Self-recruiting species in farmer managed aquatic systems: their importance to the livelihoods of the rural poor in Southeast Asia

By

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Dedicated

to

My Parents and Family

Declaration

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

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

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Abstract

The self-recruiting species (SRS) are aquatic animals that can be harvested regularly from a farmer managed system without regular stocking as described by Little (2002a, b). The potential and current role of self-recruiting species from farmer managed aquatic systems (FMAS) is often overlooked, whilst much attention has been given to stocked species (often associated in conventional culture ponds and cages) as well as the fisheries sector (often relates to large water bodies i.e. river lakes and reservoirs). Using the combination of qualitative and quantitative research approaches, the current status, the important contribution of SRS and factors undermining this contribution to the livelihoods of rural households in mainland Southeast (SE) Asia were investigated. The overall analysis of this research was done based from the sustainable livelihood (SL) framework (Scoones, 1998; DFID, 1999) in order to have a broader understanding of the importance of SRS as well as the rural livelihoods in selected areas of mainland SE Asia which often benefit from this resource.

The research was carried out in rural villages of southeast Cambodia (SEC), northeast Thailand (NET) and Red River Delta in northern Vietnam (RRD). The sites (region of the country) were selected based from the intensity of aquaculture practices (less established and mainly relying on natural production, aquaculture established but also relying on natural production and mainly aquaculture dependent) as well as the agriculture i.e. intensiveness of rice production. Eighteen villages (6 villages/ country) were selected to represent the two agro-ecological zones (i.e. LOW and DRY areas) of the study sites. In order to fully assess the

situation and meet the objectives of the research, the study was carried out using three stages which dealt with different approaches and sets of participants/respondents; i) participatory community appraisal (PCA), ii) baseline survey and iii) longitudinal study. The different stages of the research were carried out during the period of April 2001 until September 2004.

During the first stage, a series of community appraisals using participatory methods were conducted in all of the participating villages in the three study sites. The participatory appraisal was conducted in order to understand the general rural context in the villages as well as the importance of aquatic resources. Moreover, the PCA in a way helped build rapport between the researcher and the communities. The series of appraisals were conducted with different wellbeing and gender groups (better-off men, better-off women, poor men and poor women). The various shocks, trends and seasonality that influenced the status of living in the community, diversified livelihoods and the differences in preference of socioeconomic and gender groups were analysed in this stage. The important aquatic animals (AA) and the local criteria for determing their importance were the highlights of this stage of the research. The important AA identified were composed of large fish (*Channa* spp., *Clarias* spp., *Hemibagrus* sp, Common, Indian, Silver and Grass carps), small fish (*Anabas testudineus*, *Rasbora* spp., *Mystu*s spp., *Carassius auratus*) as well as non-fish (*Macrobrachium* spp., *Rana* spp., *Somanniathelpusa* sp., *Sinotaia* spp.) which were particularly important to poorer groups in the community. The local criteria used were mainly food and nutrition related (good taste, easy to cook, versatility in preparation), abundance (availability, ease of catching) as well as economic value (good price). Significant differences were found between various interactions of sites, agro-ecological zones, gender and wellbeing groups.

The second stage of the research was the baseline survey (cross-sectional survey) which was also carried out in the same communities and collected information from a total of 540 respondents (30 respondents per village or 180 per country). This stage of the study was carried out in order to generate household level information (mostly quantitative) regarding the socio-economic indicators to triangulate the information generated during the participatory appraisal and the different aquatic systems that existed in the community as well as the various management practices used (not limited to stocking hatchery seed and feeding). The different livelihood resources (human, physical, financial, natural and social capital) and the diversified strategies of rural households in SE Asia were analysed in this phase. Another highlight of this phase was the understanding of the various aquatic systems that rural farmers managed and how they related to the existence of self-recruiting species. The common aquatic resources identified during this phase included farmer managed aquatic systems (FMAS) and openwater bodies (OWB) where rural households usually obtained their aquatic products. The various types of FMAS which included ricefields, trap ponds, household ponds, culture ponds and ditches were identified as important aquatic resources which mainly provide food as well as additional income to the rural poor. All of these FMAS were being managed at various levels which directly affected the SRS population. Different types of farmers were identified based on their attitudes towards and management of SRS: i) SRS positive, farmers who allow and attract SRS into the system, ii) SRS negative, farmers who prevent or eliminate SRS and iii) SRS neutral, farmers doing nothing that would encourage or prevent SRS from entering into the system. Variations were related to the main factors (i.e sites, agroecological zones, wellbeing groups) and their interactions.

The final stage of this study was the year-long household survey (longitudinal study) that investigated the seasonality of various aspects of rural livelihoods, status of the different aquatic systems and the important contribution of AA in general, and SRS in particular, to the overall livelihood strategies employed by rural farmers. This phase involved a total of 162 households (9 per village or 54 per country) selected based on the aquatic systems they managed and had access to. Other socio-economic factors (gender and wellbeing) were also considered during the selection of participants in this phase of the study.

The results of the year long household survey highlighted the important contributions of SRS: i) to the total AA collections which were utilised in various ways, ii) contribution to overall food consumption in general and AA consumption in particular (which was found to be the most important contribution of SRS), iii) contribution to household nutrition (as a major source of animal protein and essential micro nutrients in rural areas), iv) contribution to income and expenditures, and v) improving the social capital of rural households (through sharing of production and mobilizing community in local resources user group management). Moreover, the social context and the dynamics of inter and intra household relationships were understood, especially the gender issues on division of labour (where women and children played an important part on the production), access and benefits (how women and children were being marginalised in terms of making decision and controlling benefits).

The various results of the combined approaches that were utilised in all stages of the research were analysed and presented in this thesis. The results of the community appraisals and the baseline survey were used in setting the context (background) of each topic (e.g. livelihood activities, AA importance, etc). Meanwhile, the results of the longitudinal survey were used in illustrating the trends and highlighted the seasonality of particular issues.

Overall the study contributed to knowledge by elucidating the status and roles of self-recruiting species in maintaining/ improving the overall livelihoods of rural farmers in Southeast Asia. Various factors influenced the importance of SRS to rural livelihoods such as social (wellbeing and gender), ecological factors (agroecological zones, intensity of both agriculture and aquaculture) and seasonality. Moreover, results of this thesis illustrated the variations or complexities of aquatic resources in the rural areas and also how and where the SRS fits in the aquaculture – fisheries continuum which therefore can be used in future research and development.

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Acronyms and Abbreviation

Abbreviation	Terms
AA	Aquatic animals
AARM	Aquaculture and Aquatic Resources Management
ADB	Asian Development Bank
AEU	Adult Equivalent Unit
AEZ	Agro-ecological Zone
AFGRP	Aquaculture and Fish Genetics Research Programme
ARMP	Aquatic resources Management Programme
AIT	Asian Institute of Technology
AIT/AO	Asian Institute of Technology/ Aqua Outreach
BAAC	Bank for Agriculture and Agricultural Cooperatives
BO	Better-off
CPUE	Catch per unit effort
DFID	Department for International Development
EDSD	Economics and Development Resource Center
EI	Equal Interval
EUS	Epizootic Ulcerative Syndrome
FAO	Food and Agriculture Organization of the United Nations
FE	Fishing effort
FG	Focus group
FMAS	Farmer managed aquatic systems
FMSP	Fisheries Management Science Programme
GLM	General Linear Model
GO	Government organization
GSO	General Statistics Office
HDI	Human Development Index
HH	Household
HHP	Household pond
IDS	Institute for Development Studies

IK	Indigenous Knowledge
IoA	Institute of Aquaculture
IMF	International Monetary Fund
ITDG	Intermediate Technology Development Group
KI	Key informant
LRUG	Local resource user group
NET	North East Thailand
NGO	Non-government organization
OWB	Open water bodies
PCA	Participatory Community Appraisal
PEMT	Planning Evaluation Monitoring and Transference into Action
PRA	Participatory Rural Appraisal
PUFA	Polyunsaturated fatty acid
RF	Rice field
RIA -1	Research Institute for Aquaculture No. 1
RRD	Red River Delta
SEC	South East Cambodia
SIS	Small indigenous species
SL	Sustainable Livelihoods
SNS	Small native species
SRS	Self-Recruiting Species
SRI	System of Rice Intensification
TL	Total length
TP	Trap pond
UN	United Nation
UNDP	United Nations Development Programme
UNDP/HDR	United Nations Development Programme/ Human Development Report
VBSP	Vietnam Bank for Social Policies
VP	Very poor
VR	Very rich
WFP	World Food Program

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

1.1 General background

Freshwater fish and other aquatic animals (i.e. crustaceans, molluscs, amphibians and reptiles) play a very important role in the livelihoods of households in rural areas of South (Immink *et al.,* 2003; Islam *et al.,* 2003; Roos *et al.,* 2003) and Southeast Asia particularly for their contribution to household food requirements (Bush, 2004; Gregory and Guttman, 2002b; Hoan, 2006; Mogensen, 2001; Prapertchob, 1989; Ruben, 2007; Saengrut, 1998). Aquatic animals are both the principal source of animal protein (Dey and Ahmed, 2005; Kent, 1998; Ling, 1977; Meusch *et al.,* 2003) and provide essential vitamins and minerals vital to human health, particularly children and lactating mothers (Karapanagiotidis, 2004; Mogensen, 2001; Roos, 2001; Sugiyama *et al*., 2004). Such aquatic animals have been commonly obtained from wild, unmanaged stocks. However, in recent years, the supply of such aquatic animals has decreased due to the demand of increasing populations (Bush, 2004; Dey and Ahmed, 2005; Kent, 1998) and environmental degradation/management.

The contribution of both aquaculture and capture fisheries vary between areas in Asia (Table 1.1). Sugiyama *et al.* (2004) reported that Cambodia had one of the highest percentages in terms of the contribution of capture fisheries to the country's GDP amongst the countries in Asia Pacific. However, Cambodia was also identified as having one of the lowest levels of aquaculture production. The contribution of the two types of production system to the GDP of Thailand and Vietnam were relatively similar. However, this figure did not include the value of production that was being consumed locally i.e. household consumption. Furthermore, such figures do not include aquatic animals other than finfish that are mostly consumed by the poorest members of the community, particularly in those households living below the poverty line.

Table 1.1. Contribution of aquaculture and capture fisheries to GDP. (*Source: Sugiyama et al., 2004*)

Countries	Production values as percent of GDP	
	Aquaculture	Capture Fisheries
Cambodia	0.90	10.03
Thailand	2.07	2.04
Vietnam	3.50	3.70
Bangladesh	2.67	1.89
Lao PDR	5.78	1.43

Despite recognising the importance of fish and other aquatic animals, the complexity and the specific contribution of certain types or groups of aquatic animals is still unclear. Nowadays, exploited aquatic animals are mainly categorised by the type and source of seed i.e. stocked and unstocked or 'wild' species. Stocked species are those determined to have come from any conventional aquaculture system where seed is produced from a hatchery. Unstocked or capture fisheries are based on aquatic animals harvested from unmanaged natural water bodies where there has been no augmentation based on hatchery produced seed.

In Southeast Asia, there are several types of management being employed in particular types of aquatic system. Aquatic systems are not only classified into conventional ponds and natural water bodies, but a wider variety of aquatic systems ranging from very intensive closed aquaculture systems to extensive open capture fishery systems (Figure 1.1, Guttman, 1996). However, there is an information gap regarding these intermediate systems and the aquatic animals coming from such systems were often classified based on the simplistic criteria mentioned above.

Self-recruiting species (SRS)

Little (2002a) described self-recruiting species (SRS) as "aquatic animals that can be harvested regularly from a farmer managed system without regular stocking." The species that can be included in this group include species originating both from natural and controlled environments. Unstocked animals in cultured systems are often considered 'wild' and viewed negatively by promoters of conventional aquaculture as weeds or predators (Setboonsarng, 1993). In Bangladesh, some of these species were categorised as small indigenous species (SIS) (Islam, 2007; Wahab, 2003).

Farmer managed aquatic systems (FMAS)

The most common conventional aquaculture systems in Asia are excavated ponds which are usually closed and static water systems i.e. flow and exchange of water if it occurs is occasional and discontinuous. This restricts the natural entry of aquatic animals into the system (Fedoruk and Leelapatra, 1992) and necessitates regular stocking of seed. However, particularly in rural areas in Asia, aquatic systems used to produce fish and other animals by farmers/ households are more variable in their characteristics. In addition to ponds of various types these 'farmer managed aquatic systems' (FMAS) have been recently defined by researchers (Amilhat, 2006; Little *et al*., 2004; Morales *et al.,* 2006) to include rice fields and adjacent water bodies (e.g. trap ponds and ditches). The complexities of the various types of FMAS in rural areas are rarely investigated as the main focus of previous studies has tended to be conventional aquaculture ponds or community managed systems.

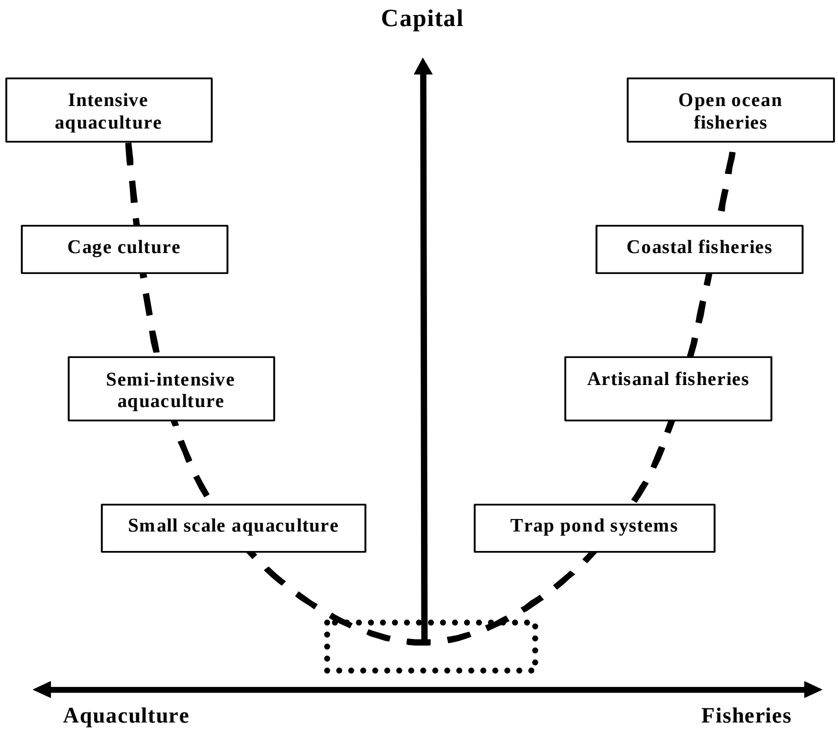


Figure 1.1 Aquaculture-fisheries continuum related to capital intensity of the activity (Guttman, 1996)

There is a great need to better understand and increase the awareness of the different types or groups of aquatic animals, and more so the different types of production systems, that contribute to livelihoods in rural communities. These measures would lead to more appropriate management being developed and implemented and limit any negative effects of change.

This section provides a general introduction of the research (1.1). A review of literature related to various issues addressed in this research is explicitly discussed from section 1.1.1 to section 1.1.5. The different approaches employed in this research are briefly discussed in sections 1.1.6 and 1.1.7. Further background and review of relevant literature on various research approaches and methods are described in the relevant chapters of this thesis. Section 1.2 provides general descriptions of the study sites of this thesis. Background information regarding the research project (SRS in Aquaculture, R7917) which supported the different activities of this thesis is presented in section 1.3. The rationale, the key research questions, study outline and limitations are presented in sections 1.4,1.5 and 1.6, respectively.

1.1.1 Aquatic resources

In Asia, freshwater aquatic systems contain important resources of fish and other aquatic animals and plants. Such systems and organisms comprise the 'aquatic resource' (Soubry, 2001). A further sub-classification of this resource was proposed by Bush (2004) where all the organisms in the aquatic systems were called "living aquatic resources". The non-living aquatic resources (aquatic systems) in Asia can be classified in various types from the extreme ends of the spectrum; from the natural, unmanaged systems to very intensive aquatic systems. Aquatic systems under the natural and unmanaged categories may include small water bodies like lakes, rivers, streams, swamps, reservoirs, and canals (Lorenzen *et al.,* 1998).

However, interest in exploring the roles and the potential contribution of such systems to the overall livelihoods of the poor households/ farmers and individuals is recent. Many people would classify many FMAS as 'wild' or 'unmanaged', but even a cursory observation of current practices suggests rural households do practice various forms of management. But these systems are typically not independent of broader aquatic resources- there are often dynamic linkages of these systems with perennial/ open water bodies that may be critical to sustaining their functions and productivity.

Aquatic resources in livelihoods

The two main tangible benefits of the aquatic resources are their direct contribution to a household's food consumption and as an additional source of income. Additionally, aquatic resources may also contribute to enhancing social capital of households or individuals within rural communities. Several researchers have reported the important contribution of aquatic animals to total food consumption of rural households in Asian countries (Ahmed *et al.,* 1998; Ahmed *et al.,* 1999; AIT/AO, 1992; ARMP, 2000; Bush, 2004; Dey and Ahmed, 2005; Dey *et al*., 2005; Garaway, 1999; Gregory and Guttman, 2002b; Gregory *et al.,* 1996; Middendorp, 1992; Mogensen, 2001; Prapertchob, 1989; Saengrut, 1998; Shams and Hong, 1998; Tana *et al.,* 1994; Wahab, 2003).

Aside from their contribution to general food security (Dey *et al.,* 2005; Sugiyama *et al.,* 2004), aquatic animals contribute specific nutritional values in many Asian diets, especially in rural areas (Mogensen, 2001; Roos *et al.,* 2003; Thilsted, 2003; Wahab, 2003). Aquatic animals also fulfill important ecological (Kamp *et al.,* 1993) and economic roles in the region (AIT/AO, 1992; ARMP, 2000; Baird, 2000; Prapertchob, 1989).

Access to resources

Ostrom (1990) differentiated resources according access: common pool resource (CPR) and private property resource (PPR). A common pool resource is a given resource where every individual have equal rights of exploitation. On the other hand, access to any private resource is limited to selected individual based on 'rules'. Different resources have different degrees of accessibility. Most of the natural and unmanaged aquatic systems in rural areas of Asia, at least in Cambodia, Vietnam and Thailand are considered open access i.e. use or exploitation of the resource is unrestricted. Throughout the year, such systems are the predominant source of living aquatic resources in rural areas. Additionally, some aquatic systems that are owned or managed by farmers or households are also open to everyone during certain periods of the year; for example rice fields were traditionally open access during the rainy season when flood waters link adjacent natural water bodies and managed rice paddies (Amilhat, 2006; Gregory and Guttman, 2002b). Living aquatic resources are often collected from rice fields at the onset of the rainy season. However, increasingly such access changes as the main crop harvest approaches and when the water becomes concentrated in deeper areas which are usually managed.

Seasonality can greatly affect not only agricultural production (Gill, 1991) but also accessibility to different aquatic resources and the required inputs in rural areas (Brummett, 2002). Seasonality can also influence the behaviour, livelihood strategies of individuals or households in the community (Beaton, 2002; Morales *et al.,* 2003) and access to various livelihood resources (natural and human capital) as privately owned rice fields for example can be a common pool resource during the rainy season as observed in some part of Asia (Amilhat, 2006; Gregory and Guttman, 2002b; Little *et al.,* 2004). Similarly, low-lying areas close to reservoirs and lakes can be inaccessible during the dry season as privately managed trap ponds are located in this area (Little *et al.,* 2004).

Accessibility to large aquatic systems likes swamps, reservoirs and lakes, can also be negatively impacted through research or development work that leads to management changes being implemented (Garaway *et al.,* 2001; Gregory *et al.,* 2007). This includes initiatives such as community or group-based management activities or privatisation of wetlands. Natural aquatic systems and large water bodies were the most common place for the resource poor to acquire living aquatic resources in Cambodia (Gregory and Guttman, 1996). Introduction of community-based management risks once open access systems becoming limited to those that manage it and in most cases, this group is mainly composed of better-off members of the community (Lorenzen *et al.,* 2001). Such initiatives can therefore potentially marginalize poorer groups in the community or those that are not involved in the actual management of the system (Baird, 2000).

1.1.2 Aquatic system management

There are several benefits that households, especially in rural areas of Asia, get from various types of aquatic system. However, due to various issues and trends affecting the sustainability and productivity of such systems, such benefits are often in decline (Bush, 2004; Soubry, 2001). Different management approaches have been developed and implemented by several organizations in order to enhance the production from aquatic systems. The following section discusses a range of different management activities.

1.1.2.1 Capture fisheries

The act of harvesting or collecting of aquatic animals from wild or unmanaged aquatic systems is referred to as capture fisheries. The majority of aquatic animals being consumed in the diets of most Asians originate from capture fisheries (Baird, 2000; Bush, 2004; Coates, 2002; Roos *et al.,* 2002; Sugiyama *et al.,* 2004). In Asia, capture fisheries play a significant role in terms of employment, foreign exchange earnings and food supply. Moreover, such activity contributes significantly to the socio-economic stability of rural areas where a large proportion of the Asian population live (Chua, 1986). Cambodia is an example of a country where most aquatic foods derive from such systems, especially from the large and productive Tonle Sap fishery (Baran, 2005).

Due to the fact that most capture fisheries are unmanaged, therefore the population as well as diversity of the aquatic animals is under threat. Decreasing catches have been experienced by fishermen in the region. This scenario can be attributed to increasing pressure on capture fisheries as a result of increasing population, increasing resource exploitation brought by modern technology and few opportunities for livelihood diversification.

Several research and development organizations have been working towards sustainable capture fisheries. Several fisheries management strategies have been employed such as restriction on the type of gear, limiting the duration of fishing season and designating fishing grounds. Furthermore, restoration of identified breeding grounds for important species in the wild has also been carried out by government, development organizations and research institutions.

Capture fisheries have an important role to play in food security and poverty alleviation but the pressure on most stocks is increasing with demand brought by an increasing population. However, fisheries need to be managed properly in order to meet the demand for food consumption. De Silva (2001) and Welcomme and Bartley (1998) and reviewed approaches that have been carried out by researchers and development organizations to enhance yields from reservoirs and other perennial waters especially in Asia. Enhancements are attempted through interventions such as group management and restricting access, which can be categorised as community-based approaches. Stocking of seed and/or broodstock and provision of other inputs define culture-based fisheries. The succeeding part of this section discusses these approaches in enhancing fisheries yield.

1.1.2.2 Community-based fisheries

Community-based management is the co-management of natural or common pool resources by a group of individuals in order to improve or sustain production (Middendorp *et al*., 1996; Pomeroy, 1998). It recognises local knowledge, institutions and establishes common property regimes (Berkes *et al.,* 1998; Ostrom, 1990). This approach is usually implemented in small water bodies (Garaway *et al.,* 2001) and other perennial water bodies that are naturally productive but pressure for change has resulted from declining yields linked to over exploitation, pollution and habitat modification (De Silva, 2001; Welcomme and Bartley, 1998). Considering the problems mentioned above, several approaches by both research and development organizations (Amarasinghe and de Silva, 1999; Amarasinghe *et al*., 2002; Middendorp *et al.,* 1996; Pomeroy, 1998; Sultana and Thompson, 2004; Thompson *et al*., 2003; Wiber *et al*., 2004) have been taken/ implemented to sustain the productivity of such water bodies, which included community based approach.

1.1.2.3 Culture-based fisheries

Another approach to enhancing fish yields as well as stock diversity from small water bodies is the regular stocking of suitable species and harvesting at a marketable size (Middendorp *et al*., 1996; Nguyen *et al.,* 2005; Radheyshyam, 2001). Such culture-based fisheries can increase fish productivity from perennial water bodies and has been widely practiced, particularly in developing countries in Asia, to increase fish food production. The approach however is typically managed using a community-based approach as it does not only involve privately owned resources (Radheyshyam, 2001) but in most cases involves utilization of common pool resources (e.g. small reservoir, non perennial reservoirs, tanks, and canals) (Garaway *et al.,* 2001; Jayasinghe *et al.,* 2005; Nguyen *et al.,* 2005; Wijenayake *et al.,* 2005).

Both community-based and culture-based fisheries can enhance the production of water bodies, however, there are still issues that undermine the success of such management approaches. These include lack of organizational capacity; poor distribution of the benefits; and access restrictions to those that were not part of the management approach (Radheyshyam, 2001). These issues are still unsolved and not fully understood (Kumar, 2002; Thakadu, 2005).

1.1.3 Aquatic production systems

1.1.3.1 Rice field fisheries

Aside from producing rice and other agricultural crops, another role of rice fields in lowland areas in Asia is to provide temporary habitats for AA during the rainy season when water from the adjacent perennial water bodies overflows (Fernando, 1993; Gregory and Guttman, 1996). During this period AA graze for food, breed and grow in rice fields (Gregory and Guttman, 1996; Halwart *et al.,* 1996; Little *et al.,* 2004). Harvest of aquatic animals also takes place in rice fields and they are an important source of food in Asia (Gregory, 1997; Gregory and Guttman, 2002b;

Little *et al*., 2004; Shams and Hong, 1998). Fish from rice fields have been considered an additional source of income by most farmers in Malaysia (Ali, 1990).

Gregory (1997) classified rice ecosystems of Cambodia into five types based on a culture and capture perspective; rainfed upland, rainfed lowland, irrigated, recession, and deep water ricefields. Lowland rainfed and irrigated ricefields have greatest potential for capture fisheries development while ricefields at higher elevations are perceived to have more potential for culture-based fisheries or even conventional aquaculture.

Some research has been conducted to investigate issues related to culturing fish in rice fields in Asia (Das, 2002; Fernando and Halwart, 2000; Frei and Becker, 2005; Little *et al.,* 1996; Middendorp, 1992; Purba, 1998; Rothuis *et al.,* 1998; Vromant *et al.,* 2004 and 2002; Yaro *et al.,* 2005). However in lowland rice fields of Cambodia and rainfed areas in Northeast Thailand, capture rather than culture is more popular (AIT/AO, 1998; Gregory and Guttman, 1996; Gregory, 1997; Guttman, 1999). The production of aquatic animals from rice fields is under great pressure due to human activities like the use of destructive fishing gears and intensification of agriculture. Modern varieties of rice and economic incentives encourage widespread application of pesticides and more efficient use of water that tends to mean less is retained in the rice field; both measures are potentially problematic for aquatic animals coexisting in ricefields (Gregory and Guttman, 1996; Kway, 2001; Soubry, 2001).

1.1.3.2 Aquaculture

Aquaculture is defined by FAO (1992) as “the farming of aquatic organisms, which includes fish, crustaceans, molluscs, amphibians, and aquatic plants”. Furthermore, the term “farming” in this context pertains to a form of intervention in the rearing process by households or individuals. Such interventions include regular stocking, feeding and protection from predators (Bailey *et al*., 1996). The development of aquaculture may not be a panacea for increasing problems of food security but it has been associated with improving continuity of supply of aquatic products (Bailey *et al.,* 1996; Smith and Peterson, 1982) and to lessen the pressure on depleting population of wild stocks (Phelps and Bart, 2001). Little *et al.* (2002) reported that the availability of seed for stocking has been a major factor in the rapid spread of conventional aquaculture in Asia. Nowadays, aquaculture seed are considered synonymous to young AA produced under controlled conditions in hatcheries. The majority of these seed are of herbivorous/omnivorous carps that are then cultured in semi-intensive culture systems (Coche, 1982; Edwards, 2000), although the range of cultured species continues to grow and includes higher value species.

Edwards (2001) compared two types of aquaculture; traditional and modern-based, at opposing ends of the culture spectrum. In this classification however, the source of stock and socio-economic factors were not considered (Table 1.2). A comparison between the two differing types was its primary purpose, examining systems intended to provide food for household consumption or cash for household income. This simple classification is valid although aspects of the intensity of production as well as mode of culture may overlap between aquaculture types. For instance, although in most cases monoculture relates to intensive and modern aquaculture practices, it can however be traditional if resource poor farmers are doing it and they have other crops or livestock that can integrate into the system (e.g. duck and poultry). In contrast, integration with crops, livestock and various types of wastewater can be classed as modern aquaculture if practiced as intensively managed systems. There are several approaches to characterising aquaculture through groups or typologies and their validity ultimately stems from the purpose for such classification.

Aside from comparing the two types of aquaculture, Edwards (2001) also attempted to show several possibilities of integrating the two, which he perceived to be more sustainable. The nature of seed supply is one criterion that warrants inclusion in any comparison as availability of seed is an important factor in aquaculture development in Asia (Little *et al.,* 2002). Both the cost and availability of conventional hatchery seed may constrain their use by households in rural areas. In Cambodia for instance, the development of aquaculture has been constrained through lack of hatchery seed (Gamucci, 2002).

