money attempt to find ways to reduce the costs.

> "The more density of fish we have, the less profit we gain. For instance, raising 10,000 fish, we gain just 1,000 - 2,000 kilograms. We don't know why the fish dies. On the other hand, using some 1,000 fingerlings, we get more profit with less fish death," one medium fish farmer in Maekaedluang said (02-02-2014).

Using high quality feed and fingerlings are worthwhile for reducing the rearing duration while increasing frequencies of crops and fish survival rate. This is because using fingerlings is believed to reduce risks of fish death and increase fish crops, but it is costly. The big fingerlings can survive in different temperatures against fish diseases. However, a small fry is at risk of fish prey such as snakes, birds, and the snake - head fish. It is found that all small and medium fish farmers particularly in Sanpakhee and Tamphralae prefer using fry fish (a very small baby fish about the size of a matched head) and cheap feeding which might not be qualified. By contrast, every large fish farmer in the three sites decided to invest in fingerlings (baby fish with the length of one finger). Meanwhile, like the farmer quoted above, all scale operators in Maekaedluang, in which the fish groups have high information exchange, prefer using fingerlings to minimize the risks of fish death. Some people have 80 fingerlings/ kg, 53 fingerlings/ kg and 6 fish/ kg.

Aerators have become necessary for oxygen circulation nowadays, but different scale operators used them differently. Three small and three medium fish farmers in Sanpakhee who run the integrated farm; and three small and two medium in Tamphralae from conventional commercial farm find it difficult to pay for the expensive equipment. Thus, all of them use aerators particularly only during the time of stresses to save on electricity costs. The integrated system in Sanpakhee is more prone to water-stratification resulting from the differences in density between warm and cool water from absorbing solar radiation passing through the water surface (Patcharawalai et al., 2013). The fish farmers as a result experience the stress that fish are exposed to low dissolved oxygen levels during rainy seasons if they decide not to implement the machine to mix the water. That makes them more prone to fish death than the larger- scale operator who can pay for the high cost. On the other hand, all medium and small fish farmers in intensive farming in Maekaedluang to which the feed companies give financial support and information, are aware of the risks and agreed to set up aerators to prevent fish loss. Similar to the large fish farmers in the three sites, they decided to pay for many expensive aerators widely spread in the ponds and the increasing electricity costs for their operations. In addition, they invested more money to develop their water and pond systems as a way to simply prevent risks in the ponds and reduce the investment cost in the long term.

Table 4.2 Farming system and income generation per crop in three villages (Source: Santita, 2014b)

Fish Income	Sanpakhee	Maekaedluang		Tamphralae	
Production system	Pig-fish integrated farm	Chicken-fish integrated farm	Intensive farm	Pig-fish integrated farm	Intensive farm
Density of fingerlings	3,000 - 5,000 fish/*rai*	3,000 - 5,000 fish/*rai*	2,000 - 3,000 fish/*rai*	3,000 - 5,000 fish/*rai*	3,500 - 5,000 fish/*rai*
Frequencies of rearing practices/year	2 crops/ year 3 crops/ 2 years	2 crops/ year	2-4 crops/ year	2 crops/ year	2-3 crops/ year 2 crops/ year 3 crops/ 2 years
Sources of fish feed	Feed+ pig manure	Feed+ chicken manure	Feed	Feed+ pig manure	Feed
Number of feed	65 - 100 feed bags*/ 3,000 fish	75 - 90 feed/ 5,000 fish	120 - 150 feed bags/ 3,000 fish	70 - 100 feed/ 5,000 fish	150 - 270 feed bags/3,000 fish
Fish production yield	1,300 - 1,700 kg/ *rai*	1,000 - 1,400 kg/ *rai*	1,000 - 1,600 kg/*rai*	1,000 - 1,700 kg/ *rai*	600 - 1,200 kg/ *rai*

* 20 kilograms per feed bag

Stocking density has impacts on yields depending on water quality and quantity as well as and oxygen levels. Having high density of fish stock reduces the level of oxygen in the pond that weakens the fish immune system. Fish farmers nowadays in the three sites tend to reduce fish stock density for more oxygen distribution in the pond. Thus, lowering its density to 3,000 fish/ *rai* (0.16 hectares) is an average ratio to increase fish survival rate. However, knowledge and information is not widely understood across scale operations in all sites. Large- scale operators have low density of fingerlings such as 2,500 - 3,000 fish/ *rai*. Six out of nine who are smaller fish farmers from integrated farms in Sanpakhee and from intensive farms in Tamphralae raise 3,000 - 5,000 fish/ *rai* (table 4.2), but lately they have been suffering more from fish death and loss. Every fish farmer in Maekaedluang significantly reduced the density of fingerlings. They shortened raising fingerlings into 1 - 2 months and further feed intensively for more 3 - 4 months. Some nurse fry in hatchery prior to raising fingerlings in the pond.

"One of the feed brands here cost 450 baht in Chiang Mai, but it is sold at 530 baht in Phan, Chiang Rai. Why do those people there have higher investment still get profit?" said one large fish farmers in Maekaedluang (24-01-2014).

The farming system and management in each village might answer the curious question above. From the table 4.2, it is seen that integrated pig - fish farming in Sanpakhee and Tamphralae and chicken-pig farming in Maekaedluang can save on payment of feed. Water with pig or chicken manure producing planktons and algae as a kind of fish feed can reduce commercial feed use. In addition, putting too much artificial feed in the integrated faming possibly makes the water quality poor. All fish farmers in integrated farming in Sanpakhee, two in Maekaedluang and three in Tamphralae, thus use a smaller number than those fish farmers in conventional commercial systems because they rely more on the plankton from pig or chicken manure.

Nonetheless, the rearing duration of integrated farms is longer than the intensive system. Nine out of eleven fish farmers in Maekaedluang mainly use artificial feed but still less than those in intensive farming in Tamphralae. It is because six out of nine lack understanding on how much feed portion is fit for the appropriated amount of fingerlings. That is why they use extra. Additionally, the more frequencies of fish crops increase, the more fish farmers are likely gain more income. However, it is depending upon a density of fish and fish survival rate that require the amount of intensive feeding and investment costs. Ninety percent of large fish farmers in all sites have more frequencies of fish crop than the smaller scale. Seventy-seven percent from medium and small fish farmers in Sanpakhee and Tamphralae takes 2 crops a year and 3 crops per 2 year. But 63% from all scale operations in Maekaedluang takes 3 - 4 crops a year. The rest of them take 2 crops a year. Consequently, it is found that the fish production yield in integrated farms in Sanpakhee is highest due to high stocking density and a low number of feed. The production from integrated and intensive systems in Maekaedluang and the integrated farms in Tamphralae are compatible. The production in intensive farms in Tamphralae is lowest because of high fish density, which is at risk of fish death; and the high number of feed which costs high investment. It is interesting to study other factors influential on fish farmer information and management.

4.1.3 Labor availability

Table 4.3 Labor availability in the three villages

Village	scale	Family labor	Hired labor	Exchange labor
SPH	Large (n=3)	6	16	A number of labor depends on a number of water users in each canals
	Medium (n=3)	5	n/a	
	Small (n=3)	6	n/a	
	Exit (n=1)	2	n/a	n/a
MKL	Large (n=3)	4	6(migrant)	n/a
	Medium (n=4)	10	n/a	n/a
	Small (n=4)	6	1(aging)	n/a
	Exit (n=1)	1	n/a	n/a
TPL	Large (n=3)	5	3	n/a
	Medium (n=3)	6	n/a	n/a
	Small (n=3)	5	n/a	n/a
	Exit (n=1)	2	n/a	n/a

The labor factor is significantly important in running the farming. Different scale operations rely on different labors such as family labor and hired labor whereas exchange labor is available based on location. The more the larger scale fish farmers have labors, the more effective their farming management is. For the small-scale operation, labor is important for earning a living, because even if households have no lands they could seek both farm and off-farm employment. Based on the table 4.3, all farm sizes in all villages use their family labors, but some large fish farmers (19% of all case studies) in all sites hire total 26 labors. At the same time, exchange labor is particularly available in all farm sizes in Sanpakhee. However, labor availability is different upon the spatial contexts of fish farm types and the association with the fish groups.

In terms of integrated fish farms in Sanpakhee, no matter how much farm size they own, all of them tend to rely on their family labors (husband and wife), while 88% of their children would rather seek off-farm employment. The site has the largest number of aging fish farmers who do farming while supporting their children to do off-farm work and study outside the village. Due to weakening health, 8 out of 9, as a result spend almost a whole day to feed fish and pigs as well as to manage farming that does not offer fish farmers' many opportunities to do off-farm work. Three of all case studies do farming alone all day, which reduces the chance for them to rest and participate in social activities. Furthermore, some fish farmers with large- and small-scale operations decide to use feeding machines instead since they lack labor for a lot of work in the pig and fish farming. Their home-based production is, as a result, hardly expanding unless the small aging fish farmers have more money and labor. Only one large farm size hires 16 local people to help farming. He has the largest number of hired laborers comprising of 6 fish distributors, 6 fish harvesters (2 out of 6 also work on the fish farm), 1 accountants and 3 fish merchants.

The intensive pond-based aquaculture in Maekaedluang and Tamphralae does not highly require laborers. Most small- and medium-scale operators with small pieces of lands can thus rely on family labors in order to save cost of investment. For example, in case of a small fish farmer in Tamphralae, she and her husband help take care of the fish together. Near her fish farm, there is another divorced woman also raising livestock, poultry and pond-based aquaculture alone. With some help from her children and limited money, she decided not to hire anyone. On the contrary, large-scale fish farmers use both family and hired laborers to help take care of the expanded business. Some of them assign their children to take care of the fish ponds while they themselves work in off-farm jobs. Some of them allocate their children some partial ponds for further investment. However, if there is no help from the family, they decide to hire labors.

Hired labors are important for both large and aging fish operators. Two large fish operators in Maekaedluang hire labors to support a large number of farming works and determine the capacity of rearing practice. The labor more they have, the more effective and widespread the feeding and pond management are. The first one hires 4 laborers and the second, 2. Meanwhile, most migrant labors are mostly found in the big city like Chiang Mai. In Maekaedluang, migrant workers replace Thai labor shortage. Those laborers are at first suggested by fish farmer neighbors who know some of migrant workers. Then the workers introduce their friends to work on other farms until the migrant workers connections are wider and more spread out the district. They are not only working on the farms, but are also seeking for other incomes like that of fish harvester and fish retailer. One offspring gains money from off-farm employment to invest in fish farming by hiring migrant workers. Aging fish farmers with less help from their families also hire migrant workers to clear out the pond dike and to transport feed to the farm.

The intensive fish farm systems in Maekaedluang also provide farmers with opportunities to seek other income sources out of fish farming and time to participate in other social activities. They agree that fish production can be supplementary income - just spending a particular short time in taking care and feeding for 20 - 30 minutes. That is the reason why two offspring working off farm returned to invest in fish pond farm. The first, a large sized fish farm operator, inherited the business from his parents or relatives and works fulltime on the farm. Another offspring working off-farm or seeking for employment let his parents takes care of the farm; the profits are shared among the family members and partially kept for the next investment. Eighty percent of fish farmers can also work for social activities and charity works such as weddings, new house warming and funeral ceremonies.

In terms of fish group assistance, exchange labor in fish harvest activity remains in Sanpakhee. Besides to the hired harvest labor from the fish group, fish farmer kin or neighbors, who use the same canals but belong to various fish groups, voluntarily help each other in the morning. Different from the other two villages, Maekaedluang primarily uses hired migrant workers provided by the fish group to harvest fish while Tamphralae hires local people. The fish owners are required to pay the hiring cost. Fish farmers in all villages who are not in the local fish group do not get exchange labor. They rely on the external trader and have to pay for the hired laborers.

4.1.3 Land utilization

Land size and ownership determine the different capacities of rearing practice. Land utilization is a way to maximize farming income for all scale operations. Fish farmers in Sanpakhee and Tamphralae have more capacities to develop or expand their lands because the land price is cheaper than in the peri-urban Maekaedluang. It is unsurprising that the well-off fish farmers have more purchasing power over a number of land ownership. The more lands they have, the more they can benefit from land use allocation. Most large operators are also able to allocate their lands for nursing fingerlings and rearing fish, aiming at reducing the rearing duration and increasing survival rates.

One of the large fish farmers in Tamphralae, for example, has been rewarded for an efficient fish pond system to raise fish all year round. He can raise fish for 3 - 4 crops a year within 4 ponds by allocating lands into 2 rearing ponds of 0.32 hectare (2 *rai*) and 2 rearing ponds of 0.64 hectare (4 *rai*) as well as 2 nursery ponds of 0.04 hectare (0.25 *rai*). He can raise fingerlings for 3 months before transferring to the rearing ponds for another 3 months. Many of the smaller scale fish farmers in Sanpakhee and Tamphralae cannot follow the systems because they have limited pieces of land as well as lack of techniques and information. Still, due to the knowledge exchange in the fish groups, many farm sizes in Maekaedluang adopt the ideas, use the fingerlings and maximize their small pieces of lands by increasing the fish crops. Some of them, especially large fish farmers, furthermore gain more income by selling nursed fingerlings to the smaller fish operators who have a smaller piece of lands.

All scale operations can diversify and ultimately utilize their lands upon their land holdings. For instance, four smaller- scale out of nine fish farmers in Sanpakhee grow vegetables around the levee and sometimes share the product with their neighbors and kin. One large-scale fish farmer in Maekaedluang allocates a big plot of land for 23 fish ponds while raising ducks for eggs as supplementary income for his migrant workers. However, the smaller fish farmers in Maekaedluang only do fish farming and look for off-farm incomes. Additionally, two small farms out of nine in Tamphralae are allocated into fish ponds, a small piece of rice paddy field and orchards while the rest of the land is used for raising cows, chickens and ducks for domestic consumption and sale.

4.1.4 Social network as a consequence of information distribution and implementation

Social networks can facilitate innovation and knowledge development. There is a sharing of information among kin groups, neighborhood and fish farmer cooperatives; so called an interrelationship between social and human capital. Being a member of the fish group provides opportunities to learn and exchange information to increase the adaptive capacity. Adaptive capacity as a consequence is enhanced by new information, technologies and resources from social learning and self-organization among fish farmer cooperatives. Accessing information, fish farmers basically learn how to rear fish, what kind of size is good, age, feed, fish disease, water, climate and weather. Notwithstanding, non-group fish farmers lack such opportunities to experience like their other friends, to exchange and learn from others. Their adaptive capacities as a consequence are probably lower than other friends who are in the group. Being a member of the fish groups does not benefit all farm sizes. It is found that 67% of all large fish farmers learn a lot through experiences and other organizations. Five out of nine share with other friends, the rest keep the information to themselves. In other words, such information distribution depends on the kind of social connections in the three sites.

Maekaedluang fish groups have the highest level of close relationships among kin, neighbors and other external feed agencies, compared to fish groups in Sanpakhee and loose fish farmer operatives in Tamphralae. Fish farmers in Sanpakhee usually learn from their experiences and local exchanges among kin and neighbor groups but Tamphralae fish farmers are highly supported by the state and university. However, the information distribution is not as widespread because there is less local exchange among the members across all scales of operations. Just three large and one medium farm sizes get benefits from state support.

Fish farmers in Maekaedluang have the highest learning process via monthly meeting among the fish groups. A large-scale fish farmer leader is a key person who mainly encourages the smaller-scale fish farmers to learn from each other while asking the feed agencies to distribute information for the group members. For instance, they learn how to adjust the geographical landscapes of the pond to fit better with the fish nature. Deep water can reduce temperatures during summer time while shallow water is good for the fish under the cold weather. Moreover, deep ponds with not too much water and high bunds can prevent flooding. In Maekaedluang, the height of pond walls depends upon the location. According to the farm system, the height should be at least 1.80 meters at the water entrance and 1.20 meters at another water exit. The height in high landscapes can be least one meter. Fish can survive in 25 - 30 ^{0}C within these heights. The idea is similar to the location in Tamphralae, one bottom of the pond is 1.50 meter depth and another is 1 meter. Even though the Department of Fisheries and universities supports the knowledge, just all large- and one medium-scale operators indeed adopted this idea. Two medium- and three small-scale operators built up their ponds without academic knowledge and understanding.

In terms of feeding, in the past fish farmers just fed fish as much as they could without cost-benefit calculation like two large-, two medium- and three small-scale operators in Tamphralae in these days. Although the state and university tried to share the academic information, the farmers seemed not to follow their advice but selected feed more from the propaganda of fish groups or neighbors than from their consideration. Nevertheless, two large fish farmers use high FCR feed, but do not share the successful profit information to other fish friends. Conversely, fish farmers with all scale operations in Maekaedluang and some in Sanpakhee have now learned from each other and from the fish groups about how to feed fish more systematically. They learn not only how to select the feed by focusing on the feed conversion ratio (FCR) but also how to compare the protein and price among different feed brands. For example, from local calculations, comparing two feed brands with similar price, the higher FCR the more protein is in the feed. FCR of the first brand is 17 for/ feed bag (20 kg), but the second is 13/feed bag. Thus, fish farmers prefer using the first brand because, with the same number of fish, feeding fish 20 kilograms can be converted to a fish weight 17 kilograms.

> "We have done local research on experiments and experiences. Using the premium feed with high protein increases the fish weight. Implementing a ring blower (a kind of aerator) into the pond is effective and working well. So everyone is curious about the solutions and voluntarily wants to change the fish system," a fish farmer leader in one Maekaedluang fish group claimed (26-01-2014).

Nowadays aerators have becomes important for oxygen circulation with the hope of reducing the risks in the pond. Ten out of eleven of fish farmers in Maekaedluang are obviously aware of the risks. They also often learn how to appropriately run an aerator at the time of low oxygen, especially in early morning and for the fish aged over 4 months old. If there is less density of fish, it is not necessary to run the aerator all the time. Accordingly, aerators are mostly implemented by all farm sizes. Supported by the feed agencies, they are given 10 baht reduction per a feed bag in exchange for a ring blower (a kind of aerator shown in the figure 4.1). It costs around 6,000 - 9,000 baht depending on its size. However, the topic of aerator types is controversial. To find the most investment- worthy aerator, one large fish farmer said in a monthly meeting, that ring blowers just reduce the hazards, but do not totally play a much more important role in reducing oxygen shortage indeed. It is better to use more the expensive paddle-wheel aerators (figure 4.2) that in fact can be afforded by a few well-off people in the three sites. Thus, the 4 smaller fish farmers still prefer to use the cheaper water pumping system (figure 4.3); at least it can reduce the risks.