Table 1.2 Definition of traditional and modern aquaculture. (Source: Edwards, 2001)

Criterion	Traditional	Modern
Derivation of technology	Farmer-based	Science-based
Nutritional input	Natural food from organic fertilizers and or supplementary feed from by-products	Agro-industrial pelleted feed
Intensity of production	Semi-intensive, i.e. mainly natural food	Intensive, i.e. nutritionally complete feed
Mode of culture	Integration with crops, livestock, sanitation	Monoculture

In Bangladesh for example, Karim (2006) reported that seed costs dominated pond investment and purchase often occurs at a time when cash is in short supply. Most seed is supplied intermittently by traders in rural areas (Little, 2001; Little *et al.,* 2002; 2007) resulting in both the individual size of seed and range of species often being limited. Subsequently, this can lead to poor performance in farmers' grow-out systems because of poor survival and a restricted polyculture of species respectively. The conventional approach to improving the performance of rural aquaculture (Edwards and Demaine, 1997) is to upgrade production and delivery systems of hatchery seed but the importance of unstocked aquatic animals that are typically produced and harvested alongside stocked species has been ignored. Such species, (self-recruiting species, SRS) that are harvested from aquatic systems managed by the household (FMAS) appear to be a common feature in Asia (Morales *et al.,* 2006) and to be meeting rural peoples' needs. In conventional aquaculture systems, such species have been considered 'weeds' in the system, requiring control or eradication.

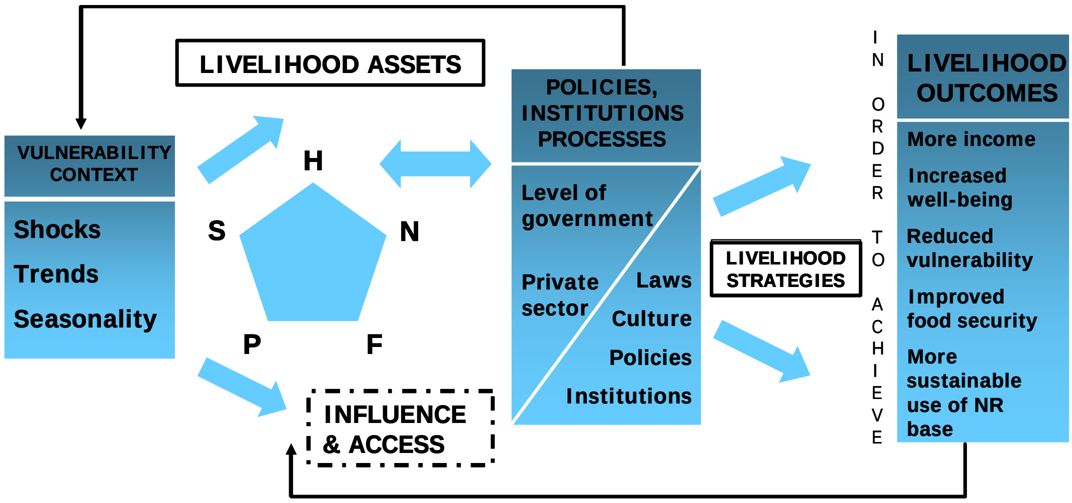
Ling (1977) previously identified important roles played by aquaculture in southeast Asia: (1) a source of food for the common man; (2) income for the individual and contribution to national income through export earnings i.e. ornamental fish and other high value species; (3) a good means of utilizing human and animal wastes (4) helps to control water pollution and eutrophication; (5) helps to reclaim unproductive land such as mangrove area, swamps, lowlands and floodplains; and (6) offers opportunity of employment to other farmers/ other individuals. To date, all of these roles are still being met by most individuals directly or indirectly connected to aquaculture. Several researchers have reported the importance of aquatic animals to general livelihoods of Asian people especially its contribution to meet food security. Ahmed and Lorica (2002) have examined the role of aquaculture within overall food security in developing countries in Asia and have concluded that although significant contributions to household consumption occur, impacts on livelihoods are insignificant. Halwart (2005) suggested that aquaculture contributed to poverty alleviation through employment gains made by local people generating income to support other basic needs including their provison of food. The adaptation of aquaculture in various environments and systems makes it more possible to contribute to food security in developing countries particularly in Asia as reported by several researchers and development agencies (ADB, 2005; Demaine, 2001; Demaine *et al.,* 1999; Edwards, 2000; Little *et al.,* 1996; Luu *et al.,* 2002; Sugiyama *et al.,* 2004). Dey and Ahmed (2005) reported that the contribution of aquaculture in most Asian countries has increased rapidly over the last few decades.

In rural areas, particularly with resource poor individuals/ households, aquaculture is inevitably a food farming activity integrated with other food producing activities (FAO, 1996) such as rice, other crops and livestock. Traditional or extensive culture systems are practiced in rural aquaculture, with no or minimal extraneous inputs. Such systems depend heavily on natural food produced within the whole farmer's system i.e. crops and livestocks. Both on- and off-farm resources are used to enhance the natural fertility of the aquatic systems such as manure, processing by-products and other organic materials.

1.1.4 Sustainable livelihoods (SL)

A livelihood can be defined as the set of capabilities, assets (natural, physical, human, financial and social capital) and activities (mediated by institutions and social relations) required for a means of living (Chambers and Conway, 1992; DFID, 1999; Ellis, 2000b). Such livelihoods are perceived to be sustainable when someone can withstand stresses and shocks, maintain or enhance their capabilities and assets while not undermining the natural resource base (Chambers and Conway, 1992; Scoones, 1998). There have been several livelihood frameworks developed and applied by different development organizations such as DFID, CARE, Oxfam and UNDP: these are being used by researchers and development institutions at present. Although variation exists in terms of application and foci of the different organizations in applying sustainable livelihoods analysis, their similarities far outweigh such differences (Carney *et al.,* 1999). The CARE organization sees the application of a livelihoods framework as an effective way of improving intersectoral coordination which subsequently increases the impact of its activities and programmes (Carney *et al.,* 1999; Frankenberger *et al.,* 1999). DFID on the other hand (Carney *et al.,* 1999) employed a livelihoods approach to better support accumulation of assets and towards more effective functioning of structures and processes (Figure 1.2). Oxfam have used a livelihoods framework in a different way, using it to integrate several perspectives of development including economic, social networks, institutional and ecological assets (Carney *et al.,* 1999). For the UNDP however, the SL approach was applied largely in agriculture and natural resources work where they focused on promoting access and sustainable use of the assets upon which all sectors of the community rely.

Understanding livelihoods and determining the sustainability of such livelihoods are two different activities, although they are linked together. The first is elucidating the present situation or characteristics of the household or individual based on assets and capabilities. Livelihoods analysis however, based on the IDS perspective (Scoones, 1998) seeks to understand a given situation i.e. policy setting, politics, agroecology and socio-economic conditions. Understanding how households or individuals utilise their livelihood resources to carry out agricultural intensification/ extensification (mediated by institutions and other organizations), diversify their livelihood activities, and migrate to maintain or sustain a livelihood are considered critical (Bebbington, 1999; Chambers and Conway, 1992).



Note: H = Human capital; N = Natural capital; F = Financial capital; P = Physical capital; S = social capital

Figure 1.2 DFID Sustainable Livelihoods Framework (Source: DFID, 1999)

Chambers and Conway (1992) describe two types of livelihood sustainability: (1) environmental sustainability and (2) social sustainability. The first type concerns the impact on resources and other assets while the latter concerns the capabilities for coping with stress and shocks. The external impact of livelihoods on other livelihoods is the focus of environmental sustainability whereas social sustainability focuses on the internal capacity to withstand outside shocks or pressure.

Seasonality is inevitably an important factor in the diversification and sustainability of livelihoods amongst households in rural areas (DFID, 1999). This factor influences directly or indirectly several aspects of livelihoods such as food security, health, livelihood strategies, and even income and expenditure (Sahn, 1989). Short-term migration of the labour force is one result of seasonality, especially in rural areas where farming is the main livelihood activity (AFGRP, 2003; Beaton, 2002).

Vulnerability is defined by Henninger (1998) as the susceptibility of an individual or household to external shocks and fluctuations. Several factors or risks may contribute to the vulnerability of an individual: environmental risks (droughts, floods and pests), markets (e.g. price fluctuations and unemployment), political risks, social risks (reduction of community support and entitlements) and health risks (e.g. exposure to disease) (ADB, 2006). Such risks were considered as the driving force in the livelihood adaptation and diversification. Households or individuals who are unable to cope or diversify due to the stresses posed by the external shocks are considered vulnerable and achieving sustainable livelihoods is a significant challenge to them (Ellis, 1999; Scoones, 1998).

1.1.5 Poverty

ADB (2005) defined poverty as the deprivation of basic capabilities. Such deprivation includes not only material factors which can be measured by income and consumption but also non-material factors such as unemployment, ill-being, education, high risk or vulnerability, gender and social discrimination. The World Development Report 2000/2001 provided a detailed description of all the dimensions of poverty which includes: people without fundamental freedom of actions and choice, lack adequate food, shelter, education and health (World Bank, 2001). Households in the community can be considered to be in such a state when they lack the capacity to access the type of food/diet, participate in activities, or are unable to live in a condition with amenities that are customary in the community they belong (Alcock, 1993) in other words deprived from leading the kind of life that everyone else value (World Bank, 2001). The definition of relative poverty may also vary depending on the person/researchers exploring it (Boltvinik, 2006).

The links of poverty to the environment have been explored by several institutions and organizations in pursuit of pinning down the causes and possible solutions to alleviating poverty (Mariara, 2002; Reardon and Vosti, 1995; UNEP, 2004). Considering the two types of deprivation i.e. material and non- material, a large proportion of this relates to the available resources which individuals or households possess or have access to. Income and consumption can potentially be affected by how much households or individuals can earn from their own agricultural products or from other production areas where they have access. Likewise, the amount of consumption (including expenses) could be based on the available products which individuals or households can consume or have access to. It is therefore important that these resources contributing to livelihoods and poverty alleviation in a local community should be maintained, particularly those which account for the majority of production. These resources may include living aquatic resources. Bush (2004) reported the important contribution of the living aquatic resources to the rural poor in Southeast Asia including aquatic animals, plants and the water itself. However, as described by the World Development Report 2000/2001, poverty has several faces and addressing it through improving physical capital alone is not enough. It was argued that health and education were at least as important and that improvement of such will promote growth and income for rural people (World Bank, 2001). Three ways of attacking poverty were proposed: promoting opportunity, facilitating empowerment and enhancing security. It is necessary to address poverty in a broader approach i.e. attacking it in all faces as the different aspects of poverty interact and influenced one another. For instance, addressing deprivation in human capital would not only result in better human assets but also positively influence the capacity of individuals for different strategies to achieve security. Moreover, the impact of poverty on women maybe different compared to men. Consideration of gender aspects in addressing poverty or understanding its causes may provide a broader understanding (Jackson and Palmer-Jones, 1999). Susilowati and Karyadi (2002) reported that approximately 70% of the world's poor are women, who face income deficiency, lower level of education, skills, employment opportunities and mobility. All these factors contributed to the limited human development capacity that in turn results in poor health.

Several issues have been discussed already regarding the reporting and measurement of poverty in different areas of the world. Clearly basing any measurement on monetary deprivation alone is not enough and might lead to the wrong conclusions. Although using monetary income and consumption has been a long tradition in determing poverty, there are a lot of issues identified in this approach (World Bank, 2001). It has been recognised that proper reporting of the severity of poverty, particularly in rural areas, should be prioritised as much development work and policy makers' decisions are based on such reports. Ravallion (2003) suggested that prior to quantifying anything and determining solutions, it is necessary to be clear first about the concept to be quantified.

1.1.6 Research approaches

Generally, there are two broad types of research approach being employed by researchers in all fields of evaluation, namely (1) qualitative and (2) quantitative. Researchers who wish to understand the social reality and participants' perspectives often favour qualitative approaches. In contrast, researchers who seek to understand relationships without any particular emphasis of the participants' perspective often use quantitative approaches (Reichardt and Rallis, 1994). Both research approaches have their merits and weaknesses (Table 1.3). Libarkin and Kurdziel (2002) presented a continuum of data and methodology where "pure" qualitative data can be found towards one end of the spectrum and criticised for being too anecdotal. On the contrary, quantitative approaches are more theoretical in nature. Although located at the opposite ends of the spectrum, both approaches can shift towards the other depending on the methods of collection and analysis (Libarkin and Kurdziel, 2002). Both approaches are useful and it is best to combine the two to find a balance and make sure social and economic factors are taken in to account. Each approach can complement the other (Mulhall and Taylor, 1998).

Table 1.3 Comparison of some aspects of qualitative and quantitative research. (Source: Libarkin and Kurdziel, 2002)

Characteristics	Qualitative		Quantitative	
	Pros	Cons	Pros	Cons
Methodology	Issues can be studied in great detail. Analytical approach is unconstrained.	Results maybe applicable to only a narrow range of individuals or settings. Often no connection to causes.	Results from a variety of individuals or settings can be used to developed a single explanatory model.	Analytical approach is constrained by established standardized methods. Individuals maybe artificially forced into categories.
Interpretation	Interpretation often based on manipulation of raw data and is therefore tied directly to the data source.	Individual beliefs of the researcher may shape the data interpretation.	Statistical analysis although not perfectly free of subjectivity, is typically independent of the researcher's personal belief system.	By the time a quantitative study reaches the interpretation stage, the context in which the data was collected maybe lost.
Validity/ reliability	Validity and reliability are established through logical reasoning and concensus; statistics not required	Researcher acts as the instrument; training and skills of practitioner can bias results.	Validity and reliability are highly controlled variables established statistically; limited training required.	Establishing validity and reliability is time consuming.

1.1.6.1 Qualitative approaches

Qualitative methodologies usually produce data in descriptive forms, mostly non-numeric (Maxwell, 1998). In some cases, the numbers are just arbitrary. The main aim of qualitative approaches is to develop concepts that will help us elucidate social phenomena (Libarkin and Kurdziel, 2002). The approach aims to take into consideration the meanings, experiences, knowledge and perceptions of the participants. This approach is more concerned with exploring the 'what' and 'how' aspects of investigation rather than 'how many' (Pope and Mays, 1995). A common set of tools used in qualitative research is participatory rural appraisal (PRA) and rapid rural appraisal (RRA). Semi-structured interviews, focus group discussions, mapping, modelling, participation observation, trend analysis and well-being ranking are also included in this approach. Seeking to generalise or formulate universal theories are not the main foci of this approach, rather formulating theories grounded in the perspectives of those who participated in the process i.e. farmers/individual households. Critics have challenged the rigour of the data collected using qualitative approaches and have labelled them as subjective, imprecise and 'soft'. Maxwell (1998) argued that qualitative methods cannot be used to draw statistical inference but information can be utilised to draw logical and analytical inference. However, a recent study has found that participatory techniques can produce 'hard' data and be used to generate statistics (Barahona and Levy, 2002).

1.1.6.2 Quantitative approaches

Quantitative approaches usually comprise of methodologies that involve mathematical or statistical techniques (Maxwell, 1998) used to test hypotheses and validate theories and subsequently produce or generalise knowledge (Libarkin and Kurdziel, 2002). Such quantitative approaches can usually be replicated in other areas/ fields and mostly deal with large data sets. Examples of this type of research approach are social surveys, structured interviews, experiments, structured observations, content analysis and analysis of statistical information (Bryman, 1992). Aside from the strengths mentioned earlier, quantitative approaches also have some weaknesses. The greatest critique of this approach is that its tendency to concentrate largely on the problems that can be easily quantified which eventually neglects socio-cultural and other issues that are more difficult to quantify.

1.1.6.3 Combined qualitative – quantitative approach

A combination of the two approaches can lead to a richer and more useful conceptualization of information as illustrated by several researchers (Reichardt and Rallis, 1994; Sandelowski, 2000; White, 2002). Holland and Campbell (2005) reiterate the importance of combining resource methods by explaining that the quantitative approach can produce data which can be analyzed to illustrate relationships and on the other hand, the qualitative approach helps in probing and explaining the relationships. Furthermore, Holland and Campbell (2005) described how the iterative relationships between describing and explaining proved its combination power. Furthermore, it can enhance the practice and utilization of both research and evaluation. Although this may be a relatively new approach and have received little attention from qualitative researchers, probably due to some uncertainty on the advantage of using them (Abeyasekera, 2005), there are a number of researchers already applying a combination of the two approaches mainly to study poverty (Place *et al.,* 2005). Researchers such as Appleton and Booth (2001), Hargreaves *et al.* (2005), Howe and McKay, (2005), Lawson *et al*. (2006), Maxwell (1998), Place *et al.* (2005) and White (2002) combined the two approaches in elucidating the dynamics of poverty and have proven that there is value in combining qualitative and quantitative approaches to understand the key factors responsible for poverty causation or alleviation. The insights from qualitative approaches can also subsequently contribute to the development of quantitative analysis (Pope and Mays, 1995; White, 2002). There are several aspects of reality and each aspect lends itself to different methods of inquiry (Sandelowski, 2000). People from the evaluation field suggested that both approaches can contribute to all aspects of evaluation enquiries and can be successfully used together (Brieddenhann and Wickens, 2005). This argument supports the claim of Holland and Campbell (2005) that different approaches have their respective strengths but cannot substitute for each other; their combination can bring both strengths together. Abeyasekera (2005) highlighted the importance of generalizable results in development research; in other words, a set of data being able to be qualitatively interpreted and described for a target population.

Holland and Campbell (2005) suggested that combination of the two approaches is often powerful when combined at different levels or sequences and cited White and Carvalho (1997) who identified three ways of combining the two approaches: integrating, sequencing and merging. These three approaches were suggested in doing quali-quanti research in order to have better measurements, more powerful analysis and combining findings for better recommendation or action (Holland and Campbell, 2005).

1.1.6.4 Participatory approaches

Participatory rural appraisal (PRA) or approaches have been described by Chambers (1992) as a 'growing family of methods and techniques' to enable a community to let their views and perceptions be shared and take part in the analysis of their life and conditions. These participatory approaches aim to empower local individuals to plan and act for the betterment of their livelihoods. Local people in the community, regardless of literacy level, have capacity to analyse and manage complex and detailed information regarding their community, most of which have been underestimated (Chambers, 1991; Leurs, 1996). Barahona and Levy (2002) further described PRA as a set of tools that emphasise local knowledge and allows development practitioners, officials from the government and the local community to work hand and hand to plan appropriate programmes.

Since PRA evolved in the mid 1980's, there has been a paradigm shift towards more participatory development (Chambers, 1994a). Through participatory research, individual participants, farmers, households or even communities have been empowered to manage their own assets and resources (Lightfoot and Noble, 1993). In the development field particularly in carrying out project assessment, monitoring and evaluation, PRA is now mainstream, however, its role in research has often been challenged (Biggs, 1995). The capacity of the participatory approach to produce hard data has been criticised (Barahona and Levy, 2002). Chambers (2005) however, discussed ways in which participatory approaches can produce quantitative information and cited several reference sources where this approach has been used. There are three ways of generating quantitative information from participatory approach: (1) in a comparative research mode (Brock, 1999); (2) more empowering mode – participatory monitoring and evaluation (Estrella and Gaventa, 1997; Guijt, 1998); and (3) standardised participatory approaches and methods. The standardised participatory approach is usually carried out by individuals, or groups in different locations doing similar things that provide numbers which can be used in any mathematical or statistical analysis (mean, frequencies, comparisons).

However, caution has been advised to the degree that standardisation can be employed. It is perceived that the more the approach is standardised the more extractive, less empowering and less accommodating of local priorities the approach becomes (Chambers, 2005). Recently, Immink *et al.* (2003), Islam *et al.* (2003) and Morales *et al*. (2003) used a portfolio of methodologies that attempted to reconcile the need for openness of questioning with a structured approach that allowed comparison of and learning between social groups, communities and sites. Moreover, key design principles were taken into account and the approaches used were consistent and systematic and subsequently produced hard data that could be treated statistically. Standardization of the PRA tools allows researchers to scale up studies that employ participatory approaches (Barahona and Levy, 2002). However, making sure that relevant questions are asked in each community required some sensitive modification.

The evolution of PRA developed from an earlier approach (RRA) in the late 1980s. Both of these approaches challenged the conventional methodologies of research in terms of producing hard data to be used in generalisation and understanding phenomena. Although both approaches involve the participation of community, these two approaches are completely different (Table 1.4) in terms of data collection and use. A general difference between two approaches is that PRA is being employed with the aim of enabling local communities to conduct their own analysis and subsequently plan or take action based from their learning, whereas the intention of RRA is for outsiders to learn about the local community.

Table 1.4 RRA and PRA compared (Source: Chambers, 1994b)

Characteristics	Rapid rural appraisal	Participatory rural appraisal
Period of major development	Late 1970s, 1980s	Late 1980s, 1990s
Major innovators based in	Universities	NGOs
Main users at first	Aid agencies; universities	NGOs; Government field organizations
Key resource earlier undervalued	Local people's knowledge	Local people's analytical capabilities
Main innovations	Methods; team management	Behaviour; Experiential training
Predominant mode	Elicitive; extractive	Facilitating; participatory
Ideal objectives	Learning by outsiders	Empowerment of local people
Longer term outcomes	Plans, projects publications	Sustainable local action and institution

Several participatory tools are now being implemented in social, health and food security, natural resource management, forestry, agriculture and fishery research. In social research, studies on livelihood analysis, poverty assessment and institutional analysis were the most common areas in which participatory approaches were being employed (Adato and Meizen-Dick, 2002; Bergeron *et al.,* 1998; Chambers, 1994b; Reardon and Vosti, 1995). Several livelihood analyses with farmers and fishers have also employed participatory approaches (Allison and Ellis, 2001; Gladwin *et al.,* 2002; Lightfoot and Noble, 1993; Takasaki *et al.,* 2000). Amongst the collection of participatory tools used, wealth and well-being ranking, preference ranking and scoring and matrixes were the most commonly practiced in both development and research fields. If the PRA tools were adapted through a process of standardisation i.e. taking into account the requirements of compatibility of data between sites or groups, these participatory techniques can also be tested statistically, particularly the ranking and scoring activities (Barahona and Levy, 2002; Fielding *et al.,* 1998).

Aside from the criticism that participatory approaches only produce soft data, there are several other challenges that this approach faces. These include the constraints that inequalities in power, knowledge, time and money impose on true participation, and the validity of research outcomes. Cultural differences may also undermine participation, especially of marginal groups (Cooke and Kothari, 2001). Leurs (1996) discussed that in all the different contexts that PRA is used i.e. individual, community, organizational, project and programme, donor and policy levels, these are common concerns. These issues needed to be considered by those that are just starting or planning to engage in a participatory approach, as these issues can influence the results of the activities or program. Mosse (1994) discussed theoretical reflections on the practice of PRA based on experience of constraints and raised issues regarding its application. Amongst the concerns were: 1) the use of PRA depended upon established links between an agency and local communities, 2) the issue of participation i.e. whether the perspective and knowledge of all sections of a community are equally accessible to the methods of PRA, and 3) that complicated questions of the existence of different kind of knowledge and problem may pose in generating information for planning. Meanwhile, Scoones (1995b) identified some dilemmas and challenges of PRA, and found PRA was not as quick as it was claimed; it was a rather slow and difficult process to organize people and experienced facilitators were essential. Moreover, Scoones (1995b) suggested that there is a need for anthrophology in PRA, to continue the process of reflection, self critique, theoretical and methodological enrichment. Leurs (1996) however reported that the current challenges that PRA is facing have different levels starting from individual, community, organizational, project/ programme, donor and policy levels. The challenges identified by Leurs (1996) included power, knowledge, cultural differences and time and money. In practice, Laderchi (2001) critically refected on the use of participation in poverty assessment and the problem of scaling up of the results. The main concern is the difference in understanding participation and different agendas of different people. Moreover, the problem of raising the level of expectations among people is another challenge.

These issues need to be considered by the practitioners in order to generate true and "reliable" information to help in planning for further research (for researchers) or development activities (development organizations). Cornwall and Fleming (1995) suggested that PRA can offer practitioners a different role, as facilitators of processes. Hence, the critical point in PRA may not be the approach itself, but rather the person trying to implement it. The success then depends on how facilitators could maintain the integrity of the information regardless of the relationship with the community or by ensuring that true participation occurred. Mosse (1995) identified factors that could implicitly impact on result of the approach: 1) gender relationships, 2) social dominance, and 3) existence of outsiders that tends to shape public information. Chambers (1994a) reiterated that in facilitating PRA the behaviour and attitudes of outsiders matter more than the specific methods. Practitioners require special skills particularly in communication (Scoones, 1995b) to be able to handle the situation in the community and making sure the issues and concerns inumerated above were properly resolved. Moreover, for researchers including PRA in the programme, it should be a reminder that PRA is not only limited to sets of tools but also to changes in behaviour and attitude. Laderchi (2001) further suggest that the issues can be solved by working with other groups for triangulation.

Gender issues

The differences in the social and cultural roles of men and women are contextually defined as gender which is considered one of the most important variables in the composition of a household (Buenavista *et al.,* 1994; Feldstein and Jiggins, 1994). Gender divisions within households/communities are not only limited to those occurring strictly between men and women. The classification on age i.e. young, adult, children and older member of the household are also considered part of the gender context (Buenavista *et al.,* 1994; Handa, 1994). The roles of different gender groups are socio-culturally, economically, and psychologically determined i.e. they are not only biological phenomenon (Setboonsarng, 2002; Srinath, 2004). Moreover, these roles can vary over time and among different cultures. However, these variations in the roles of different genders have also been undermined by researchers and policy makers. Assumptions that households are homogenous units and that resource and benefits were equally allocated to each member, regardless of gender, are common. Furthermore, gender is typically hidden under the collective terms such as the people, the oppressed, the farmers, and the disadvantaged (Guijt and Shah, 2001).

Guijt and Shah (2001) have identified six factors that can influence imbalances in addressing gender issues (Table 1.5)

Table 1.5. Factors influence the unbalancing of gender issues. (Adapted from Guijt and Shah, 2001)

- Development activities only focused on alleviating poverty and analysis of such is only limited to below and above poverty line.
- Initially professionals involved in field work were mainly men which constrained communication with women
- Rapport building with women and negotiating changes with men took a lot of courage and required a lot of time, hence the activity becomes unappealing
- Influence of limited and poor quality documentation on participation in perpetuating poor practice should not be underestimated
- Diversion from the community-driven or community-based planning and implementation to community appraisal only
- Gender issues are being implemented in a mechanistic fashion as a result of pressure from donor and other institutions/organizations.

Considering the different roles of gender groups, gender influence and contribution to livelihoods and utilization of different resources may also vary. As for many participatory projects, one of the main objectives is empowerment and targeting the poorest or the most disadvantaged (Chambers, 1997), however, even in this sector of society differences still exist. Understanding the gender roles in livelihoods is necessary for any development work to be better targeted and have higher rates of adoption. Aside from the roles of the different genders in the production side of livelihoods, each group has also varying requirement in order to maintain their livelihoods.

Several studies have highlighted the complexity and the dynamics of the different gender groups at the household and community level (Argawal, 2001; Handa, 1994; Johnson *et al.,* 2004; Miller, 1997; Mosse, 1994; Saith and Harris-White, 1999; Westernmann *et al.,* 2005). Gender aspects in development should not be narrowed down to women alone. Gender is about maintaining balance between gender groups i.e. men, women, children and old people and not creating competition between sexes (men versus women) or worse, conflicts (Setboonsarng, 2002). Making sure that all gender groups are being considered and that none are marginalised is the main aim of gender focused research (Humble, 2001).

In rural areas, particularly in households whose main source of livelihood is farming, both men and women have responsibilities for ensuring that the family can cope and sustain their livelihoods. Distribution or allocation of farming labour is a common scenario in such situations. The introduction of natural resource management i.e. managing aquatic resources or even aquaculture activities inevitably changes the responsibilities and labour allocation within the family (Setboonsarng, 2002). Understanding how certain activities are being allocated to different household members of different gender types is a necessity to avoid undermining marginalised groups and more so to enhance empowerment at the household and community levels.

In 1997, a workshop (Bueno, 1997) and seminar (Nandeesha and Hanglomong, 1997) were carried out to analyse gender issues in aquaculture in the Asia – Pacific. Both activities revealed that the major contribution of women in aquaculture was routine, mechanical and menial (Setboonsarng, 2002). Aside from the labour allocation, issues of access to different resources (natural and financial) and opportunities were also elucidated. Increasing the awareness on the situation regarding the current and potential roles of different gender groups in aquaculture could provide better guidelines for both development workers and technology disseminators on who will be the appropriate user of the technology.

An issue that hinders the mainstreaming of gender in the research field is that gender is widely mistaken as being synonymous with women (Srinath, 2004). This misunderstanding eventually creates competition between gender groups instead of incorporating issues affecting both genders. It is very important to look at gender within a broader context i.e. within the whole society and not isolated or targeting both gender groups as participants (Mowla and Kibria, 2004).