Figure 4.1 A ring blower aerator mainly implemented in Maekaedluang

Figure 4.2 Paddle-wheel aerators used by large fish farmers

Figure 4.3 Water pumping implemented by medium and small fish farmers

Due to low knowledge sharing and exchange among fish farmers and other external organizations in Sanpakhee and Tamphralae, different scale operations have various understanding and awareness, particularly 6 smaller scale operators out of 9 case studies who rarely exchange information with state and feed agencies have low level of risk awareness. One small fish farmer in Sanpakhee and three in Tamphralae thought climate-related risks were not vital enough to take prevention action. Thus, oxygen circulation was perceived as unnecessary with extra electricity cost. They decided to set up cheap water pumping which was operated just before harvesting time, which increased the risk of fish stresses. The one small fish farmer in Sanpakhee urgently borrowed an aerator from his kin or neighbors during the time of crisis, which might be too late to solve the problems. Hence there is a huge contrast between the different perceptions and understanding from the small-scale farmers and the three large-scale fish farmers in Sanpakhee and Tamphralae, who have more experience and information from external organizations. On the feed agencies' suggestion, they tended to use expensive turbines such as paddle-wheels and ring blowers.

4.1.5 Productivity

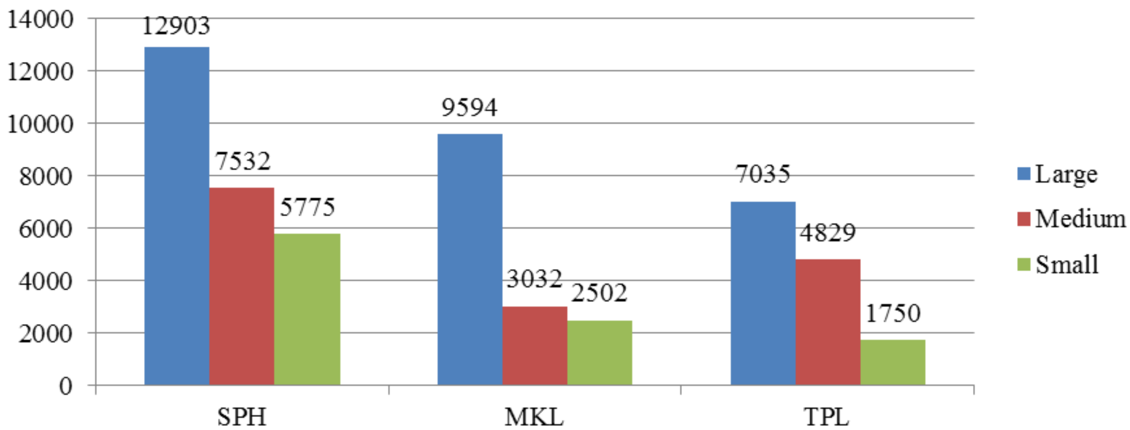


Figure 4.4 Overall production (kg)/ crop divided by scale operations in 2013-2014

It could be said that water, knowledge, labor, money, land and social networks are a component of farming management to function the capacity of production of each site. The figure 4.4 demonstrated overall fish production (kg)/ crop divided by scale operations in 2013-2014. The data was collected from all farm sizes in integrated system in Sanpakhee, except one large operator; all intensive farms in Maekaedluang comprising of 3 large, 2 medium and 3 small; and all intensive farms in Tamphralae comprising of 3 large, 2 medium and 2 small operators. Some missing data from the rest of the 7 fish farmers in Maekaedluang and Tamphralae was not counted due to their incomplete records. Calculating the production per crop per sale operation by multiplying total production of each scale with the number of land holding and then dividing that by the number of land holdings. It was found that Sanpakhee had highest average fish production at 26,210 kilograms/ crop/ rai, mainly comprising of 12,903 kilograms from the large-scale operators. Producing a large ton of fish per crop in a big piece of land at least once a year was generally much more than 2 times of the overall fish production in

Maekaedluang and 3 times of Tamphralae. It was because they had less cost of investment (integrated farming). Efficient water quality and quantity allowed fish farmers to raise a high density of fish.

Nevertheless, Maekaedluang had higher knowledge exchange and implementation than the other two villages. Still the medium- and small- scale operators had low production because they experienced water stresses and land ownership changes resulting from urbanization. All scale operators hence decided to increase the frequencies of crop and reduced the density rather than to reduce the production per crop. So they had more production than Tamphralae which had less knowledge distribution. Though the latter had fertile water, the fish productivity was lowest at 13,614 kilograms/ crop/ rai. Just the large- and some medium-scale operators gained benefits from such water and knowledge. They reduced the density of fish but increased a number of crops per year. Meanwhile the smaller fish operators had less capacity to produce because they used unqualified fingerlings and feeding with low technology.

4.2 Coping Capacities of Fish Farmers with Different Scale Operations

This part focuses on coping capacity, which means short-term and immediate orientation towards survival. Fish farmers are motivated by stresses, but urgently react or respond to reduce the risks. In this way, better adaptive capacities functions better coping capacities based on different scale operations and social learning processes. Better coping capacities rely on not only technology but also the individual fish farmer’s management. Fish death results from the conditions that fish cannot naturally get through the climate variability and uncertainty. Thus, better prevention by implementing aeration or assisting water circulation is taken into consideration.

Table 4.4 Summary of physical coping strategies of fish farmers with small-, medium- and large-scale operations to climate-related risks

Stresses		Flood	Drought	Water pollution	Rainfall	Cold
Impacts		- fish loss - higher water level that causes transportation difficulty	- no water exchange - fish death - fish diseases - water conflict	- fish death - fish diseases	- fish death - fish diseases	- eat less - grow slowly - fish diseases
SPH	Large	-	- run aerator (expensive) - drain out water - reduce feed portion	- close/open pipe - reduce feed portion	- run aerator - choose the right and safe water - harvest fish earlier - reduce feeding	- reduce feed portion - postpone feed time
	Medium	-	- run aerator (cheap) - fill more water			
	Small	-				
	Exit	-	-	-		-
MKL	Large Medium Small	- stretch mesh around the pond - build higher pond dike after flooding - negotiate for flood compensation	- run aerator - put salt, chemical and herbs (EM) - reduce feed portion - fill more water	- close pipe - negotiate with the casual fish farmers - reduce feed portion	- run aerator - put chemical, herb (Vitamin C), salt, - harvest fish earlier - choose the right and safe water - reduce feeding	- reduce feed portion - postpone feed time
	Exit	-	- run aerator - use ground water	-	- run aerator	-
TPL	Large	- close entrance pipe	- run aerator (expensive) - fill more water	- close pipe - reduce feed portion	- run aerator - put chemical - reduce feeding	- reduce feed portion - postpone feed time
	Medium	- not prepare	- run aerator (cheap) - fill more water			
	Small	-				
	Exit	-	-	-	-	-

From the table 4.4, the physical coping strategies with many stresses such as floods, droughts, water pollution that is stimulated by long low flow, rainfall and cold. It is found that the strategies are similar among small, medium and large farms in the three sites. But large fish farmers apparently have more abilities to cope with the stresses than the ones with smaller scales. The smaller hence are more likely to face fish death and loss than the larger- scale. However, the fish farmers with all sizes in Maekaedluang who often share and exchange information have various coping strategies towards the stresses than fish farmers in Sanpakhee and Tamphralae.

Flood causes fish loss. Higher water levels also make the fish trade transportation difficult and reduce the total fish harvest. In 2005 and 2011, Maekaedluang faced severe floods and slight ones in 2013.The more severe flood in 2011 caused damages to fish farm. At that time, all scale farm operations were affected. The fish farmers at mid and downstream could prevent the flood in time. They asked their relatives for help to stretch mesh around the pond to prevent the fish from escaping. In contrast to the affected fish farmers in Tamphralae, without preparation and social help, one medium-scale fish farmer's pond was damaged by flash flood suddenly within less than an hour.

Many fish farmers at all sites have experienced low flow. They have no water exchange in the ponds that cause fish death and fish stresses. Water conflict is most severe in Tamphralae, followed by Maekaedluang and Sanpakhee. Most fish farmers with different scale operations in all sites basically run aerators and fill more water. Moreover, it is outstandingly clearly that some large fish farmers in Sanpakhee and most fish farmers with all scales of operations tend to reduce feed portion. After frequent exchange, most fish farmers in Maekaedluang learned how to use chemical and herbs to maintain the water quality. In addition, water pollution results from the mixed toxic and poor used water upstream causes fish death. Most fish farmers thus close the pipes and reduce feed portion. Through neighborhood ties, fish farmers mid- and downstream in Maekaedluang decide to negotiate with the casual fish farmers upstream for social benefits.

Rainfall or changing weather causes water stratification in the pond that results in fish death and fish diseases (Patcharawalai et al., 2013). Most fish farmers in all sites similarly cope with the stresses by running aerators, reducing feed portions and checking the water to make sure it is qualified for use. All farm sizes particularly in Maekaedluang put chemicals, herbs and salt in the ponds hoping to purify and maintain the water quality. In winter, the weather is cold, especially in the beginning of 2014. Fish eat less, grow slowly and are at risk of fish diseases. All fish farmers with any scale and all sites tend to reduce feed portions and postpone feed time. From the table, during low flow periods, water pollution and rainfall, one medium and the ex- fish farmers who are out of the group in Tamphralae have to rely on their available water and their own ways. They mainly use underground water and run aerators to sustain the water quality. The farmers who used to do fish farming and exited from the fish group turn to do intensive and integrated agriculture to avoid drought and water pollution. They still face the new risks of pests and poor water from the fish ponds.

To explore the coping strategies towards climate-related risks, fish farmers' tactics and social connection are elaborated more in terms of feeding time adjustment, plan of water exchange, stocking and calendar adjustment, risk prevention and the use of social networks during the time of stresses as well as how different farm sizes play their role to solve the problems.

4.2.1 Chemical use towards fish diseases

In this regard, through fish farmer kin, neighbors and feed company agencies, the farmers start learning how to cure fish diseases. All fish farmers attempt to learn how to use chemicals properly. Wrong use of chemicals or medication cannot deal with some bacteria or parasite, but in turn cause the water and soil to pollute in the pond. Some chemical substances should be mixed with water before splashing around the surface of the ponds. But, it was noticeable that not all large fish operator who have much experience and knowledge could precisely examine the characteristics of fish diseases and better choose the right chemicals to cope with the diseases. The large fish operators in Sanpakhee tended to use the chemicals from the well-known companies rather than general chemical stores. In contrast, all small and medium fish farmers tended to use the chemical promoted by the fish farmer cooperatives or groups and neighbors. When asking them about their use of common chemicals, they replied that they sometimes did not know the fish diseases. They just explained the symptoms to neighbors who might know and could suggest the right chemicals. They also often told others the wrong and shortened names of fish diseases and chemical substances. These evidences caused the possibility of chemical misuse in treating the fish diseases.

Due to high social learning in Maekaedluang, all scale operators had shared knowledge with one another on how to choose and use the right chemical to fit with the fish conditions. Because of knowledge exchange, for example, after fish diseases spread in many ponds, all large, medium and small fish farmers ordered the expensive imported Amoxycillin from other fish networks. The streptococcus diseases could be cured after taking the chemical for 3 days. It cost 2,000 baht/ kg. However, fish diseases are hard to control and beyond expectation. Three small fish farmers still used mismatched chemicals, which hardly solved the problems.

"I paid almost 10,000 baht for the chemical, but it doesn't work just like wasting money. I bought it 600 to 700 baht each time for 4 to 5 kinds of chemicals. I just run my operator water pumping with hope to stop the fish death," a small fish farmer in Maekaedluang (20-07-2013).

Two out of three fish farmers, particularly large ones, in Tamphralae knew about used chemicals effectively, but rarely exchanged knowledge with one another. No matter which scale operations they have, they might use the wrong chemical substances. They are likely to waste money paying for the wrong chemical. For instance, during an urgent matter, one large fish farmers decided to use the existing chemicals such as formalin that was not fit for the existing disease treatment. The problems could be coped with and the solution worthwhile in the short term, but they are not totally solved in the long term because the farmers were still prone to the climate-related risks. Moreover, one small fish farmer bought many wrong chemicals for a total of 3,000 baht, which could not deal with her fish death at almost 200 kilograms for a week. As a result, without a choice, she asked the fish farmer cooperatives to harvest her fish earlier.

4.2.2 Feeding time adjustment

All fish farmers in the three villages adjust the feeding times depending upon the weather and fish conditions. During the rainy season, the abrupt change between hot and cold temperatures reduces fish respiration rates. If the fish eat too much, the rate of oxygen needed will be high for respiration and for digesting food. What the fish farmers should do is to reduce feeding from 3 meals a day to 2 or 1 or none in order to save the fish. If the famers lack awareness, fish loss is highly likely to occur. For example, 1,000 fish belonging to a large fish farmer die per day since his laborers dutifully feed the fish without being conscious of the weather change. Furthermore, during winter, there is little possibility of fish death, but they grow slowly and eat less. Farmers therefore tend to reduce feed by half of a normal portion but feed the fish more often, like 3-4 meals a day. Moreover, they postpone feeding time later than other seasons. In the summer, they feed the fish as much as usual, together with running aerators to increase the fish's eating capacity.

4.2.3 Plan of water maintenance and stocking calendar adjustment

Based on their past experiences of fish diseases and fish death, fish farmers have to plan when water should be exchanged and maintained as long as it could. If the waterway is closed, it is their task to maintain water quality in the pond. Sanpakhee fish farmers exchange water once a week to coincide with the existing water quality mixed with the pig manure. During low flow periods, they reduce the feeding portions and allow fish to eat plankton and algae stimulated by the pig manure. Furthermore, adjusting the stocking calendar can prevent risks. Raising fish during the time between summer and the rainy season has increased exposure to polluted and fluctuating water as well as changeable weather. So all fish farmers in Maekaedluang and seven out of nine in Tamphralae reduce the density of fish or stop raising them from April to June and some from August to November. They decide to wait for the safer winter-time by starting during late rainy season because it is not necessary to pump water into the pond but getting it from the rain and avoiding the abrupt temperature change. During the temporary stop from fish farming, the farmers of mostly medium- and small-scale operations offset the missing income by relying on off-farm income. For instance, one small fish farmer elder in Maekaedluang is given a monthly salary of 6,000 baht by her daughters one of whom is an accountant and the other, a teacher. Thus she makes a fast decision to not to take risks during the hazardous seasons. However, this strategy is rarely seen in Sanpakhee because they have access to a good amount of water.

The fingerling shortage occurs in winter and is hardly cultured. Fish farmers in Sanpakhee and Tamphralae face this shortage. Meanwhile, fish farmer groups in Maekaedluang stock 300,000 - 400,000 fingerlings per year in advance. The fingerlings are then nursed and stocked by the fish farmers who have to a large number of ponds before selling to other fish farmer members during the shortage time. It is a strategy that solves the fish production shortage and generates income for the related fish farmers and makes the production period faster. Fish farmers can raise fish for few months before harvesting.

4.2.4 Risk reduction

Rather than coping with the stresses by using the chemical substances, prevention strategies are taken into account. Most fish farmers with all levels of scale operations (59% of all case studies) increase in use of pro-biotics, medication and vitamin application mixed with feed to prevent fish diseases. However, three medium- and three small-scale operators especially in Sanpakhee and Tamphralae have less awareness of fish diseases. They do not take action to prevent the risks, but rather cope urgently with the stresses. For example, they mix chemicals with feed just in time so that the fish unusually eat less. Conversely, fish farmers in Maekaedluang have learnt the better prevention strategies against fish diseases and fish death. Getting knowledge from television, magazines, books and their neighbors, some of them use effective micro-organisms (EM) to purify water.

Vitamin application is used for increasing fish immune systems. Here, fish farmers have a chance to exchange their knowledge with each other about whether the vitamin is suitable for use and if it works in reality. As a result, after knowledge exchange and encouragement, most of them eagerly implement vitamin C and some use EM. They mix fermented fruits with pellet feed after raising fingerlings for a week. Thus, the fish is stronger with a better weight against the climate variability. Two large fish farmers in Maekaedluang use natural products from their farm such as lime, tamarind and malacca tree, but they are not available all year. Sixty percent of all fish farmers in this village decide to pay for extra artificial vitamin instead with the hope of preventing any risks in the long run. At the same, time, the knowledge is not extensively adopted in the other two villages, just found in one medium fish farmer in Tamphralae who applied it upon the suggestion of her son who is working in the related aquaculture field.

The aerator is another technology used to help reduce the climate-related risks. Eighty percent of fish farmers with all sizes in Maekaedluang and two large fish farmers in Sanpakhee and Tamphralae adopt the machine. They tend to run aerators for adult fish of over 4 months old and during rains, changing weather between hot and cold; and in the early mornings from 3 - 7.00 am, which is the low oxygen time. However, 2 small and 3 medium fish farmers respectively in Sanpakhee and Tamphralae run their aerators just in the time of stresses to save electricity cost. They do not run the aerators unless there is a clear signal of fish death that uncontrolledly causes loss.

4.3 Fish Farmers Adaptation to Climate-related and Socio-Economic Risks

This part investigates whether scale operations and social networks are able to allow the adaptations. Adaptation in this regard is practices towards long-term livelihood security. Interrelated physical and social adaptation is taken into account in fish-pond intensification, reduction and exit (figure 4.5)

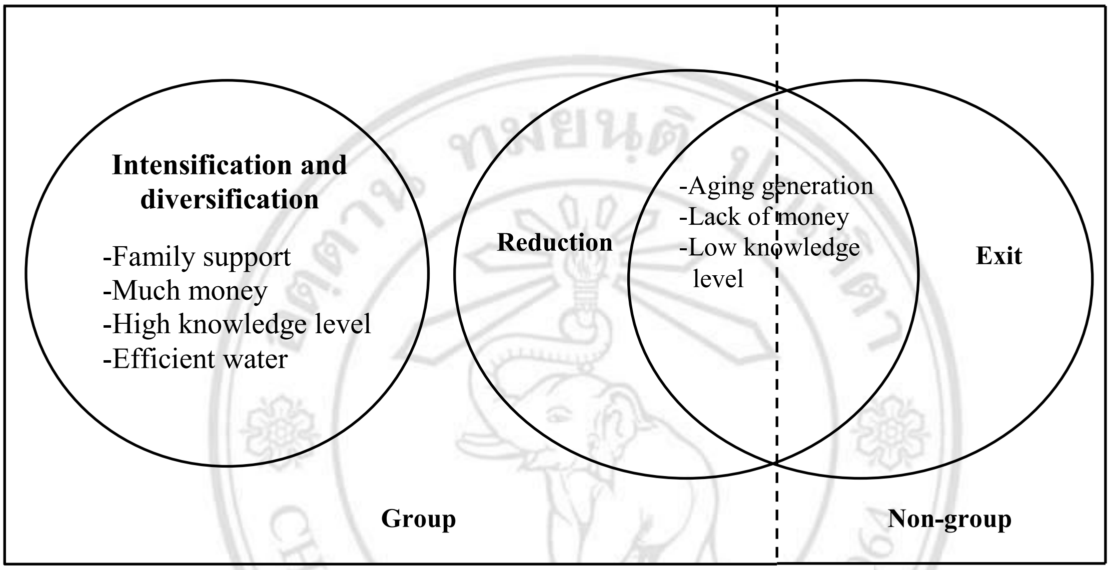


Figure 4.5 Adaptation of fish farmers

4.3.1 Farming intensification and diversification

Aquaculture intensification increases average inputs of labor or capitals to increase the value of output per *rai*. Most fish farmers who intensify the fish business are mostly large- and medium-scale operation. Their investments are supported by family members in generating the high cost of investment and enough costs for household living. Being a part of a fish grouping also provides them opportunities to access social networks and knowledge as well as fruitful information. Above all, it is useful for them to access good quality and quantity of water in order to effectively sustain their fish businesses and to increase their productivities.

No matter how much the cost of water management, based on financial capital, all scale operations are willing to invest in the pond systems for more stable productivity and income security. Allocating a piece of land and adding value, its utility can increase the productivity and return of investment. Fifty percent of large-scale operators in all sites; 3 out of 4 medium- and small-scale in Maekaedluang; and one medium in Tamphralae, try to raise fish with low density but increase its frequencies in order to gain consistent income. In this number, most of the farms use the intensive system; just three large fish farms in Sanpakhee are integrated systems. In addition, six out of nine large fish farmers in the three villages try to develop the long-term water system to prevent the polluted water. They decide to allocate one of the ponds for stocking water to prevent the uncertainty of water quality and quantity. They also widely connect the pipes to each pond. The smaller fish farmers also attempt to solve the water problems. For instance, one medium- scale operator in Maekaedluang lacks water and rents an idle natural fish- pond as an alternative water source.

Aging fish farmers downstream in Maekaedluang are furthermore affected by the stocking water and poor quality for households and farming upstream. They thus, invest in groundwater with 72 meters' depth. Furthermore, to invest in technology, after a great fish loss in the previous crop, the medium fish farmer in Tamphralae raise fish with low density and set up aerators. Thus, he gains profit of around 200,000 baht. After that he adjusts the amount of fingerlings depending upon the seasons. He raises fish with lower density in the dry season and more from the rainy season to winter. Moreover, he will expand his pig farm to benefit from the market.

It is found that one large- scale operator in Sanpakhee who does intensive fish farming tries to be at the forefront of the fish suppliers and the leader of the fish farmer group. Besides raising pigs, he is deciding to convert the tilapia fingerling farming into catfish farm, which rarely takes place in Phan. Thus, he offers opportunities for his son to learn freshwater aquaculture. To deal with excess fish supply and increased fish market value, his wife opened a transforming fish franchise under his farm's name. The stall provides grilled fish, Northern Thai spicy sausage and steamed fish with curry paste and so on. He also aims to expand the business in the future. One medium fish farmers in Sanpakhee raise tilapia and red tilapia (more expensive than the Nile tilapia) in the same pond to serve the high market demands during the market time. Similar to the small fish farmer in Tamphralae, she plans to rear snake-head fish with tilapia to increase income at once.

4.3.2 Reduction of production due to market fluctuation and aging

Most medium- and small- scale operators tend to reduce the production scale because they are affected by markets and are getting older. They also gain less support from family members with low levels of asset capital, and low interaction among social networks. It is found that all scale fish farmers in Sanpakhee tend to reduce a number of pigs while some stop the farming completely because of the pig price fluctuation. Some fish farmers yet attempt to minimize costs of investment by replacing the commercial pig feed with natural grains such as paddy husk and rice bran. Thus, they still continue the business under the crucial market forces.

> “I stopped raising pigs because the pig feed price is too expensive to get profits in return. It is not worth the investment. The price should be 60 - 65 baht. But now it is cheaper. I stopped pig farming since the mother pig died. It is so risky,” one small fish farmers in Sanpakhee said (6-04-2014).

In terms of aging, most types of families skipped-generation or have grandparents living with grandchildren. Their children have gone to seek off-farm employment, leaving the farming with the elders. Technology has thus become more influential in pig farming. For instance, they rely on feeding machines, setting particular times and the portion of feed. Thus they have enough time to feed pigs and fish in other ponds. As a result, many old fish farmers aim to reduce the business or might exit totally. One large- scale operator who runs intensive farming in Tamphralae, for instance, thinks he is too old to do fish farming. He might retire soon and hand the business to his son and his relatives. Furthermore, the old fish farmer from conventional commercial farming in Maekaedluang expects to stop the fish farming, soon but no one seems to want to take over. Above all, due to help and social connectedness with fish farmers and cooperatives/ groups, they decided not to completely exit from fish farming. They still continue doing their jobs as long as they can.

4.3.3 Complete exit

The fish farmers who decide to leave fish farming have something in common. Most of them are small fish operators who have low investment costs and low levels of social interaction. There is no help from fish farmer friends or external organizations who have academic and practical information. During the time of stresses, they cannot cope with the problems in the right way and on time. Little assistance and less knowledge sharing from family members, in addition, reduce the capacities to manage the farm more effectively. To make things worse, household burden is an obstacle to further investment or to expansion of the business. One small fish farmer in Tamphralae for instance decided to leave because she cannot bear fish death and loss of investment. She also has to take care of one elder and five children at home.

Some of them are getting older and it is difficult for them to learn new and more modern technology, fish pond management and numerous new fish diseases. Some of them stop fish farming because of profit losses from fish deaths and diseases. It might be because the pond location is prone to floods, low flow and polluted water. This is the reason why they prefer seeking for lower risk jobs like other types of farming that require lower investment costs. The small fish farmer in Sanpakhee converted his pond into rice paddy fields while the fish farmer in Tamphralae adjusted her lands for natural fish and farming. To minimize risks, she diversifies her farm for various kinds of vegetables, flowers, trees and poultry. She also trades in farming products and works off-farm. The small fish farmer in Maekaedluang replaced his commercial ponds for natural fish in which rearing time is not required much. He then turned to work in more stable off-farm jobs that face less climate uncertainty such as painter, building contractor and so on.

4.4 Summary

Findings indicate that exposed location, social and financial status, knowledge and social capital have impacts on the ability of different-sized operators and social ties to cope with climate-related risks. In terms of coping capacity, all scale operations of fish farmers in Sanpakhee with low levels of social learning but low exposure have fewer impacts from climate variability. All fish operators in Maekaedluang with high social learning seem to implement higher and more modern technology than other villages, but struggle with rapid urbanization. Because of loose social network and high resource conflict, uneven knowledge distribution is found. Large fish operators in Tamphralae have much more knowledge than the smaller sizes, which are more prone to risks. Conversely, the fish farmers with non-groups have little information and social interaction. They have less help from fish farmer friends and other external organizations, which reduces their ability to cope with the climate-related risks.

In terms of farm sizes, large- scale operators have high financial assets, and more opportunities to gain information from other external sources; as a consequence they have less hazard impacts and stresses than smaller operators. Medium and small operators suffer more from fish death and diseases. These latter operators have fewer financial assets and fewer contacts with external partners. Thus, the small fish farmers have less capacity of fish production and suffer from fish loss. In this way, cooperatives can help small-scale fish farmers expand their networks, which, in turn, is helpful in supporting innovation, improving access to financial services, and overall, in building adaptive capacity. All in all, the social capital plays an important role on adaptive capacity but it is not yet clear about the interaction among fish farmers with different farm sizes. Chapter 5 further elaborates the formation of social connection and its roles on water- related stresses.

CHAPTER 5

Social Capital Roles in Climate Adaptation

The study examines how fish farmers household and kin are united to increase their adaptive capacity to cope with and adapt to the climate related and socio economic risks. In this way, ties within a social group show bonding social capital based on homogeneous family, kinship and locality and local *Muang Fai* membership. The water users have socially and culturally committed to help maintain the common water systems. Bridging of networking social capital is made up of economic and other external ties. Most fish farmers set up the system of the organization; reduce transaction costs, provides fish-related jobs; and access fund, new knowledge and technology. Both relations represent the sharing of knowledge, financial risks and the labor force. The study first focuses on the construction of kinship and friendship of fish farmers made by bridging networks with horizontal and vertical links. Secondly, it shows how building up social capital components determines the level of adaptive capacity. Bridging, bonding and the notion of reciprocity, trust and collective action provide a framework for examining relational power. Lastly, it demonstrates that the social networks are utilized during times of water-related stresses. It comprises the different interactions among different scales of agencies on collective access to resources.

5.1 Construction of Bonding through Bridging Cooperatives

According to the nature of rural livelihood, Scott (1976) states that people living as a cluster of social and cultural units are bounded with a set of social norms, structures and processes. If peasants face the hazards affecting harvest failure and starvation, the close-knit kin can ask for support and reciprocity from community networks or the so-called 'moral economy'. This rural life shows the egalitarian, corporate, communal, safe and closed community with non-market, mutual assistance, reciprocity, safety-first and sharing.

> "Relationship with kin is harder to break off, but also because kin have more mutual aid and material assistance to offer one another," stated by Bott Elizabeth (1971)

In these days the relationship has been changed through the urbanization development that increases the spatial mobility of local people from rural to urban area and from farming to non-farming. With loose-knit networks the members of the group or so called household families no longer closely see, give and take and support one another. In accordance with Rigg's statement (2012), a higher number of local villagers in the Asian countryside seek for non-farm income sources opportunities. The mobility of people doing off farm jobs in the city is high as the number of their heirs, who have less cultural attachment to the land and tended to pursue higher education. The process is called delocalization, which leads to a growing geriatricfication of farming (Rigg, 2011). Increasing spatial fragmentation of the young for salaries from off-farm work and studying away from home also remains a component part of the household. Most elderly people are, as a consequence, left to do the farming in the rural areas. Few offspring return to farming and pond-based aquaculture. Households and communities are also inevitably disembedded and less socialized as households become extended units and skip-generation households. In this way, a new kind of fish farmer networks across generations is built up for financial interests. Bonding of family members and relatives are also found to be no longer about traditionally staying put and helping together, but living with more material and financial linkages.

5.1.1 Kinship and neighborhood of fish pond farmer cooperatives

Fish farmer cooperatives or groups are founded economically to reduce transaction costs; enhance access to knowledge, technology, labor and funds; and increase adaptive capacities to respond to the stresses. Moreover, there is a gap of separation of kin groups and neighbors who are fish farmers; either they are young or old. In this regard, fish farmer relationships are expanded through marriage, kinship and friendship. In the past most farmers decided to convert their agricultural lands into fish-ponds because of high economic returns as well as peer and kin pressure. The following process kicks off one by one, time-by-time, step-by-step until there are kin, neighbors and friends in the fish farmer cooperatives or fish groups.

Most fish farmers have relatives, neighbors and friends in the three villages. Most are participants in fish farmer groups. The groups are of two types: (1) a private one commercially driven by individuals or traders; and (2) a cooperative led by the elected fish farmers as the committee managing the system. Even though those fish farmers belong to different fish groups, they are friends in helping each other do both fish-related and other social service activities. The relationship is different from Tamphralae fish farmer organizations that include both a major fish farmer cooperative and small trade groups from Phan, Chiang Rai. Eighty percent of fish farmers are a part of the major local fish farmer cooperative; while fifty percent of them are both the cooperative and the Phan fish groups. One participates just in the fish trade group, which provides not only feed and marketing, but also academic advice. Most of them who have different memberships in fish groups are relatives and neighbors; but they started experiencing resource conflicts after the commercial farming and fish farming expansions. Since then, the clan relationship has weakened, which affects the social service activities, collective action and resource negotiations.

The fish farmer group structure in Maekaedluang is used in detail in an attempt to demonstrate how connectedness of networks is constructed and expanded. According to the figure 5.1, in Maekaedluang, there are three fish farmer groups that comprise of their kin and neighbors. The first group is the biggest, followed by the second and the third groups. The second and third groups just separated from the first old group due to disagreement of regulations. The regulations such as increasing feed price and inputs, previously made by the fish committee without public participation, made the rest of the group members dissatisfied. A large number of fish farmers in the village mainly participate in the first two groups, which have a competitive relationship. Even though fish farmers are relatives across the groups, they have difficulties in working with each other within the groups as well as sharing about fish-related issues, except for joining in the social activities. Meanwhile, fish farmers outside the village from the third group have a compromise relationship with other two groups. They offer joint assistance by allowing fish traders to buy fish when the first two groups cannot make it in time to meet the excess market demands.

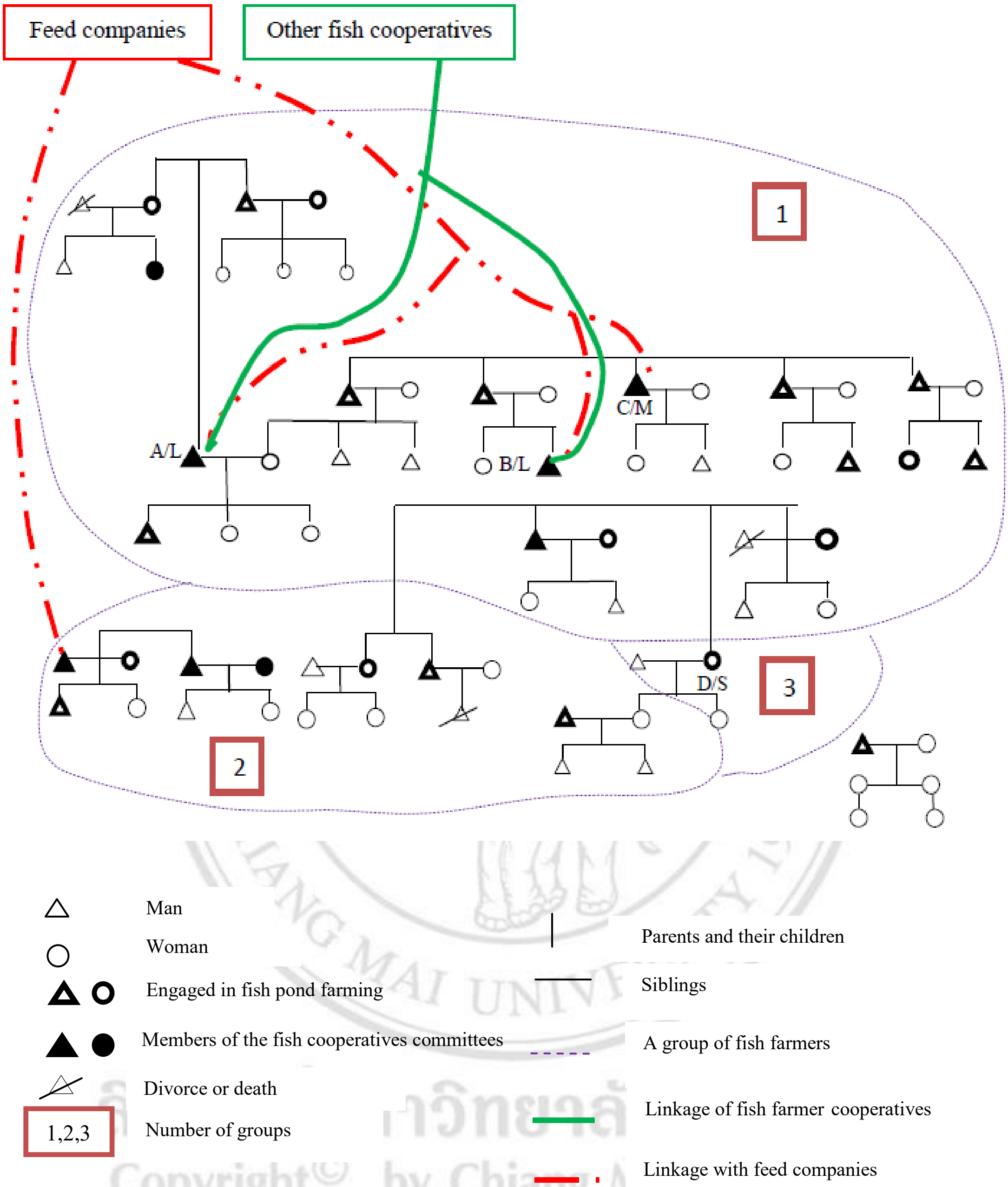


Figure 5.1 Example of relationships among kin groups, neighbors and other fish cooperatives in Maekaedluang

From figure 5.1, fish farmer kin and neighbors of both genders are urged to take part in fish memberships; some play roles as group committee members and others as regular members. For example, Mr. A (pseudonym: A/L), a large-scale leader of the first group in Maekaedluang, has a great deal of contacts with his kin and his wife's relatives who are also involved in pond-based aquaculture. His wife's father has younger brothers whose children are also in fish farming. One of them is Mr. B (B/L) who inherited the fish farm from his father and became a large operator and a member of the fish cooperative committee. His uncle, Mr. C (C/M) is a medium fish farmer and also in the committee. Three of them belong to the same group and work closely in running the first fish group. Furthermore, fish farmers across the three groups are relatives. For instance, Mrs. D (D/S) is a small fish operator in the third group. Her siblings are fish farmers in the first group while her son in law is a member of the second. They often indirectly share information and help one another.

It is seen that most large- and medium-scale operators who are mainly in charge of a group's committee have good contacts with external feed agencies and other fish cooperatives. Some of them get to know other fish cooperatives via fish-related conferences or joint activities held by the Department of Fisheries and other private feed companies. On the contrary, the fish farmer household out of the fish group lacks opportunities to interact with other fish farmers. Thus, there is less knowledge sharing and skill development.

Family and extra-familial kin previously did not play much part in the economic and occupational unit including access to means of earning a living. However, ties among kin are likely to be stronger if the kin are able to provide or offer one another jobs (Bott, 1971). It is evident that the fish cooperatives provide skill development in addition to full-time and part-time job opportunities for kin and neighbors including the young. New sorts of jobs including fish producers, fish retailers/ wholesalers, harvest men, accountants, checkers and committee membership are made and assigned to fish farmers and other neighbors. They are also given new roles such as fish group leaders, secretaries and committee members responsible for the group management and system.

These kinds of jobs encourage the fish farmers to seek for more income and develop their skills to fully derive benefit from fish-related employment. For instance, when one particular large-scale operator was young, he was an intern in the fingerling farm in Phan, Chiang Rai. Here, he gained much experience and developed himself to become the fish commercial fish farmers in the village. At that time, he and his wife also helped one another to trade in other provinces nearby for more than five years now. Since he has gained a large number of fish retailers in different provinces, he initiated his own private fish group. He hires his neighbors to work on fish and livestock farms, fish trade and processing. He also hires the offspring of his fish farmer neighbors. One of them works as a hired fish wholesaler while helping his parents with the fish farming. Now this neighbor and his brother has put together some money to invest in an agricultural pesticide shop whist letting their parents run the business.

5.1.2 Neighborhood ties with *Muang Fai* institutions

While the fish farmer groups have been formed, the *Muang Fai* group is still declining. Fish farmers are a part of the *Muang Fai* (local irrigation system) with common responsibilities in managing water resources. The relationship between the *Muang Fai* groups and fish farmer cooperatives determines the collaboration of water management and access. Fish farmers are a member of water users, which is a kind of bonding relationship rooted from the past. When times passed, the relationship has bridged between the old water users and newcomers taking benefits from fish ponds and agriculture activities in the areas. The expanded relationship has a great impact on the participation in collective *Muang Fai* activities. Water is also rarely used effectively. It can easily be overused by those who have access first, resulting in water shortages and conflicts over water scarcity and water pollution. This exacerbates competition for water among agriculture, aquaculture and villagers.