1.1.7 Social science in aquaculture

Bailey *et al*. (1996) and Bush (2004) illustrated the dearth of social inquiry into aquaculture and other projects that aim to help farmers/ individuals/ and households in developing countries. It is necessary to understand socio-economic conditions where the objective of aquaculture is to enhance development. A broader understanding of such issues will contribute to the successful adoption or failures of aquaculture (Bailey *et al.,* 1996; Little and Edwards, 2003; Ruddle, 1996). The 'Green Revolution' that was hailed during the 1950's, created other problems such as over supply of single crops, market problems, etc. This served as a lesson to those involved in research and development and pushed forward a more holistic approach. The whole system needs to be understood explicitly (Bailey *et al.,* 1996), and most importantly the social factors within it, to ensure the development of appropriate technology and high adoption rate and subsequently solve the problem trying to addressed (Smith and Peterson, 1982). In social research in aquaculture, the main focus is not on how to improve the aquaculture production through more advanced hatchery or rearing techniques but rather on the extent to which such advancement that was developed based on considering the socio-economic conditions, power relations among different social strata, gender and ethnic groups (Bailey *et al.,* 1996). Higher uptake and dissemination of new technology in aquaculture particularly in the rural areas is possible when prior identification of farming systems that complement the social and economic context of the community have been critically understood (World Bank, 1991). Developing more appropriate aquaculture technologies may be achieved if researchers, development workers and policy makers would accept the fact that fish farming is just one dimension of a broader human ecological system (Ruddle, 1996).

As identified by Ruddle (1996), researchers and development workers need to critically address the following socio-economic and cultural contexts in developing fish farming projects/ activities: (1) factors internal to producing households (i.e. decision making, household economics, resources, labour, and marketing) and (2) factors external to the households (i.e. community and governmental issues).

1.2 The study sites

Three countries in mainland South East Asia (SEA) were the geographic focus of this research. General socio-economic information regarding the three countries is presented in Table 1.6. Overall, the three sites were selected to reflect the spectrum of agro-ecological conditions and the level of aquaculture development in Southeast Asia.

The research was focused in specific areas within the three countries as presented in Figure 1.3 (see specific location at each site in Appendix 2 - 4). In Vietnam, Phu Xuyen and Soc Son districts within the Red River Delta (RRD) were selected as a highly modified, intensive agro-ecosystem where conventional aquaculture is well developed (Luu *et al.* 2002). The majority of households in this area possessed at least a small excavated pond near their homestead. Moreover, stocking hatchery reared seed is common in this area.

Table 1.6. Country profiles

Characteristics		Cambodia	Country Thailand	Vietnam
Area (km2)		181,035	514,000	331,000
Government		Constitutional monarchy	Democratic constitutional monarchy	Communist people's republic
Main religion		Buddhism	Buddhism	Buddhism
Population (million)		13.5	64.20	82.02
Population density (No./km^2)		75	125	249
Rate of population increase (%)		1.9	0.9	1.4
% of population living in poverty		35.9	9.8	28.9
GDP per capita (US$)		309	1,906	267
Human development index (2002), (ADB, 2005)		0.57	0.77	0.69
Labour force (thousand)		6,359.2	36,291	42,500
% of working age population	Male	84.3	89.7	83.5
	Female	83.9	77.7	77.3
Prevalence of underweight children (%)		45	3	32
Life expectancy	Male	57	73	74
	Female	50	67	68

(Source: ADB, Key Indicators 2004; Coates, 2002; EDSD, 2001)

On the contrary, in the sites in southeast Cambodia (SEC), in Takeo and Svay Rieng provinces, the agricultural systems are extensive in most areas and aquaculture is underdeveloped and relatively new (Gamucci, 2002; Gregory and Guttman, 2002a). The majority of households in this area were assumed to have high dependence on wild aquatic animals (Morales *et al.*, 2003; Morales *et al.,* 2006). Yasothon, Roi-et and Srisaket provinces in northeast Thailand (NET) were selected for their intermediate status for both criteria; whereas wild fish resources remain relatively abundant stocked fish are also widely available (AIT/AO, 1992; Demaine *et al.,* 1999; Little *et al.,* 1996; Morales *et al*., 2006; Pant, 2002; Saengrut, 1998).

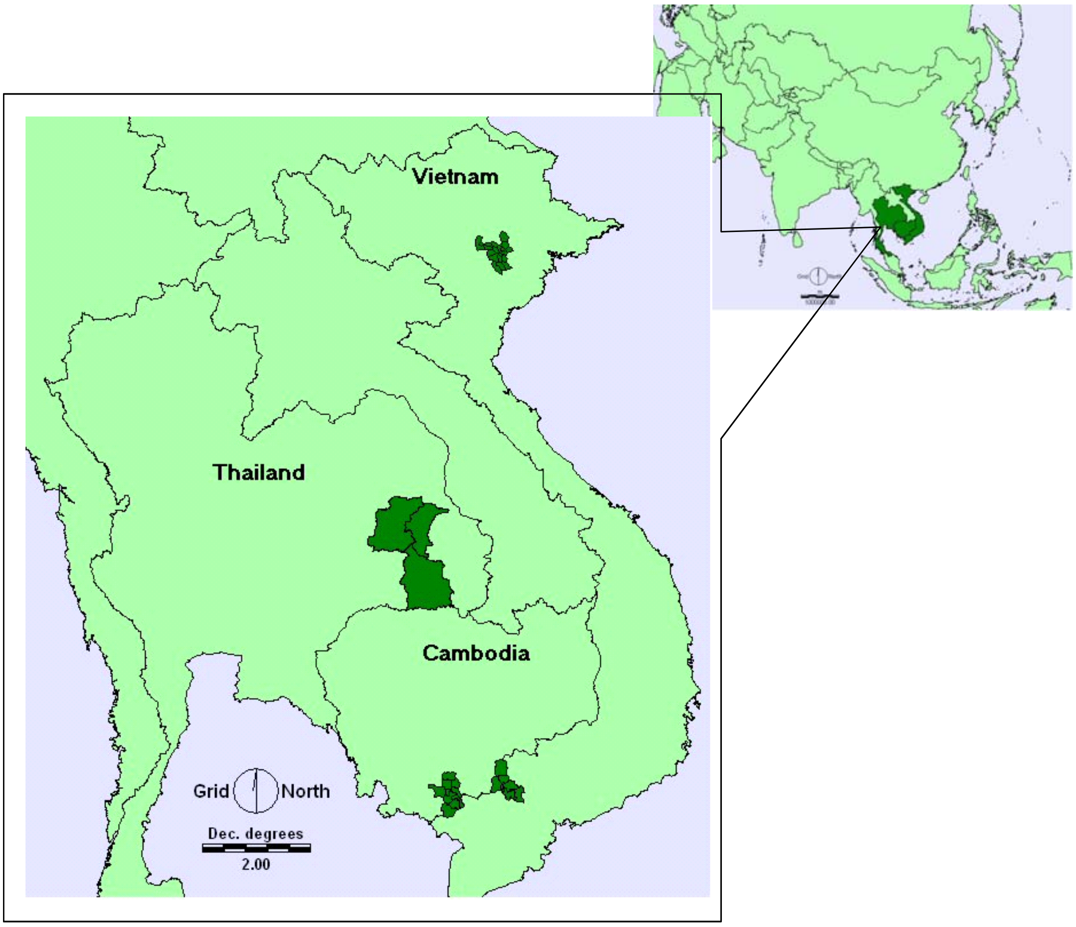


Figure 1.3 The study sites

1.2.1 Red River Delta of northern Vietnam (RRD)

The Red River Delta is the heart of Vietnamese government and culture, situated in the northern part of Vietnam which occupies approximately 5% of Vietnam's total land area (Luu *et al.*, 2002). The RRD is the most densely populated area in Vietnam, accommodating 20% of the total population of the country despite the small area. The majority of the population (80%) in this region earn their living through agricultural activities, mainly rice production.

Phu Xuyen district represents the LOW zone in RRD (approximately 3m above sea level) which is situated in the southern part of Hanoi City, 60 km from the city. The district is also situated close to a river system (Red River Delta). Based on the secondary information collected from different government offices (AFGRP, 2003), the majority of the inhabitants in this district (91.74%) are engaged in agriculture and most of the households in this area were classified as generally poor.

Soc Son is the northern most district of Hanoi City in RRD. It lies some 40 km away from the north of the city. The majority of the population in this district (87.4%) are engaged in agriculture, mainly rice production. The district was chosen as the representative of the DRY zone of RRD. The western edge of the district has a line of small hills with an elevation of approximately 550 feet above sea level.

1.2.2 Northeast Thailand (NET)

The north eastern part of Thailand is geomorphologicaly referred to as the "Korat Plateau" because of its shallow basin or saucer-shaped area which is slightly sloping down to the southeast area of the province (Demaine *et al.,* 1999; Pant, 2002; Saengrut, 1998). The north eastern region *(Issan)* covers approximately 33% of the total area of the country (Little *et al.,* 1996; Saengrut, 1998). This region is situated around the border of Lao PDR on the northeast. In the southern border, the Kingdom of Cambodia, Prachin Buri and Nakhon Nayok provinces share borders with this region of Thailand. Sara Buri, Lop Buri, Phetchanbun and Phitsanulok provinces border the western boundary of the region.

In general, this region is characterized with undulating and varying altitude which ranges from 200 – 1000 meters above sea level. With this characteristic, the whole region was divided into six zones (western highland; northern highland; Sakon Nakhon Basin; central highland; Korat Basin and southern lowland) of which, the

Korat basin is where the provinces (Roi-et, Yasothon and Srisaket) in the present study are located.

The agro-ecosystems of north east Thailand are generally classified as heterogeneous due to its topography and rainfall variation. An undulating plain or plateau and slightly tilted toward one corner and bordered by rugged hills is an example of heterogeneous ecosystem (Pant, 2002).Three types of agro-ecosystems were identified by Little *et al.* (1996): (1) mini- watershed; (2) non-floodplain and (3) floodplain (Figure 1.4). With this heterogeneous characteristic of the area, agricultural activities as well as fish farming were being practiced in different areas. The rice-fish culture was mainly present in mini-watershed and non-floodplain while capture fisheries are more important in the floodplain.

The water resources in northeast of Thailand are mainly composed of rivers, swamps, ditches, canals and man-made impoundments (Saengrut, 1998). The Mun and Chi rivers and their tributaries are the main water resources in this part of Thailand. Despite the availability of these water resources, approximately less than 10% of the agricultural land area is irrigated in this region and the majority of the land area still relies on rain (Pant, 2002).

In general, the climate of the north east Thailand is characterised by low precipitation and distinct dryness in the cold period (Pant, 2002). There are three distinct seasons in this part of Thailand: the rainy season (May to October), the cold season (middle of October until February) and the summer or the hot and dry months of the year (middle of February until the end of May).

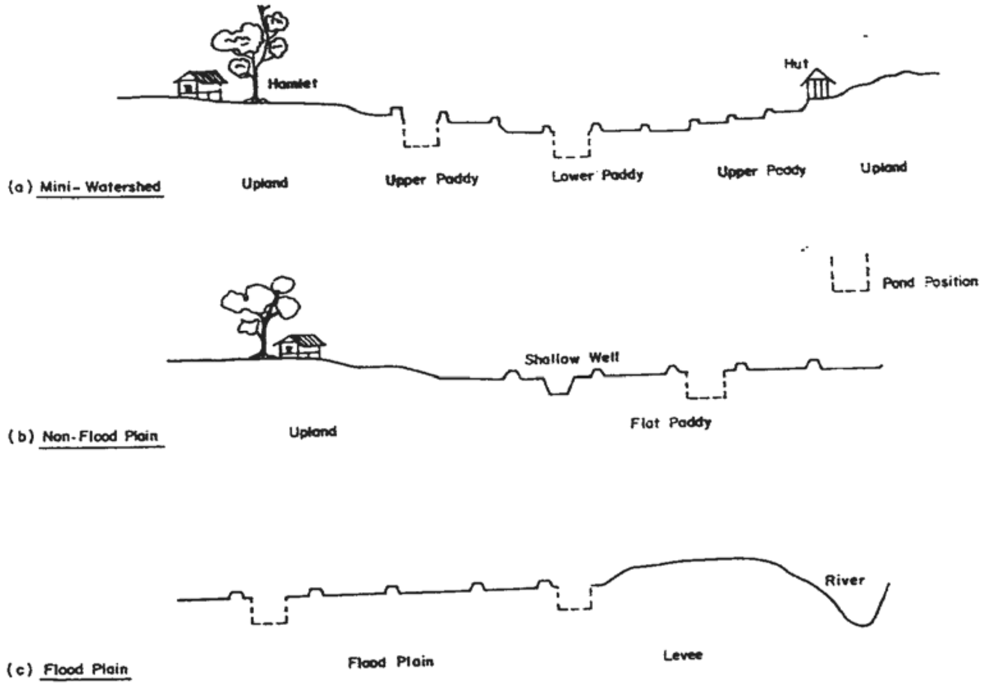


Figure 1.4 Agro-ecosystems in Northeast Thailand. Adapted from Little et al. 1996

1.2.3 South eastern Cambodia (SEC)

The two sub-sites in Cambodia are situated in the south/ southeast part of the country (Takeo and Svay Rieng respectively). Takeo province is approximately 78 km away from the capital (Phnom Penh) of the country and Svay Rieng is about 124 km away from the capital. Situated in the southern part of Cambodia, Takeo province shares its northern border with Kandal province, its eastern border with Kandal province and the Vietnam, its southern border with Vietnam and its western border with the provinces of Kampot and Kompong Speu (Ath, 1996). Svay Rieng borders with Vietnam to the south and eastern part of the province. In the north and western part of Svay Rieng, it shares a border with the Cambodian province Prey Veng (Tana, 1993).

Takeo is considered to be a relatively dry and elevated province (10 – 15 km above sea level, Ath, 1996) and was therefore selected to represent the DRY zone of this research. Water resources are limited in this province and the quality of the soil for cultivation is unfertile with a relatively low water retention capability. Although the land for cultivation is unfertile, the majority of inhabitants are still depending on agriculture as their main source of income, growing rice as their main crop (Catalla and Catalla, 2002; Gregory and Guttman, 2002a).

Svay Rieng is a relatively low province in the central plain region of Cambodia which represents the LOW zone of this research. Due to its low elevation and topography, aquatic resources are relatively abundant in this province, although wild fish production is only sufficient to meet the demand for local consumption (Tana, 1993). The two main streams (Tonle Vayko and Tonle Kompong Trach) that traverse the province are the main sources of water and aquatic animal distribution (Tana, 1993). Furthermore, small lakes, swamps, household ponds and ditches are abundant in this region (Gregory and Guttman, 2002b). The main agricultural product in the province is rice (wet season and dry season rice) despite the fact that approximately 70% of the arable land is infertile sandy soil (Tana, 1993).

There are three distinct seasons in the whole county: (1) the dry season which usually starts from February until the end of April; followed by (2) the rainy season which runs from the beginning or middle of May until November; and (3) the cold season is usually from November until February. Generally, the climate is hot in most months of the year except during the cold season (November to February).

1.3 SRS project

The Self-Recruiting Species in Aquaculture project was implemented with financial support from the Department for International Development (DFID) UK Aquaculture and Fish Genetics Research Programme (AFGRP) and the Fisheries Management Science Programme (FMSP). This research was carried out through a collaboration between the Institute of Aquaculture (University of Stirling, UK), Imperial College (London, UK) and the Aquaculture and Aquatic Resource Management of the Asian Institute of Technology (Bangkok, Thailand). Implementation of the field activities was carried out by local partner institutions; the Department of Fisheries Thailand and the AIT - Aquaculture outreach office in Thailand and Cambodia; Research Institute for Aquaculture No. 1 in Red River Delta, Vietnam; Intermediate Technology Development Group (ITDG) in Bangladesh and Gramin Vikhas Trust in India. Additionally, technical assistance for the research was provided by IACR Rothamstead and the Natural History Museum in statistics and taxonomy, respectively.

The main purpose of the project was to characterise the role of self-recruiting species in different aquaculture systems, and to develop management approaches that enhance the production of and access to such resources by the poor. These purposes were achieved by delivering four distinct outputs:

1. Assessing the role of SRS in Asian farmer managed aquatic (aquaculture) systems.

2. Defining the importance to livelihoods of SRS produced in aquaculture systems.

3. Identifying appropriate management strategies to optimise production of and access to SRS for the poor.

4. Dissemination of results and promotion of management and policy recommendations.

The research implemented a broad range of theoretical and field-based activities to understand the ecology of self-recruiting species, which was mainly covered by Amilhat (2006), and assess their role in livelihoods which is the focus of this thesis. Moreover, adaptation of the sustainable livelihood framework (DFID, 1999; Scoones, 1998) enabled different physical environments of SRS, agricultural systems and socio-economic conditions in the study sites to be understood. Results of the field trials on the management of aquatic systems through the local resource user groups illustrated the possibility of managing common aquatic resources to sustain the population of self-recruiting species.

Although the geographic focus of the overall research was south and southeast Asia, the author of this study was only involved in the implementation of the field activities in the three sites of southeast Asia (Red River Delta in Vietnam, northeast Thailand, and southeast Cambodia). Programme management was part of the task of the author under the supervision and support of the principal and local supervisors (IoA of University of Stirling and AARM of Asian Institute of Technology, respectively).

1.4 Rationale of the research

Intensification of aquaculture and agriculture are becoming the main problems in the sustainability of the yield from natural stocks of wild aquatic animals. While the government focus is on increasing production for stocked species, the conservation and maintenance of the population of the wild stock is often neglected. Most of the extension workers recommend eradication of "unwanted species" from new aquaculture systems because researchers and practitioners believe that these species compete with the food resources available for the stocked species, lowering yields.

This contrasts to practice and perceptions of many farmers in the region who perceive that unstocked animals are an important component of their system (Middendorp, 1992; Setboonsarng, 1993). Understanding all the ecological interactions of stocked and unstocked aquatic animals (AA) are beyond the scope of this study but farmers observations and practice suggest that they are far from being only antagonistic. Furthermore the relative importance of unstocked animals might be expected to vary with system and surrounding agro-ecosystem and social-economic condition of the household. Most of rural farmers do not grow aquatic animals only for sale but also/ primarily to meet their own consumption needs as a food security measure (Little and Edwards, 2003).

1.5 Research questions

This research aimed to understand the overall contribution of the self-recruiting species to the sustainable livelihoods of the rural poor. By employing an analysis using the SL framework and other quantitative research approaches, the aim of this research was achieved by answering the following research questions:

1. What are the different types of aquatic resources which households/farmers in rural areas manage and exploit?

2. What are the self-recruiting species (SRS) that are important to the rural poor?

3. What are the current roles of aquatic animals in the livelihoods of rural poor?

4. How does seasonality influence the level of importance of such aquatic animals on its contribution to the overall livelihoods?

1.6 Outline of the thesis

This thesis is divided into five chapters. The first chapter **(Chapter 1)** contains the general background of the thesis and the rationale for understanding the research. It also attempts to provide a comprehensive review of literature regarding the current status and trends within aquaculture in the study area. Moreover, it also reveals the importance of wild aquatic animals to the livelihoods in rural households. Key information and issues that were considered in implementing this research as well as the geographic focus and the process by which the different target groups were identified are clearly illustrated in this chapter.

Chapter 2 provides a general description of the different research tools and approaches employed in this research. This chapter also discusses general issues regarding these research tools, with a more detailed discussion on specific issues covered in preceding chapters.

Chapter 3 describes typical livelihoods characteristics in rural areas, derived from assessments using a combination of qualitative and quantitative approaches. Contextual concepts, livelihood assets and strategies were the main focus of the information presented in this chapter. Results from a study are presented in this chapter to illustrate seasonal variation in household livelihoods conditions in rural areas.

The different groups of aquatic animals, particularly the self-recruiting species, and the aquatic resources from which such species come are described in the following chapter, **Chapter 4**. The seasonal contribution of the different types of aquatic animals to the overall livelihoods is also elucidated in this chapter.

Finally, **Chapter 5** presents the general discussion distilling and placing into context all the key elements from the previous chapters. The importance of SRS, their sources and exploitation, and how they can be sustained are discussed in this chapter.

2 General Methodology

2.1 Introduction

The aim of this chapter is to describe the overall methodology used in the implementation of the research. This chapter is divided into nine sections. Following this section is a general description of the approach employed in selecting the site for this research (section 2.2). Section 2.3 describes the rationale and the forms of training given to field staff prior to the implementation of the research. The methodological process with which the different research tools were applied is presented in section 2.4. In section 2.5 agro-ecological zones that were identified are described. Section 2.6 presents a general description of the different data collection tools used in the research; their applications as well as the different types of respondents are described in this section. The complementary use of qualitative and quantitative methods and how the data was utilised is explained in section 2.7. In section 2.8, the different statistical analysis used and how the data collected was interpreted is presented. Finally, in section 2.9, reflections on and critique of the different method used is discussed in this section.

The main focus of the broader research project was to understand the social and ecological importance of self-recruiting species (SRS). This study focuses more on the livelihood implications of the way SRS are managed with a lesser emphasis on ecological aspects.

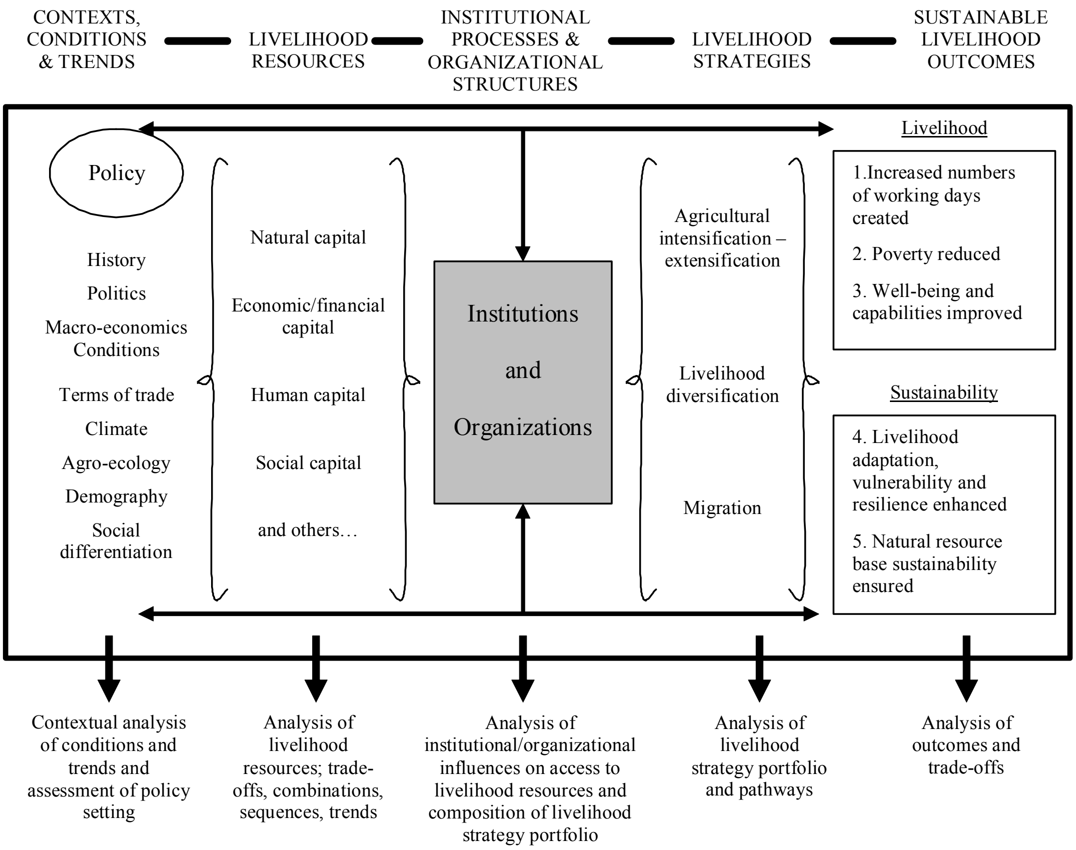


Figure 2.1 Sustainable rural livelihoods: a framework for analysis (Scoones, 1998)

The framework of analysis that was applied in this research was based on that proposed by Scoones (1998) (Figure 2.1) which is similar with the DFID's (1999) sustainable livelihoods framework, and seeks to place people at the centre of development. These two frameworks were both adapted from Chambers and Conway (1992). Scoones (1998) and DFID's (1999) framework both view people living in a context of vulnerability. Furthermore, both frameworks suggest that livelihoods are shaped by a multitude of various factors that are constantly changing. From earlier discussion (Chapter 1), Carney *et al.* (1999) compared DFID's sustainable livelihoods (SL) approach with that of other organizations using the SL framework. They found similarities in their focus, particularly with respect to the importance of assets and micro-macro links. However, DFID (1999) suggested that there is no fixed way of implementing the SL framework with the most important factor being to remain true to the core concepts that underpin the sustainable livelihoods approach. The livelihoods framework proposes the importance of initially understanding the general condition of people and the community as a whole, taking into account the physical, environmental, climatic, and social conditions which generally influence the livelihood assets of individuals. Moreover, current policies and how such policies affect the conditions and trends in the community were also considered. Assessing the five livelihood capitals (natural, financial, human, social and physical) which constitute the five elements of the livelihood pentagon is integral to the framework. The roles of different institutions and organizations for households achieving a sustainable livelihood through supporting the needs of households to employ different strategies such as intensification of farming activities, migration, changing of economic activities or diversifying the sources of income were also investigated.

The framework is a simplified representation of the livelihoods of local communities; however the complexities of the livelihoods particularly in rural areas can be better understood at the local level and with people's participation (DFID, 1999). The contextual conditions and different trends affecting the farmers/households and the community as a whole were first understood through a participatory appraisal of the community using a suite of participatory rural appraisal (PRA) tools.

Livelihood resources in the SL framework refers to a combination of the different 'capitals'; human, natural, physical, financial and social (DFID, 1999; Scoones, 1998). The capacity of an individual to sustain their livelihood depends on how they can utilise these resources.

Institutional processes and organizational structures are considered very important in the SL framework as they mediate the complex and highly varied process of achieving sustainability (Scoones, 1998). 'Institution' as defined here does not refer to an organization *per se* but covers a very complex context such as common understandings, shared beliefs, customs, rules (formal and informal), regulations, laws, public agencies, internal and external solutions and control over outcomes (Crawford and Ostrom, 1995; Ellis and Freeman, 2005; Ostrom, 1990). Scoones (1998) described institutions (both formal and informal) as the the social cement linking various stakeholders with access to resources of different kinds and their means of exercising power in pursuit of livelihood sustainability through various livelihoods strategies.

In basic terms, livelihood strategies and diversification are the various activities carried out by households using their tangible and intangible assets in order to sustain their livelihoods (Scoones, 1998). In the literature this term is replaced with adaptive strategies which can be distinguished from coping strategies (DFID, 1999). DFID (1999) suggests that the probability of households to withstand various shocks and stresses depends on the diversity and flexibility of the household livelihood strategy. The most common strategies include intensification of the use of natural capital i.e. agricultural intensification, diversification from on-farm to off-farm activities, and migration (both seasonal and long term) (Scoones, 1998).

In this thesis, an emphasis was placed on understanding the different livelihood resources that affect the current predicament of rural households, and household links and network capacities with various institution and organizations. During the longitudinal study, various strategies including diversification of household livelihoods were examined. Understanding the importance of age and gender roles in the livelihoods of those involved in managing aquatic resources and the benefits derived from aquatic systems, particularly SRS, was a key part of the study.

2.2 Site Selection

Secondary information was collected from different institutions (e.g. Asian Institute of Technology; AIT) in the region and enabled the researcher to set up criteria (Table 2.1) in order to select the three study countries. Within each site - south eastern Cambodia (SEC), northeast Thailand (NET) and Red River Delta – Vietnam (RRD) - sub-sites were identified through the application of three steps: (1) review of secondary information; (2) discussion with 'key informants', (3) field visits and transect walks.

Several local institutions (e.g. Provincial office of the Department of Agriculture and Fisheries, District and Commune) were visited and secondary information collected at each site in order to generate robust information regarding the sub-sites. After the secondary information were reviewed and assessed using the different criteria (Table 2.1), the areas were visited and discussion with the key informants (commune and village level) took place with the objectives of verifying the information collected from the different offices, and at the same time introducing the research objectives and activities.

The research was based at sites in three countries in Asia (Cambodia, Thailand and Vietnam) reflecting different levels of conventional aquaculture development and hatchery seed availability. Sites in south east Cambodia (SEC) were chosen to represent areas where conventional aquaculture is relatively undeveloped and hatchery seed is less available (Gamucci, 2002; Gamucci *et al.,* 2002; Gregory and Guttman, 2002b). The Red River Delta (RRD) in northern Vietnam is representative of an area where aquaculture is traditional and well established and where hatchery seed is widely available (Luu *et al.,* 2002). Northeast Thailand (NET) was selected as an intermediate between the first two sites based on both level of aquaculture development and availability of hatchery seed (AIT/AO, 1992; Demaine *et al.,* 1999; Little *et al.,* 1996; Pant, 2002). Sub-sites were selected on the basis of proximity to perennial water bodies and categorised as, DRY, tending to be higher elevations and experiencing short duration flood and distant from perennial water bodies or LOW, sites with longer flood duration and closer proximity to perennial water resources.