In Sanpakhee, the RID manages efficient water all year round to all stakeholders without any water fee, whilst the *Muang Fai* activities still remain with local participation to clear the waterways in some canals. No obvious resource conflicts are undoubtedly found. In Maekaedluang, the responsibilities of water management mainly belong to the *Kae Muang* under the RID with the collaboration of fish farmers and other farmers. However, the *Kae Muang* working alone cannot manage the water to meet every single water user’s demand. They are asked to pay for the water fee and to help clear the waterways. In any case, many canals are sometimes designed and developed by the RID without any public hearing. This causes disagreement among local water users because some constructions block the water flow.

Conversely, in non-bonding interaction Tamphralae, few water users from both local and outside communities respect the *Muang Fai* laws and the activities in particular. Moreover, most canals are still earthen, making it necessary to regularly clear the waterway. Every water user has to pay for the water fee according to the number of their pipes. But under the same fee rate, some use bigger pipes for overusing large amounts of water. Thus water conflict is highly likely between fish farmers and farmers; and between insiders and outsiders. Even though the *Kae Muang* has rights to meet out punishment to whomever break the laws, he avoids arguing with the big-pipe men and leave the conflict unsolved.

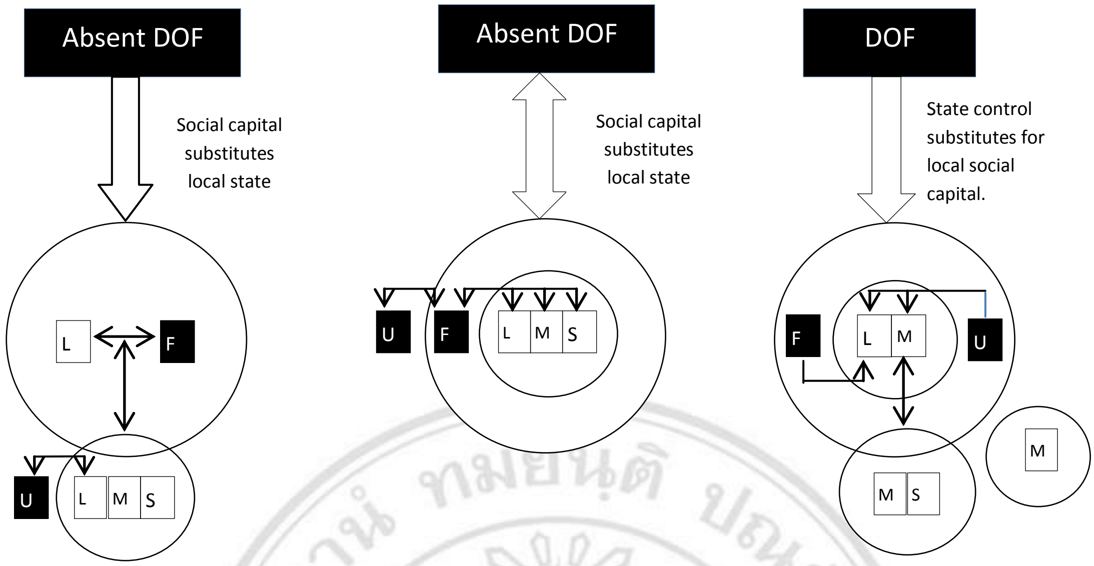
5.1.3 Bridging fish farmer network management and direction of social ties

Bonding and bridging of social capital enhance networks and connectedness. Vertical and horizontal ties functioning in the network are also ways of increasing trust and abilities in working together and expanding access ability. Social capital can reveal the power dynamics between social actors in the social inequality and risks; and resource access inequalities (Pelling, 2005). The relationship between bonding and bridging; and vertical and horizontal are linked to form social networks and their operation.

In figure 5.2 below, social capital is divided into three kinds of networks: (a) high bonding with minimal bridging interaction (Sanpakhee). Fish farmers have strong kinship and neighborhood but have fewer contacts with DOF agencies, university and feed companies; (b) high bonding with bridging interaction (Maekaedluang) means high interaction between kin and neighbors in fish farmer group; and external organizations, except DOF; and (c) minimal bonding with high bridging interaction in Tamphralae is low at the level of kinship and neighborhood, but high level of interaction with DOF and university, except feed companies. Based on the actual phenomena in the fields, the three figures are made to understand the complex relationship among fish farmers with different scale operations and other stakeholders. I wonder how those people with different kinds of bonding and bridging relationships interact with one another and what the results are. Here I categorize the actors into external groups (the state, feed firms and universities) and local fish farmers with small-, medium- and large-scale operations. They have both vertical and horizontal relationships upon the kind of relationship.

Sanpakhee Village symbolizes closed bonding with low bridging interaction. They pay less attention to the state's help since their projects extend unevenly to some particular fish farmers. The state's image thus seems negative from the fish farmer's point of view for they rarely take care of those fish farmers. In the past, the agencies took some fish and water as well as some portion of the feed, but there are no informed results for the fish farmers in return. In addition, the views between the DOF and local people are different. DOF attempts to take responsibilities for the health of customers but local fish farmers aim to increase fish productivity and income by any means whether or not it is harmful for the environment and to health.

According to the Good Aquaculture Practice (GAP), they also compel the fish farmers to reduce chemical substances and give up their pig farm. The agencies of the DOF claim that the fish fed by pig manure is contaminated with chemical substances and waste. For food safety for consumption, they moreover sometimes show up and ask fish farmers to use qualified chemical substances that are registered to the GAP standard. Indeed, the fish farmers unavoidably have to use the available chemical substances suggested by their neighbors and fish groups, which might not serve the state's demand. Consequently, fish farmers decide to independently run their farming without cooperation with the state. However, some do contact the state agencies to get the chemical substances.



a) High bonding with minimal bridging interaction (Sanpakhee)

b) High bonding with bridging interaction (Maekaedluang)

c)Minimal bonding with high bridging interaction (Tamphralae)

Figure 5.2 Kinds of bonding and bridging interaction of three sites

Smaller circle = Bonding ties Bigger circle = Bridging ties ⟷ = Exchange → = Discursive demand
L M S = Large, medium and small fish operators F = Feed companies U = Universities

Most fish farmers in Sanpakhee are members of fish farmers groups and some are in the cooperative. Each organization is led by either the powerful and well-off fish farmers or fish traders who have exited from the formal biggest group. They develop their skills and network and build up the private fish group. Such leaders monopolize both kinds of groups. But the cooperative is again regulated by the elected fish farmer committee (from all scales of operations) who are in charge of rechecking the transparency of the accounting. The leader of the group accumulates wealth from the fish trade and becomes a feed agency while seeking for fish productions and managing marketing. In this way, they are supported commercially by feed agencies as seen in the big circle of the diagram 5.2a. The rest is small, medium and large fish farmers in the smaller circle. They are the members of the group.

The leaders and the cooperative committees set up regulations and takes control over the smaller-scale members. The group committee or the leader without participation of the majority of group members regulates the decision-making process and regulation of price, harvest systems and yearly meetings. Different from the group leader, either reducing or increasing feed and fish prices and dividing profits should be approved by the committee first in order to save the cost of investment and increase income for the members. Still the fish groups individually control the price and divide mostly for their individual interest. This provides opportunities for the larger operators and traders opportunities to take advantage of the smaller fish farmers.

Each group, cooperative or group uses a few feed brands suggested by the familiar feed agencies. They often approach the leader of the fish group by not only giving credit but also providing knowledge and technology. By contrast, they hardly care about or give advice about fish diseases and rearing techniques to smaller fish farmers. One related university also has a good contact with one large operator. This project is about climate-related sensitivities of aquaculture production. It studies the effects of climate variability on chemical and physical water properties and tilapia production in fish-ponds in Northern Thailand. From the interviews conducted, information and knowledge are not well distributed to other fish farmers. It is obvious that the knowledge exchange among fish farmers is built up more through horizontal bonding of kinship and neighborhood than the vertical help from the state, companies and university. Thus, fish farmer members do not have a sense of belonging to the group and willingness to share knowledge and experience. They rely very much on their experiences and sometimes exchange among each other across scale. They are also more bound to each other though informal lending money and materials; and reciprocal labor exchange among themselves.

> "The students from the university tested water from Mr. A's (pseudonym) pond. I just saw that from my pond and Mr. A told me when we drove past that the cloud cover starts between 2 - 4 o'clock. We have to open our aerator. I do believe him, but better believe my own experience" said by a large fish farmer in Sanpakhee (16-08-2013).

The second one shows the interaction between bonding and bridging with both vertical and horizontal ties. There are three big fish groups in Maekaedluang, but they work like a cooperative because they are run by the elected leader along with the committee and hired staff. The bonding of fish farmers who are relatives, neighbors and friends is reconstructed into the financial relationship of fish farmer groups. From the diagram

5.2b, the smaller circle includes fish farmers with all scales of operations. The account represents the bonding embedded in the bigger bridging relationship with external stakeholders. The constructed group aims to reduce transaction costs; to provide employment and income opportunities (fish harvest, accounting, and fish trade); and to manage farming and marketing.

Due to the absent state condition in Maekaedluang, the state agencies rarely support the fish farmers; they just apply the GAP standard for large-scale operators. On the contrary, the feed agencies often access the fish farmer members via the leader and committee of the group. Here, each group generously opens the space for feed agencies to promote their products. The more they present their cheap and high quality products with advanced technology, the more fish farmers are interested. Unquestionably, ties with feed companies is more commercially and challenging. They not only promote feed but also provide training, knowledge, survey and exchange travel. They also offer help on fish disease treatment, fish dead protection and increasing fish productivity. Nonetheless, ties between the group and the related university are indirectly enhanced by the feed agencies that are alumni of the institute. Many researchers and specialists are invited to give talks about biological change in the ponds, fish disease, and chemical use.

Even though the large scale operators have wider social capital and more abilities to access resources and to increase the common benefits for all fish farmer members, they tend to horizontally share knowledge and technology with other smaller scales. Additionally, the group leader (large operator) and committee (all operators) critically negotiate the price of the feed and fingerlings as well as equipment used in the fish farming. Furthermore, fish farmer members are a part of the decision-making process like, setting up fish prices and agreements to use technology and changing the fish system to reduce risks and maximize land use. The first two relationships substitute local management for state control but are different from the last one.

Minimal bonding with high bridging interaction takes place in Tamphralae Village. The state control substitutes for local networks. The fish production project is vertically supported by the state and university aiming to increase bio-friendly fish production. They fully provide fund for fish farmer cooperative initiation as well as knowledge and technology for increasing fish productivity. In turn, the project interests both local people and outside authorities bridging together into the fish farmer cooperatives. The state agencies mainly apply the GAP standard to fish farmers as much as possible. The diagram 5.2c shows the local state control substitution over local networks and the complex position of the fish farmers with different scale operations. There are three circles: the biggest circle (bridging relationship) and the small circle linked with the big circle and the isolated small one.

Most large and some medium fish farmers are major actors in the fish cooperative in the big circle. They are mostly given advice and opportunities by the university and the state. Meanwhile, the feed agency with one brand often supports especially the fish group leader with a large farm size and the committee as a way to promote their products and increase the sale from other fish farmer members. The agency provides the group with seed and feed supply on top of market distribution that increases the production base and the cooperative’s income. Still the feed agencies seldom visit and take care of the smaller-scale fish farmer member. They are slightly supported by some larger scale fish farmers. It is seen that all farm sizes get advantages more or less in being a part of the fish cooperatives except for the isolated fish farmer. Lack of participation in any fish group activities limits the opportunities to take such advantages like the others, which forces him to find new ways.

> The medium fish farmer in Tamphralae (15-08-2014) states the reason why he does not want to be a member of the cooperative: “I am not a member of the fish cooperative. I buy feed from Mr. N (pseudonym). He lends me feed because I do not have enough money to pay cash. Though it is more expensive than the feed from the cooperative, I am willing to pay because its interest is fixed. But the interest of the cooperative is increasing through the number of months I borrow feed before harvesting. I therefore do not want to be part of the group.”

The expert ideas and knowledge of how to cure fish disease and purify water are just stuck in particular well-off fish farmers and less applicable by poorer farmers. Why is that so? Why can ready-made knowledge not be used in the real society? The distributed knowledge from the university and the input supply from the feed companies are set into the regulation of the cooperative and distributed to most medium and small fish farmers. They are members of the cooperative and allowed to get funds, but not full support like the previous group. The committees are normally the first to get information and knowledge, which some might not distribute to others. Consequently, the second group does not totally understand the offer and instead follows the new knowledge and practices from those with larger-scale operations and works closely in the cooperative and with external sectors. Last is a medium fish farmer who does not belong to the cooperative. By his own choice, he prefers not following the regulation of the cooperative, but decides to take part in the fish group from Phan- providing feed and fish harvest. So, he admits to lack the opportunities, knowledge and funds like others in the cooperative. Above all, most members of the fish cooperative do not link to the fish farmers out of the group.

> "The university encourages us to purify water from water hyacinths, but I do not do it. Let others do it first, if it works, I will follow. But now I do not think about it yet," said the small fish farmers in Tamphralae (20-01-2014).

Due to their different financial status and loose-neighborhood, the locals cannot get very familiar with local wealthy people and powerful outsiders. Most local people feel otherness but just participate for economic interests. They individually turn to learn by their own experimenting and from other related neighboring fish farmers instead. At the same time, most large and successful operators become group leaders and other large and medium farmers, the committee members. But the smaller-scale operators are not allowed to participate in the decision-making process. They are excluded from regulating the price of feed, fish, harvest and loan condition. The fish farmer members are as a result given the payment burden for high priced feed (plus interest) and hired labors. Some do not socialize with the group, but seek feed and marketing from Phan District. It is seen that productivity and quality are so far different among the different scaled operations, some get profits while others lose. Each operator rear fish as best as they could, depending on knowledge access and financial status. All in all, vertical bonds might be less helpful for information distribution than horizontal ties which might undermine the capacity for collective action and the ability to access resources.

5.2 Social Capital Components towards Level of Adaptive Capacity

As I allude to physical and social risks and vulnerability in the earlier chapters, pond-based aquaculture is exposed to floods, drought, rainfall and cold weather. The different types of social networks in each site hence have an impact on different adaptive capacities in response to the stresses. These sets of held networks shape different institutional forms that influence social patterns of access to water, knowledge and money. Does adaptive capacity constitute capacities of self-protection and collective action to prevent or cope with stressors?

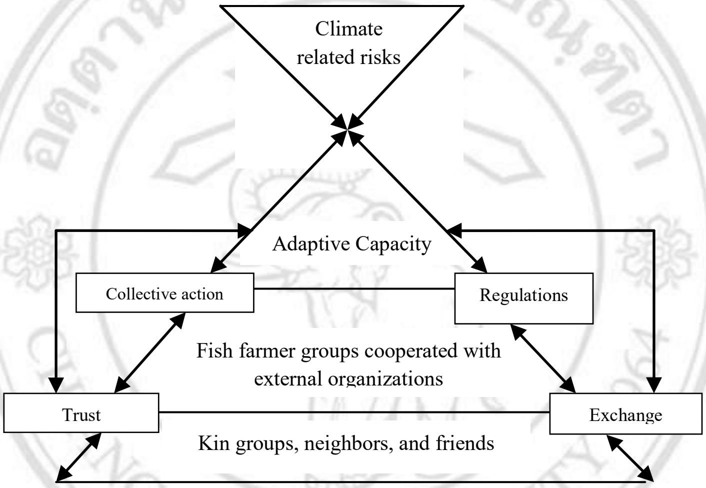


Figure 5.3 Social capital impacts on adaptive capacity

I outline the social capital components (figure 5.3) embedded in the actors' relationships. Starting from the smallest level of the community, the relationship of kin groups, neighbors and friends is enhanced through trust and exchange under social obligation and norms. If they trust one another, they are willing to share, exchange, follow and practice like what they are supposed to do. Based on the strong foundation of local bonds, the constructed fish farmers cooperatives or groups are placed in the larger frame and strengthened by collective action and regulation. The group cohesion with trust can encourage the members' ability to work voluntarily together. The more they jointly share their voices on the regulations, the more their feelings are full of the sense of belonging. They will also accept and eagerly follow the regulations. Right then, nesting people with those interrelated trust, exchange, collective action and regulation can massively build up their abilities to adapt to the stresses. However, the social capital components are various upon the types of networks that determines different benefits and adaptive capacities.

5.2.1 Building trust and trust results

Prior to elaborating the adaptive capacity, the social components of trust, exchange and collective action are assessed in order to explain different levels of bonding and bridging interaction in Sanpakhee, Maekaedluang and Tamphralae villages. There are social capital components based on bonding and bridging interaction in the three sites. Assessing trust is the intangible quantity members have and the measurement is the trust payoff, which is the amount of benefits the individual can draw on trust building. In this sense, trust can be assessed by the frequency of interaction; the voluntary willingness to contribute in social group; and to cooperate, to transact and to invest as well as to create innovation.

Trust results from the social interaction and social structure and it in turn enhances trusting relations (Fu, 2004). According to Paldam (2000), trust and cooperation have some simultaneity; trust brings about ease of voluntary cooperation which is tied together. Trust is generated from exchange and sharing over time; voluntarily reciprocal relationships; collective actions; willingness to conform to the regulations; transparency, accountability and participation in the group. They can voluntarily share what they have with others that convert into practices resulting in innovation creation and risk reduction. They also get more trust in return, if they often share their knowledge and information with other fish farmers. The information from education institution, feed companies and the state are also useful for fish production and management. For example, in case the oxygen level in the water is low, it is necessary to run the aerator and change water as well as put the chemical and vitamin. However, each fish farmer implements different kinds of aerators based on network structure and trust sources.

It is noted that different relationships between people involved in trust building have different reasons. Links with kin and neighbors can be both negative and positive, depending upon the kinds of relationship. Some might be aware, while some might really care for each other that determine the direction of building trust. Links with fish farmer groups is made for common economic interest in fish farmer cooperatives and for individual interests in a private group. Links with feed companies working for profit and private interests can be both trustful and untrustworthy for local fish farmers. Whether or not they trust the state and university, they aim to provide common benefits. More elaboration is demonstrated below by using 3 out of 9 in the same fish group in each village. They represent large (L), medium (M) and small (S) fish farmers who have various circles of networks from the DOF (S), university (U), feed companies (F) and other fish farmers who are kin and neighbors (F). All of them have important roles on trust and trust payoff.

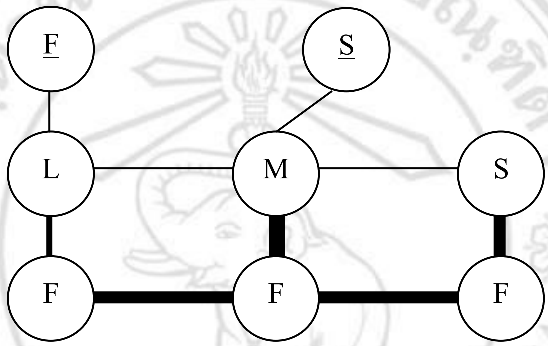


Figure 5.4 Intensity of contacts in Sanpakhee

It is found that only the large fish farmer who is the fish group leader has close contact with one feed companies. He has a lot of experience and knowledge from trainings, seminars and meetings provided by the feed companies. That makes the medium and small fish farmers, member of his groups, trust him. But he in turn prefers trusting the feed companies to other fish farmers who have fewer opportunities than him. However, he has less contact of fish farmer ties than the other two scales that have more very close relationships with other fish farmers. Often interacting with a lot of fish farmers exposes the last two scales to exchange different information from one another. They trust not only the large fish group leader but also other fish farmer neighbors who often work together. Above all, the DOF does not play a significant role here. Although the officials contact some fish farmers like the medium operator, for example, he does not trust DOF at the first place. It is because the officers rarely show up in the areas to help other fish farmers. He thus denies the DOF suggestions and provided activities.