Table 2.1. Set of criteria used in selecting sites and sub-sites

Criteria	Descriptions
Site	
Status of aquaculture	New to aquaculture; intermediate; aquaculture well established
Dependency on natural production	Mainly collecting aquatic animals from natural water bodies; dependent on both natural and conventional aquaculture; mostly collecting AA from conventional aquaculture
Sub-site	
Availability of aquatic resources	Abundant water resources; limited water resource; flooded; away from perennial water bodies
Poverty level	Relatively poor; less or distant from services (e.g. market)
Size of community	Less inhabitants (< 150 households)

2.3 Training of field staff

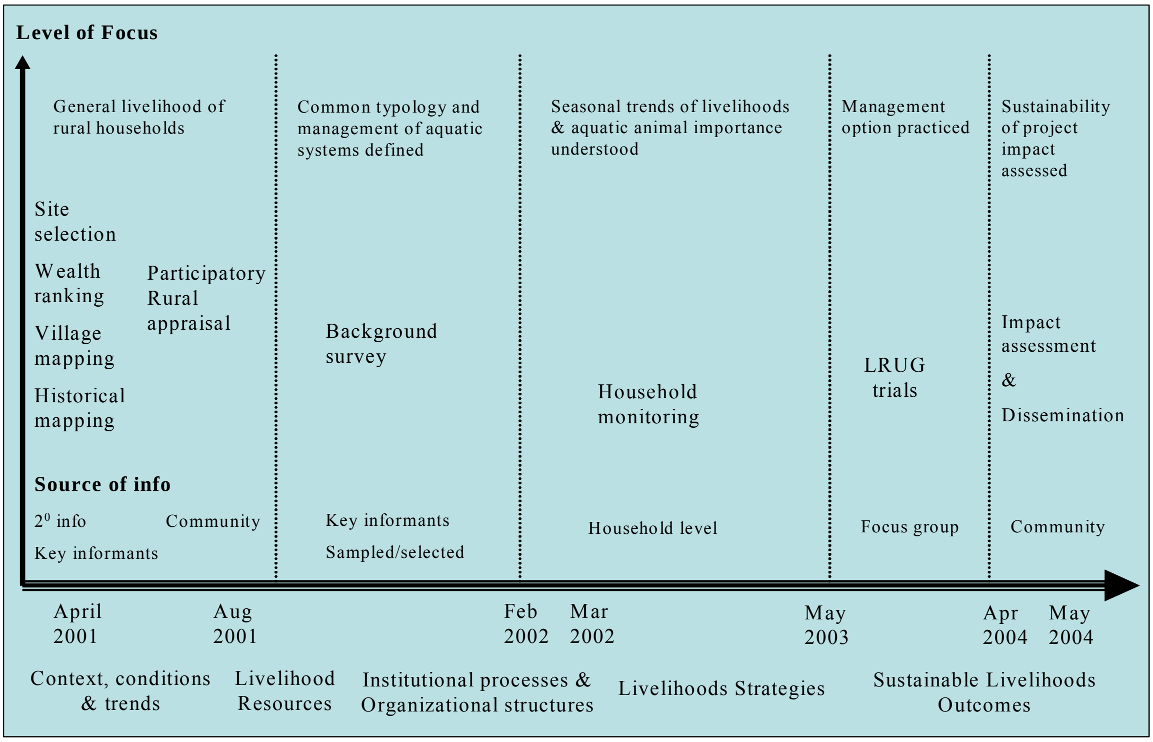
The research was carried out in collaboration with the AIT-Aqua-Outreach Programme and its counterparts in Cambodia and Northeast Thailand and with Research Institute for Aquaculture No.1 (RIA-1) in the Red River Delta, Hanoi, Vietnam. Amongst the three sites (SEC, NET, and RRD), staff from RIA-1 had the least experience in terms of using systems orientated field research methodologies, particularly participatory tools, and orientation and training was therefore necessary. Two types of training for field staff was carried out prior to the implementation of the field activities of this research; (1) classroom lecture/discussion and (2) field-based training as described in Pretty *et al.* (1995). The researcher worked closely with a team leader at each site to ensure that field staff fully understood the different participatory tools and the rationale for taking a participatory research approach. Chambers (2002) emphasised that a few days training on PRA is not enough as no one can understand and learn this technique until they practice it. Training continued in the field and field staff became more familiar and confident in the PRA activities as they progressed.

Pretty *et al.* (1995) emphasised the importance of appropriate attitudes and behaviour when conducting PRA exercises. Training in these specific skills such as local customs and researchers' self awareness was provided. Experienced facilitators working with NGO's were also invited to provide and share their experiences as facilitators to the field staff. At the end of each visit, the researcher and field staff had a debriefing and reflection session to discuss the field activities and any potential improvements.

A questionnaire survey was used at the household level to complement the community-level PRA data. Field testing of a questionnaire is a key requirement to ensure that the questions are appropriate to the local context (Pollock, 2005). This approach can also determine the level of understanding of the user of the questionnaire. The field questionnaires were discussed with the team and NGO staff to clarify each question and to ensure a similar understanding of the questions was reached. Training on how to estimate the size and weight of aquatic animals (AA) using measuring sticks and bowls was also carried out with the field staff using field visits and interviewing selected households (not included in the monitoring households) regarding their AA catch.

2.4 Methodological process

There were five stages of the overall research framework of the AFGRP-DFID funded project; (1) exploratory stage, (2) background information collection, (3) longitudinal survey (household monitoring), (4) field trials with resource users and (5) output dissemination and impact assessment (Figure 2.2). This thesis was set within the context of the larger project. Due to the size of the body of work, this thesis focuses on the first three stages.



*LRUG refers to local resources user group that were formed during the trial of the management of aquatic resources in the community.

Figure 2.2 Timeline and chronology of the different research tools employed in the research (adapted from Little *et al.*, 2004).

During the exploratory stage, two main activities were implemented, site selection and general understanding of the site through participatory community appraisal. Secondary information regarding the situation of the aquatic systems in southeast Asia was collected and assessed for identifying potential areas of study. A series of field visits was conducted to evaluate each potential area. Initial contacts were made at this point with community leaders and other key informants in the area (e.g. village headman, commune head etc.). Discussions between village representatives and the research team took place and follow-up activities were suggested and agreed by the both parties. The main part of the exploratory participatory community appraisal (PCA) was then implemented. Subsequently, triangulation and validation of the information collected during the PRA exercise was followed up in community presentations and meetings.

Following village PCAs, background surveys were conducted. At this stage, key variables relating to aquatic systems generated from the PRA exercise were utilized and used as guide in designing the questionnaire. The details of this stage of the thesis are described in section 2.6.2.

The longitudinal study that followed improved our understanding of seasonal differences and the role and importance of different types of aquatic systems and their products through the year. Detailed information on how this particular stage was implemented is presented in section 2.6.3.

On conclusion of the field work stage, all data generated were collated and standardized for unit of measurement. Information was often collected using local units of measurement (i.e. weight of food (including AA), currency, area of land, names of AA, etc.). Furthermore, since the survey used semi-structured and open ended questions, information needed to be coded prior to any statistical operations/analyses. Preliminary outputs of the research led to materials (policy briefs, best practice guidelines, posters and video) for extension and dissemination. These are now being used by different partner institutions in Southeast and South Asia.

2.5 Agro-ecological zones (AEZ)

Agroecology is the holistic study of agroecosystems including all environmental and human elements which focuses on the form, dynamics and functions of their interrelationships and the process in which they are involved (Altieri, 2000 and 2002; Altieri *et al.,* 2000; Jordan *et al.*, 2005; Reijntjes *et al.,* 1992). Agroecosystems however are not simply natural outgrowths of humans and landscapes that have production potential but are also the product of human communities and are mediated by culture and technology (Flora, 2001; Thomas and Kevan, 1993). The term agroecology however, dates back to the origins of agriculture (Clements and Shrestha, 2004; Hecht, 1998). The consideration of agroecology often incorporates an approach that is considers not only environmental aspects but social aspects as well. In contrast, the investigation of purely ecological phenomenona within a given field can also be referred to as agroecology (Hecht, 1998). Thomas and Kevan (1993), Altieri *et al.* (2000), and Clements and Shrestha (2004) described the agroecosystem as a major ecological unit that contains both abiotic and biotic components that are interdependent and interacting. Certain types of crops and other organisms (e.g aquatic animals) may have different dynamics or interaction in particular types of environment i.e. site specificity (Edwards *et al.,* 1993). In other words, a particular aquatic animal may have different interaction in a particular environment. The social and physical aspects of the environment may also contribute to the ecological processes taking place in the area. The availability of both natural and physical resources can contribute to the production and sustainability in any type of environment. Lack of markets and other social services, for example, can limit the improvement of the yield from aquatic production systems due to lack of sources of external inputs (Flora, 2001; Hecht, 1998). Understanding the dynamics and diversity of ecology as well as the social aspects in different types of environment is essential (Altieri, 1989 and 2000; Altieri *et al.,* 2000; Clements and Shrestha, 2004; Reijntjes *et al.,* 1992; Thomas and Kevan, 1993). By doing this, appropriate technology can be improved or introduced which may lead to a better and more sustainable development outcome (Altieri, 1989 and 2000; Altieri and Nicholls, 2004; Edwards *et al.,* 1993; Gliessman, 1998 and 2004a; Jordan *et al.,* 2005; KKU-FORD, 1982). Furthermore agroecology provides ecological concepts and principles for analysis, design and management of productive, resource-conserving systems (Altieri *et al.* 2000).

In certain areas or regions, agroecosystems are unique (Altieri *et al.,* 2000) and often have multiple resources (Flora, 2001) which are the results of local variations in physical and biological conditions, natural resource (soil, water, climate), economic relations, social structures, as well as history and management (Altieri, 1998; Gliessman, 2004a, b). Marshall (2004); Edwards *et al.* (1993) and Reijntjes *et al.* (1992) stated that agricultural landscapes are extremely variable, brought about by the different cropping systems, intensity of management and topography. Altieri (2002) reported that several researchers and development organizations have applied the concept of agroecology in their respective programmes in the developing world. Schumacher and Rickerl (2004) reported that conservation within an agricultural landscape should have an objective of supporting essential physical, chemical, biological and also socio-cultural functions of sustainable agroecosystems. In the development of integrated aquaculture farming systems, Lightfoot and Pullin (1995) reported that the agroecosystems analyses had provided a strong basis for the development of such systems.

In this study, the agroecological systems were considered in the design with the aim of understanding the variation between two distinct zones based on the physical/natural factors (i.e. topography and water resources), as well as the socio-economic relations (Clements and Shrestha, 2004; Gliessman, 2004a, b). Considering agroecological zones in doing research leading to development can provide the ecological guidelines to point development in the right direction (Altieri, 1989). Thomas and Kevan (1993) reported that most agricultural activities are not intrinsically sustainable because they ignore ecological relationships existing between crops and the natural habitats in which they grow. This theory was supported by the work of Sivakumar and Valentin (1997) who reported that sustainable agricultural production systems should be based on an initial assessment of the physical and biological potential of natural resources. Additionally, varieties/species of plants and animals and the management methods have different optima in different places (Sivakumar and Valentin, 1997). Previous reports (Little *et al*., 2004; Soubry, 2001) showed that elevation of the area and the proximity to perennial water bodies could affect the level of importance of aquatic animals to rural peoples' livelihoods. The topography was also assumed to affect the dynamics or movements of the aquatic animals from the wild or 'unmanaged' aquatic systems to systems that were maintained or managed at the household level. On this basis, the researcher decided to consider the importance of agroecological zones where one has more aquatic resources than the other in order to evaluate the general importance of AA with specific resources/locations. The two different agroecological zones (LOW and DRY, respectively, Table 2.2) were selected in each country based on secondary information collected from key informants and field verification visits. The following sub-sections define the two AEZ, LOW and DRY respectively.

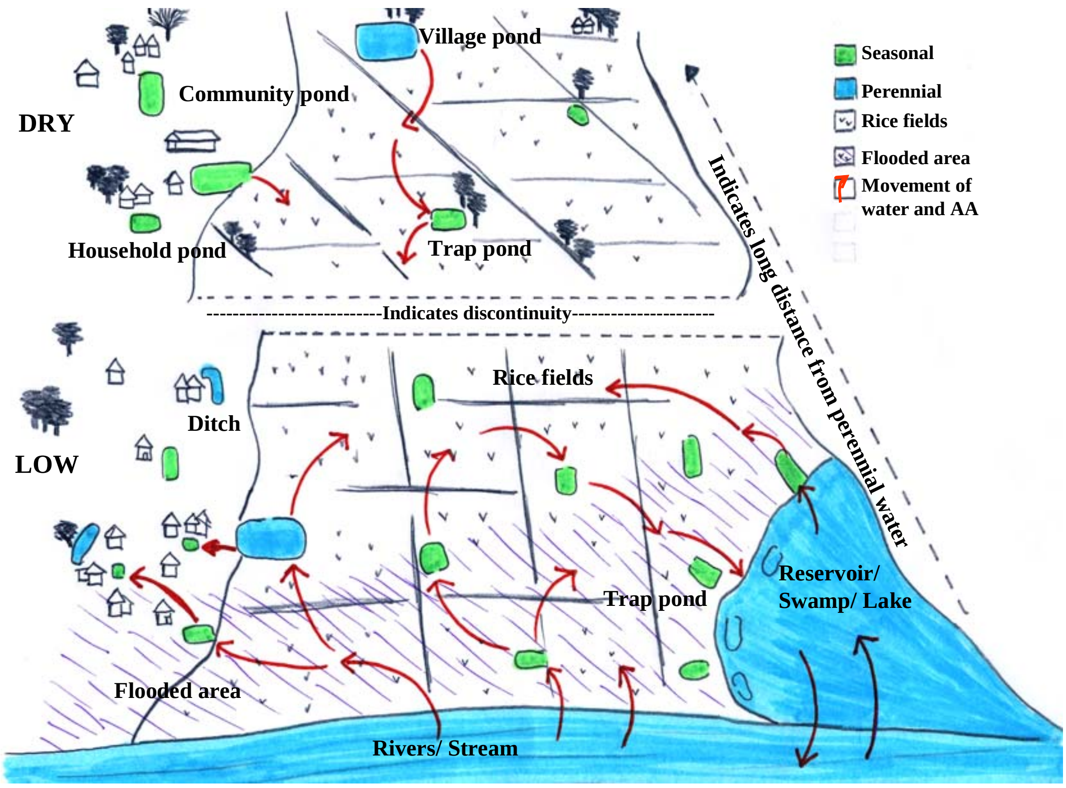


Figure 2.3. Schematic diagram of various types of aquatic systems present in different agroecological zones

The schematic diagram of various forms of aquatic systems that are present in different agro-ecological zones used in this thesis is illustrated in Figure 2.3. The following sections 2.5.1 - 2.5.2 provide detailed information regarding the two agroecological zones (LOW and DRY) regarding the aquatic systems and the movement of water and aquatic animals from the two agroecological zones.

2.5.1 LOW

Areas in this sub-site were generally low-lying and flood-prone. Aquatic resources, particularly perennial water bodies were abundant in this zone. A large proportion of rice fields retained rain and run-off water for a prolonged period during the rainy season. Large water bodies in this zone such as lakes, reservoirs and swamps did not dry up during the dry season.

2.5.2 DRY

Generally areas in the DRY zone occurred at a higher elevation than in the LOW zone; however, 'DRY' areas are not always located in upland areas. This zone, particularly rice fields, generally lacked an adequate supply of water for most of the year. Large water bodies typically became very shallow or even dried up completely during the dry season. Perennial aquatic resources were limited in this area and soils tended to have poor moisture retention characteristics.

Table 2.2 Summary description of different AEZ of the three study sites

Sites	Sub-sites	AEZ	Description
SEC	*Svay Rieng*	LOW	Lowland, abundant in aquatic resources like swamp, lakes, streams, household ponds and ditches
	Takeo	DRY	Limited water resources; little established conventional aquaculture; very few households with ponds; rice fields are usually dry during the dry season
NET	*Yasothon/ Roi-et*	LOW	Close to perennial water body – Chi river, streams, trap ponds, and long term flooding[*]
	Srisaket	DRY	Far from perennial water body, upland area, limited water in the rice fields, short-term flooding
RRD	*Phu Xuyen*	LOW	Lowland, irrigated, far from urban area, close to river – Nhue river, and flood-prone
	Socson	DRY	Upland area; irrigated, near urban area – Hanoi, far from river, less flood-prone

[*] Flooding where the area is submerged in water for a number of days and the water recedes gradually.

2.6 Different research tools used

This section briefly describes the different tools, how they were used (process), and with whom (respondents) they were used. This research used a combination of qualitative and quantitative techniques as described by Brannen (2005), Hagmann *et al.* (1995), Marsland *et al.* (2001), Niglas (2004), Sandelowski (2000) and White (2002). These different approaches were applied sequentially (Marsland *et al*. 2001) from the exploratory stage of the research using qualitative techniques followed by the quantitative approaches that were used for the background information gathering (cross-sectional survey) and monitoring (longitudinal study) components. Aside from this sequential approach, the integration of a formal survey into the participatory process (Bryman, 2001; Hagmann *et al.*, 1995; Sandelowski, 2000) or vice versa was also employed. The following sub-sections (2.6.1 - 2.6.3) provide detailed information on how the different research tools were used.

The various types of research tools require specific individuals or groups of people to provide or generate the necessary information. The rationale and the approaches employed in identifying various types of respondents are also described in this section.

2.6.1 Participatory community appraisal

Community appraisal using various PRA tools is an approach taken to understand and assess the situation in the target area. This method enables the researcher to be taken into account and used as starting point (Chambers, 1994b; Chambers, 2003; PEMT, 1993). The application of participatory approaches has increased considerably in both the development and research world (Andreassen and

Mikkelsen, 2003; Chambers, 1994a; Lightfoot and Noble, 1993; Lightfoot and Pullin, 1995; Mosse, 1995; Mulhall and Taylor, 1998; Prein, 1994).This approach originated in the field of rural development and emerged as the need for new approaches to understanding complex situations in rural areas became increasingly apparent (Chambers, 1994b; Hall and Nahdy, 1999). Conventional data collection was generally too lengthy and often did not allow local people to understand their own livelihood situation. The main characteristics of this approach are greater participation of local people in the whole process with the tools/methods designed to improve communications and overcome differences in language and cultural beliefs (Pretty *et al.,* 1995). The principle of 'handing over the stick' is essential in this approach as it not only allows the facilitator to monitor and facilitate but most importantly, it empowers the local community (Chambers, 2003; Simanowitz, 1999). Participatory approaches were used in this study not only to provide general understanding of aquatic animals but also to allow local people to express their own opinions and observations. Moreover, with this approach, large amounts of information were generated over a relatively short period of time about the general livelihood situation of people living in these rural areas, which was essential to meet the research objectives.

As defined by Chambers (1992 and 1994b), PRA is a growing family of approaches and methods that enable local communities to share, enhance and analyse their knowledge of life and socio economic conditions. Several tools have been developed and implemented as part of participatory approaches in research and development work in the fields of sustainable agriculture, aquaculture and natural resource management (Andreassen and Mikkelsen, 2003; Agarwal, 2001; Cornwall, 2003; FAO, 2004; Johnson *et al.,* 2004; Lightfoot and Noble, 1993; Lightfoot *et al.,* 1994; Patterson and Samuel, 2005; Prein, M., 1994; Pretty *et al.,* 1995).

In this thesis, a systematic approach (Schönhuth and Kievelitz, 1994) was used to carry out the community appraisal using similar PRA tools in all sub-sites in order to generate information that was comparable between sites and groups (Barahona and Levy, 2002). The initial stage of the appraisal involved field visits and meetings with the heads of the communities to introduced the research and gain permission from the local authority to conduct the research activities. This was followed with activities with selected key informants. Mapping activities (wellbeing ranking, historical transect, and village mapping) were also carried out. Focus groups were utilised during the main part of the appraisal with whom an understanding of the differences and similarities of perceptions on different issues amongst different social and gender groups was developed. The PRA tools that were used at this stage included seasonal calendars, ranking and scoring, resource flow diagrams and trend analysis. The final stage of the community appraisal was the community workshop. At this stage members of the community were invited and outputs of the key informant and focus group exercises were presented for validation and clarification (Figure 2.4). The following section provides further explanation of the methods used in the PRA. Examples of the visual outputs of the community appraisal in each site are presented in the appendix.

Stage	Activity	Outcome
First visit	Introduction	-Researcher was introduced to the village leaders
	Village transect walk	-Researcher becomes familiar with the area and starts building rapport
Key informants	Wellbeing ranking	-Understand socio-economic stratification in the village
	Historical transect	-Important events that have happened in the village
	Village mapping	-Important resources (natural and physical) in the village
Focus group	Seasonal calendar	-Seasonality of events in the village (social events, economic activities, health, & weather)
	Activity scoring	-Important activities identified and ranked
	Aquatic animals ranking	-Aquatic animals ranked using local criteria
	Trend analysis	-Factors affecting the trend of AA
Community	Feedback and validation	-Returning outputs to the community Triangulation and clarification of unclear information

Figure 2.4. Flow of activities during the community appraisal

2.6.1.1 Well-being ranking

Well-being ranking is a technique commonly used by development organisations and researchers as part of participatory community appraisals (Adams *et al.,* 1997; Grandin, 1994). Through this technique, differences between the levels of social strata as well as the relative status of individual households in a given community can be understood (Chambers, 1994a, b; Conway, 1999; Noël, 1997). Additionally, by this technique, groups of poorer group can be rapidly identified (Conway, 1999). Furthermore this technique can also provide insights on how local communities or villagers perceive wealth (FAO, 2004; Grandin, 1994; Pretty *et al*., 1995; Shah, 2001; White and Pettit, 2004). Local villagers can provide a wider range of wealth indicators and ascribe appropriate weight to them compared to "outsiders" (Takasaki *et al.,* 2000). It should be noted that this technique considers the household as a single unit and assumes that the household is homogenous in terms of wealth status. The term well-being was used instead of wealth as well-being covers all aspect of livelihoods including social and health conditions whilst the term wealth usually connotes solely money or physical assets (Shah, 1990).

Key informants for this exercise were identified with the assistance of the village headman and some other member of the local community. The researcher relies a lot on the key informant who becomes particularly important in the research (Bryman, 2001). However caution must be taken as too much dependency on a single key informant may limit the validity of the research by taking into account a single opinion only. The consultation of more than one key informant can minimise such problems. There were three key informants per village in this activity which were identified based on their knowledge of all other inhabitants in the community (Chambers, 1994b) and their awareness of various events that had happened in the community. Amongst the key informants identified were a health worker, a local tax collector, a shop owner, a village council secretary and a representative of the poorer group in the village. The first respondents chosen tended to be the village headman or his/her assistant as they were in possession of any administrative details of each household and were also most likely to know everyone in the village. The next two respondents from this exercise were identified through random selection from a list representing the poorer group within each village based on the criteria mentioned earlier regarding key informants. Detailed information on the different key informants is presented in Table 2.3.

Table 2.3 Key informants during the well-being ranking exercise

Sites	AEZ	Village	Type of respondents: Village headman	Men	Women
SEC	LOW	Trapiang Deakrom	√	√	√
		Thom	√	√	√
		Svay Cheak	√	√	√
		Prey Srokum	√	√	√
	DRY	Prey Tadoc	√	√	√
		Angtasom	√	√	√
NET	LOW	Yangnoi	√		√
		Saingam	√		√
		Kudload	√		√
	DRY	Nongweang	√	√	√
		Samoechai	√		√
		Lumphu	√	√	√
RRD	LOW	Cham Ha	√	√	√
		Hoang Nguyen	√	√	√
		Trai	√	√	√
	DRY	Phu Cuong	√	√	√
		Yen Tang	√	√	√
		Cong Hoa	√	√	√

The well-being ranking exercise using cards was carried out in all of the study sub-sites (Table 2.3) as an initial activity to understand the social context of the community. As described in section 2.2, one of the criteria in selecting study areas was the size of the village (i.e. <150 households). In case of a large number of households in a village, particularly in RRD, a "*xom*" or hamlet was selected for this particular activity. This exercise was based on the methodology published by Pretty *et al.* (1995). The activity was conducted with 2 – 3 key informants in the village. Below is detailed information on how this PRA tool was employed.

A list of the households in the community was obtained (either from the village headman or from the commune office) and the names of households were written individually on cards. These cards were shown to the first key informants one by one to make sure that the key informant recognized or was familiar with every name written on the cards. The cards were then placed in piles by the key informant denoting a similar level of 'well-being'. This was done by showing the cards initially in pairs and asking the key informants to determine who was 'better-off' between the two names using their own criteria. The next card was then shown to the key informant who was again asked to compare it with the names already in the piles. This process was continued until no more cards were left to identify. As a result the key informant was able to place the cards into a number of categories. The key informant was asked to review and make changes to the groupings if necessary. Groupings of households were finalized by the key informants.

To elicit the different characteristics of each category, the researcher asked the key informants to discuss their selection criteria used for grouping households. By doing this, the complexities and realities of wealth and poverty were more fully understood (Jeffries *et al*., 2005). The group number to which the card belonged was noted on the back as well as the total number of groupings. For example a card with '3/4', written on the back, represented the group where the card belonged (3) and the total number of groupings (4).

The cards were reshuffled and the same technique was used with another key informant. This technique was carried out up to three times in each community in order to triangulate the information collected. Since this exercise allowed key informants to group individual households based on their own criteria and well-being groupings, the number of well-being groups were not limited and were not always similar with the views of other key informants in the same community. This aspect of the exercise makes it dissimilar to other approaches where household groupings were limited to a set number imposed by the researcher (Noël, 1997).

Spearman's correlation was used to test the consistency of the rankings made by different respondents. The results of this activity were then used to identify participants for a broader appraisal in the target villages where participants were grouped according to gender and wellbeing status.

Conversion of ranks and standardising the scores

The main purpose of carrying out the well-being ranking was to identify the different social strata in the community. Obviously, since the technique exercised a participatory and unlimited ranking, the result produced an uneven number of groupings in each trial (Table 2.4**)**. Standardisation was therefore needed in order to get the average ranking of individuals and finaly analyze the results. Standardisation of ranked data however is not as simple as getting the average of the ranks. Ranked data are considered categorical or nomical data which normally cannot be computed for means (Fielding *et al*., 1998) but mode only. In order to get means of the well-being ranking of households, converting the ranking into scores was done (Abeyasekera, 2001; Grandin, 1994). This step was done by giving total scores to each household. The score was calculated by dividing the household pile number by the total number of piles. The result was then multiplied by 100 and the average was then taken. For example, for each household:

Respondent 1 3/4 = 0.75 x 100 = 75

Respondent 2 4/4 = 1.00 x 100 = 100 = Average score: 85

Respondent 3 4/5 = 0.80 x 100 = 80

HH rank No of subdivisions (piles)

Note: HH = household

Although the result of the transformation of ranks into scores provided numerical value, statistical applications other than mean were discourage. Caution should be taken in interpreting the results of this method as scores were all based from villager's perceptions and therefore should be treated as unique to that area alone.

Groupings can be defined by a value that corresponds to the well-being of the group. If the lowest group (poor) was assigned a value of 1 and value of 5 was assigned to represent the better off, the average score with highest value (i.e. 100) represented a household from the better off group and that was ranked consistently as better off in every trial.

Table 2.4 Average number of groups/socio-economic strata identified by key informants during the well being ranking exercise

Sites	Mean	Median	Mode	Min	Max
SEC	5.11	6	6	3.00	9.00
NET	4.5	4.5	4	4.00	6.00
RRD	4.67	5	6	3.00	6.00

Groupings of well-being scores

There are two ways of grouping the averages of the score to identify social strata; dividing the average scores using ***equal intervals*** (EI) and grouping the average using ***natural breaks*** (NB) (Grandin, 1994). **Equal intervals** can be obtained by subtracting the lowest score from the highest score and dividing by the desired number of groups:

$$\text{Equal Interval (EI)} = \frac{\text{(Highest score – Lowest score)}}{\text{Desired number of groups}}$$

Natural breaks can be obtained by scanning the list of arranged average scores from lowest to highest. The gaps or breaks between the average scores determine the natural breaks. Table 2.5 shows the gaps/breaks of the scores in the three sites. As presented, the only clear gaps common to the three countries were the last two breaks, 94, 96, 100, in SEC; 82, 92,100, in NET, and 89, 94, 100, in RRD. Most of the gaps were not very large therefore making it difficult to determine the natural breaks. For this reason the equal interval was used in this research to determine the average well-being groupings (Table 2.6).

Table 2.5 Natural Breaks in mean score of well-being ranking in the three sites

No. of break	SEC	NET	RRD
1	17 -18	20 – 25	19 – 21
2	20 – 81	29 – 30	23 – 27
3	83 – 85	33 – 38	29 – 34
4	87 – 90	42 – 50	36 – 44
5	92 – 94	53 – 55	46 – 64
6	96	58 – 71	66 – 83
7	100	75 – 82	85 – 89
8		88 – 92	92 – 94
9		100	100

Table 2.6 Groupings of well-being scores based on equal intervals (EI)

Sites	Social Strata				
	Very poor	Poor	Medium	Rich	Very rich
SEC	17 – 34	35 – 51	52-68	69 – 85	86 – 100
NET	20 – 36	37 – 52	53-68	69 - 84	85 – 100
RRD	19 – 35	36 – 51	52-67	68 - 83	84 – 100

2.6.1.2 Mapping Exercise

Mapping is one of the most widely used PRA tools (Chambers, 2003) amongst development and research organizations. It can illustrate spatial relationships within any community as they are perceived by the residents. It is a visual representation of the different land uses, physical and social features of the area being studied (Chambers, 1994b; Conroy, 2002; FAO, 2004). This PRA tool is multipurpose as it can be used in assessment, planning, baseline, monitoring as well as evaluation (FAO, 2004). Maps may also be used to visualize discussions enabling participants (including the illiterate) to see, comment and alter their physical representation of the situation (PEMT, 1993). Additionally, it can also lead into or be utilised in other PRA tools such as wellbeing ranking and resource flows (Chambers, 2003; Conroy, 2002). Maps are very useful within participatory activities because they not only help key informants to recall events, issues, and activities, but also help in making the whole process more relaxed (Chambers, 2003; Shah, 1990).

In this thesis, three types of mapping exercises were used: (1) village mapping (i.e. physical boundaries and resources available); (2) historical; and (3) social mapping. This mapping exercise was carried out in each community with the key informants (at least 9 key informants each village). Below are the descriptions of each of these mapping exercises.

Village and Resource Mapping

The main aim of this activity was to determine the awareness of the local people regarding the boundaries of their community and the available resources in their area. Furthermore, this activity also helped in understanding how local people value their resources and who can access such resources (Conroy, 2002; FAO, 2004). The presence or lacking of important resources can also be understood in this activity (SEAGA, 2004). This activity was carried out by brainstorming with the participants what constituted a 'resource'. This was followed by determining if certain resources were available in the area and identifying their location/position in the community by drawing the village map. This tended to stimulate participants to discuss the importance of each resource and its accessibility. This was noted by the researcher. The output of this activity is generally a rough diagram/sketch of the community with the different locations of resources (man-made and natural) indicated. Additionally, an output of this exercise was that key informants and other villagers were reminded of the resources that were lacking in their community. One constraint in doing this exercise with larger communities is that some resources are more likely to be missed by key informants (Simanowitz, 1999). Therefore asking key informants and even other groups to cross check the output of the exercise is a necessity.

Historical Mapping

Historical transect or timeline is a visualizing tool in PRA used to illustrate the key historical events and perceived changes (Chambers, 1994a, b; FAO, 2004; PEMT, 1993; Schönhuth and Kievelitz, 1994). The aim of this activity was to understand the changes/ events that happened in the village or in the area through time and how it has impacted on the general well being of the villagers. With this activity the researcher was able to understand the different shocks, development and changes in activity that had occurred in living memory in the village (FAO, 2004; PEMT, 1993).

In this thesis, historical mapping was carried out using a group of key informants* which included older villagers and some village officials. The activity was carried out by asking the key informants to recall the earliest period that they could remember when major events happened and affected village life. From this first question, key informants discussed the different events that they could remember. The name of the event and its result were then recorded on a big sheet of paper. To make sure the discussion continued, the facilitator asked the key informants to recall other events that had happened before and after the initially identified event. This recalling exercise continued until they reached the present period.

Outputs of this activity were presented in two ways (see example in appendix). Some of the key informants drew a line which started from the earliest time they could recall and the other end was the present. Periods and events that happened were illustrated along the line. An alternative way of presenting this activity was using a table. The first column showed the different dates and the second column described the events that had happened and what impact it had on the community. At the end of the process, both the researcher and the villagers understood the developments which had taken place in the community. The maps were left in the community to enable further reflection.

* Key informants are group of villagers who are knowledgeable on the issue/topic being discussed.

Social Mapping

The main purpose of this activity was to understand the distribution of different social strata in the village and the allocation of each member to a particular social strata (Mearns and Bayartsogt, 1994). The activity also showed any clustering of certain groups or if there were any families being excluded (FAO, 2004). This activity is usually done in relation or combination with well-being ranking (FAO, 2004) and participatory poverty assessment.

This PRA tool was conducted separately from the main PRA workshop. It was implemented during the longitudinal study (see section 2.6.3) to be able to determine where the monitoring households were located in relation to the rest of the community. It was carried out using a number of key informants who were familiar with the majority of the community members. Using a copy of the village map produced from previous community appraisal, key informants marked the places where the different households being monitored were living and indicated their relative level of wealth. Furthermore, households that were ranked poor during the wellbeing ranking were also marked in the map. The relative distance of the poor households to important resources can be determined using this type of mapping exercise. It also helped the researcher identify the potential target groups and areas in the village.

2.6.1.3 Focus group exercises

The third stage of the community appraisal involved working with focus groups (Figure 2.4). A focus group (FG) can be defined as group of individuals with a common or homogenous state of characteristics in question (Ashby, 1993, Chambers, 1994b; Fink, 1995; Lamug and Catalan, 1995), i.e. gender, well-being, farming system, location, occupation, etc. Morgan (1997), however, considered the focus group as a research method for collecting qualitative data and generating information through group discussion. Grouping people of the same characteristics has several purposes (Ashby *et al.,* 1993; IDS workshop, 1993; Norman *et al.,* 1993). Group discussion can lead to a better interaction and communication as well as empowerment (Bryman, 2001; IDS workshop, 1993). The focus group allows an opportunity for immediate feedback or clarifications (Clayton and Gorman, 1997). Separating poor and better-off or men and women for focus group exercises aims to encourage disadvantaged or marginalised groups to share their knowledge and perceptions. In a mixed-sex group discussion, men tend to dominate, often overshadowing the ideas of women (Bryman, 2001; SEAGA, 2004).

In this thesis, the term focus group refers to the earlier definition by Lamug and Catalan (1995). During the initial PRA, focus groups were created based on wellbeing and gender in order to understand the general perceptions on livelihoods amongst these groups. Using the results from the well-being ranking exercise, the representatives of both genders (men and women) and wellbeing (poor and better-off) were randomly selected. Names of households that were ranked consistently in the same well-being category i.e. poor and better-off, were identified and the head of the village was asked to randomly pick at least 10 names from each group (total of 20 names per village) using draw lots ('lottery'). The village headman was then asked to invite the villagers whose name were picked BUT making sure that an equal representation of men and women was maintained (at least 5 villagers from each gender group) (Table 2.7). Through this process, the PRA exercise was based on four social groups; poor men, poor women, better-off men, and better-off women in each community.

Table 2.7 Total number of participant during the PCA exercises

Site	Sub sites	No. of Villages	Participants: Poor Men	Poor Women	Better-off Men	Better-off Women	Total
SEC	LOW	3	40	55	42	45	182*
	DRY	3	15	28	27	17	87*
NET	LOW	3	16	17	15	17	65
	DRY	3	15	16	15	15	61
RDD	LOW	3	15	18	15	16	64
	DRY	3	15	12	14	15	56

*To avoid conflict (jealousy) among the villagers, some villagers who voluntarily came to the PRA place were allowed to joined in groups were they belong.

2.6.1.4 Resource mapping

Similar to village mapping, resource mapping was used to determine the awareness of the local community about the various resources available in their area and how they value such resource (Conroy, 2002; FAO, 2004; Mascarenhas and Kumar, 1991; SEAGA, 2004; Willmer and Ketzis, 1998). This PRA tool has been widely used by researchers and development organization especially those focusing on gender issues to determine the gap between ownership and accessibility of different resource by men and women (Buenavista *et al.,* 1994; Mascarenhas and Kumar, 1991; SEAGA, 2004; Willmer and Ketzis, 1998).

This mapping exercise was not part of the original community appraisal of the thesis, rather an additional activity during the longitudinal study to determine gender and wellbeing differences in terms of access to resources. Results of this PRA tool are presented in Chapter 3. As this activity was carried out during the longitudinal study, participants from this exercise were mainly those households that were being monitored. Participants still remained grouped according to gender to assess the difference of perceptions on access between gender groups. The distribution of respondents based on gender is presented in Table 2.8.

Table 2.8 Summary table of participants during the resource mapping activity

Sites	AEZ	Village Nos.	Groups Men	Women
SEC	LOW	4	20	20
	DRY	2	10	10
NET	LOW	3	15	15
	DRY	3	15	15
RRD	LOW	3	12	9
	DRY	3	12	9

2.6.1.5 Seasonal Calendars

The main purpose of the seasonal calendar was to explore changes in the livelihood systems of focus group participants over a one year period (Chambers, 1994b; FAO, 2004; SEAGA, 2004). Conroy (2002) described the seasonal calendar as a tool to show temporal dimension of resource use. This tool acts a diagram of various activities, problems and opportunities as well as the as climatic condition in the community as perceived by local people themselves. The information gained through seasonal calendars helped the planning and implementation of any intervention programmes.

Four focus groups (poor men, poor women, better-off men, and better-off women) in each village (6 villages/ site) carried out a seasonal calendar exercise. A checklist of topics was given to the facilitator to guide the group discussion. The discussion was focused on the following topics; climatic changes, social and religious activities, economic activities, migration, income and expenditures and health conditions.

The seasonal calendar was initiated around provision of an empty matrix and asking the group members to discuss how they wanted to start their calendar. The international calendar, i.e. January as the first month, was not usually followed in this exercise as participants were more accustomed to local calendars related to lunar cycles or agricultural activities. The next step was listing the different information on the first column of the matrix. The weather was always being listed first as it somehow related to different economic activities. Discussions were then started until all the blocks in the matrix were filled with relevant information. At the end of exercise, the group members become aware and agreed on the information about the situation during the year regarding the different aspects of their livelihoods. A presentation of the outputs from this activity was made to gain consensus whilst at the same time understanding variations in perceptions amongst or between groups.

2.6.1.6 Ranking and scoring

Ranking and scoring techniques are tools commonly used to determine the relative importance of particular issues (Conroy, 2002; Pretty *et al.,* 1995; PEMT, 1993). They may also be used to indicate the priorities of local people (FAO, 2004; Fielding *et al.,* 1998; Schönhuth and Kievelitz, 1994; SEAGA, 2004). In social research, these methods are useful devices in determining the relative order among objects or judgements (Frankfort-Nachmias and Nachmias, 1997). Aside from knowing which are important, ranking and scoring tools can also elicit the underlying factors or criteria affecting the importance of resources or issues being classified (FAO, 2004; Mearns *et al.,* 1994; Pretty *et al.,* 1995; SEAGA, 2004). Scoring has a similar objective with ranks, however, scoring does not only show order of importance but it also provides some indication of relative importance of one object/subject from another, based on score differences.

In this research, ranking and scoring were used in several ways in the focus groups and also during the longitudinal study. During the main community appraisal, scoring of important activities and identification of important aquatic animals was carried out. Ranking of important aquatic resources and their benefits were carried out during the longitudinal study.

The ranking/scoring exercise were conducted by first enumerating relevant information regarding key topics such as different activities common in the community, species of aquatic animals for AA ranking, criteria of importance for AA, etc. The next step was to ask the participants to discuss among themselves each of the items listed and start ranking them in order based on their perception of importance. Beans were used as counters to allocate relative values and participants were asked to distribute the beans to different items listed; the item with more beans representing higher importance, and those with least, low importance. After all the beans had been distributed to the different items, discussions among participants were encouraged and final redistribution of the beans was done until a consensus was reached.

2.6.1.7 Community workshops

Community workshops at the end of the appraisal were an important activity as they allowed triangulation and validation of the results generated from key informants and focus groups interviews and exercises (PEMT, 1993; Smucker *et al.,* 2004) as well as the bigger part of the community (Pretty *et al.,* 1995). At the end of the PRA exercises, representatives from the different groups were asked to present their group outputs to the community in order to clarify findings that may have contradicted one another between groups, thus cross-checking the validity of the results. A small village workshop was also conducted in each village after the research team had collated and summarized all the information during the exercise. Such workshops, apart from being an important opportunity to cross-check information, created an early opportunity to share results and discuss implications with the community as a whole (Smucker *et al.,* 2004).

2.6.2 Cross-sectional survey

A cross-sectional survey is the predominant survey design employed in social science research (Frankfort-Nachmias and Nachmias, 1997) and is often called an applied social survey (Bryman, 1992). This type of survey entails the collection of data from individual respondents at one point in time (Goldstein, 1979; Punch, 2003) in order to collect a body of quantitative and qualitative information in relation to a number of variables (Bryman, 2001). The researcher using this approach is interested mainly in variation of several types of variables (e.g. families, organization, gender, etc). This approach usually requires a larger number of samples as it more likely to encounter differences in all variables (Bryman, 2001). The limitation of a cross sectional survey however, is it can only compare data between variables regardless of time (Bryman, 2001; Frankfort-Nachmias and Nachmias, 1997). Trends in variables are very difficult to generate using this type of approach.

2.6.2.1 Background survey

In this thesis, a background survey was used in order to describe quantitatively the various types of aquatic systems as well as the current situation of household livelihoods in the target communities. The interviews were focused on two main topics; social and ecological information. The social part of the interview included information regarding the households' overall livelihood and the ecological part of the interview covered all aspects related to aquatic systems (physical, biological and management). A checklist of information collected in the survey is given in Table 2.9.

Table 2.9 Checklist of information collected during the background survey

Info category	Information
Human capital	Age, gender, education, occupation (primary and secondary), number of household member, health status, other skills
Social capital	Membership of organizations, benefits received from institutions
Natural capital	Land area, aquatic systems (types and area), draft animals
Financial capital	Income, savings, credit, and remittances
Physical capital	Houses and appliances, transport, fishing, farming equipment, rice mill and shops
Access	Ownership of aquatic system, irrigation and other water sources, access to common property, access to credit
Livelihood strategies	Migration Business and other sources of income
Management	Years of experience in managing aquatic system Physical profile of the system Stocking practices (including species, sources of seeds; mode of acquiring) Management practices (attitudes towards SRS) Collection/harvesting practices Important AA collected

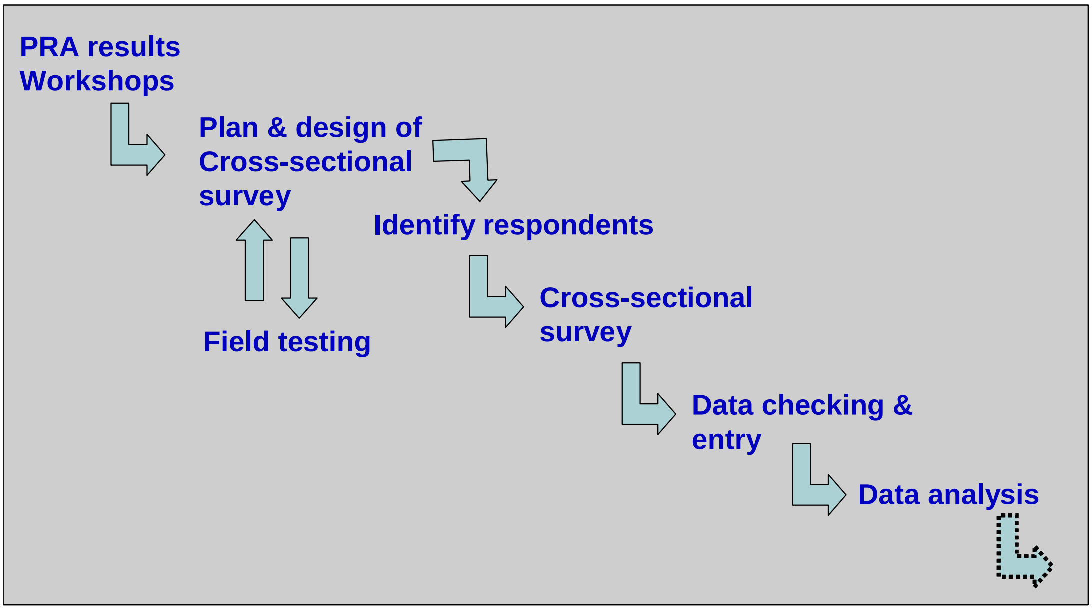


Figure 2.5. Chronology of the different activities during the background survey

Outputs from participatory community appraisals from all the three countries were reviewed and analysed at a regional workshop (Figure 2.5). The results were reviewed and presented to a larger community of researchers and development organizations (Islam, 2002). Some of the recommendations from this workshop included gaining a better understanding of various types of aquatic systems accessible to poor and addressing aquatic systems in an integrated way. Taking these recommendations on board, the cross-sectional survey was planned and designed. Questionnaires were field tested and orientation with the enumerator was conducted in order to ensure that a common understanding was established to minimise variability. A total of 30 respondents from each village (6 villages per country) were interviewed in this survey. The survey was conducted simultaneously in all three sites between late August 2001 and February 2002. Individual households were visited by field staff and information collected using semi-structured questionnaires (see Appendix 10). During this period, data checking and clarification also took place as well as preliminary data analysis. The result of cross sectional data led to a broader understanding of the various types of aquatic systems in rural areas. The next stage of the research (the longitudinal survey) was based on this output (Figure 2.6 in section 2.6.3).

Respondents were selected based largely on the needs of the study (Frankfort-Nachmias and Nachmias, 1997) i.e. to ensure that the respondent had an understanding of the different aquatic systems present in the community. Two approaches for identifying respondents were implemented in this research; targeted (focused) using proportional stratified sampling (Blalock, 1979) or in recent literature this approach is referred to quota sampling (Fink, 1995; Frankfort-Nachmias and Nachmias, 1997; Little, 2003) and random (i.e. not necessarily farmers) (Table 2.10). The target sampling was limited to fish producers whom the village headman had identified and that practiced conventional aquaculture i.e. stocking hatchery produced seed. The randomly identified respondents were those selected from the complete list of households held by the village headman. Randomly identified respondents were included to capture other management systems aside from conventional aquaculture. In this way also, any bias relationships between identified respondents and key informants was minimised. However, in locations where more than 50% of the households practiced conventional aquaculture, no target respondents were selected. After determining the total number of target respondents (maximum of 10 households), the number of random respondents were identified by subtracting the number of target respondents from 30 (the total number of respondents per village). Systematic sampling (Dytham, 2003) was then applied to identify the remaining respondents from the list of households. A total of 30 respondents were identified in each village.

Table 2.10 Summary of respondents during the background survey

Site	AEZ (sub-sites)	No. of Village	Type of Respondents		Total
			Random	Focused	
SEC	LOW	4	102	18	120
	DRY	2	53	7	60
NET	LOW	3	51	39	90
	DRY	3	59	31	90
RDD	LOW	3	58	32	90
	DRY	3	61	29	90

2.6.2.2 Market visits

Markets are the final destination of the commodity (Kleih *et al.,* 2003) before reaching the households which is the final destination on the production chain. Markets of different types can be found at village, commune, district and urban locations. Market assessment is vital to gather information regarding buyers and sellers, the prices of commodities etc (Kleih *et al*., 2003). Markets were assessed through direct single visits and the information gathered was related to quantity and quality of vendors and availability of food and other household goods which complemented the longitudinal study. The number of markets visited varied according to locality (Table 2.11).

Market locations mentioned in the longitudinal study were visited. During the visits, the research and field staff collected two main pieces of information: (1) the number of vendors selling aquatic animals compared to meat, vegetables and processed AA; and (2) the prices and types of aquatic animals available in the market (see Appendix for the checklist used in those visits). Further detailed individual interviews with market vendors were not carried out due to time and budget limitations.

Table 2.11. Number of market visited

Site	No. of market visited	Type of market
SEC	1	Provincial
	5	District
	1	Commune
NET	6	District
RRD	4	Village
	5	Commune
	3	District

2.6.3 Longitudinal survey (Household monitoring)

A longitudinal study is defined as a survey approach undertaken with the same individual/households measured or information collected repeatedly through time (Diggle *et. al.*, 2002; Goldstein, 1979; Punch, 2003). Lambert (2005) presented five approaches of longitudinal data analysis namely; repeated cross-sections, cohort studies, event history, time series, and panel studies. Household monitoring is commonly termed by most sociologists and economists as a panel study (Goldstein, 1979; Diggle *et al*. 2002). The main purpose of using this approach in social research is to map social changes (Bryman, 2001). Frankfort-Nachmias and Nachmias (1997) stated that panel survey designs are a more rigorous solution to the time dilemma in cross-sectional surveys. Bryman (2001) suggests that longitudinal designs can allow insights into the time order of the variables and subsequently allows the researcher to chart trends and connections over time. The use of this type of research approach has often been limited, not only because of time and cost requirements but also due to the difficulty of recruiting respondents to commit to such long term survey (Bryman, 2001).

The main purpose of employing this approach in this thesis was to understand the livelihood strategies of households with different aquatic resources over a period of

12 months, to gain specific understanding of seasonal or monthly variations in keyl aspects of their livelihoods. There were five main areas of information collected during this approach; (1) activities of household members (on, off, and non-farming), (2) management of aquatic resources, (3) collection of aquatic animals, (4) food consumption, and (5) household income and expenditure information. These variables are presented in Table 2.12

Table 2.12 Checklist of information collected during the household monitoring (longitudinal study). All information was based on seven day recall.

Variables	Descriptions
Farming activities	• All activities conducted on-farm and off-farm • Who is doing what (men, women, children) • Time spent, and frequency of doing different activities • Purpose of activities
Non-farming activities	• All activities not related to farming • Purpose of doing the activity • Location where the activity conducted • Participation of different gender and age groups • Benefits of doing the non-farm act
Food consumption	• Type of food consumed by household • Amount of different food groups consumed • Sources of food, particularly AA
Income and expenses	• Total amount of income and expenses in the household • Contribution of different gender groups and ages to expenses and income • Different sources of income (on-farm, non-farm, remittances)
Social and health status	• Include all social and religious activities • Participation of different gender and age group • Record of household members who suffered ill health during the period • Occurrence of illness by gender and age
AA management	• All activities related to aquatic resource management • Distribution of activities among gender and age groups (men, women, children) • Time spent and frequency
Collection of AA	• Location of collection, type of aquatic system • Quantity of aquatic animals collected • Utilization of AA • Fishing gear being used • Participation of different genders and ages in collection

The longitudinal study was carried out after the background survey had been completed and analysed. Figure 2.6 illustrates the chronology of activities.

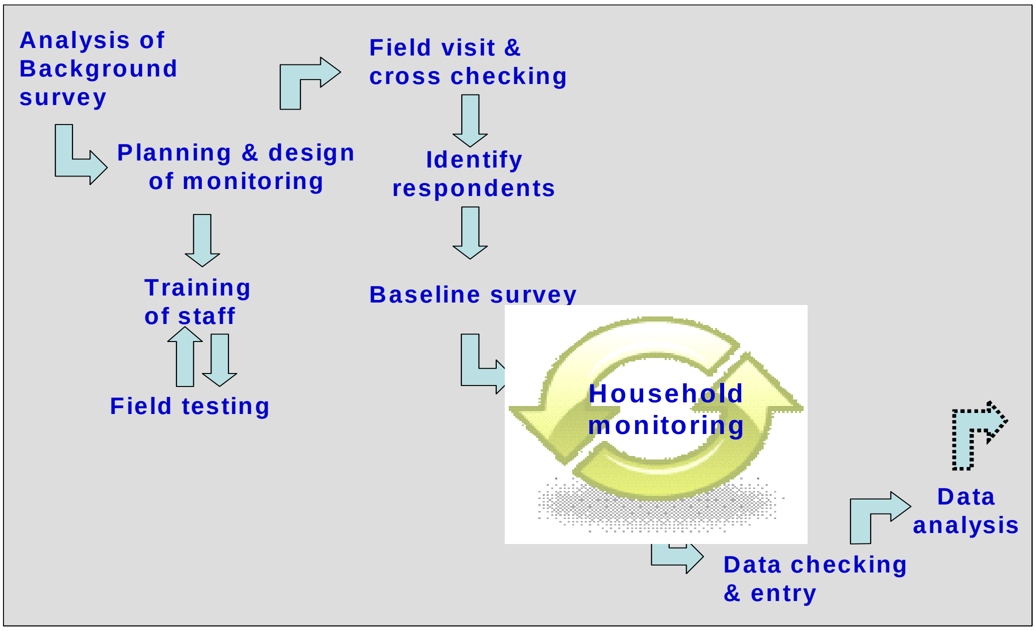


Figure 2.6. Chronology of activities during the longitudinal study

Based on the results of the background survey (2.6.2), the various types of aquatic systems that households possessed or had accessed were identified. The preliminary findings were used in designing and planning the subsequent research activities. Semi-structured questionnaires were developed based on information collected during the background survey. Prior to field testing, local field staff members were trained both theoretically and in the field. The field-based training took place at the same time as questionnaires were being field tested. In each study site, field visits were repeated to coordinate and make research agreements with the households participating in the 12 month survey. Frankfort-Nachmias and Nachmias (1997) reported that the main problem of panel studies is obtaining representatives who are willing to be interviewed at a set interval over an extended period. This was taken into consideration and therefore was used as additional criteria in selecting respondents i.e. willingness to participate and unlikely to migrate. The field visit also enabled the researcher to cross-check the study area as well as the availability of aquatic systems. Households that were found unsuitable at this stage or not committed to participation were replaced by other households with similar characteristics.

A total of 54 households were identified in each site. In each site, respondents were divided from two agroecological zones (LOW and DRY respectively). There were a maximum of 27 respondents in each sub-site for the six villages in each site (9 respondents/village x 6 villages = 54). Respondents were selected based mainly on the availability of different aquatic systems. However other criteria were also employed to ensure representation of different socio-economic and gender groups. As representation of the various types of farmer-managed aquatic systems (FMAS) was the main criteria used, proportional stratified sampling (Blalock, 1979; Fink, 1995; Frankfort-Nachmias and Nachmias, 1997) was employed; as a consequence the number of households monitored under each type of aquatic system was not the same. Little (2003) classified this type of approach as “quota sampling”. The unbalanced number of respondents indicates the dominance of a particular aquatic system in a given area. Although the researcher was aware that the larger the sample size, the less the standard error (Fink, 1995), the total number of respondents for this part of the research was restricted to 54 due to time, budget and logistical considerations. The distribution of households in the longitudinal study is presented in Table 2.13.

A semi-structured questionnaire was used in this survey (see Appendix) to collect the information needed to understand the seasonal behaviour of different households in the study sites. Initial visits to the 54 households and formal agreement of the schedule of the 12 months longitudinal study took place during the first quarter of 2002 (February in NET; March in SEC; and April in RRD).

Table 2.13 Distribution of households who participated during the longitudinal study

Country	Agro-ecological zone	Type of system I	II	III	IV	Total
SEC	LOW	-	28	7	1	36
	DRY	7	11	-	-	18
NET	LOW	4	2	5	16	27
	DRY	3	2	5	17	27
RRD	LOW	6	21	-	-	27
	DRY	8	19	-	-	27

Note: Type of systems: Type I = household with rice fields (RF) only; Type II = household with culture pond (CP) or household pond (HHP, Cambodia) + RF; Type III = household with culture pond or household pond + trap pond (TP) + RF; Type IV = household with trap pond + RF

The first round of monitoring was used to collect baseline information from each household. Thereafter, regular visits (every month) were carried out by the field staff, and in some cases with the researcher, to the households participating in the study. Similar questions were asked during each visit. During the appointments, an attempt to ensure the same member of the household responded, whenever possible. However in some cases, particular household members involved in specific activities were also interviewed, particularly when collection and utilization of aquatic animals was concerned.

The information collected during the duration of the longitudinal study was based on the previous seven days using participant recall (see section 2.6.4). Skinner (2003) suggested that aside from incomplete data, recall error is very common in retrospective measurement in longitudinal study. Visuals like village maps, farm maps and local measuring devices (stick and bowls) were used in the data collection to help households in remembering the relevant informations such as the location of different activities, amount of collection and consumption and so on (Chambers, 2003; Garaway, 1999; Shah, 1994). The initial interview took longer as the households needed to draw their own farm maps. Subsequent monthly interviews did not last longer than one hour.

At the end of the 12-month study, summarised information was fed back to the whole community. This was done through a series of village workshops in all study villages (6 villages/site). This allowed all information collected to be verified, triangulated and a broader awareness of the research among other community members created. One part of the workshop led to a planning exercise for the aquatic resources in the village, based on the information presented to the community. Aquatic systems in the area were identified and villagers discussed potential approaches to sustain or improve them. Resource users and villagers who could potentially manage such systems were also identified. This then led to the next phase of the research (Little *et al.,* 2004).

2.6.4 Methods used in data collection

Most of the information collected during the longitudinal study and cross-sectional survey was based on recall and estimation. Taking actual measurements from individual households in the field was difficult in practice considering the volume of information being collected and the frequency of collection. Moreover, most of the households were busy with household or farming activities.

2.6.4.1 Recall method

Recall is an approach to collecting information based on the respondent's ability to remember the information for a given topic being asked for over given time frame

(Hankin *et al.,* 1975; Lemmens *et al.,* 1988). These methods are applied to the consumption data and usually referred to consumption within the last 24-hours. However, due to the limitation of 24-hr recall not capturing the diversity of information (Swindale and Ohri-Vachaspati, 2004) i.e. food, activities, and collection, the period over which recall was used was increased to seven days to capture the "usual" range of behavioural information (Gibson *et al.,* 2003).

2.6.4.2 Estimating weight of aquatic animals

Fishermen, aquatic animal buyers and household members in charge of preparing food can typically estimate the sizes and weight of aquatic animals they have eaten or caught (Garaway, 1999). As mentioned in the introduction of this sub-section, direct measurement of the amount of aquatic animals collected and consumed by households was not undertaken due to time and logistical constraints. Therefore household estimates were used in this study. To aid households/farmers in estimating the amount of aquatic animals they collected or consumed, measuring sticks and bowls were employed in this part of the research.