In addition, they have low interaction levels in fish groups that limit their willingness to share their information among the group and to develop the better system. In other words, trust in fish groups does not arise because of high flexible opportunities of fish farmers to follow regulations. The fish farmers are not fully controlled and compelled in a way as to unite the members to build up trust in the group. One fish farmer is able to apply to more than one fish group for individual benefits. For instance, groups A and B allow the members to borrow feed with credit, but group A prefers a big fish size with higher price than the group B which prefers a medium fish size. Thus, the fish farmers apply to those two different groups. They borrow feed from both but sell fish to group A, if the fish size is big enough at that time. But if it is too weak to survive before harvesting time, the fish farmer decides to sell the fish to group B to reduce risks. In this way, applying to many fish groups help them reduce individual risks and get financial benefits, but not for social solidarity. Fish farmer cooperatives or groups just offer materials and marketing, except advices and information. Furthermore, the fish farmer members seldom take part in collective activities in the fish farmer groups unlike those in Maekaedluang. They are also not allowed to be a part of decision-making process and to voice out their problems to change the group system.

Table 5.1 Activities indicating trust and results of trust in three villages

Trust activities	Sanpakhee	Maekaedluang	Tamphralae
Social structure	The community with high bonding and minimal bridging has higher trust among local people than external organizations.	The community with high bonding and bridging builds high trust between local people and external organizations.	The community with minimal bonding and high bridging has different opportunities to build trust.
Exchange and sharing over time	Kin and neighbors more often exchange information than external agencies.	Fish farmers (80%) often attend the monthly meeting and always exchange information with feed companies.	Most large and medium fish farmers, who are part of the group committee, have more opportunities to regularly exchange information with external organizations than the smaller-scale ones who seldom participate in the group activities.
Voluntarily reciprocal relationship	Reciprocal fish harvest labors in the morning	-	-
Collective action	Organizing as group to compel the fish traders to increase the fish price	Collectively negotiating to get water with the *Kae Muang*	-
Willingness to conform to the regulation and group agreement	Since each fish farmer can engage in many fish groups for resource access, he/she does not strictly follow the regulations of any certain group. Thus, there is low trust in fish group.	Each fish farmer has to follow the regulations of a particular group; otherwise he/she will not get any benefits and has to quit the group. Thus, there is high trust in the fish groups.	Since each fish farmer engages in either local fish group or fish group from Phan District for resource access. Thus, he/she does not strictly follow the regulations of any group that results in low trust in fish group.
Transparency, accountability and participation in the group	Due to low trust in fish group, only the elected fish group committees are allowed to check the accounting and group system without member participation.	To widely build trust, not only elected fish committee who manage the fish group system, but also group members can voice out their opinions.	Due to low trust in fish group, only the elected fish group committees are allowed to check the accounting and group system without member participation.
Results of trust: technology implementation	Most fish farmers use low technology such as cheap water pumps instead of advanced technologies introduced from outside village.	Most fish farmers use advanced technology such as ring blowers (a kind of aerator) supported by the feed companies. Sixty percent of them use herbs mixed with feed to prevent fish diseases.	Different scale operations use different levels of technology. Two out of three large fish farmers use advanced aerator, one out of three medium and two out of three small use cheap water pumps.

It can be seen here (table 5.1) that Sanpakhee has more horizontal bonding trust among clans and neighbors due to the low level of repeated exchange, sharing and participation in the fish groups. With the close relationship among clans and neighbors, working together quite often encourages them to have a closer relationship, which is a foundation of trust.

> “Due to kinship, we trust each other. My niece also gives me advice and financial support to buy initial land and feed. I distrust other external people. You know, kin is the one we trust, rely on and we have to be faithful to,” claimed a fish farmer lady in Sanpakhee (11-01-2014).

The quote above represents the voice of those fish farmers in Sanpakhee who rely more on horizontal relationships within the groups than external stakeholders. The local fish farmers who are clan and neighbors often informally exchange their experiences. For example, sharing the idea of fish prices, fish farmers who get the low fish price from the same group help one another to negotiate an increase in the price from the fish group owner. Such a collective action helps them to keep their benefits and maintain fairness.

There is voluntarily reciprocal relationship of fish harvest activities every early morning like the figure 5.5. Fish farmers using the same stream naturally help their neighbors whose product is ready for harvest. Since there are a few number of hired harvest teams (the men in yellow), male fish farmers help harvest voluntarily while women cook breakfast for all the people related to the fish harvesting. Moreover, the kinds of bountiful relationship benefits for the water users at the same canals to collectively help build a weir and clean the waterways while sharing water with others with less resource conflicts.

Figure 5.5 Reciprocal fish farmers assisting the hired harvest team

They also think that knowledge and techniques suggested by those feed or external related organizations are just keen on academics, but they are not practical and applicable in reality. For instance, the organizations sometimes do not allow the use of chemicals to the fish diseases because they are harmful. Such an idea is in contrast to fish farmers' experiences that the chemicals often stop the fish diseases. Still, less contact with external vertical organizations limit their knowledge to what they have done. Comparing to Maekaedluang, for example, the majority of fish farmers in Sanpakhee prefer not to invest more in technology like aerators and to prevent the risks by using vitamins. Just two large fish farmers out of ten adopt the technology while the rest of them continue the same rearing practices, although they have experienced stresses.

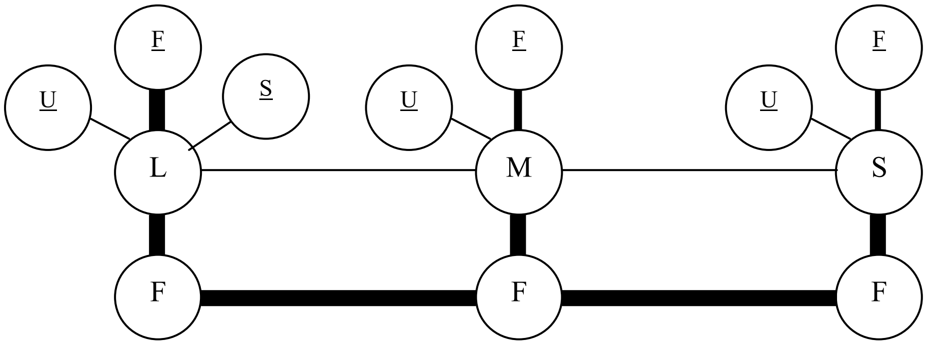


Figure 5.6 Intensity of networks in Maekaedluang

Maekaedluang with both strong bonding and bridging ties obviously have the highest trust of fish group members, fish farmer neighbors, fish farmer committees and feed companies. Based on the above trust, as a result, with strong internal and external relationships, fish farmers in Maekaedluang have the highest level of knowledge and technology exchange. Trust in leaders and practices in working toward common goals in Maekaedluang (figure 5.6) enable knowledge formation and distribution. Feed companies, universities and the state mainly approach the large fish farmer who is the leader of the group. The large fish farmer tends to share his knowledge with other group members. He has a large number of lands, increased fish production and initially adopted advanced technology in his farming that always encourage other group members to do so. From his practical and concrete outcome, that is why the followers trust him and see how successfully he is. He also trusts feed companies and always consults with feed company agencies about feed efficiency, fish diseases and other related issues.

Feed companies are allowed by the fish leader to participate in the monthly meetings as a time for them to convince the fish farmers to buy their feed brands. Then they use different tactics to build trust such as taking care of the fish production process, giving advice about fish disease treatments and so on. High frequency of contacts makes those fish farmers buy their feed and ask for help during urgent matters. The way the feed agencies use technical equipment to test water helps the fish farmers deal with the fish death and poor water accurately; and urges them to prevent the risks. They often take care of the fish farmers especially when fish death and loss unexpectedly occur the daytime or night-time or even on the weekends. One of the feed agencies also invited the professors from the university to test fish conditions in order to promote good care and customer service.

Increasing the accumulated trust between the bonding ties of fish groups and the bridging ties is made by increasing public participation and providing opportunities to do activities together in the fish group. Since the fish groups are not supported by any organization, each member is urged to found the group and distribute individual money used for common investment (table 5.1). The sharing and willingness to pay get them psychologically into the sense of belonging. With shared benefits, they are basically encouraging them to accept the regulations aiming to develop the organizational system and fish production. To reduce transaction costs, the money is used to buy cheap feed and chemicals including public equipment. Additionally, the way the large fish farmer keeps retelling the good points of fingerling use and technology implementation persuades all the fish farmers in the group to consider changing their farm system. Based on trust enhancement, they tend to share and exchange their knowledge among the group members.

Trust is developed from transparency of the organization in the monthly meetings and information updates. Frequent working together keenly urges more than 80% of the members to easily follow the social norm, accept and exchange new knowledge and improve the farm system. Fish farmers who participate in the meetings, seminars and field trips have more opportunities to have more experiences. Monthly fish farmer meetings are always held as an opportunity and space for identifying accounting, news updates, information exchange, solution finding and peer encouragement in order to develop fish productivity. Successful fish farmers who produce the highest fish product are selected every month as a good example for others. The feed companies also support the field trips to visit the feed and fingerlings factories. Getting real experiences about how advanced technology and techniques are implemented can build up trust. Most of them are agreed that the aerator becomes necessary as a risk minimization strategy. Choosing qualified feed and chemicals is moreover important to the fish's immune system. Using vitamins and EM application are taken into account to ensure fish survival rates with good weights. That is why most members committed to changing their farming system. Consequently, fish farms here are more systematic and more technological advanced than those in the other two villages.

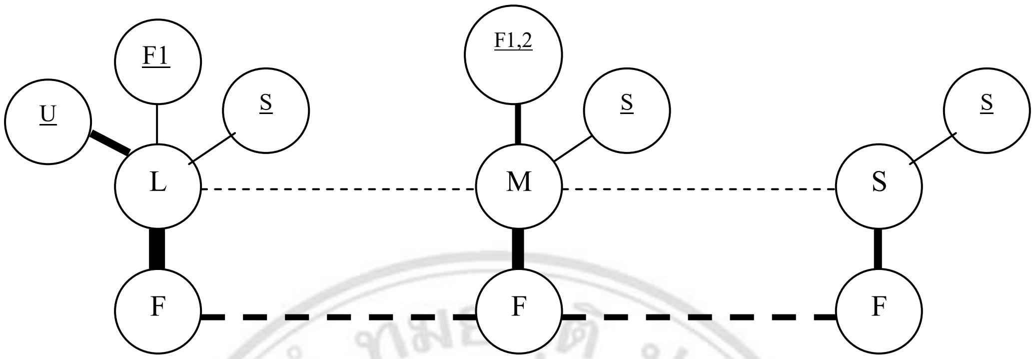


Figure 5.7 Intensity of networks in Tamphralae

In Tamphralae, many stakeholders involve in the fish farmer cooperatives (figure 5.7). The cooperatives use only one big feed brand (F1) of which the feed agencies often approach the large fish farmer who is the group leader, but not the small fish farmer who also uses the feed. The uneven distribution of customer service makes them fragmented in that the small and medium fish farmers decide to look for other feed sources. The medium fish farmers thus use not only the first brand sold in the fish farmer cooperatives but also a second feed brand from Phan District. The state and university also play a big role in fish farming extension for farmers with all farm sizes. It is seen that the state has great contact with all farm sizes. They often visit them on site to test the water and to test for fish diseases, making the farmers trust what the DOF officers advise on matters such as the water change system, chemical use and fish disease symptoms. On the contrary, even though the university cooperates with the DOF to launch the water purification project, those farmers including the large fish ones uninterested in the idea. It is also noticed that the university only directs the large and related fish farmers in the fish cooperatives. Based on minimal bonding community, those people in fish group rarely share or participate in activities together. Only the large fish farmers get more information from external organizations than others. But, less contacts (dotted lines) with each other limits the opportunities to share and exchange with each other. As a result, the medium and small fish farmers do not trust each other and the large fish farmer even when he gets lots of external assistances. They tend rather to trust their kin or neighbors who work in the same area than other villagers. If some fish farmers in strong bonding relationships like those in Sanpakhee and Maekaedluang retell the rumor or suggestion about successful fish production a second and third timev, other villagers tend to share and start to consider trusting.

According to table 5.1, the loose regulation of the local fish group leads to high fragmentation in Tamphralae where local people have more opportunities to be exposed to DOF advice and other smaller fish traders from Phan. They take part in the group for economic interest without the sense of belonging and the willingness to develop the group for common achievement. Only elected fish group committees are allowed to check the accounting and manage the group; while the rest of the members do not have opportunities to engage in the transparency process and public participation like in Maekaedluang. They thus tend to trust either DOF or kin/-neighbors or both who often interact with each other. Nonetheless, they do not trust the ones who rarely visit like the feed companies and the related university that promote the water purification project. No one grows water hyacinth like what the university suggests; they still wait for others to start first. If it is working, they will follow.

> "A fish farmer's knowledge recognition is different. The fish farmers who have practiced fish farming for a long time and pay interest in improving the farm might be skillful in curing fish diseases. Some people don't even consult with me, but rather buy the harmful chemicals that stimulates poor water in the pond and leads to fish death. I notice that some large fish farmers better ask me how to choose the chemicals and maintain the water quality but there are still a lot of fish farmers who ask one another who might not have the correct information. I am really concerned," Explained the state agency in Tamphralae (9-08-2014).
>
> The professor from the university (7-08-2014) also claimed "from my experiences, the ones who have better skills are the ones like the group leader and the fish farmer committees who often participate in the fish cooperative. However, the knowledge gap is made by the differentiation between the first group and other fish farmers who seldom participate in the group. When having a meeting, the second group might not attend because they believe more in their own experiences than the outsiders. In

> fact, they hurriedly find the chemicals to deal with the fish death instead, but in fact it might not work."
>
> At the same time, some small scale operators viewed that "the external organizations do not really help us as much as we help ourselves. Their seminars or meetings are so academic. They suggest to us to use certain safe chemicals, but do not provide us with any. We also do not know the kind of medication and where we should buy it."

Trust is generated by voluntary exchange and sharing among group. In fact, fish farmers comprise of both local fish farmers who are kin and neighbors and the outsiders. They have long distance relationships and live in different villages. Having fish farm compounds close to others does not seem like their pond neighbors play their role to take care of the fish-ponds. Each pond located out of the village is hence fenced to prevent thieves and outsiders from walking through the area (figure 5.8). Eight out of nine fish farmers come to feed fish just in the morning and evening and then return home or work on other farming that reduces the frequency of meetings. As a result they are not close and hardly ever share together. At its core, the level of networking social capital has an impact on social innovation to prevent from and cope with fish diseases. Low bonding levels and interactions in fish groups result from low trust levels from rare learning and exchanges with each other. As are result, innovation creation derives from individual ability to build trust with the one he/she is willing to share with. Two out of three large fish farmers use advanced aerators while one out of three medium and two out of three small use cheap water pumps.

Figure 5.8 The fenced pond areas

5.2.2 Regulation and advantage of membership

From the building trust process above, regulation and preferential treatment for membership (table 5.2) are further elaborated. The cooperatives in Sanpakhee and Tamphralae mostly set up the regulations in terms of commitment and encouragement. The fish farmers are urged to pay the common fund that is used to buy feed and other public properties for all the members' benefits. Moreover, there are bonuses and saving money like a bank in order to indirectly commit the member to produce fish for the group. Then they will get money in return. In this way, some fish farmer members are selected or voted to be committee members to check the accounting and to manage the system as well as to deal with the group problems.

Like the fish farmer members of the independent group in Sanpakhee, the owner of the groups here mainly operates it more privately and commercially. Thus, the price of the production factors is higher, but the system is faster than the cooperatives. However, even though Maekaedluang is the fish farmer groups, they are run by a kind of cooperative system. Through public participation, the fish farmers vote for the committees democratically while all members can voice out their problems. It can be clearly seen that inputs of fingerlings and feed prices are cheaper than other two villages because the committee and fish members regulate them. Some groups have bonuses from fish production and feed profit. Meanwhile, other groups removed the bonus system, preferring to use the bonuses to offset the profit from feed.

Table 5.2 Regulation and preferential treatment for membership

Villages	Conditions
Sanpakhee	
Regulations	Groups: (1) buy only a big size of fish; (2) buy feed, but fingerling is optional; (3) buy feed on credit of 30 baht/ a bag; (4) the profit given to staff salary
	Cooperatives: (1) pay 100 baht as an application fee; (2) pay at least 2,500 baht for share (if less than 100,000 baht, the members have to guarantee their properties which will be reconsidered by the committee); (3) buy feed on credit of 20 baht/ a bag of feed and will be refunded 5 baht/ a bag of feed after refunding the whole credit; (4) provide a bonus by returning 0.1 baht per a bag of feed, depending upon the fish weight and share; (5) keep some amount profit for staff salaries
Advantages of membership	If any fish farmers get familiar with or often participates with the fish group, they might be not charged from credit of the feed.
Maekaedluang	
Regulations	Group 1: (1) pay 10 baht/share (total 500-2,000 shares) as a common fund for investment and field visit; (2) no credit of feed, chemical, and fingerlings; (3) remove 3 kg of fish weight per time: one for harvest cost, second for a common fish truck and third for common fund (eg. Weighting fish 58 kg minus 3 kg equals to 55kg.) Group 2 and 3: (1) pay 600 baht as an application fee; (2) pay 10 baht/share as a common fund (at least 500 stocks); (3) buy feed on credit, 30 baht/ a bag of feed a month before harvest time;(4) provide the bonus 2-4 times a year to encourage for fish farmers to increase fish production;(5) sell extra 25 baht per a bag of feed to nonmember; (6) pay 0.3 baht/ fingerlings if anyone does not buy fingerlings from the group; (7) set a price of feed, fingerlings and chemical based on agreement of committee and members; (8) remove 2 kg: one for harvest cost, another for common fund; (9) allocate profit from fish, feed, fingerlings and chemicals to staff salary and office construction. (10) fish group staff receives money from fish traders instead of the farm owner to clear the debt first. Ps. all fish members in all groups are required to participate in monthly meeting.
Advantages of membership	The one who often participates in the group activities is allowed to buy feed on credit more than the one who is absent. The group also first prioritizes him/her the fish harvest queue during over fish supply.
Tamphralae	
Regulations	Cooperative: (1) pay application fee for 100 baht; (2) pay 10 baht/ share, 100 shares; (3) save 50 baht a month; (4) provide the yearly bonus according a total number of profit from fish and feed; (5) withdraw a saving money and bonus after quitting or death; (6) buy feed on credit depending upon a number of stock, if want more, more stock will be paid;(7) provide a loan for the members to buy feed; (8) buy feed on credit for 15 baht/ a bag of feed, four months before harvesting; (9) pay for checker according fish weight, 300 baht for 1,000 kg. of fish; (10) allocate profit for staff salary, feed investment and loan
Advantages of membership	The group also first prioritizes him/her who often buys feed and inputs from the fish groups the fish harvest queue during over fish supply.