2.6.4.3 Computation of Net Income

Income is one of the most tangible outcomes of different livelihood strategies. It is therefore very important to estimate the net income of households from all the three sites in order to compare and understand the importance of available resources particularly the aquatic resource in the improvement and sustainance of livelihoods. The computation of net income was mainly based on the total income and expenses incurred by all members of the households during the duration of the study. Both income and expenses were recorded based on the last seven days prior to the survey period.

NET = total income – total expenses; where:

Total income includes all the combined money received by the households from different sort of activity (farming, non-farm, and off-farming) including remittances from other family members working away from home. Total expenses include all sources of expenditures by all members of the households.

2.6.4.4 Computation of fishing effort (FE)

The computation of fishing effort (FE) was done in order to determine the catch per unit effort (CPUE) which is commonly used as an indicator of aquatic animal abundance (Bannerot and Austin, 1983). The calculation of fishing effort (FE) was based on Amilhat (2006) which was basically calculated using the time spent in fishing/collecting AA and the frequency of vist made in a week.

FE = time spent in hours/ household member/ frequency of visit, where:

Time spent refers to the duration of time the individual household spent away from their house collecting aquatic animals. This also includes the time spent preparing or setting fishing traps. Frequency of visit on the other hand refers to the number of times the household carried out fishing activities in the duration of 1 week.

2.7 Processing and Utilization of information

Although different approaches were used in each particular phase of the research, outputs of each stage have contributed to different sections of the thesis. Such combination and utilization of different types of information towards a common hypothesis demonstrates how qualitative and quantitative methods can support one another. Table 2.14 illustrates the different approaches used in this research and where the relevant outputs were utilized in particular chapter of this thesis.

Table 2.14 Summary of all the activities employed in the research and how these informations were utilized in writing the thesis.

Approach	Unit of analysis	Purpose	Described in chapter(s)	Results presented in chapter(s)
Wealth ranking	Household level, village	▪ Define socio-economic composition of the area ▪ Define target groups	2	3
PRA techniques	Village, groups	▪ Define livelihoods situation ▪ Site selection	2	3 and 4
Background interview	Household level	▪ Understand different aquatic systems ▪ Define target households	2	3 and 4
Resource mapping	Group, village level	▪ Utilization and access to different aquatic systems ▪ Understand the benefits from the system	2 and 4	4
Household monitoring	Individuals, household	▪ Seasonality of aquatic animals ▪ Collection and utilization of AA	2, 3 and 4	2,3 and 4
Market visit	Community, village	▪ Contribution of aquatic animals as available food	2	4

The different sets of data were processed following data entry into the computer (Figure 2.7 and Figure 2.8). Several software programs were used in data organisation, storage and analysis (Excel, Foxpro database and SPSS). During the cross-sectional survey, data gathered were entered directly into Excel program where a similar design of spreadsheet was used at all three sites. Some reorganisation was required prior to the combination of all the information into one spreadsheet. After making sure that all data were in the same format, Excel was used for exploratory data analysis and SPSS version 11 for more advanced computations after import of Excel files.

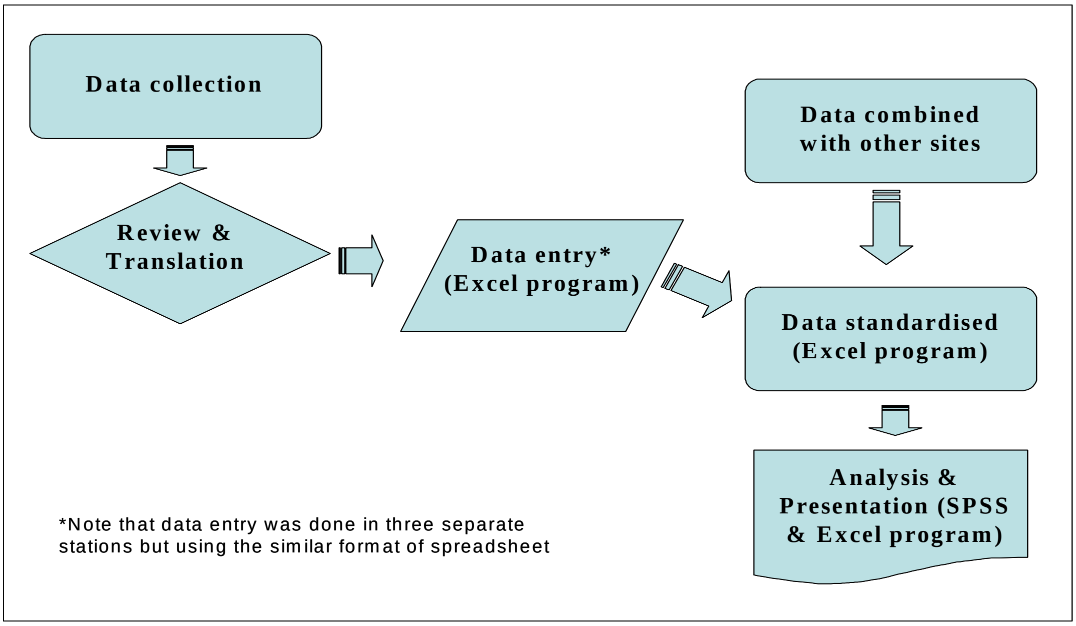


Figure 2.7. Pipeline for data processing during the cross-sectional survey.

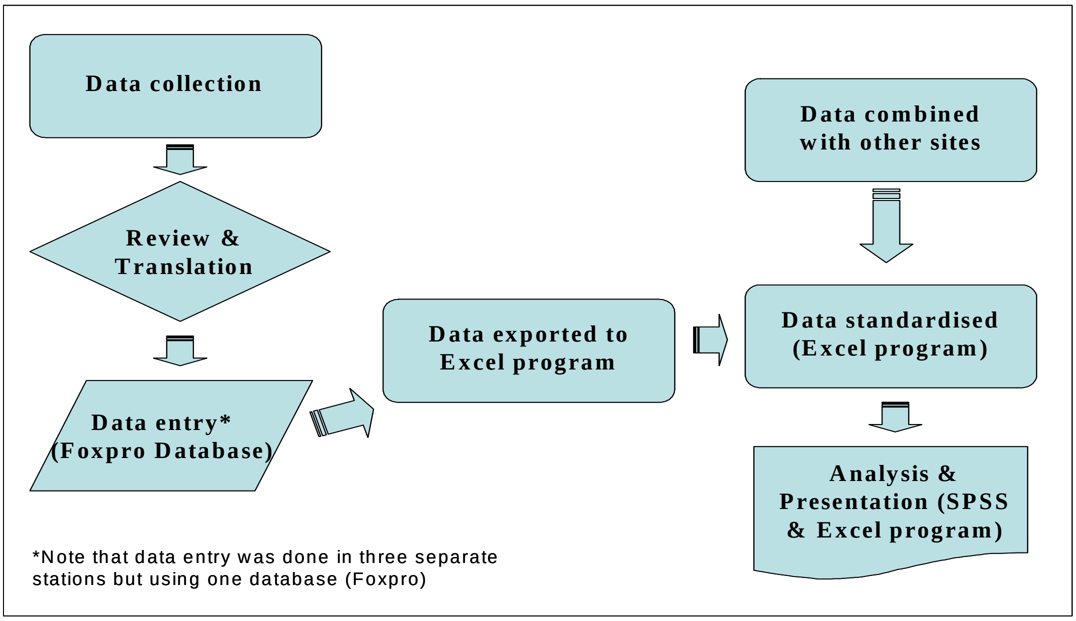


Figure 2.8. Pipeline of data processing during the longitudinal study.

Considering the problems encountered with the data during the cross-sectional study and partly the intention of the main SRS project, a database was created for the information that were collected from the longitudinal survey. The advantage of the databased was that uniformity of the spreadsheet was maintained and therefore combining all the datasets from the three sites was not a problem. After all the information were entered in the database, the data were then exported into Excel for further checking and exploration. Standardization of the data was done in Excel thereby preserving the original information in the database. Once all the information were standardized, relevant information were then exported to SPSS for statistical analysis. Both SPSS and Excel program (pivot table command) were used in producing graphs for the manuscript.

2.8 Statistical analysis

The data generated during the PRA particularly the scoring activities, was analyzed using SPSS 11 software. Where the distribution was normal, quantitative data were analysed using parametric tests such as the general linear model (GLM), to analyse differences between both sites and groups within each sites. Categorical data was tested using non-parametric tests such as Friedman's test and Spearman's rank test (Field and Hole, 2003). Descriptive summaries were also carried out for most of the PRA activities.

As several types of data were collected during the cross-sectional survey, both parametric and non-parametric tests were used. Similar tests were employed with the longitudinal study data, however there were some variables that were specific to individual areas, i.e. the poor group in SEC site were not comparable with the poor group of NET nor RRD sites. Therefore these variables were grouped/nested under specific variables (Horton, 1978). Nesting of some of the variables is necessary to ensure that the particular type of household was being compared to another group of households. The statistical tests such as GLM, chi square (χ^2) and comparison of means were commonly applied to assess any significant difference between test groups and also to understand the different factors causing these differences.

2.8.1 Key factors

In general, four main variables were initially the focus of the data analysis (site, AEZ (sub-site), months and wealth ranks). However, as the approach was sequential and participatory, other variables emerged and were subsequently considered in the analysis. Due to the sequential approach and flexibility of the research design, secondary variables were mostly unbalanced. These add-up variables were originally responses from some of the questions during the cross-sectional data. Table 2.15 shows the different variables used in the analysis.

Table 2.15 Different variables tested and used during the study

Factors	Variables	Type of data
Sites	SEC, NET, and RRD	Balanced
AEZ	LOW and DRY	Balanced
Village	6 per country	Balanced
Months	January - December	Balanced
Wealth rank	Poor and Better-off	Unbalanced
Farming system	Type I - IV	Unbalanced
Age and Gender	Male, Female and Children	Unbalanced
Household type	Stocking and non-stocking	Unbalanced

2.8.2 Data exploration

The first step that was employed after the standardisation process was data exploration. During this process, data was tested for normality. Transformation (e.g. natural log) of data to normalize the distribution (Field, 2005) was used where appropriate. This process is essential as it helps to determine whether the result of the analysis is robust or not (Osborne, 2002). Values that were considered very different to others, i.e. outliers (Field, 2005), were usually omitted as it would change the result of the analysis drastically if included.

2.8.3 Statistical models

A number of main models were used in analyzing the quantitative data in this research, particularly the parametric data (Field, 2005). To test the level of significance of the variations, a generalized linear model (GLM) was used. In this test all possible factors that could influence the value of the dependent variable (DV) were included in the model.

The following section presents the actual syntax/ program used in executing the data analysis from the different sets of data i.e. cross sectional and longitudinal. The symbol "( )" represents nesting of variables and the symbol "*" represents interaction between variables. For example, in testing the difference of amount of AA consumed, design I should be read as follows: the main factors are country, AEZ, wealth, village that is nested with country and AEZ, households that is nested with village, country and AEZ. Two-way and three-way interactions were employed.

<u>Analysis for cross-sectional data:</u>

Dependent variable (DV) by country AEZ wealth village household

Design I: country AEZ wealth village (country*AEZ) household (village*country*AEZ) 2 way interaction 3 way interaction

Design II: AEZ wealth village (AEZ) household (village*AEZ) 2 way interaction 3 way interaction

Analysis for longitudinal data:

Dependent variable (DV) BY country months AEZ wealth village household

Design I: country months AEZ wealth village (country*AEZ) household (country*AEZ*wealth*village) 2 way interactions 3 way interactions 4 way interactions

Design II: AEZ months wealth village (AEZ) household (village*AEZ*wealth) 2 way interaction 3 way interactions

Nesting relevant variables i.e. village nested with country and AEZ and household nested with country, AEZ, wealth and village was the key element in this analysis particularly in running tests using longitudinal data. Through this technique, individual households were observed over a particular time. If the variables were not nested, then households would have been pooled together (Horton, 1978) therefore disregarding the wealth, AEZ and the village where the household belonged. In this case the test can be considered as a conventional repeated measure ANOVA.

2.8.4 Unit of analysis

The three most common units of measurement, analysis and presentation of the outputs of this study are (1) *per* household, (2) adult equivalents units (AEU), and (3) *per* capita. The *per* household (hh^{-1}) unit was used to present information regarding the household as a single unit such as AA harvest/collection data (total catch in kg/ household/ visit) or the total farm production in certain period of the year. The individual unit was used in presenting information that considered the contribution of different genders and age groups such as the time spent performing activities such as farming and fishing. The *per* capita ($capita^{-1}$) unit was used in presenting information from the household and took into account the total number of household members. The *per* adult equivalent units (AEU^{-1}) was used to present the information for the households taking into consideration the age and gender of all members of the household (Deaton and Muellbauer, 1986).

Using the above research methods and analysis, this thesis generated a very broad understanding of the importance of aquatic animals, especially SRS within the livelihoods of rural households in Southeast Asia which are presented in the succeeding chapters (3 and 4).

2.9 Critique of methodology used

In pursuit of understanding the overall livelihoods of the community in the rural areas, several research approaches were employed in this thesis. This section critically reviews the different methodologies and approaches used. Moreover, the strength and effectiveness of combining different research approaches is also highlighted in this section.

2.9.1 Participatory rural appraisal

The use of participatory rural appraisal (PRA) in this thesis has enabled villagers to share in the analysis of their knowledge of life and conditions. The use of such activities can lead rural people to be able to plan and act to improve their situations (Chambers, 1992). From a research perspective, the outputs of these exercises used in an exploratory way provided a broader understanding of the local situation (political, social, and natural) and also guided the researcher in developing further research activities and developing more appropriate questions (Gladwin *et. al.,* 2002). The use of such a participatory approach also enabled this research to involve a large number of the members of the community in a very limited time (five days) and at minimal expense. A major criticism of PRA is that expectations of open and equitable participation are rarely met (Arasu, 1997; Cornwall and Pratt, 2003; Leurs, 1996; Mosse, 1994), although in this study a more systematic approach to identify participants for the PRA were employed. Pretty (1996) identified six types of participation and amongst those, this thesis employed the interactive type of participation where the exercise was used as the first stage of a longer participative process. Farmers were involved in joint analysis that eventually led to action planning and later on practical implementation.

PRA, as defined several times already, encompasses a growing family of approaches and methods (Chambers, 1992), of which several were used in a standardised portfolio that attempted to reconcile the need for openness of questioning with a structured approach that would permit comparison of, and learning between, sites, communities, social groups and individuals. Participatory ranking and scoring were among the tools used that generated numeric information, moreover, similarities and differences amongst social groups in terms of preference were elucidated, contesting the claims of many critics that PRA could not produce numeric data (Barahona and Levy, 2002). A common criticism of PRA is that only similarities within and between observations are sought and interesting variability is ignored (Gladwin *et al.,* 2002). Community workshops being carried out after the community appraisal created a good rapport with the community as a whole and eventually resulted in smoother implementation of further research. People in the community were particularly interested in knowing what outside researchers had found out and their interpretation of the local situation in order for them to plan and implement actions (if necessary) in pursuit of more sustainable livelihoods. The activity of triangulation through workshops or participatory fora not only clarified issues and contradictions in the data collected from focus groups and key informants but possibly also empowered the local community who were involved in the process (Smucker *et al.,* 2004).

The orientation and training of local staff in carrying out participatory methods improved the capacity of the local staff in facilitating such approaches. This orientation also helped in making sure that the different participatory tools were employed in more or less a similar way and reduced errors associated with data collection (Morales *et al.,* 2003).

2.9.2 Well-being ranking

Understanding the socio-economic context of a given community can be achieved in different ways. Participatory approaches such as the well-being ranking technique certainly provide enough information on the socio-economic composition of a community and can produce a holistic view of household well-being (Conway, 1999). Moreover, well-being ranking also helped to understand how local community members with different economic and political status perceive well-being. Local community members' perception of well-being were different between countries but not between gender within the country. Criteria used by local community members - key informants - were influenced by the local situation. In general, 'livelihood strategies' or the source of income for a household was the main criteria used by local community members. Poorer households tended to have more limited livelihood options. Comparing wellbeing levels across villages within the country is possible provided that the villages are within the same socio-economic level (rural, peri-urban, or urban). Comparing the results of well-being ranks across countries is, however, unacceptable due to differences in socio-economic and political status of the areas. Interpreting results of well-being exercises should be treated with caution and well-being characteristics should be considered unique in each area and situation.

Limitations of well-being ranking

Well-being ranking is a technique that can be used by any group of people, researchers or developmental organization to understand the socio-economic situation of a specific community. There are however, some issues that need to be considered when applying this technique. These are discussed below.

Total number of community inhabitants

It can be difficult to rank households within a community with a large number of members. In practice it was found that key informants found it difficult to recall and compare 200 or more households. It is therefore more appropriate to use this technique in communities with relatively few households. Well-being ranking in Vietnam therefore took place in sub-villages or hamlets.

Economic status of the community

Well-being ranking is most practical in rural communities that tend to be more cohesive. Such ranking by key informants is also more likely to be useful as livelihood activities are more likely to be based within or near the village and regular, casual social interactions more likely. This situation is very unlikely to happen in an urban area where most of the households' residence and economic activities are less likely to be located in the same area.

Clarity and reliability of household list

Before any ranking technique is performed, the list of households should be verified with the key informants. Familiarity of the key informants with formal names of the households is also a key issue in this exercise as voters' or residential lists tend to usually use formal names that key informants may not be familiar with. Long term migration of some households should also be considered particularly if the voters list is used in this exercise.

2.9.3 Sustainable Livelihood analysis framework

Several forms of livelihood framework exist and are used by developmental, research, and multilateral organizations (Carney *et al.,* 1999; de Haan and Zoomers, 2005; DFID, 1999; Murray, 2001; Nicol, 2000; Norton and Foster, 2001; Scoones, 1998; Solesbury, 2003). The livelihood analysis used in this study was mainly based on that described by DFID (1999) and Scoones (1998).

As this thesis was conducted as part of a bigger DFID research project (SRS in Aquaculture, R7917), the analysis focused on the producer household level and how SRS species influenced the maintenance or improvement of the different livelihood capitals of these households. However, there are some aspects of the livelihood framework (e.g. institutions) that were not investigated thoroughly and very limited information was generated.

2.9.4 Cross-sectional survey

The cross sectional survey provided a fairly detailed overview of the current situation regarding aquatic systems at all the study sites. However, the data collected only represented the situation at the time and could not be extrapolated to other times of the year. The closed, structured nature of this form of enquiry was also extractive by nature and its contribution to building rapport with the local community was limited.

2.9.5 Longitudinal study

The longitudinal or household panel study was able to provide information regarding seasonal variation. Identification of respondents appropriate for participation for a long duration survey such as this one is a critical step. Rapport and trust need to be built between the respondents and enumerator. On the other hand, confidence was built through the required regular visits.

2.9.6 Recall method and estimates

Recall methods were central in the collection of data regarding time spent on different activities, the amounts of aquatic animals harvested and consumed, income and expenses, most food consumption. The use of visual aids such as "fish sticks and bowls (Garaway, 1999), and maps helped respondents in recalling the information requested. Exact distribution of amounts consumed, spent or earned by each member of the family requires direct measurement (Garaway, 1999) which is highly costly, intrusive and not a practical option for this type of study. However, comparing estimates of amounts between household is also misleading considering that the composition of households (e.g. number of male and female members, number of children, number of unable to work) also varies between households. The use of per capita and adult equivalents in presenting consumption and expenditure was considered the closest estimate to reality and therefore were used in this thesis.

Asking sensitive questions and securing accurate responses is a major challenge in studies of this type as some level of respondent apprehension can lead to misleading information. However, mixed methods approach has improved the analytical strengths of studies seeking such personal information (Sandelowski, 2000).

2.9.7 Language and translation

The relatively wide geographic focus of this study raised the issue of language and translation being an area of bias and error. Dependency on translation was an important element in the methodology as learning the languages and specific dialects used to even a basic level of fluency in the three study areas was impractical. However, the researcher did learn some common words and phrases that were commonly used during the conduct of the research which allowed important cross-checking of the research process and specific elements of the enquiry. A high dependency on a translator is a necessary but high risk for any researcher. As discussed by Sheriff (2004), there are some possible factors that could distort the quality of the translation. Direct translation of words and concepts is a common problem, particularly if the translator is unfamiliar with the subject focus or the construction of the questions/thoughts of the researcher are unclear. Another issue that may affect the translation is the cultural and social norms in the community.

Detailed discussion with all the field staff prior to initiating field work was carried out to ensure a good understanding of overall objectives and specific questions and activities. All the questionnaires/checklists were already translated into the local language. Such thorough preparation was required, since many of the activities required the use of simultaneous focus groups, as the researcher could not be present and fulfil a central facilitation role at all times with each group but rather took an observation and quality control role.

2.10 Comparison of qualitative and quantitative data

The result of the different approaches (qualitative and quantitative) in terms of collecting information did not show significant differences as presented in the two previous chapters (Chapter 3 and 4). Aside from providing more or less similar results, the used of the two approaches in a way benefited the research in terms of triangulation of the approaches.

3 Understanding livelihoods in rural areas

3.1 Introduction

This chapter presents the general situation and livelihoods of the villagers in the different study sites. There are five main sections in this chapter including the introduction section (3.1). Section 3.2 is the methodology section which illustrates the chronology or the process by which the different tools were applied. Section 3.3 presents the results of the study and is divided into five sub-sections (section 3.3.1 to section 3.3.5). The main aim of this section is to bring a general knowledge of the livelihoods of villagers from the rural areas of the study regions. The discussion part of this chapter (section 3.4) gives a general discussion on rural livelihoods.

As defined in its simplest sense, a livelihood is a way to earn a living (Chambers and Conway, 1992). However, although the definition is simple, its concept is very complex as typically there are many ways to earn a living; moreover, a number of factors/elements can influence the means (Sajor, 1999; Scoones, 1998). A major component of livelihoods is the availability of different ‘resources’ or capitals (i.e. human, natural, financial, physical, and social capital) that households can utilise or have access to (Allison and Ellis, 2001). The way in which people utilise or access individual resources or combinations of these resources defines their livelihood strategy (Ellis, 2000b; Scoones, 1998).

There are several factors directly and indirectly affecting households’ capitals which subsequently affect their livelihood strategies. Such factors include the different conflicts and trends in the community and various types of ‘shocks’ (e.g. human illnesses, natural calamities, social or economic instability, and epidemics in draft animals) (ADB, 2006). The effects of seasonality are also apparent in strategies and outcomes (DFID, 1999). Households aggregated using different factors such as location (i.e. AEZ) or well-being may respond differently to ‘shocks’ of different types based on their capacity and available assets. Such capacity or resilience of individuals/households to cope with different stresses and shocks determines the sustainability of the household’s livelihoods (Scoones, 1998). However, not all can cope and recover from stresses arising from such negative factors particularly those that have limited assets/resources. Such people who are susceptible to these ‘shocks’ and negative events are considered to be vulnerable (ADB, 2006), and achieving a sustainable livelihood is very difficult (Scoones, 1998).

This chapter illustrates the context, the different livelihood resources available in the area that households possess or have access to. The different activities on which household livelihoods are based and the different shocks that have to be coped with are also presented in this chapter. The whole chapter utilized information collected from different phases of the research study including the participatory community appraisal or PCA (village mapping, timeline, wealth ranking, resource diagrams, seasonal calendar, trends analysis) (Chapter 2), cross-sectional survey and longitudinal study. Qualitative information collected during the PCA was used to provide an overview of livelihoods at the community level. Information from the baseline survey and longitudinal study were utilised to provide more quantitative and seasonal information, respectively, regarding livelihoods at the household level.

3.1.1 Research questions

Most published recent research and development activities have focused their attention on either fisheries i.e harvest from a river or some other water body (‘Open access’ water bodies, OWB) or aquaculture focusing on pond or cage production (Edwards *et al.,* 2002). The aquatic animals concerned in these two systems have been simply categorised as wild or stocked species respectively (Bush, 2004; Garaway 1999; Mogensen, 2001; Saengrut, 1998). A number of researchers have described the importance of aquatic animals caught from ricefields (Gregory and Guttman, 2002a; Halwart *et al.,* 1996; Little *et al.*, 1996; Middendorp, 1992) but this has been placed within the fisheries sector within the continnum developed by Guttman (1996). This is a grey area however as there is well established evidence that management is often practiced to enhance and sustain yields of aquatic animals in rice fields and surrounding water bodies (Edwards *et al.*, 2002). Simplification of such systems as fisheries is unhelpful when considered from the perspecive of the users and beneficiaries and the resources they expend. Self-recruiting species are being maintained and managed in such systems. Bush (2004) developed an ecologically based approach to living aquatic resources and classified a system in between aquaculture and fisheries as a hybrid system which is more or less where the SRS fits in.

Therefore, the main purpose of this chapter is to fill the gaps of information regarding the hybrid system specifically analysing explicitly the importance of SRS within a broader livelihood context. Thus the profile of aquatic resources and aquatic animals at the community and household level is analysed within farming systems as well as the surrounding environment. The following research questions were addressed in order to achieve this objective:

1. What are the different resources available and how do households from different agro-ecological zones (AEZ) and well-being groups utilise such assets?

2. What are the different livelihood strategies of households located in different AEZ and well-being groups?

3. How do different shocks and seasonality affect the livelihoods of vulnerable individuals/ households and what are the strategies being carried out in order to cope with such shocks?

3.1.2 Limitations

The overall livelihood of an individual is being influenced by the status of the five capitals; natural, human, physical, financial, and social capital (Scoones, 1998). However due to the broad geographical coverage of this study (SEC, NET, and RRD), limitation on time and budget, information regarding some livelihood capitals was inevitably incomplete. In particular assessment of the nutrition and health status of rural households of different well-being status was limited by resources available, restricting estimations of weights of food rather than their expression as kilocalories for example.

3.2 Methodology

An interdisciplinary approach was applied in this analysis as mentioned in section 3.1. Both participatory community appraisal (PRA exercises) and conventional data collection through a semi-structured survey (cross-sectional and longitudinal) were used in this section of the research. The background information regarding the different research tools used were presented in Chapter 2.

The figure below (Figure 3.1) illustrates the chronology of the different research tools applied in this section of the study and how it fits within the sustainable livelihood framework (DFID, 1999; Scoones, 1998). The framework of this research was based from the research framework of the DFID funded project – R7917- Self-recruiting species in aquaculture (Little *et al.*, 2004).

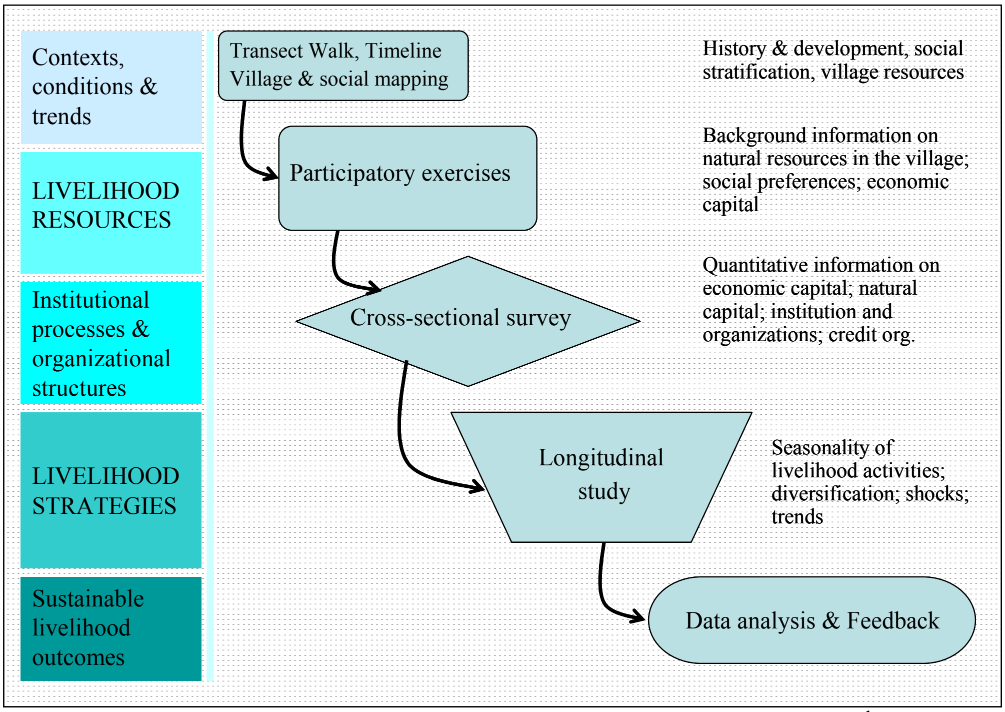


Figure 3.1 Chronology of activities in understanding rural livelihoods[1]

[1] Modified from DFID project report by Little *et al.* 2004 (R7917)

Understanding the general situation of the study areas was the first step of the research. This was carried out through initial visits to the different villages in the study sites and carrying out participatory assessment in the area. In this stage, information were generated through discussion with key informants in the village. The key informants were mainly village leaders and others that were knowledgeable of the area. Social stratification followed the initial visit and was done through the well-being ranking exercise. The results of the social stratification were then used to identify groups of villagers according to gender and wealth categories. Participatory exercises (PRA) were then carried out among the different groups in the village. Information generated from the PRA was presented to the majority of the villagers at the end of the exercise. A complementary survey (cross-sectional) followed the PRA activities to generate a more quantitative information regarding the households in the area. This survey led to the identification of households that were monitored monthly over the course of a year. The monitoring survey (longitudinal) was carried out in this research to understand the seasonal variations in terms of the livelihood conditions of rural households.