The fish farmers decide to take part in any kind of fish group because firstly they trust in the suggestions of neighbors, kin and fish members; and secondly, of the acceptance level of the group regulation. To be a fish farmer members are required to adhere to the regulations of the groups for further assistance from the groups. For example, if the fish farmers always follow regulation, they are allowed to buy feed on credit out of the restricted time. Moreover, if there is any urgent fish death, the fish group will help harvest their fish earlier than others who hardly follow the regulations. The fish groups overtake the advantages for the farmers. If not, they are required to quit and seek for a new group and build new relationships.

Bringing social ties into economic framework is both strength as well as weakness. Social capital can also be beneficial for included groups but not always good for everyone. The relationship between fish farmer cooperatives and groups in three sites is connected in terms of competition, a win-win advantage and taking advantage of one another. In the case of competition, due to economic returns, each fish cooperative aims to grab market shares from one another. However, Chiang Rai is the highest supplier distributing the fish product to Phayao and Chiang Mai and other provinces in upper Northern Thailand. Phayao with its natural water source also aims to control their provincial market and hit the Chiang Mai market. Phayao and Chiang Mai regrettably face lesser and more unstable productivity. Accordingly, the regulations of each fish farmer cooperative to develop market strategies are designed to encourage their group members to increase production.

Table 5.3 Different fish prices in Chiang Mai, Chiang Rai and Phayao

Provinces	**Chiang Mai**		**Chiang Rai and Phayao**	
Fish size	Weight (g)	Price (bht/ kg)	Weight (g)	Price (bht/ kg)
1	> 500	58	> 7	58
2	> 400	48	> 5	47
3	> 300	43	> 4	37
4	< 300	20	< 4	27

(Data collected on September 15, 2013)

Although the relationship among the networks is competitive, the local levels of fish trade can seek for benefits from each other. Table 5.3 shows the examples of different fish prices in the three sites at particular times. It is found that the real price of the two provinces is lower than that of Chiang Mai. It is because Chiang Mai is a big city and a big market base in which the transportation cost is less taken into account. Nonetheless, the other two provinces have to count on the cost that basically makes the fish price lower to complete with the Chiang Mai market. However, fish farmers in Maekaedluang gain the highest price. But due to a limited number of lands, they hardly produce the fish amounts as much as the market demands all year round like Phan District, Chiang Rai and some areas in Bantam Sub-district, Phayao. In case of fish product shortages, fish traders in Chiang Mai are able to buy fish from other groups in the village and from fish networks in Chiang Rai and Phayao. Two of them are located in Sanpakhee Village and Tamphralae Sub-district. The Maekaedluang groups also gain benefits from the large fish farmer in Sanpakhee. Because he has a good relationship with the fingerlings and feed supplier, they take the opportunity to contact the supplier via the large fish farmer in order to get high quality products.

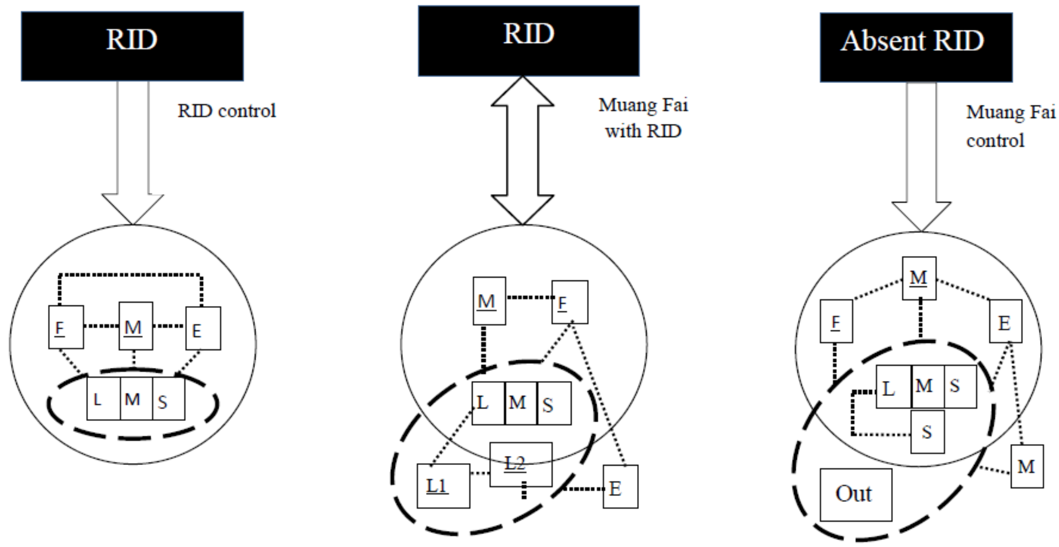
5.3 Roles of Social Capital on Water-Related Stresses

In this part, the study highlights how high the interactions of social capital among different scale agents can support adaptation to water-related stresses. To lubricate co-operation, social networks are reinforced when trust, share and exchange with one another increase connectedness for collective action. However, it is skeptical that the probability of fish loss increases since the water users lack collective action and negotiation to access water. Do fish farmers individually facing physical risks prevent or cope with the stresses on time? In fact, the structure and fish farmer networks and the irrigation systems are different in each village. That takes this study to focus on resource access in relation to many stakeholders who are farmers, fish famers with different scale operations and the *Kae Muang*. Utilizing social capital into fish farmer network in adapting to the stresses is analyzed based on the three social network frameworks identified in figure 5.2. The adaptation of each village is clearer when applying the framework of the *Muang Fai* relationship in Figure 5.6. It is to study how the networking social capital in each site differently interacts with the *Muang Fai* group. When facing the stresses, even if the fish groups do not cooperate with the *Muang Fai*, it is necessary to examine how each fish farmer play his/her role to solve the problems. What kind of social capital do they use, either bonding or bridging? This part emphasizes two water issues: (1) water scarcity and conflict; and (2) flood.

5.3.1 Water scarcity and conflict

The figure 5.6 explains the relationship between bonding of kin and neighbors and bridging of fish groups cooperating with external organizations. *Muang Fai* group are embedded in both bonding and bridging because those kin and neighbors are a water users in the *Muang Fai system*, which is under RID. The framework is divided into the three types of relationship: (5.6a) bonding of water users in the RID system in Sanpakhee; (5.6b) bonding of water users in the RID and *Muang Fai* system in Maekaedluang and (5.6c) non-bonding of water users in the *Muang Fai* system. Water scarcity and conflict become a problem in relation to high water demand and low collaboration of the *Muang Fai* system. It is evident that water conflicts in Sanpakhee and Maekaedluang are less radical than that in Tamphralae, even though they are pressured by the demand among fish farmers in the community and the surrounding urbanization influences. Why that is so will be elaborated below.

The diagram 5.9a conveys the less resource conflict due to the widespread water distribution and the nested bonding of local water users. The RID plays a major role in controlling water allocation but assigns the local *Kae Muang* to work in local activities such as informing irrigation news, clearing waterway and streams, and developing the street along the local canals. All fish farmers and farmers are a part of the irrigation system. The large scale leader of the fish group and other fish farmers with large, medium and small-scales in the fish group as well as the ex-fish farmer have to follow the allocation plan while participating in the *Muang Fai* activities. Thus they urge each other to take part in collective irrigation activities through kinship and neighborhood, not through membership of fish group. The fund of infrastructure development is from both raising money from the water users and the sub-district administrative organization. Furthermore, the upstream Sanpakhee Village receives water prior to others downstream. The regular allocation allows the farmers and fish farmers to do their activities throughout the year even during the dry season. Getting water as widespread as possible reduces the likelihood of having conflicts, just a-little problem downstream. But based on bonding ties, they can basically deal with each another and make an agreement.



a) Bonding of water users in RID system (Sanpakhee)

b) Bonding of water users in both RID and *Muang Fai* system (Maekaedluang)

c) Non-bonding of water users in *Muang Fai* system (Tamphralae)

Figure 5.9 Bonding and bridging interaction with *Muang Fai* system

M = *Muang Fai* F = Farmers L,M,S = Large, medium and small fish farmers Out = Outsiders
E= Fish farmer who exit from fish farming ······· = Kinship and neighborhood ━ = Fish farmer group

Diagram 5.9b represents the collaboration between local water users and the *Muang Fai* system which is predominated by state irrigation schemes. RID regulates the water allocation plan and assigns the *Kae Muang* to manage the system at the local level. All water users who are kin, neighbors, farmers and fish farmers with all farm sizes are a part of the *Muang Fai* system, they have to participate in collective activities and follow the irrigation rules. There is one large-scale fish farmer who moved his production base to another district; and one ex-fish farmer who is out of the *Muang Fai* group. They do not pay water fees and participate in any *Muang Fai* activities. Another large-scale fish farmer who is in the *Muang Fai* and fish group pays the water fee, but lacks participation in the irrigation activities. The rest of fish farmers with all farm sizes and farmers are under the *Muang Fai* institution. The large fish farmers in the fish group lead other fish farmers in any fish group for water negotiations and access. Still the irrigation situation becomes more problematic than in Sanpakhee, since the *Kae Muang* deals with the system and related problems alone. In reality, he hardly controls every single water users on the same track. Some water users refuse to paying the water fee and to participate in collective clearing waterway activities. By using a 'fine' letter drafted by the RID (figure 5.10), the *Kae Muang* is required to fine the absent person who breaks the irrigation rule. In fact, he prefers not using his right and power to force such a person to comply because they are all neighbors who are supposed to keep their good relationship.

The communal irrigation leaders often firstly coordinate with large fish farmers and other smaller fish farmers and farmers who always follow the rule and participate in the activities. He feels comfortable and willing to share with them the information about such water allocation and collective action plans. Either farmers or fish farmers who participate in the *Muang Fai* activities are the ones who easily access to get water. Moreover, if there is no water, he will not work for the ones who are absent from the *Muang Fai* activities. For instance, one large fish farmer who broke the *Muang Fai* regulation did not know the water allocation information, which made it difficult for him to plan water change systems in his farm. Thus, he tried to use the circulating water system instead, which increased his costs of investment. Conversely, other smaller fish farmers who always join the *Muang Fai* activities have better water access beneficial for pond water change and adjusting feed calculations to maintain water quality.

Water User Group of the canal 15th
Sansailuang Sub-district, Sansai
District, Chiang Mai

Date

Issue: Absent participation in clearing waterway activity

Dear……………………………………..

Your participation of clearing waterways from …(village name)… to ….(village name)… is necessary for all water users. But since you are absent on…. (date)… at….(time)…. Please be informed that you are fined at 300 baht/day.

Respect

………………

(*Kae Muang*'s name)

Figure 5.10 A fine letter (literally translation from Thai to English version) made by the Royal Irrigation Department and run by the *Kae Muang*

In the fish farmer cooperative, after receiving information or having a meeting with the RID, the large fish farmers chiefly work as news distributors. They share the water allocation plan with other fish farmers who lack opportunities to take part in the meeting. They also urge other fish farmers to help with the collective activities such as paying water fees, clearing waterways and access to water. During low flow periods, the water pollution becomes a big issue because of the increasing used poor water from a majority of fish ponds. Because of the limited amount of water, the leader and the large fish farmers encourage the group members to maintain water quality by using EM and reducing feeding. For the sake of all water users, the large operators also lead other smaller fish farmers in the group to negotiate with the *Kae Muang* and the RID to get access to water and address the water pollution. After meeting with the fish groups, the large operators voluntarily propose the issue to the *Muang Fai* committees and related organizations for further solutions. Due to their neighborhood, they can directly negotiate with the causal fish farmers who release polluted water downstream. Then, the farm owners temporarily commit to changing the releasing water time and reducing the rate of polluted water. The problems are still not solved unless all stakeholders sit and talk to find the way out.

Diagram 5.9c symbolizes the least level of local collaboration between local water users and the communal irrigation system. Even if sub-district municipality manipulates the *Muang Fai*, in fact it is the *Kae Muang* who manages the system. The sub-district municipality allocates yearly financial fund for canal construction and improvement, but the money is inconsistent each year. They also hold a meeting before the in-season in order to collect a number of land uses and water for agriculture production. In addition, the irrigation system of each water source is not linked to other sources, but it is rather designed upon each local irrigation leaders' plan. Anyway, both farmers and fish farmers are members of the *Muang Fai* and have to follow its rules like those in Maekaedluang. *Muang Fai* membership is labeled based on the location of the ponds and agriculture lands. For instance, Mr. C and Mrs. D (pseudonym) belong to the Mai Yang Weir upon his pond and her rice paddy field settlement respectively. The members of each water source have to be responsible for clearing the waterways and paying for the water fee and other common irrigation materials. If anyone breaks the rule, she/he cannot avoid being fined 10 times of the actual water fee.

Four groups of water users are divided based on grouping. The first three groups belong to the *Muang Fai* and fish groups. The ones in the fish cooperative are under the irrigation regulation. The first group is made up of local fish farmers with all farm sizes in the fish group. The second is two small fish farmers and an ex-fish farmer who use underground water but still participate in the *Muang Fai* group. The third is outsiders who buy the lands upstream from local people and mostly convert them to fish ponds and agriculture lands. They are supposed to be *Muang Fai* members, but 60% of them are not. They get water without paying the fee. Local people then seldom interact with the third group. The fourth group is a medium fish farmer who moved from Bangkok to marry a local girl and has lived in Tamphralae for more than 15 years. He is not in both the fish and *Muang Fai* groups. He relies on underground water and has no rights to water access. He is hence not supposed to pay the water fee and participate in *Muang Fai* activities. Above all, even though fish farmers and farmer are united in the *Muang Fai* group, each fish farmer access water by any means they can such as buying the pond upstream and piping the water. Settled above agriculture farming, fish farmers mostly take as many opportunities as possible to stock water.

Water scarcity and pollution becomes a crisis in Tamphralae due to the reducing water level and the weak and separated irrigation system. The water capacity is lower from the increasing mass agriculture and fish production. To make things worse, there is no measurable record of water capacity in each weir and catchment that results in the ineffective water allocation plan to meet the higher demand of water users. Therefore, those water users (farmers, fish farmers and outsiders) compete for water with one another especially during the dry season. Unfortunately, the *Kae Muang* role has declined since they are too old and too powerless to deal with a great number of problems. They cannot control water users to reduce using water and cannot force the well-off people to pay the water fee and take part in social irrigation activities.

> "The *Kae Muang* is no longer respected. No one is scared of or cares about his punishment. The existing *Muang Fai* law is no longer active. The more opportunities they have to access water, the more they gain by using a big water pipe," explained an affected fish farmer in Tamphralae.

Many water users thus no longer value the *Muang Fai* system and respect the *Kae Muang* and the rules like they did in the past. In turn, the rule is often broken and the overuse of water increase resource conflict among water users. However, the problem is not raised because all of them are kin and neighbors. Avoiding blaming those casual people directly maintains their relationship in the same community. Two out of three large- and medium-scale fish farmers gain efficient water because their farm locations are upstream. Furthermore, there is a conflict between the local and outside water users. They mostly have fish-ponds and agriculture lands upstream that release polluted and poor water downstream. Those well-off authorities and outsiders not only use a large amount of water but also break the rule by using big pumps and stock water without sharing to others. As a result, farmers and fish farmers destroy their connectedness in the fish farmer cooperative. It can be said that the lack of social relationships breaks the rules and the creation of trust.

To solve this issue, both the *Kae Muang* and affected water users decided to passively do nothing. He cannot negotiate and deal with the users and ignores his rights and power to manage because he is afraid of the powerful people. The local irrigation leader here generally works during the rainy feed season, except for summer. The *Muang Fai* agreement commands that water during daytime is to be used by farmers and at night by fish farmer. But farmers and fish farmers are required to manage the water by themselves. At the same time, the fish farmer members do not link and share the news about the water problems with each other. Specifically, during the time of stresses, it is obvious that the fish farmer members do not gather to negotiate with the *Kae Muang* to address the water shortage. Even worse, most individual farmers and fish farmers passively avoid direct negotiation with the large fish farmers and powerful people who stock and pollute poor water. For example, poor water from fish-pig farm of the large-scale fish farmer upstream affects the medium-scale fish farmers whose ponds are downstream. The latter does not want to challenge him, but would rather engage in hidden action through gossip and complaints in small informal chat groups. Furthermore, to release water to their farms, some farmers close the pipes of fish famers without asking for permission. Even harder still, some small fish farmers downstream individually try to negotiate to use another water source nearby, but their voices are not heard by the *Kae Muang* and sub-district municipality. Notwithstanding, being a part of the fish group does not help the members to have access to water, some small fish farmers temporarily stopped raising fish and some decided to exit the farming.

In terms of farming management, facilitating the information transfer from the state and university down to the fish farmers is likely to have difficulties in the non-bonding communities. Most fish farmers decide not to apply the knowledge to improve the farming system, but learn by their mistakes and experiences. Hence, adapting to drought and water pollution is so different across the scales. Large operators accessing the water upstream have less polluted water problems. They also enable to improve their farming systems, reduce fish density and increase the number of fish crops to prevent risks. Most large- and medium-scale rely more on advanced modern technology than the small -scale. The smaller fish farmers have less ability to own land with access to good quality and quantity of water. They have to bear and persist through the low flow as long as the rainy season arrives.

The most affected case is found in a medium-scale operator who is neither a part of the fish farmer cooperative nor *Muang Fai* system. His pond is located in the low-land downstream that is prone to low flow and stocked water upstream. During the dry season in 2013, the lower level of underground water and hot weather intensified tons of fish deaths. There was no help from any social partners and even the state's compensation since he is not registered to the fish farmer list of the DOF. A year later, he started operating an aerator and decreases his fish density to reduce risks but vulnerably still faces lower flow periods. To keep the water quantity, he sometimes has to reluctantly use overused poor water from other ponds upstream.

5.3.2 Flood occurrence

Severe flooding occurred in 2005, 2011 and 2013 in Maekaedluang; and 2005 and 2013 in Tamphralae, but it never happens in Sanpakhee. To study how social connectedness plays an important role in floods, here is the comparison between the strong bonding village and the non-bonding village in different aspects. Besides the climate related risks, the flood occurrences in Chiang Mai resulted from the mismanagement of related organizations and poor *Muang Fai* communications at the local level. The flood in 2005 in Maekaedluang was caused by the previous weak water allocation management plan. The communal irrigation leaders seldom held meetings with other irrigation leaders and water users. The few meetings resulted in ineffective communication and a weak water management plan that reduced the water users' capacities to prevent, and to deal with the hazards on time. A vast majority of fish-ponds and agriculture farms were uncontrollably damaged and ruined.