Information from the participatory exercises, cross-sectional survey and longitudinal survey were processed and analyzed separately. Non- parametric tests were used for the PCA data and GLM were applied to most of the data from the cross-sectional and longitudinal studies.

3.3 Results

3.3.1 Contexts, shocks and trends

3.3.1.1 Defining socio-economic composition of rural areas

In general, all of the three study sites communities were considered poor in comparison with other communities based on the secondary information collected from the commune or district offices. However the level of poverty at the community level may not be easily compared across sites, as there were clearly different standards and economic profiles between sites. In each case, the research targeted 'poor' communities as defined using secondary information. However, local communities have other ways of measuring relative wealth or well-being of households demonstrated during the wealth ranking exercise. Similarly, several researchers have reported findings regarding the different views of the local villagers on wealth (Grandin, 1994; Guijt, 1992; Jeffries *et al.,* 2005; Mukherjee, 1992; White and Pettit, 2004).

Table 3.1 presents the number of groupings or well-being levels identified by different types of key informants. In SEC, the number of groupings identified by the key informants to describe categories of 'well-being' ranged from three groups to nine groups. The mode or most frequent number of groups was six. The well-being groupings in NET were relatively similar among key informants where most of them have identified four groups only (mode = 4) (Table 2.4). The maximum number of groupings identified in this site was six. In RRD, the well-being grouping identified by the key informants ranged from three to six groups, and six was most common.

One of the criteria used in identifying villages for this study was the number of inhabitants (less than 150 households). However, there were cases that particular areas were selected even though the number of households was large because of other criteria employed by the project (e.g. topography, aquatic resources and secondary information on socio-economic status). Amongst the three sites, SEC had one village with almost 200 households which probably explained the higher discrepancy in terms of number of wellbeing groups (9 and 3 for female and male key informants respectively). On the contrary, NET (<150 households/village) had the most number of villages (3 out of 6 villages) where both male and female key informants identified the same number of well-being groups. Key informants from RRD on the other hand had the least discrepancy (1) in determining number of well-being groups.

Table 3.1 The average number of well-being groups identified by male and female key informants during PCA exercise.

Sites	AEZ	Village	Total households	Key Informants	
				Female	Male
SEC	LOW	Thom	190	9	3
		Svay Cheak	161	6	6
		Trapiang Deakrom	126	6	3
		Prey Srokum	107	5	4
	DRY	Prey Tadoc	177	5	6
		Angtasom	74	5	4
NET	LOW	Kudload	94	6	4
		Yangnoi	90	4	5
		Saingam	111	5	4
	DRY	Samoechai	114	4	4
		Lumphu	148	4	4
		Nongweang	142	6	6
RRD	LOW	Hoang Nguyen	107	4	3
		Cham Ha	142	4	5
		Trai	113	3	3
	DRY	Phu Cuong	134	6	5
		Yen Tang	130	6	5
		Cong Hoa	85	6	6

For the purpose of comparison, the number of groupings among the three sites was standardised using the equal interval as described in chapter 2 (section 1.6). Figure 3.2 illustrates the percentage distribution of households among different well-being ranks in the study areas after adjusting the ranks based on equal interval (EI).

Distribution of households based on well-being ranks

Using the different criteria set by the key informant, which are not entirely based on per capita income, the distribution of households in the community was determined (Figure 3.2). The significant difference between sites was found to be the average percentage of very poor and very rich. NET has the lowest percentage of households classified as very poor (9%) whilst SEC has the highest percentage (20%). RRD has the highest percentage of households classified as very rich (15%) while SEC is the lowest, with only 9% of the community ranked as very rich.

Unpacking the differences within sites, Figure 3.2 illustrates the similarities and variations among villages and AEZ. In SEC, the well-being group with the lowest percentage is the very rich group with 9.8% and 6% from LOW and DRY area respectively. A higher proportion of the villagers in SEC belong to the poor and medium groups. In contrast, in NET, the smallest well-being group belongs to the very poor (10.7% and 8.7%, LOW and DRY respectively). However, the bulk of the villagers in NET belong to the poor and medium group which is similar to SEC. In RRD the smallest group varied between AEZs; the poor were the smallest group (11.3%) in LOW whilst the very rich was the smallest group (10.3%) in the DRY area. Unlike the other sites, most households in RRD were classified as medium and rich.

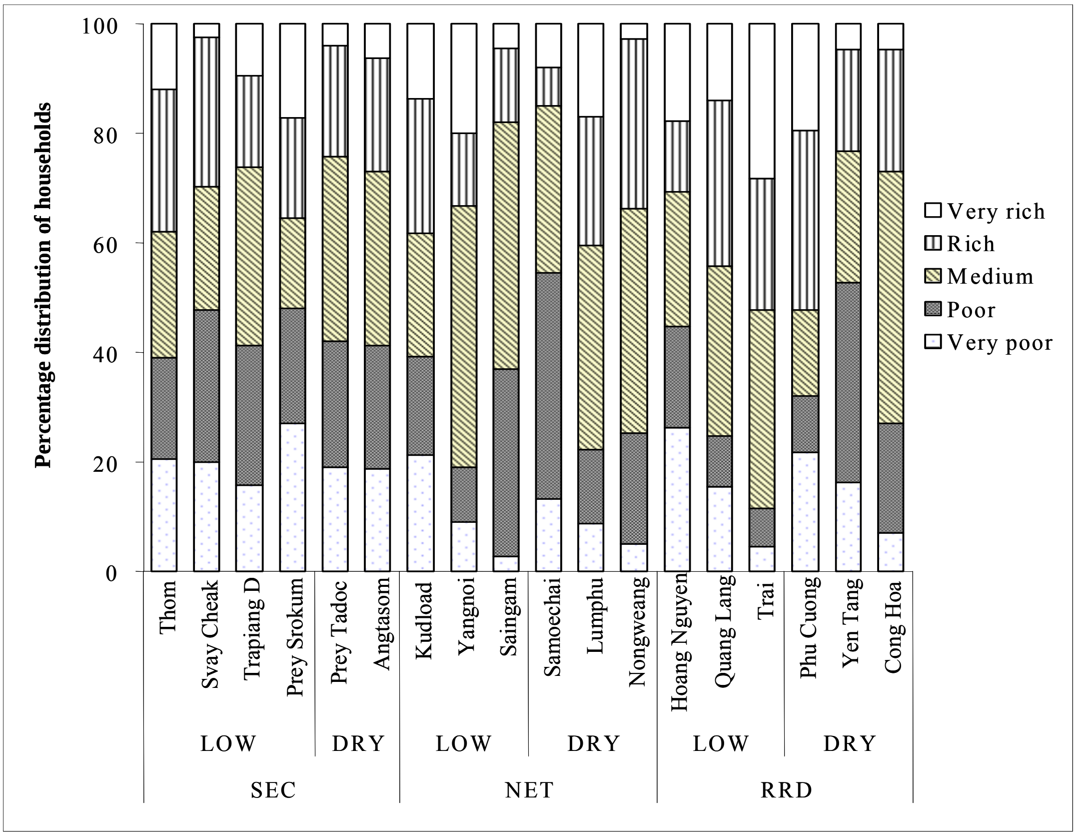


Figure 3.2 Percentage distributions of households in the different well-being groups. ***Data presented based from PCA exercise.***

Important criteria in well-being ranking

One of the purposes of the wealth ranking technique is to describe and analyse how villagers in rural areas perceive well-being. Results of this exercise not only elucidated the complexity of rural peoples' criteria in stratifying the community but it also demonstrates key informant familiarity with their locality and their co-villagers. Figure 3.3 show the different groups of criteria used by key informants in grouping households in the rural areas according to their socio-economic strata. There were 13 groups of criteria used to describe the different levels of wealth. During the well-being exercise it was observed that local villagers use the "well-being" of the head of the household in determining the socio-economic level for the entire household. Below are the different categories and their indicators that were used by key informants in determining the well-being level of household in the community. Details of the different criteria used by key informants from the three sites are presented in the appendix.

Livelihood

The type and the number of sources of income (livelihood) were the major criteria used to described well-being. In SEC, poor households were identified to have very limited sources of income. Most of the poor households in SEC sold their labour for income. In NET and RRD, poor households mainly earned their living from farming and only very poor households were dependent on selling their labour. The number of sources of income also indicated the well-being of households. In all three sites, having other sources of income apart from wage labour and farming is an indicator of a better-off family.

Land

The estimated area and/or quality of land possessed and to which the households had access was also an important criteria, particularly in NET and SEC. In SEC, poor families usually had small land holdings (0.5 to 1 hectare). Some poor families in SEC also use their land as collateral for loans. In NET and RRD, most households owned land, even poorer households. The size and the type of land however were used in determining the level of well-being of the households. In RRD a lack of quality land was a criteria used in identifying the poor.

Housing

Ownership of housing for shelter and the type of materials used in constructing the house were also common criteria across sites and well-being groups. In SEC, the poorest families could have their own house, however the material they used in building their homes were usually made of cheap and easily available locally such as palm leaves, rice straw and mud. In NET and RRD, the size of the house and the type of ownership were mostly used to determine well-being; poor families at both sites usually did not have their own house and mostly shared with other families. Better-off families at all sites used better materials for house construction such as ceramic tiles, wood and galvanised iron sheets in SEC and concrete/brick in NET and RRD.

Social state/Age and demography

The social state refers to the capability of individuals to maintain networks to relatives and other individuals in the community. In this activity, these criteria referred to the present state of the household based on household size and age profiles of household members (Beaton, 2002). Households constituting single adults living alone or with a large number of children were considered poor at all sites. In RRD, young couples are usually considered poor as they had limited resources. Although a large number of children were considered indicative of poorer households, in contrast some key informants considered this indicator of better-off families particularly those families with more adults, i.e. adult children and <u>not</u> dependents.

Finance

This criterion encompasses access to credit and level of savings. In all sites, poor families did not have access to formal credit organizations. On the contrary, better-off families at all three sites had access to such organisations. However in SEC, this criterion was hardly mentioned which suggests the limited availability of credit-supply. Aside from credit access, indicators like the capacity of households to pay loans, the level of remittances received, and capacity to invest, were also used by key informants.

Appliances

Possession of different household appliances/equipment was also used by key informants to describe well-being. In all three sites, very poor households own very few appliances, and usually only simple and cheap items such as transistor radios. On the contrary, better-off families at all three sites had better appliances, often electrical. In SEC, however, most electrical appliances were run by a battery or generator.

Livestock

The type and number of large ruminant animals possessed by households was also an indicator of well-being at all the three sites, however this indicator was not common in RRD. Poor families usually had only 0 – 2 livestock. In RRD, key informants did not use livestock in describing very poor to medium households. In general, the number of livestock increased with level of the well-being. The maximum number of draft animals that better-off households possessed ranged from 8 to 10 heads of livestock.

Food supply

The amount of food available for the households during the year was the main indicator under the food supply criteria. Poorer families in SEC and RRD do not have enough food for almost six months in a year. However, in NET, key informants did not use this type of indicator in defining well-being.

Education

The level of education of the household head and the capacity to send their children to school were included within this criterion. Very poor and poor families do not have the capacity to provide a good education to their children as mentioned by key informants at all the three sites. Better-off families in NET can send their children even to university. In contrast, households (even better-off) in RRD can only afford to send their children to secondary level. In SEC, education was not mentioned as an indicator of well-being.

Transport

This criterion was used to identify rich and very rich households in NET and RRD where ownership of a car sets these people apart and everyone else has bicycles. In contrast, in SEC, wellbeing groups in were distinguished based on ownership of bicycle/motorbikes. Better-off families in SEC mostly possessed a motorbike and a bicycle. The majority of poor households in SEC do not possess any type of transport; in contrast bicycles are very common in poor families in NET and RRD.

Equipment

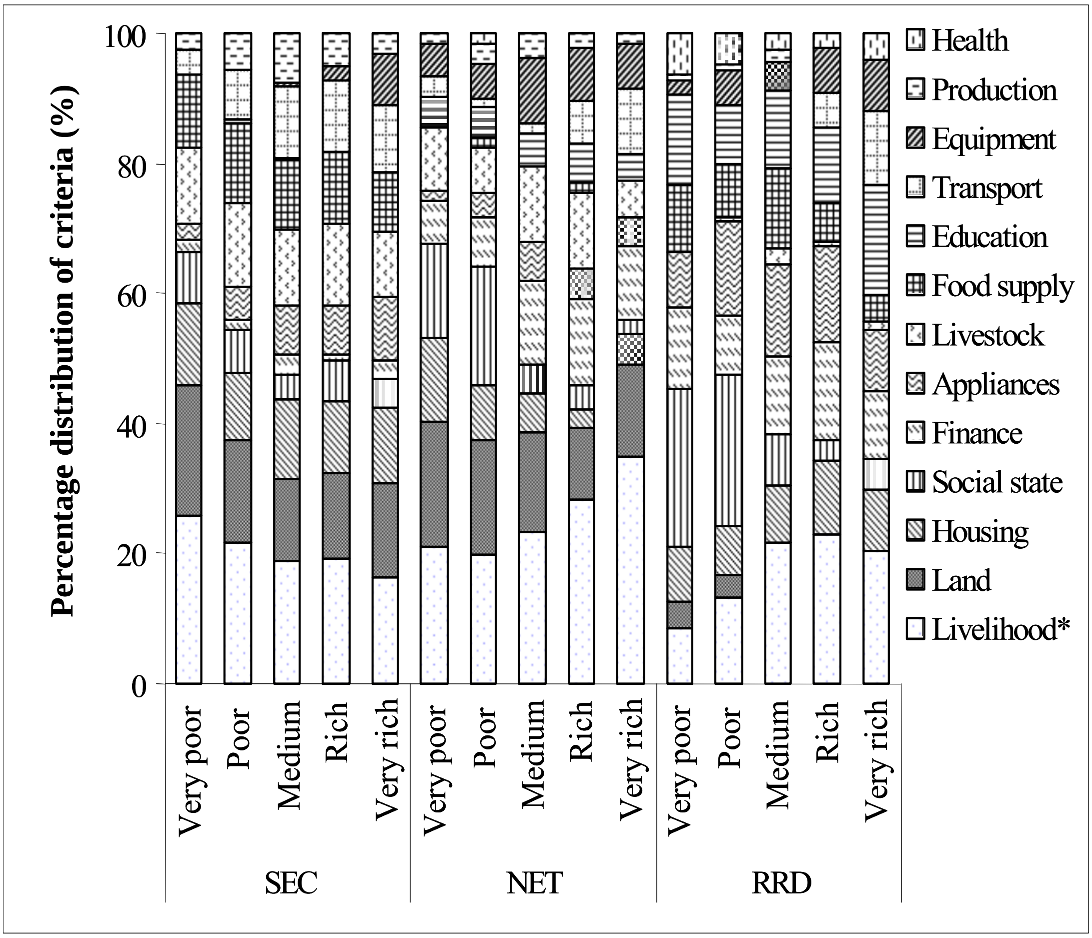
The indicator used under this criterion includes the types of farming equipment the household possess or have access to. In SEC and RRD, very poor to poor households usually do not possess any farming equipment. On the contrary, in NET, a lack of the most modern agricultural equipment i.e. two wheeled tractor, indicates the household is poor. Better-off families in NET and RRD possess better equipment in farming; however in SEC, having a generator or water pump is already indicative of a better-off household.

Production

The estimated amount of rice production per hectare (enough for consumption only or with surplus) and the capacity of household to use chemical fertiliser were used by KI particularly in SEC and NET as indicators of well-being. In RRD this indicator was only used in classifying very poor to medium households. In general, households with lower production i.e. inability to secure surplus production and no capacity to use optimal rates of fertilizer were considered poor. Households that can produce more than enough for their own consumption were considered better-off.

Health

The health condition of the household head was used least as a criterion for assessing well-being and then mostly limited to the key informants in the RRD (Appendix 5 - 9) and by a few key informants in NET. Key informants in SEC did not include health in determining the well-being of households. Households with poor health were considered poor or very poor in RRD and NET.



*Note: Livelihood criteria includes all income generating activities

Figure 3.3 Distribution of different criteria used in describing well-being in the three study sites. ***Data presented based from PCA exercise.***

Definition of wealth by gender groups

The similarities and differences in the perception of well-being between gender groups were also analysed in this study. Figure 3.4 illustrates the distribution of criteria used by groups of men and women in determining well-being ranks of individual households.

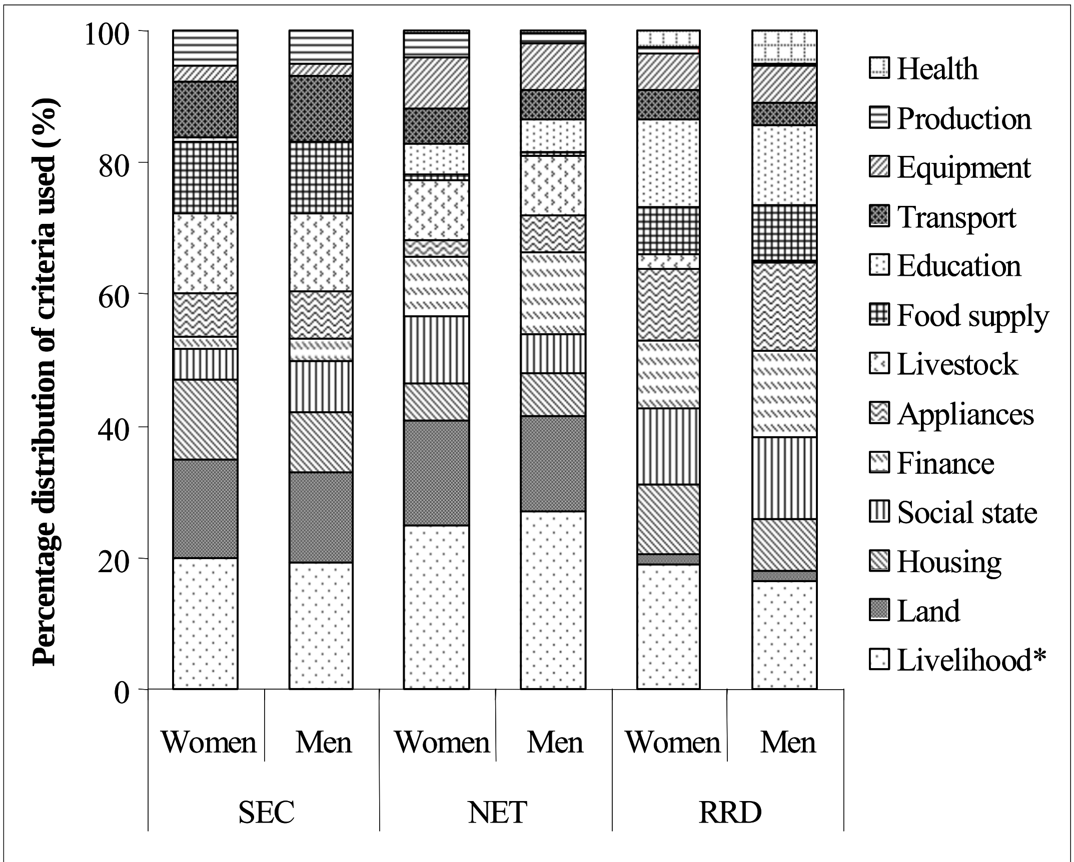


Figure 3.4 Distribution of the different criteria used by men and women in determining well-being ranks of households in the study sites. ***Data presented based from PCA exercise.***

Men and women at the same site tended to use similar specific criteria and indicators within each criteria. Differences between gender groups were observed however. The importance of finance as a criterion was higher among men at all three sites. The use of household appliances/equipment as an indicator was also different between men and women; men considered this indicator more important than women at all sites. In health, though the percentage was very low at most sites, in RRD, men gave it higher importance compared to women.

Consistency of well-being assessment

A test for consistency was carried out to determine the level of agreement between the male and female respondents within each of the villages. Spearman rank correlation (Spearman's rho ρ) was used to look at the strength of association between the two ranks (Kinnear and Gray, 2001). Based on the test results, rankings done by male and female informants were strongly correlated. The criteria used by men and women to assess well-being were similar.

Although the results of the test showed a very significant correlation between male and female respondents ($P < 0.01$) i.e. households were ranked by both gender groups on the same well-being level, there were inconsistencies observed from the rankings. The percentage of inconsistency in each village is presented in Table 3.2 with the exception of one village in Vietnam in RRD (Cong Hoa) that did not show any inconsistency i.e. households were ranked similarly between key informants. This data was measured by simply scanning the results of the two (3 in Cambodia) rankings. The inconsistencies described here are: households ranked from: very rich (VR) to very poor (VP) or vice versa; medium to VP or to VR; and households with ranking to no ranking.

Table 3.2 Summary of total number of households with inconsistent well-being rank

Sites	Sub-sites (Village)	Total number of HH ranked	Number of inconsistency	Percentage of inconsistency (%)
SEC	Thom	190	14	7.37
	Svay Cheak	161	7	4.35
	Trapiang Deakrom	126	12	9.52
	Prey Srokum	107	7	6.73
	Angtasom	74	5	6.76
	Prey Tadoc	177	18	10.17
NET	Kudload	94	8	8.51
	Yangnoi	90	5	5.56
	Saingam	111	1	1.00
	Samoechai	114	3	2.63
	Lumphu	148	9	6.08
	Nongweang	142	7	4.93
RRD	Hoang Nguyen	107	4	3.74
	Cham Ha	142	3	2.11
	Trai	113	8	7.10
	Phu Cuong	134	3	2.24
	Yen Tang	130	9	6.92
	Cong Hoa	85	0	0.00

Some reasons for these inconsistencies were (1) poor familiarity of KI with the full or formal name of some of the villagers, relating to the frequent use of nicknames or local names among villagers; (2) two families sharing one house (some are extended families); (3) confusion between the name of father and son; (4) seasonal migration led to some households being excluded by some key informants. Among the three sites, SEC had the highest percentage of inconsistency (7.48 %) as one of the sub-sites had 10.17% of the inhabitants that were ranked differently by the key informants. On the contrary, RRD had the least percentage of inconsistency (3.7%) with one sub-site (the smallest) that did not show any inconsistency (Table 3.2).

3.3.1.2 Understanding the historical context in rural areas

There were several events that had happened to the rural areas that impacted on people's livelihoods in one way or another. In this thesis, these events were grouped into five categories: socio-political; infrastructure and communications; agriculture;

fisheries; and man-made or social. Figure 3.5 summarises the events that had happened in the six communities at each study site. Apart from the events that led to development in the rural areas, the historical transect also captured the different 'shocks' that had happened in the area, however, this information is presented under the 'shocks' and vulnerability section of this chapter.

Socio-political events

These are events concerning political activities including government activities. Major socio-political events were only recorded in two study sites; SEC and RRD, villagers from NET did not recall any significant event under this category that had happened in their community (Figure 3.5, NET). Although information was limited, it is still worth including for the reason that major events in this category have influenced (positively and negatively) the livelihoods of the people in other study areas.

In SEC, as shown in Figure 3.5 - SEC, Independence from the French rule in 1953 was a major development for the whole of Cambodia. From 1953 to 1970, there were few positive socio-political events that happened in the study sites. The *coup d'etat* in March 1970 led by General Lo Nol changed the government from Kingdom of Cambodia to the Khmer Republic. This form of government ended when the Khmer Rouge (1975-1979) took over the government by force and during this period 'ultracollectivism' was implemented. More of the impact of this period is discussed in the next section - shocks and vulnerability section. The national election under the UN supervision in 1993 was considered another major event in the whole country as it was perceived to bring positive development with new officials running the country. It was only during the late 1990's when villagers observed an increased number of women who were seeking work and also people started working near the Vietnamese border. The only major events that were identified in RRD were the land re-distribution policy of the government (1956-57) and tax reduction that occurred in the same decade. Although this was not explicitly explained by the villagers, these two major events influenced their agricultural production positively.

Infrastructure

Amongst the different development that had happened in all the communities, changes in infrastructure were most frequently mentioned. These are the events pertaining to building or construction of different structures that subsequently provided services in the people in the area. These structures included schools, temples and churches, road, bridges and installation of electricity and communications. In SEC, it was only in the late 1970's that the first school was built in one of the communities. In 1990, a health centre and another school were also built in another community. All-weather road construction was only undertaken in early 2000. Unlike SEC, infrastructure in NET has been steadily developed from as early as 1930 when schools and temples were built in the villages. Schools, road construction and later on electricity installation (1980 – 1990) were the most important type of infrastructure in this site and recalled in most of the villages. In RRD, the major types of infrastructure identified by villagers was road construction (1950's) and installation of electricity (1980's).

Social or man-made

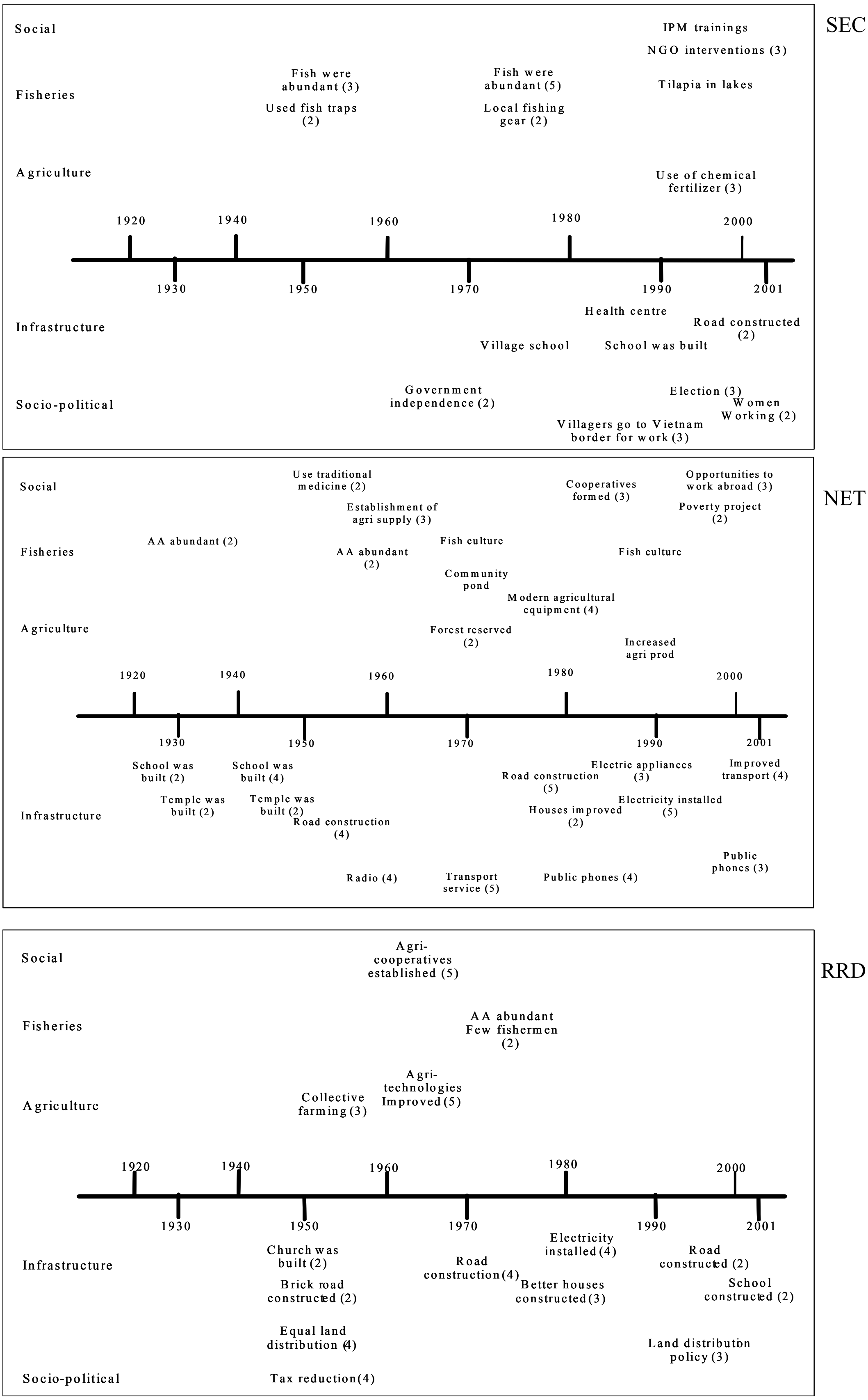
These are major events carried out by the community themselves or other development organizations. In SEC, it was only in the early 1990's when NGOs were able to implement projects in some of the communities. In NET, the availability of agricultural supplies (1960's) and forming of cooperatives (late 1980's) were considered important. Establishment of agricultural cooperatives (1960's) were mentioned by five out of six villagers in RRD as an important event that had happened in their community.