After electing the new *Kae Muang*, the flood re-occurrence in 2011 was more severe than in 2005. It was because the water storage capacity in Mae Ngat Somboon Chol Dam was over released to the areas with abnormal allocation and slow communication. Some fish ponds with higher levees were safe from the flood. But most of the housing areas at the lower lands were affected. With the strong neighborhood, many farmers, fish farmers across scale operations and villagers were willing to help each other during the time of stresses. At around 6 o'clock, the level of the flood was high by 0.5 - 1 meter, which obstructed the transportation in some areas. Their neighbors helped to move feed and other things up to the second floor. For instance, the chicken farm of the medium fish farmer was flooded. When the flood inundated the chicken farm, he immediately asked his fish farmer neighbors to move his chickens to their temporary safer place. During the urgent time, many neighbors voluntarily provided trucks to transfer the chickens.

The diagram 5.6b above is used to analyze the social functions on the strategies to deal with floods. In Maekaedluang, compensation was fully distributed. In 2011, most fish farmers who had registered for the formal fish farmer lists were given compensation at about 5,000 baht /0.16 hectare (1rai) from the Department of Fisheries and 2,000 baht/0.16 hectare (1 rai) from District Agricultural Extension Office. The village headman also gave some dried foodstuff to the farmers. On the other hand, one of the fish farmer groups in Maekaedluang did not receive the flood compensation. Led by the large fish farmer, about 30 fish famers claimed that they were supposed to get money because their name was registered on the fish farmer lists. That motivated them to negotiate for their rights asking for compensation from the Department of Fisheries and the provincial governor. Finally, they received the compensation but the negotiation later created an uneasy relationship between the DOF and this group. The group subsequently rarely contacted the DOF agencies and was seldom invited to meetings unlike in the past. The fish farmer members have to rely on the feed companies and their fish farmer friends instead.

Later flood situations had become safer with better collaboration. Both farmers and fish farmers could now prevent the latest flood in 2013. After several flood experiences, fish farmers tended to build higher pond dikes and concrete dikes along the canals to the prevent flood. High water level occurred for 2 days in 2013, but it was not severe like the previous flooding. For the time being, many villagers (farmers, fish farmers and villagers) learnt from the past and improved prevention strategies by preparing a large number of sandbags given from the sub-district municipality in advance. According to the figures 5.11 and 5.12, sandbags were used to prepare for floods at wherever was prone to the risks. Fortunately, the high water level was lowered by the *Kae Muang* who ordered the farmers to release water as fast as possible to rescue every water user. However, it is noticeable that the fish groups did not cooperate with the *Muang Fai* group to cope with the floods but to just deal with the fish production.

Figure 5.11 Farmers and fish farmers helped transport the sandbags prepared for flooding

Figures 5.12 Sandbags readied for preventing flooding

The rising level of the flood in 2013 was an obstacle not only for the fish farm owners but also for fish traders. Since the water level in the canals increased, releasing the pond water was difficult and takes longer. Consequently a lower ton of fish was harvested per time from 100 kg to 40 kg per time. It was also hard for the traders to drive along the muddy ways heading to the fish farms, which made the fish queue and harvest process slower than usual. To reduce the economic loss and to queue the process during flooding, the fish groups were in charge of maintaining the market base and the relationship of the fish retailers, wholesalers, and fish farmers with the fish groups. For example, while waiting to release the pond water for the harvest, the fish group urgently provided other fish sources nearby which were safe from flooding. Again, if the group could not provide tons of fish, the traders were allowed to buy from the other two fish groups in the area. They sometimes ordered fish from the network in Sanpakhee and other groups in Phan; and sometimes from the Tamphralae fish cooperative.

To compare the social network role towards the flood occurrence, Tamphralae Village also experiences flooding. Flash flood occurred in 2005 and 2013. From diagram 5.6c, it is evident that the medium fish farmer who is out of the fish group and *Muang Fai* system are most affected. In 2005, the flash flood spread through his pond compound without urgent warning from any related organizations. The heavy flooding damaged his ponds within as fast as half an hour since his ponds were made from soil mixed with sand, which collapsed easily. Everything was out of control and the fish was suddenly gone. He estimated 1,000,000 baht in economic damages and losses. In this regard, the *Kae Muang* did not show up while the sub-district municipality paid him 6,000 baht as compensation that could not cover the actual total loss of about 300,000 baht.

Again in 2013, without any group or association, he faced the difficulties in distributing fish in difficult conditions. He was suffered from the fish death during the long heavy-rain days. He asked the fish traders from Phan to harvest fish, but they refused because it was not his queue yet. Unfortunately the fish nature was unable to resist to the climate uncertainty and died dispersed all over the water surface. He suddenly asked for help from his unskilled neighbors in harvesting the fish. Due to poor equipment preparation and few laborers, his wife and his neighbors found whatever available boxes for freezing the dead fish and retailed them to anywhere around the districts. However, they could save just some amount of total fish and reluctantly buried more than a half of his fish production. He then got dissatisfied with the Phan fish trader and decided to seek for other fish network.

By the end of October 2013 trigged by the monsoon season, the flash flooding spread through some part of Bantam District areas, mostly severe in Tam Klang and slightly in Tamphralae Village. Whoever has many contacts has better coping capacity. A large fish farmer afraid of the flash flood in Tamphralae contacted the forest officials. He closed the pipes in time and survived the flooding. A few fish farmers who have ponds in the danger areas were affected. Floodwaters from the upland Khun Tam Waterfall reached Tam Klang Village and gathered sewage at the bridge across the main canals. An amount of water persisted and increased over the canals that forced the bridge broken, otherwise the flood might have spread through all the villages, ponds and agriculture lands downstream. The flooding badly affected several fish farmers. But fish farmers from Tamphralae who located their ponds in the area were safe. Moreover, some areas under the Thung Klong Catchment was inundated, still no fish ponds and paddy fields were damaged.

> "There was no flooding for a long time, except for this year. If there is heavy rain for 2 - 3 hours, the amount of water from the two local water sources will be increasing," said a large fish farmer whose ponds are situated in Tam Klang Village.

It is incredulous why the flash flooding occurred without any protection mechanism. From the situation above, it is seen that kin and neighbors do not play a great role helping each other during the time of stresses. Affected fish farmers or farmers and villagers face the problems individually, but without help, the situations can turn out to be big losses. It is evident that the forest areas under the Khun Tam Waterfall are mostly converted for the increasing agriculture lands, fish ponds and housing areas. The land conversion results in flooding. However, the Department of Fisheries in Tamphralae entirely compensates the flooded fish farm by providing fingerlings. But such a baby fish is low in quality and breeding and is not well accepted by the villagers. Above all, the *Kae Muang* or related and affected villagers play a small role in the water management and initiate risk warning. As a result, the people have to find their own ways for survival that are different from those fish farmers in Maekaedluang. Together with the local authorities, the villagers voluntarily assist during urgent situations.

5.4 Summary

This chapter strongly claims that the construction of kinship and friendship of the fish farmers made by bridging networks with horizontal and vertical links increases their adaptive capacities. Social capital can increase with use. The more it is used, the more it regenerates. Most fish farmers set up the organization systems; reduce transaction costs, and provide fish-related jobs as well as access to funds, new knowledge and technology gained from external organizations and through kinship and neighborhood. The differentiation of networking types conveys different problems and responses to the stresses. Thus, these lessons are emphasized in the three cases. Bonding without bridging is found in Sanpakhee and bonding with bridging in Maekaedluang. Still Tamphralae Village denotes no bonding and bridging interaction. If any community lacks the bond among kin, neighbors and friends, the fish farmers there have fewer capacities in response to all the risks.

Whether the state supports fish farmers, bonding interaction is more important in developing their abilities. The bonding can be constructed through frequencies of trust, reciprocity or exchange, regulation and collective action. How much the vertical state supports does not determine achievement unless local bonding is strong. Even though fish farmers in Sanpakhee and Maekaedluang face external urbanization and water demands, they can maintain their production and better adapt to the stresses. In other words, the bonding of fish farmers can reinforce trust, exchange and enables them to seek benefits from external networks to share among all the scale operations. The attempts increase high social learning and the capacity to access to resources. Meanwhile, lower bonding reduces the adaptive capacities of fish farmers. The large-scale gain benefits while the smaller loses, leading to resource conflicts.

Social connection also plays a great role in water management as a common resource needed by farmers, fish farmers and villagers. Whether the resource is efficient for all water users depends upon the management of irrigation systems and the collaboration of local villagers. Highlighting drought, water pollution and flood issues, the case studies demonstrate that the networks embedded in well-linking social capital play an important role during the dry season. Farmers and fish farmers can share water and other resources. They are also willing to help each other to rapidly cope with and prevent the flooding. On the other hand, due to the loose relationship in the fish farmer community, the adaptive capacities are so diverse. Most water users are individually prone to the risks and highly affected by the stresses. That is why the problems remain unsolved while the collective solution is rarely made. Neighbors who are suffered from the problems would rather stay silent rather than take any action. Some resist the stresses, others try to cope with them alone, some stop or exit, and some passively or actively negotiate with the related stakeholders. Social capital is supposed to be the significant resource for the vulnerability reduction and livelihood of fish farming households and communities. Highlighted in chapter 6, there is a need of wider and more in-depth understanding and contribution in academic discussion and policy implementation.

CHAPTER 6

Conclusion

Fish, next to rice, is the important food product for people's livelihoods, and household income opportunities for large-, medium- and small-scale fish operators. For the pond-based aquaculture that rely mainly on natural resources, destroyed natural resources due to climate-related and socio-economic risks have a great impact on the fish farmers' livelihood and well-being. With different scale operations, some fish farmers with different capacities can deal with the stresses. Vulnerable fish farmers are unable to respond to, resist or recover from the stresses that end up with losses of assets and income. Some lose and exit from fish farming. Meanwhile, some can survive and gain benefits. However, all scale operators are united into fish farmer cooperatives in managing production and marketing. Thus, this thesis emphasizes the adaptation of fish farmers in Northern Thailand via social capital.

This chapter focuses on three distinct dimensions that I have linked together in my study. The first is the major findings of my research, while the second is a debate of these findings based upon the relevant theories and concepts of risk, vulnerability, adaptation and social capital. The third point is the policy implications and recommendations in order to develop the adaptive capacity of fish farmers in response to change in climate and climate variability.

6.1 Major Findings

The findings of my research are discussed in regards to the research questions. The first question studies the vulnerability of fish farmers who experience climate-related and socio-economic stresses. This addresses how these have impacts on fish farmers' livelihood and well-being. Then I elaborate upon how fish farmers with different scale operations have different capacities to cope with, respond, and recover from the risk.

Last but not least, the study highlights the social capital strategies to solve the issues in the first two questions. These three questions are:

6.1.1 Vulnerabilities of fish-pond farming households with scale operations

Fish pond farming, a centered case study of the research, is sensitive to the variations in water supply and demand, as well as water quality and quantity. It is seen that the interrelated and multiplied weakness of household and place exposure increases the level of vulnerability of fish farmers. Place vulnerability is measured by the relative factors between the degree of urbanization and climate-related risk exposure. It is found that peri-urban Maekaedluang, followed by Tamphralae is most prone to floods, drought, water pollution, the seasonality of rainfall and resource conflicts. Particularly in Maekaedluang, converting land use to residential estate and commercial farming causes fish farmers' livelihood insecurity. Losing their land ownerships and suffering from water pollution directly affect fish farmers' productivity and income. To make things worse, water systems nowadays have become fragile due to the loose collaboration among water users. Since villagers including offspring tend to work off-farm leading to labor shortage issues and dis-socialization among community. Undoubtedly, the loose water user networks especially in Tamphralae decline the efficiency of water allocation and management, but in turn cause water competition.

The most vulnerable cases are those who lack capitals, have few social networks and get older. Fish farmers in Tamphralae, followed by Maekaedluang, are most vulnerable because most of them have uneven access to knowledge and assistances. Some medium and most large fish farmers are less vulnerable based on their capital stocks of water, labor, land, money and knowledge. By contrast, during the time of stresses, non-membership in fish networks and other water users is a threat for the smaller- and medium-scale operators in dealing with fish death or fish diseases. In addition, most small fish famers living possibly exposed to urbanization influences suffer from the land use insecurity and the poor water quality and quantity. Moreover, aging generation and weak family members in all sites reduce the household's adaptive capacities. Learning scientific knowledge and new technology adoption applied in fish farming is too difficult for the small-scale and old fish farmers. They also have a limited knowledge channels, and tend to just follow their kin and neighbors. At the same time, the more elderly people and children the households of mostly small fish farmers have, the heavier their financial burdens. Supplementary income opportunities are limited since those vulnerable generations are required time for care. In addition, their income is shared for household consumption and other domestic needs which are a threat for the existing and further investment.

6.1.2 Scale operations of fish farm on adaptive capacities

Scale operations matter in the adaptive capacity of the fish farmers. Adaptive capacity is measured by the capacity to recover from stresses and the productivity. It is found that bonding social capital enables the increase of the level of adaptive capacity as proven by the fish productivity in Sanpakhee with efficient water, and in the high social learning in Maekaedluang. The water users, enhanced with by kinship and supportive neighborhoods, can share water and have a talk when water problems happen. Fish farmers are ensured that they can raise a high density of fish and a number of pigs. Reducing the amount of commercial feed and replacing it with plankton from pig manure helps reduce cost of investment. That is why fish production and net profit in Sanpakhee are higher than that in peri-urban Maekaedluang and Tamphralae. Social capital is crucial in social learning and knowledge implementation. Knowledge for effective rearing practices is most practical in Maekaedluang through strong bonding among fish farmer members and bridging from feed company agencies. On the other hand, even though Tamphralae has a strong bridging with the external state and universities, the learning process is not distributed as extensively as possible. Due to the fragile bonding among kin and neighbors, the knowledge level is not balanced, but restricted in the accessible groups, particularly the large-scale fish farmers.

In terms of scale operations and social capital stock, it is found that large-scale operators, have high financial assets, and more opportunities to gain knowledge from other external sources; as a consequence they have less negative impacts than smaller operators. Medium and small operators affect more from fish death and diseases. These latter operators have fewer financial assets and fewer contacts with external partners. In this regard, well-off fish farmers have more purchasing power over farming system management and land use allocation. They are able to buy lands with good water quantity and quality access. They can also allocate a piece of lands or build up a water system for water stock used during low flow, whist the smaller fish farmers reluctantly rely on the uncertain water in the canals. In addition, the large operators can invest in the high cost of qualified fingerlings, nutrient feed and more advanced technology. They therefore can prevent stresses and increase fish crop frequencies.

In the places where bonding is strong, particularly in Maekaedluang Village, most large-scale operations mainly raise awareness of risk prevention and distribute their own knowledge to other smaller operators via bridging fish farmer networks. For instance, large fish farmers introduce maintaining water quality during the time of stresses, adjustment feeding, rearing period and adopting aerators for oxygen circulation. In addition, they furthermore introduce how to use chemicals and medication properly. Thus, there is a high potential of risk prevention and coping capacity across scale operations towards fish diseases and death. Undeniably, not only do the large- but also the smaller-scale operators in the communities with strong bonding decide to intensify their fish farming.

6.1.3 Adaptation via social capital

Since the household structure has been changed through urbanization influences, family members in these days often live far apart. Thus, bonding social capital between kin and neighbors is constructed through bridging fish farmer cooperatives. This relationship promises to build co-operational structures in building up the adaptive capacity of fish farmers. Fish cooperatives and groups are formed for economic interest. They aim to reduce transaction costs; to access to knowledge, technology, labor and money; and to increase adaptive capacities. The groups also provide job opportunities such as group committees, harvesters, accountants and fish traders.

The level of social capital has an impact on social innovation to prevent and cope with climate variability. In this way, social capital is mobilized by trust, exchange, regulation and collective action. Under the construction of kinship and neighborhood embedded in fish farmer cooperatives, those fish farmers in Sanpakhee and Maekaedluang undoubtedly rely more on horizontal relationships within the groups. The more collective activities are generated, the more trust builds up. Sanpakhee locals trust their kin and neighbors more than external organizations since they are united by the collective action of fish harvesting and other social activities. Their knowledge, understanding and innovation are still mainly implemented and led by the large-scale operators. The rest of them tend to follow while some rely on their experiences.

High levels of social component implementation on bonding ties increase the level of knowledge and technology adoption. Having strong bonds is a base to share new knowledge. In Sanpakhee, fish farmers trust and share information among clans and neighbors. Fish farmers in Maekaedluang prefer trusting the feed agencies as much as the large fish operators or the group leader and their fish farmers' colleagues. Together with monthly fish farmer meetings, it is as a space and an opportunity for news updates, information exchange, solution finding and peer encouragement in order to develop fish productivity. By contrast, at the low kinship and neighborhood ties in Tamphralae, fish farmers seek a full support from the Department of Fisheries and universities. In terms of farming management, facilitating the information transfer from the state and universities down to all fish farmers is likely to have difficulties in the non-bonding communities. Indeed, the knowledge implementation does not seem practical since trusting and sharing knowledge is rarely made among the group members across scale operations. As a consequence, the possibility of fish loss is high.

While the fish farmer groups have been constructed, the *Muang Fai* group is still declining, which affects agriculture and aquaculture activities. Meanwhile, the fish groups do not fully cooperate with the *Muang Fai* group. That is why this exacerbates competition for water among farmers, fish farmers and villagers. Water conflicts in Sanpakhee and Maekaedluang are less severe than those in Tamphralae, even though they are pressured by the increasing demand between fish farmers in the community and the surrounding urbanization influences. Fish farmers in the strong-bonding Maekaedluang attempt to keep benefits for all water users. Thus, the large operators chiefly lead other smaller fish farmers to negotiate with the casual fish farmers' friends who pollute poor water, the *Kae Muang* and the RID. On the contrary, in minimal-bonding Tamphralae, most water users including the *Kae Muang* passively avoid direct negotiations with the large fish farmers and powerful people who cause problems. This ongoing phenomenon seems to increase water competition and water shortage.

6.2 Discussion

In this study, social capital played an important role on fish farmers' climate adaptation at household and community level in Northern Thailand. Fundamentally based on previous studies, social capital (family, communities, the state, market and civil society) can strengthen their access abilities to resources and other types of capital assets (produced, human, natural, social, and cultural). The assets can be organized and enhanced to capabilities for better living and to change dominant rules to control, distribute and transform resources in the societies. Conversely, the study finds new dimensions of social capital in the context of fish farming as per the elaboration below.

Starting from social household ties, under the current economic development and environmental variability, livelihood diversification links to the household demographic variables (Stard and Johnson, 2004; de Sherbinin et al., 2008). The offspring's mobility, the aging people's morbidity and's mortality reduce the human and social capital in households and community. But the context of the study is very different. Doing pond-based aquaculture relies so much on the water supply that it encourages the aging fish farmers to stay put instead. Furthermore, though the young seeking off-farm work cause a lack of labor employment, in fact a few people do return to practice fish farming. With these factors, in turn, the study strongly claims that the household and community structure and relationship are not fixed. Fish farmers with different ages form and construct their relationships in the form of the formal fish groups or fish cooperatives. The new constructed cooperation role becomes necessary to fulfill the problems of lack of funds, information and technology; labor shortage; and aging labor forces. They not only reduce transaction costs but also provide fish-related jobs.

It is noticeable that numerous integrated aquaculture projects supported by the state are highly implemented, but it is not so obvious in Thailand. For instance, the DOF in Phan encourages the fish farmers to integrate their farming by raising frogs, gardening on the pond levees, and raising earthworms for agricultural soil and raising worm for fish feed in order to reduce the feed expense. In fact, those people who attended that meeting agreed that the idea is good but, comparing to their integrated pig-fish system, what the DOF suggests takes time and increase labor burdens. They were also concerned about the cost-benefit ratio and return of investment. Bosma and Verdegem (2011) and

Longoni (2011) discuss that intensifying aquaculture production in existing farming is most sustainable. They agree that the poor producer can employ new technologies to make the financial and social factors more sustainable and more resource-efficient. Khondker and Diemuth (2011) also promote that the integrated aquaculture-agriculture (IAA) training for small-scale farmers in Bangladesh can increase food consumption and better nutrition levels. Bangladesh is a densely populated Asian country with a rapidly growing market-based economy. Since there is no further expansion of farming areas, improving the productivity of farmed land would be the better solution.

On the other hand, though the mixed subsistence agriculture and aquaculture in Thailand is introduced by the state, it is in fact not widely applied. Without the earlier massive state help, the local fish farmers who have long developed the fish production and marketing process by themselves particularly in the Sanpakhee and Maekaedluang villages does not cooperate well with the state. Moreover, Thailand has a small number of fish subsistence systems because the country is a free economy country that requires high food production. Its population (66,720,153) is two times lower than Bangladesh's. The commercial feed companies, with little state assistance, can easily extend the commercial fish production to respond to the high market demand. Fish-pond lands can be transferred to others and expanded based on the fish farmers' financial capital.

Patcharawalai et al., 2013, claimed that integrated fish farming is more prone to water stratification from hot weather and rain than conventional commercial systems. High loads of nutrients and fertilizers cause phytoplankton blooms. They consume a lot of oxygen at night and during daytime with no light and post increasing thresholds of fish death. The argument is so useful and helpful for fish farmers to manage feed practices and waste management, but it is necessary to take into account individual fish farmers' management systems. It depends very much on their stock densities, aerator implementations, water access to change water in the pond, and labors. It is riskiest in the integrated pond with high density of fish without aerator implementation in the areas that do not have enough water. Nonetheless, fish farmers undertaking integrated farming have lower risks of income shortages in a particular time. If they lose any fish profits, those in Sanpakhee still have monthly pig incomes. Intensive farming is still riskier, unless those fish farmers have enough money from other income sources to cope with and recover the fish losses. Above all, it is more helpful if those information and knowledge are accumulated and exchanged by learning together in fish groups or among their peers.

It is agreed with that vulnerability can be decreased by technology (Burton, Kates and White, 1978) and the interrelation between social learning and self-organization (IPCC, 2010; and Pelling, 2010; Ford and Smit, 2004; Fabricius and Cundill, 2010; Pretty J. and Ward H. 2001). The young also become key persons who adopt nontraditional lifestyles with the new technology (Fabricius and Cundill, 2010). Here it cannot be generalized that information and technology distribution are widespread in all kinds of households and communities. Even if the fish farmer cooperative is a space of social learning, successful information distribution depends upon the type of social relations in different contexts. With the help of strong social cohesion, fish farmers with all farm sizes are able to extend technology and knowledge with one another for more flexible uses of farming. A loose relationship causes the uneven knowledge understanding and different ranges of adaptive capacities among fish farmers.

In terms of farm-size adaptive capacity, the more capitals the stakeholders have, the more abilities they have to access resources. Chiep (2001) explores the social relations of each scale in obtaining access to fishery resources in Tonle Sap, Cambodia. The situation is regulated by the state controls over fishing resources. They allow private individuals access and exclude the small- and medium-scale fish farmers from the resources. Only the larger scale of operators can benefit. Phong et al. (2007) and Khin (2003) also elaborate further that the wealthy farmers with skillful farming and many capitals intensify their farming while the poorer farmers diversify more passively and stop farming. But this is different from the context of fish-pond farming in Northern Thailand. The state role is low whilst fish farmer relationships across scale operations are interrelated and more dynamic in benefiting the resource access.

Fish farmer cooperative and group roles become significant with the collaboration of fish farmers with other large-, medium- and small-scale operators. No matter which kind of scale operation they have, having a great number of contacts can strengthen power relations and negotiations in order to access to resources. Large-scale ones with the highest number of networks is the leader of the fish group who is in charge of production and marketing management for the rest of the fish farmer members. In the strong-bonding community, for common interest, the inclusion and exclusion relations among different scale operations are combined. The large-scale fish farmers support the smaller ones with knowledge assistance and money while asking helps from external organizations for all the farm sizes. The smaller fish farmers not only defer to the regulation of the group, but also support labor and exchange knowledge with the larger-scale farmers. Without social fish networks, no one cooperate and help manage the process from production to marketing. It is easier for the large-scale or the external organizations including middlemen and feed suppliers to gain benefits than the ones out of the fish groups.

Most researches on social capital do not take into account social capital components (Pretty J. and Ward H., 2001) on bonding and bridging (Putnam, 1993) and vertical and horizontal dimensions. Bonding is necessary but bridging is still needed via trust, exchange, regulation and collective action. Kinship and neighborhood relationship constructed by fish farmers through bridging networks with horizontal and vertical links strengthens adaptive capacities to deal with climate-related risks. In this way, social capital becomes self-reinforcing when reciprocity and exchange increases connectedness between people, leading to greater trust and collective action (Prusak, 2014; Nahapit and Ghoshal, 1998, Putnam, 1993 cited in Fu, 2004). The more the frequencies of social contacts increases, the more trust, exchange and collective action are well enhanced. The willingness to learn, to share and to help also increases the innovation towards better adaptive capacity. For instance, even though fish farmers of all farm sizes in Maekaedluang face external urbanization and resource exhaustion, they can develop advanced technology to maintain their production.

Living in a strong group is sometimes a problem (Granovetter, 1973). For example, retelling rumors through the strong group can be more distorted than through the fragmented person with weak ties. The rumors may be true but not in the arena of pond-based aquaculture of which fish farmers trust and work together via formal groups, kinship and neighborhoods. The claim depends on the types of fish farmer groups. Fu (2004) proposes that trust increases the willingness of participation in social exchanges and interactions that in turn enhance social capital. Retelling by a trusted person in the close group with transparency and participation, reminds and ensures other fish farmers about the good care and willingness to let them increase their fish production.

In loose networking communities, lack of trust from loose regulation, rare sharing or, exchanges and collective action can distort social capital and exclude benefits from some individuals. If the group members do not have the willingness to sincerely share with others, the information might be distorted through time and persons. In this sense, the smaller fish operators like those in Tamphralae are not allowed to speak out on the group's decision-making by the larger fish farmers who are in the group committee. In addition, having kinship and neighborhood ties are obstacles to negotiation for their rights. They cannot negotiate for access to water or ask people who caused problems to take action. To reduce the dissatisfaction among the clans who have lived together for a long time, they decide to keep silent and let the problems continue.

In terms of linking types between horizontal and vertical social capital, Putnam (1993), Pelling (1998) and Belton (2012) argue that horizontal bonds are more important than vertical ties. But, Woolock (2001), Pretty and Ward (2001), Bebbington and Perreault (1999) claimed that vertical relationships are able to influence a wider range of resource access than are available within the community. The vertical social ties from external organizations are useful in themselves. But its implementation at local levels might not be helpful for some individuals if the horizontal bonding is weakened or fragile. In this way, uneven resource distribution reduces the level of trust as argued by Pelling and High (2005). Less interaction across all scale operations does not return any benefits to small-scale operators (Granovetter, 1973). On the other hand, being different scale operators in close networking communities do not have very different access to information. To consistently participate in the fish group activities; many small fish farmers can raise fish better than some medium fish farmers because the smaller ones improved their farming system. Moreover, even though the small aging and divorced fish farmers are most vulnerable in Maekaedluang, they do not decide to exit from fish farming. It is because they cling to the interaction among group members and the financial benefits they draw on.

Water is necessary in pond-based aquaculture. Poor water leads to fish stresses, diseases and losses. Yet, few studies focus on the cooperation between water users comprising of fish farmers, other farmers and irrigation institutions. The kinds of relationship among the stakeholders and their power relations can be taken into account to improve further water management. For better social capital implementation, the connectedness of horizontal and vertical ties is necessary when the bonding tie is strong. Again, the social capital role works well in the place in which kinship and friendships are reconstructed through bridging fish networks. The cohesion dimensions effectively increase their adaptive capacities and abilities to access resources.

6.3 Recommendations

6.3.1 Academic contribution

Many researchers suggest that subsistence integrated agriculture and mixed aquaculture with fruit, rice and livestock help especially the small-scale fish farmers to increase their food consumption and economical sustainable natural resources (Phong et al., 2007; Khondker and Diemuth, 2011; and Longoni, 2011). However, few studies focus on the social capital between intensive, integrated and semi-subsistence freshwater aquaculture. Examining its strengths and weaknesses might bring about the effective land utilization and resource maximization. Intensive freshwater aquaculture systems mainly focus on investment returns, but do not examine the risks of market uncertainty. High financial returns encourage a large number of fish farming expansion that needs a large amount of water. The intensive farming actually suffers from high risks of climate variability and largely causes environmental and social impacts. For instance, a lack of water leads to water, social and financial competition among the water users.

Many researches focus on the implementation of pond-based aquaculture as a new mainstream income source using new technology and scientific knowledge. It would be great if local knowledge takes social relationships into consideration in order to develop the fish productivity while conserving the environment. In this way, local livelihoods, the way of life and beliefs would be directly affected while the existing local knowledge gradually disappears. The local knowledge actually derives from traditional beliefs, culture and social norms and can be used as a strategy to enhance the social cohesion and conserve the environment. For example, praying to, and worshiping the spirits in the farm compound clears our minds to respect the environment and lead us to use bio-friendly products. This track is totally opposite to the way of thinking of commercial fish farming. Chemicals, technology and other external artificial inputs are undeniably used to produce rapid output, which leads to social and environmental impacts.

6.3.2 Limitation of methods and study design

Contextualizing the dynamic concept of social capital is requires us to spend a long time immersing in these case studies to understand complex links and their interactions. But taking comparative studies of 3 sites is hard for the researcher to create understanding. The relationship and power relations cannot be taken for granted because they are inconsistent and shifting all the time. For instance, Tamphralae fish farmer cooperative elects the new group leader long after I interviewed the previous leaders. Thus, I also have to take into account the new role of the leader. In addition, one action can impact other ties to which the researcher has to link. For instance, fish groups holding a meeting has an impact on the participant's information and knowledge scheme. We should follow the results and further reactions of the fish farmers. Not being in the situation, collecting this sort of data limits the researcher's ability to critically link the situation and relationship. Asking them to recall might create distortions that I have to cross check with other villagers.

Bonding and bridging is interrelated. There is no clear boundary because they overlap. For instance, the *Kae Muang* in Maekaedluang works as the irrigation cooperative while he is a member of the fish group and a kin of some fish farmers. So his status is the bridging of the RID and the fish group as well as the bonding with clans. Even if his responsibility is to collect the water fee and manage water allocation, he does not want to cause social dissatisfaction among kin and neighbors who do not pay the fee and rarely join in the collective activities. He then uses his membership right in a fish group meeting to voice out the problems. So understanding the concepts clearly before collecting data is helpful.

Collecting trust data is challenging for me because it is intangible and hardly measurable. Counting and weighting the number of contacts of each fish farmers are not enough, exchange, voluntary help, regulation, and collective action are taken into account. The analysis is so complex when applying the concepts into the different scale operations in different types of networks. It is also necessary to link those contacts to understand particular situations such as drought, water negotiation and so on. Moreover, each situation includes many diverse stakeholders who have different kinds of networking and draw different trust payoffs. Thus, it is better to set a scope of the study to understand trust embedded in very dynamic and complex relationships and situations. Furthermore, since I am an outsider of Sanpakhee and Tamphralae, those case studies might find it difficult to reply to some questions about personal relationships, either good or bad. As a result, before getting implicit information from them, building trust with voluntary help for longer time than just 3-4 days each time in the fields is highly required.

6.3.3 Further researches

Water, labor, knowledge, money and social capital are key factors to achieve the successful rearing practices. Achieving all the factors of production is made possible by the abilities of each fish farmers, sites and social contexts. One way to access those resources is via social capitals, which enhance people's relationships and encourage their knowledge-sharing. On the other hand, in the arena of fish-pond farming, it is found that social learning is left unmentioned by Phong et al. (2007); Chiep (2001); Bosma and Verdegem (2011); Khondker and Diemuth (2011); and Longoni (2011). Learning can be a key tool to reinforce transformative and social processes that occur in the communities. How the learning processes among the stakeholders should also be studied.

Additionally, the impacts of chemical and medication use in farming and fish farming should be taken into account. What kinds of chemicals affect the fish production? In what way is the chemical absorbed into the soil or water? It is necessary to study whether the chemicals used in farming has a great impact on fish farming, so that the fish farmer can plan to prevent the risks. In this regard, social learning among households and communities should be further studied. In what way do the fish farmers in different places gain, apply and distribute that knowledge from one place to another? How is this information distorted or enhanced through knowledge transmission? How does the outcome affect the communities?

6.3.3 Policy suggestions

Micro and macro levels of adaptation of policy should be taken into consideration. That adaptation from locality in response to climate-related and socio-economic risks discloses the uncertainty of the climate and the need for external help. It implies that the farmers try to adapt their life to the new situations. They also voice out to the policy makers about what really happens in freshwater aquaculture and how we should adapt ourselves to climate-related risks. With hope, the strengths and weaknesses identified in each network-type matter for related organizations especially the Department of Fisheries and the Royal Irrigation Department to deal with the knowledge gap, low quality input and unsolved issues.

Prior to promoting any fish and water-related projects, place-based extension should be taken into account. The projects should be more differentiated and specific. Knowledge distribution depends upon local contexts. In the areas without high bonds, the sense of belonging and shared experiences, local collaboration with external organizations is not effective and difficult for new knowledge adoption. Sometimes useful knowledge is not practically used and resource allocations are not widespread. Supporting the fish farmers without zoning, for instance, urges the fish farmer to scatter from upstream to downstream. The farmers downstream face troubles of water shortage and pollution. Some of them lose their profits and think it is better to move off-farm, leave the land or convert to agriculture farming. By contrast, in a place with strong community bonding, fish farmers can share, exchange and volunteer for collective action. The knowledge distribution is applied into practice. Thus, to support any fish and water-related projects, the DOF officials should slowly and consistently build trust by often visiting, asking for their demand and working with the local fish farmers. This close collaboration will help the officials understand the real situations and find the solutions for the fish farmers to better cope with the stresses.

Although fish farmers can form their own groups, external organizations are required to widen their knowledge and improve their farming management more effectively. The organizations such as the DOF, universities and feed companies should be cooperating and playing a role in fish famer cooperatives. Those organizations with various kinds of fruitful researches can create farmers' understanding on crucial problems such as fish diseases and the use of chemicals. In this way, local people should participate in the knowledge distribution. It is because they know well how to distribute knowledge and most people trust the ones who often visit and take care of them. For example, local people take part in calculating the quantity of water in the ponds in order to plan water use in different seasons. This encourages local fish famers and water users to see the overall picture of the linking problems and to come up with the solutions.

The third parties should support knowledge and technology. To improve the institutional fish farmer cooperatives, the related organization cooperation should fund the fish committees and their members to pay other fish groups a visit. Some groups can generate as much knowledge and information as possible to other fish members. They can examine the strengths and weaknesses of the groups in order to fill the gaps and develop the group systems and management. Furthermore, since fish death results from the low rate of oxygen, aerators are important. But since most small fish farmers lack extra funds for investment, it is better to fund them via fish farmer cooperatives with different incentives. For instance, they will get reducing aerator prices, if they defer to the fish group regulation. Their buying incentive is also increased by way of increasing encouragement and trust within the group.

Fish death and fish diseases are big issues for fish farmers. Hence, knowledge models used for fish farming is important for better coping capacities. So far, most fish farmers lack knowledge and understanding on how to deal with fish diseases and fish death properly. They mainly follow the suggestions of their neighbors and kin, which might lead to misuse of the chemicals and application techniques. For instance, some unknown chemical contaminated with metal is at risks of polluting the soil. Some chemicals can solve fish diseases in a short term but leave side effects in the long term. That is a reason why the knowledge model or toolkit about fish death management is useful in the first place. This way of sharing knowledge is convenient and easy to use since most of fish farmers are aging and have lower than high school education. Information and messages presented to fish farmers should be conveyed via pictures, videos or short messages so that they are able to easily differentiate the various kinds of fish diseases, parasites and other conditions. Moreover, guidance on how to use chemicals is very useful in reality. To cope with fish diseases, some fish farmers decide urgently to buy certain chemicals no matter how expensive based on hearsay from other fish farmers. In this way, the misuse of chemical substances does not help and wastes money. If the fish diseases cannot be addressed, the DOF or related organizations with technical machines should be ready for this important role.

Fish production standardization should be more differentiated by dividing into two levels: extension at the local level and export at the global level. It is because the GAP standard generalizes every types of fish farming for export-led development. Undoubtedly, the farmers of integrated fish-pig farming are not allowed to export and basically persuaded to give up. It is because the state is afraid of the contamination of food with toxic substances. In fact, even though, the fish product cannot be given the export standard, it is allowed for domestic consumption. These kinds of farming are the way to save costs of investment and earn a living for those fish farmers' households. Still, to be responsible for customer health, the fish farmers should carefully use chemical substances registered by the DOF and within the safe period before harvesting.

Local water users generally cannot solve water issues alone; therefore they need the help of the relevant institutions. To deal with water pollution from fish-ponds, extensive academic knowledge from external organizations is important. So far, there are a few of these projects, but they have not been implemented in the real sites successfully and consistently. It is because some of these are short-term whereas the new projects do not develop from the existing ones. Some are also not applicable in practice. For example, the purification of water is tested in the lab under controlled conditions. In fact, there are external factors which make the test more difficult. The real scale is bigger and needed, with adjustments made with the help of the local. It is because they understand the situation and are able to maintain and possibly develop the fish- and water-related projects.

Local *Muang Fai* groups are weakening while the role of the communal irrigation leader is being taken over by the RID. In case of resource conflicts, the *Kae Muang* is powerless and unable to deal with individual water users. Some of them are too old to take on such hard work and voice out the problem to the policy makers; and some claim that the low salary is not encouraging them to work for social service. Moreover, the RID assigns the *Kae Muang* to collect land use by using GPS, but in fact, it is beyond his capacity and understanding. Thus, the *Kae Muang* role should be adjusted to be like that of the water irrigation coordinator and negotiator. Due to the replacement by the RID, it is necessary to value the *Kae Muang*'s role, increase their salary and persuade young people who can work hard and are able to understand and communicate well with water users. If it is so, the collaboration of water users and the willingness to participate in collective action naturally increases.

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