Agriculture

These are the events that had happened where agricultural products were directly or indirectly affected. This includes improvement of technologies in farming and other agricultural related events. In SEC, although the overall livelihoods is dependent on agriculture i.e. rice production, villagers did not recall any major event that had been implemented that had a positive impact on their agricultural production aside from the introduction of chemical fertilizers and pesticides in the early 90's. However, events that had negative impacts on the agricultural production in SEC are presented in the shocks and vulnerability section - Agriculture. In NET, AA declined drastically from the early to mid 70's as recalled by the key informants from the four villages. There was an occurrence of fish disease observed in the early 1990's in both wild and cultured species. Epizootic ulcerative syndrome (EUS) was a shock to natural fish stocks; however, this event went uncommented perhaps as the gradual decline of wild stocks were believed by the villagers to be related to agricultural intensification and modification/destruction of natural habitat As in

SEC, traditional livelihoods in NET are based on agriculture especially rice production. Major events that had happened under this category was recalled during the early 80's when farmers started using modern agricultural equipment (e.g. two-wheeled tractors), which were followed by increases in productivity (early 1990's).

Figure 3.5 Timeline of the development in SEC, NET, and RRD. ***Number in parentheses represents the frequency of the event mentioned, 6 is the highest frequency. Data presented based from PRA exercise.***



In communities in RRD, collectivisation of agricultural activities was recalled by two of the villages in this site to be important and had happened during mid - 1950's. Agricultural technologies were also observed to be improving between the mid 1960's and late 1980's.

Fisheries

This category includes the general situation of fisheries over time and also major events that had happened to such resources in the village and how resources had changed. In SEC, there was very little information recalled related to the development of fisheries and other aquatic resources. However, three communities recalled that fish or aquatic animals in general were still abundant during the early 1950's and five communities recalled a similar situation during 1980's. People collected AA using traps and other simple fishing gear. In mid-1990, only one community recalled that Tilapia (*Oreochromis* spp.) was present in natural water bodies such as lakes and swamps. Wild fish were abundant in NET during the 1930's. The introduction of fish culture and management of community ponds started in some villages at this site during the early 1970's. Until the present time, fish culture is still being practiced in this area. In RRD, very little information was volunteered by the villagers under this category. Only one out of six villagers mentioned the abundance of aquatic animals in the area during the early 1970's and that the number of fishermen was very limited. Other information regarding fisheries that were generated in the historical transect is presented in the shock and vulnerability section - Fisheries of this chapter.

3.3.1.3 Shocks, trends and vulnerability

An event, activity or challenge to the sustainability of a livelihood is defined as a shock (Ellis, 2000a). These types of events are largely infrequent, unpredictable disturbance and have an immediate impact to households or individual (Scoones, 1998). Events that negatively affect the different livelihood resources and capitals such as natural calamities, environmental degradation and even activities performed by humans can be classed as shocks. Henninger (1998) referred these sets of activities as risk and had categorised them into five types of risks: environmental (drought, floods and pests); market (price fluctuations, unemployment); political (civil strife); social (reduction incommunity support and entitlements); and health (exposure to diseases). In contrast trends are longer term phenomena. Allison and Ellis (2001) identified some examples of trends: population, migration, technological changes, relative prices, national and world economic trends.

This section elucidated the different shocks and trends occurring at the three sites which challenged the livelihoods of the community and subsequently resulted to diversification of livelihoods in the communities as a coping mechanism to such challenges (Ellis, 2000a,b). The level of vulnerability of a household or an individual is demonstrated by their response to different shocks and trends (Allison and Ellis, 2001; Ellis, 2000a). Information used in this section were derived from the timeline during the PCA. In general, all information generated from the time line were combined with the development events which were presented in the previous section. As the approach was participatory, all information considered important by the key informants were included regardless of its category or information type. Due to the purpose of the activity of knowing the general situation in the area, the activity was not focused on one subject like agriculture or even aquaculture. However, for the sake of presenting information in this thesis, categorisation of the different information were made.

Trends and types of 'shocks'

As discussed from the previous section (historical context), the historical timeline produced two groups of events that had happened in the community being studied: (1) events relating to development; and (2) negative events (shocks) that had brought negative impacts to the livelihoods of individual and in most cases, the whole community. In this section, the focus is to present these 'shocks' and what had happened to the community and identify who were most vulnerable to such shocks. This information was mainly gathered from the reconnaissance and perceptions of the community during the PRA activities. Additionally, information generated from the longitudinal study regarding the health condition of the household members is presented in section 3.3.2. There were five categories of 'shocks' identified and presented in this section; natural calamities; events in fisheries; events related to agriculture; societal shocks and trends; and socio-political events (Figure 3.6). Some of the identified shocks can also be considered trends as they give long term impact to the livelihood resources of the people living in the community. Drought and floods and other natural calamities are good examples of phenomena that can be both shocks (especially if extreme) or trends if they are part of long term gradual changes.

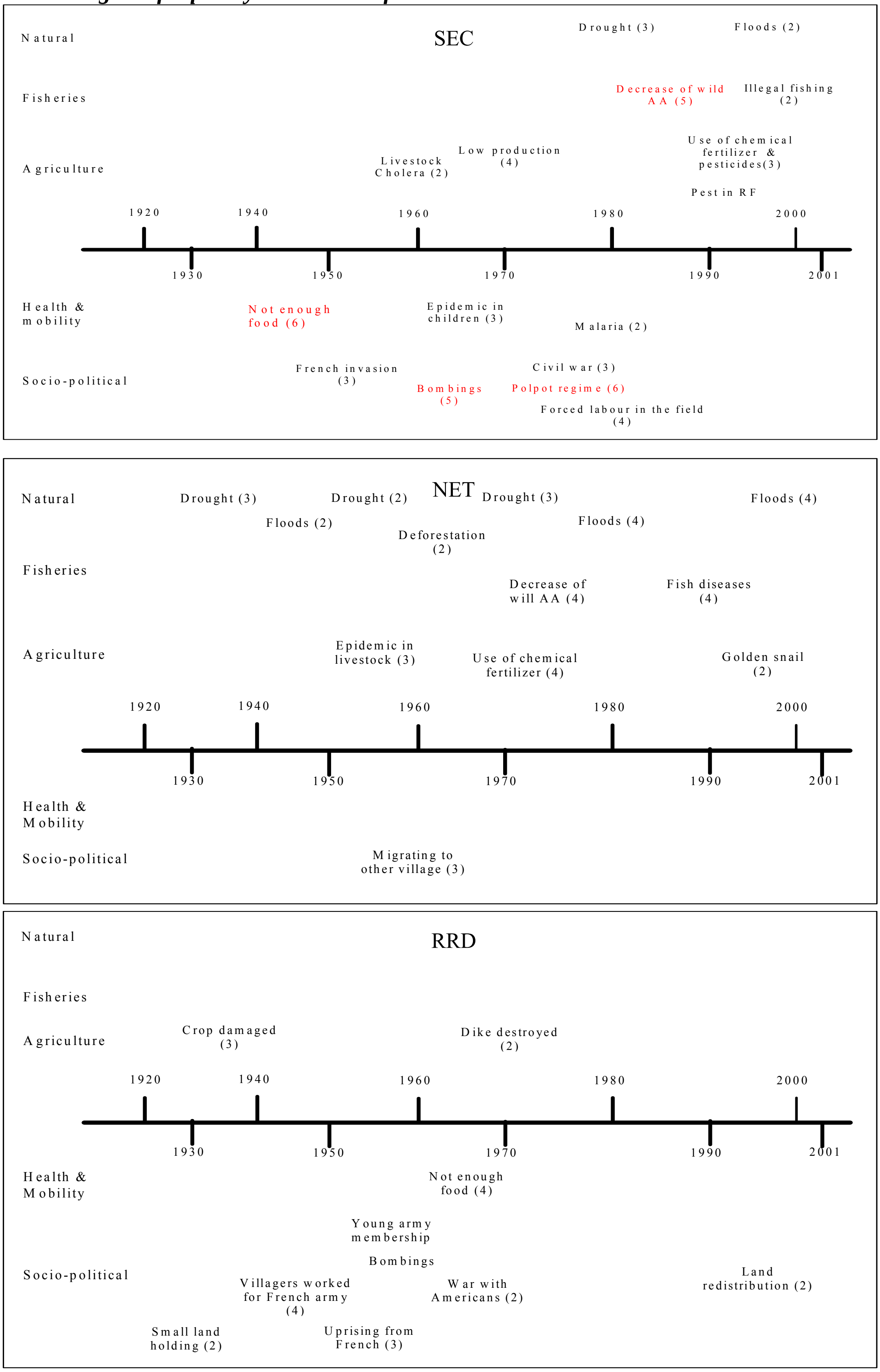
Natural calamities

The shocks brought by natural calamities were recalled by the villagers during the PRA activity i.e. timeline. The activity identified two main calamities that had happened in the communities being studied (Figure 3.6 SEC and NET). In SEC, drought and flooding were the most important events that happened and affected livelihoods negatively. Although drought and flooding were being experienced almost regularly, villagers reported that in the early 1980's there was a long drought experienced in at least two out of six villages being studied. This long drought eventually affected their agricultural production. Major flooding was experienced in the late 1990's. In NET, both flooding and drought were experienced by most of the villages studied; moreover, these calamities happened on a number of occasions (recorded 3 times, Figure 3.6 NET). It was recalled that major drought had affected the livelihoods of the community during three periods; in the 1930's, 1950's and the early 1970's. On the other hand, major flooding was also experienced by villagers in the mid 1940's, early 1980's, and the most recent flooding in the late 1990's, and mentioned in the majority of the villages studied. In NET, villagers did not recall any major calamity that had negatively affected their livelihoods.

Fisheries

Similar to natural calamities, events that were specific to fisheries were only recalled in SEC and NET. Decreasing populations of wild aquatic animals were observed in SEC in the mid-1980's. This observation was recalled by three out of six villages studied in SEC. In the late 1990's, illegal fishing became very extensive due to the introduction of electric fishing gears and also population pressure.

Figure 3.6 Timeline of the 'shocks' and trends experienced by six communities in SEC, NET, and RRD. ***Number in parenthesis represents the frequency of the event mentioned, 6 is the highest frequency. Data based from PRA exercise.***



In NET, AA declined drastically from the early to mid 70's as recalled by the key informants from the four villages. There was an occurrence of fish disease observed in the early 1990's in both wild and cultured species. Epizootic ulcerative syndrome (EUS) was a shock to natural fish stocks; however, this event went uncommented perhaps as the gradual decline of wild stocks were believed by the villagers to be related to agricultural intensification and modification/destruction of natural habitat.

Agriculture

Amongst the events that had happened in the community that directly or indirectly negatively affected agricultural production of villagers in most of the communities in the three sites were diseases of draft animals, destruction of crops during the war, use of chemical fertilizer and pesticides and pest infestation. In SEC, two communities recalled a cholera outbreak in their livestock (mainly cows) during the mid 1950's and early 1960's. Agricultural production was recalled to be very low from this period until the early 1970s. In the early 1990's chemical fertilizers and pesticides were introduced and their use become common in the communities studied. Similar to SEC, livestock epidemics also occurred in the mid-1950's in NET. The use of chemical fertilizers began at one site in NET during the early 1970's. Infestation of golden apple snail in rice fields began to impact on yields in the early 1990. In RRD, the destruction of most crops during the period of 1930's – 1940's was associated with French re-occupation of the country. Apart from this event, the destruction of river dikes during the war in the early 1970's was also recalled in one of the villages being studied in this site.

Human/health & mobility

Events under this category include those that had direct effects on humans like diseases or epidemics and scarcity of food. Such events were only recalled in villages in SEC and RRD. Food shortages were recalled by all six villages in SEC that were experienced during the late 1940's to early 1950's. In RRD however, shortages occurred between the 1960's and 1970's. Aside from the food shortage, occurrences of diseases and epidemics were also experienced by two villages in SEC in the 1960's to 1970's. However the type of illness was not known and key informants only remember that lots of children got sick. In the early 1980's, malaria occurred in two villages in SEC. Key informants from NET and RRD did not recall any epidemic or diseases in their respective villages.

Socio-political

Most of the events under this category were related to war and post-war activities. In SEC, the re-occupation by the French army during the late 1940 to early 1950's was recalled by two communities. Aerial bombings by the Americans during the early 1960's were recalled by five villages in SEC. The mid-1970's was when most of the people in Cambodia were forced into collective agricultural work by the Pol Pot regime, recalled by all six communities. There were very limited events recalled in NET relating to specific socio-political events; however, two communities recalled that long-term migration of the villagers to other places in the province or country to find better sources of income started in the mid 1950's. In RRD, most of the communities (4) recalled that villagers were forced to work for the French army during the 1940's and 1950's. An uprising of the Vietnamese against French took place in the early 1950's. After the French, the Vietnamese again fought against the Americans in the late 1960's – early 1970's. During these wars, young men from the villages were forced to join the army.

3.3.1.4 Discussion on contexts, shocks and trends

The aim of elucidating the general conditions and trends of all study communities was achieved through the combination of participatory approaches used i.e. village mapping, well-being ranking and historical transect, and the cross-sectional survey. It was interesting to find out how local people have various ways/indicators of describing well/ill-being. Most of the conditions of these criteria were linked to the various events that had happened in the community (e.g. good houses, electricity, transportation, membership to organizations, farming technologies, vulnerability to shocks, etc.). As discussed by Ellis (2000a), the severity of such shocks could result in livelihood diversification or in some cases, loss of an opportunity for improving their livelihood status and thus remain poor. For instance, in Cambodia and Thailand, opportunities in agricultural production were lost due to flooding or drought. Meanwhile in Vietnam, where collectivization and cooperativization were employed during early independence (early 1960s; Rigg, 2003) in order to produce more rice, farming is now market oriented.

The complexities of socio-economic composition of the community and the degree of well-being stratification were understood. Furthermore, the local community's perceptions regarding well-being were elucidated in this chapter. Unlike many poverty measurements and reports (Deaton, 2005; Maxwell, 1999) in which well-being stratification of individuals is commonly measured based on the level of income obtained by individuals like the setting of 1US$ per day (Maxwell, 1999), various indicators were also found to be important which covered different dimensions of poverty (Chambers, 2005; Garaway, 1999; Mukherjee, 1992) or a broader and holistic view of household's livelihoods and well-being (Conway, 1999, Grandin, 1994). Among these characteristics are access to or possession of resources, social status or household demography, physical assets, food supply, production, health, etc. Similarly, White and Pettit (2004) suggested that well-being is a complex notion and that the word 'well-being' represents not only values and assessments (from the word 'well') but also the importance of economic security, physical health, state of mind and social relationships (from the word 'being'). Rigg (2003) stated that poverty is a complex state and has multiple causes. Additionally, Rigg also provided characteristics of the poor which included location, land ownership, age of household head and health issues. Criteria used by local community members (e.g. key informants) were influenced by the local situation and even the social group to which the informants belongs (i.e. gender, better-off or poorer, agricultural area or industrialised community). This finding was also confirmed by Conway (1999) and Turton (2000) who both suggested that perceptions of poverty varied considereably depending on the predominant livelihood strategies in the community. In a rice farming community for example at all sites, the family with biggest area of land or with most modern farming equipment would be classified as better-off and the poorest would be those with little or no land to cultivate. In general 'livelihood strategies' or the source of income of the household was one of the main criteria used by local community members; limited livelihood options were used to describe the poorer households. Another interesting finding of this research is how well-being of the household head was typically equated to the whole family; each member of the households can be considered better-off if the household head have a high/ good economic status.

Comparing well-being ranks across villages within the same site is possible provided that the villages are within the same type of location (i.e. rural, peri-urban, or urban), they share the same type of resources and the methodology employed were consistent (Simanowitz, 1999). Comparing the results of wealth ranks across countries however, is unacceptable due to differences in socio-economic and political status. Interpreting results of wealth ranking should be treated with caution and wealth characteristics should be considered unique in each area and situation.

Using the local perceptions amongst the three study sites, Cambodia has the highest percentage of families considered poor (43% below medium category). This finding was relatively similar with the recent report made by ADB (2004) where it identified Cambodia with the highest rural population in poverty in Asia (>40%). Other researches conducted in Cambodia generated an almost similar percentage (35% - 40%) (ARMP, 2000; Catalla and Catalla, 2002; Conway, 1999; Friend and Funge-Smith, 2002). Meanwhile, the distribution of poor families in Thailand and Vietnam found in this research was slightly higher (>20% and 38% in Thailand and Vietnam respectively) than those reported by ADB (12.6% and >35% in Thailand and Vietnam respectively). This minimal difference maybe due to the method by which villages in this thesis were selected i.e. relatively poor (based from secondary data) whereas the ADB report was taken from a large overall sample. The minimal or insignificant discrepancy of the result of wellbeing ranking with other poverty assessments using different techniques only shows its validity, supporting the claims of earlier researchers (Adams *et al.,* 1997; Mukherjee, 1992; Simanowitz, 1999).

Overall, the distribution of incidence of poverty reported here appear to have declined in Thailand and Vietnam compared to the 2001 ADB (EDSD, 2001) report. However, the status in Cambodia appears relatively unchanged and it remains one of the world's poorest countries (Turton, 2000). This report also conforms to a recent report (Hughes, 2006) that Cambodia's continued economic growth and human development might remain uncertain unless major government reforms occur. Using the \$1 per day poverty index of the World Bank, an average percentage of 15.3% of households in east Asia and Pacific are living below the poverty line (World Bank, 2001). In the 1997 a UNDP/HDR report, as cited by Turton (2000), Cambodia was ranked only 153rd on the HDI. This ranking reflects the high incidence of rural poverty in Cambodia (43%, Turton, 2000). Farrington (2006) reported that economic growth in Asia has been continious for the last 20 years due to growth in domestic and international markets. In the early 1990s, both Thailand and Vietnam were recognised as among the three top exporters of rice in the world (Rigg, 2003). However, Farrington (2006) also reported that Cambodia might be amongst the countries in SE Asia which are likely to remain predominantly agrarian and self sufficiency orientated until 2015.

The big difference of wellbeing ranking in identifying the poor by previous researchers (ARMP, 2000; Deaton, 2005; MOP/WFP, 2003; Quisumbing *et al.,* 1995) is that it is not limited to the consumption or monetary assets of households/individual but rather to overall wellbeing (White and Pettit, 2004). In this thesis, several indicators of wellbeing were identified as important for local people, which were also identified and reported by other researchers that looked at well-being using a holistic approach (Chambers, 2005; Conway, 1999; Grandin, 1994; Islam, 2007; Karim, 2006; STREAM/CFDO/SCALE, 2002). The basis of wellbeing classification was related to the five livelihood assets (human, natural, physical, financial and even social capital) (DFID, 1999; Ellis, 2000a,b). Amongst the five capitals, indicators related to human, natural, and physical were mostly used such as the level of education, capacity to diversify livelihoods, physical assets like land and livestock holdings, and type of housing. In Cambodia for example, the sources of income, size and quality of land as well as the number of livestock possessed which they can use mainly in the field or as a source of immediate cash were the most common criteria used. This set of indicators was also similar to that reported by Cattala and Cattala (2002) and STREAM/CFDO/SCALE (2002) for fishers and farmers in other provinces of Cambodia. This demonstrates the high dependency on agriculture at this site. Similarly, the indicators mainly used in Thailand are related to agriculture activity which remains the single largest source of income in the area. The criteria used by key informants from Vietnam in this research were also relatively similar to that reported by Binh (2002). Low levels of literacy, limited sources of income, and physical isolation were criteria associated with poverty in this study in common with the findings of Binh (2002). The only contradicting indicator found between this research and of Binh (2002) was the use of land as indicator where Binh (2002) reported that poor households do not have land to cultivate and merely depending on selling labour. On the contrary, land was rarely used by key informants in this research and was given less importance as compared to other sources of income. This can be interpreted in the light of lack of land ownership by individual farmers in Vietnam, where land remains the property of the state (Kerkvliet, 2006); household landholdings tend to be very similar especially in the north. However, in SEC and NET, land is owned mainly by private individuals.

In other parts of the world, this technique has also been used and as in this study indicators relating to physical and natural assets were prominent (Hargreaves *et al.,* 2005; Howe and McKay, 2005; Jeffries *et al.,* 2005). Scoones (1995) found that wellbeing is highly correlated to livestock ownership as well as farm asset holdings in Zimbabwe. For indicators relating to human capital, in most cases, local people are referring to the status of the household head. There are a number of studies that relate the characteristics of the household head to overall status of the households i.e. financial, nutrition and resources (Chant, 1997; Handa, 1994; Kennedy and Peters, 1992; Pal, 1999). A general conclusion of this research is that income or source of income have an important influence on the well-being of individuals, as has been found by others (Conway; 1999; Headey and Wooden, 2004; Turton, 2000). The contribution of these findings to the knowledge gap is that this approach could be used to unpack the complexities of well-being/ill-being of a particular community. This is very important for other research or development organizations to enable them to target the causes of poverty thus improving their delivery of services for specific groups.

In all study sites, the shocks and trends most remembered were those that greatly affected or influenced the way of living at present or challenged the sustainability of livelihoods (DFID, 1999; Ellis, 2000a,b). However, those that happened at the macro level i.e. regional – SE Asia, may not have immediate and direct impact on them and were not recalled at any of the three sites. For instance, none of the study sites recalled the economic crisis that hit Southeast Asia during 1997. Amongst the countries mostly affected in that crisis were Indonesia, Malaysia, south Korea, and Thailand where the value of the baht lost a fifth of its value (IMF, 1998; Rigg, 2003). This crisis started from a currency problem but later developed into a major economic recession which greatly affected employment. There were lots of labourers laid of during this period that returned to their provinces which affected (positively) the labour supply in the rural areas (Rigg, 2003). Although this crisis was experienced regionally, it was not raised by participants of focus groups suggesting that communities were remained relatively self sufficient of external resources and dependent on the resources available locally.

As presented in the result section, the nature of positive events (development), shocks and trends was different among study sites. Amongst the three sites, Thailand had development activities like improved infrastructure as early as the 1930's whereas this first occurred in Vietnam in the 1950s. On the contrary, such changes in Cambodia only began in the late 1970s, to be interrupted and then resumed in early 2000. The population of aquatic animals during the mid-1970s was recalled as abundant. This maybe due to a lower population dependent on collecting fish during the Khmer Rouge era (Cattala and Cattala, 2002); this period is associated with a decline in the Cambodian population (Hughes, 2006) through mass killings and starvation. The intervention of non-government organizations (mostly international), improvement in agricultural production through the use of commercial fertilizers and pesticides and the election during the mid-1990s were perceived to have affected the development in Cambodia. Similarly, several reports from Cambodia suggests that economic development in Cambodia occurred in the early 1990s and after the election (Cattla and Cattla, 2002; Hughes, 2006; Ramamurthy *et al.,* 2001). The importance of government was reflected in the study sites in Thailand and Vietnam where most important development activities were related to agricultural production (e.g. modernization, agricultural products and transportation). The early agricultural development and liberalization of foreign investment led to the present situation now of both countries being amongst the top exporters of rice in the world (Rigg, 2003). Similarly, Sheriff (2004) reported that one of the base of the economic development in Thailand stemmed from a rich natural resource base and even after the 1997 crisis, agriculture remained Thailand's only high performing sector. Another significant event that was reported in Thailand was migration in during the period of 1950 – 1960s. Villagers (higher in adults and mostly men) move to other villages, provinces and even to Bangkok for work. This finding was similar to that reported by Vanlandingham and Hirschman (2001) who observed migration from rural areas to Bangkok was substantial and increasing.

Despite several reports of the introduction and development of aquaculture in the region (ADB, 2005; Ahmed and Lorica, 2002; Demaine *et al.,* 1999; Dey and Ahmed, 2005; Edwards, 2000; FAO, 2006; Little *et al.,* 1996; Luu *et al.,* 2002; McKenney and Tola, 2002; Pant *et al.,* 2001; Phillips, 2002; Prein, 2002; Setboonsarng, 1994; Setboonsarng and Edwards, 1998), it was not recalled in most villages except in two communities in Thailand. There are several possible reasons for this result. In Cambodia for instance, aquaculture was reported to be in an 'infant' stage and community and ricefields fisheries remained very important

(Baran, 2005; Gregory, 1997; Gregory and Guttman, 2000b; Morales *et al.,* 2003). Similarly, the importance of rice fields as a source of aquatic animals and adjacent water bodies in Thailand was high as reported by other researchers (AIT/AO, 1992, 1997 and 1998; Middendorp, 1992; Saengrut, 1998). In Vietnam however, culturing fish has a long tradition and therefore not considered as a major event. The selection process may in a way affect this as avoidance on villages who were previously or currently working with the partner institution (all are working on aquaculture research and development) was made. Another positive angle to this result was that the researcher facilitating the activity clearly did not influence or bias respondents towards ‘’talking up’ the importance of aquaculture.

Socio-political, health, mobility, natural calamities and declining agricultural production including fishery resources were amongst the major shocks (negative events) that had influenced the livelihoods of people in the three study sites. In Cambodia, the most important events that had happened in the entire country was the social upheaval during the Pol Pot regime that extended from 1970 to 1979 (Democratic Kamphucea). This was also reported by several researchers like Catalla and Catalla (2002), Hughes (2006), Murshid (1998) and Rigg (2003). The experience of this time remains vivid and dominated discussion in the villages and was evidence of the devastating long-term impacts it brought to Cambodia’s population, infrastructure, and economy. Similarly in Vietnam, the social upheaval associated with the colonial period and subsequent Indepedence struggle leading to inadequate food supplies was the most recalled event. These shocks were all related to the wars with the French (1945 - 1954) and Americans (1959 - 1968) and their damage to the main source of livelihoods in this country – agriculture. During the

French rule in Vietnam, ultra collectivism was practiced in agriculture and Vietnamese managed their own fields/ agricultural land (Kerkvliet, 1995). Similarly, Rigg (2003) reported collectivization and cooperativization were implemented in Vietnam during the early to mid 1960s. However, this was considered as one of the economic reforms that had happened in Vietnam. It was only after the French rule when the new government started redistributing land (Kerkvliet, 2006). In 1979, the government of Vietnam implemented a reform (Resolution. 6) that included loosening of state control and emphasised a shift from large scale industrialization towards smaller enterprise. It was only in 1988 (Resolution. 10) when the Vietnam government allowed individual households to cultivate agricultural land in exchange of agricultural tax (Rigg, 2003). In Thailand, however, being the only nation in Asia that was not colonised by western powers, there was little discussion of such issues but rather a focus on natural calamities that directly affected agricultural production or even human health such as long drought and floods.

The different shocks and trends like the natural calamities (drought and floods) and ill health have stimulated the community to adjust or cope with the situations when such shocks happened. Some of the causes of the shocks that had happened in the community particularly the case of the decreasing aquatic animals were not known. The only obvious reason indicated was the illegal fishing; however, there are reports that the occurrence of fish disease, particularly epizootic ulcerative syndrome (EUS), as well as the increasing population badly affected fish stocks (Demaine *et al.*, 1999; Soubry, 2001; Pathiratne *et al.*, 2001). Perhaps the obvious trends that are still affecting the livelihoods of rural people in the study sites are the increasing population and land distribution policy, particularly in Vietnam (Kerkvliet, 2006), as well as the seasonal weather i.e. limited continuous supply of water for agricultural and aquatic production.

3.3.2 Livelihood assets

Allison and Ellis (2001) considered assets owned, controlled, claimed, or any other form of access as the base of the framework of livelihood analysis. Similarly Chambers and Conway (1992) considered assets (tangible and intangible) as the basis to understanding the components and dynamics of livelihoods. The study recognises the five capitals that comprises the livelihood assets namely; human, natural, physical, financial, and social (Chambers and Conway, 1992). Understanding each capital is important to elicit overall assets of households, however; focusing on specific capitals alone is not sufficient (DFID, 1999) i.e. all five capitals need to be considered together. The aim of this section is to present and analyse the livelihood assets of households that build up their livelihoods from the three sites by focusing on the five capitals.

3.3.2.1 Human capital

The human capital refers to the overall well-being of members within households which includes skills, education, availability of labour, headship and health condition (Allison and Ellis, 2001; DFID, 1999; Ellis and Freeman, 2005; Scoones, 1998). Table 3.3 describes some of the components of human capital of different well-being groups (poor and better-off) in the three study sites.

Profile of household head

Information on the profile of the household head is a very important indicator in assessing the overall status of the household. A number of researchers have indicated how gender, and sources of income of the household head determined the overall status of the household (Chant, 1997; Handa, 1994; Kennedy and Peters, 1992). Being the household head, the overall decisions for most of the household activities is a major responsibility. Household members rely greatly on the head in terms of livelihood activities, expenses and consumption. Table 3.3 shows the profile of household heads in the three study sites, focusing on gender, educational attainment and the composition of the household.

Table 3.3 Mean socio-economic profile of households. Values in parenthesis represent the sample size (n). ***Data presented based from background survey.***

Characteristics	SEC		NET		RRD	
	Poor (n=49)	Better-off (n=75)	Poor (n=48)	Better-off (n=59)	Poor (n=66)	Better-off (n=45)
HH head profile						
Age						
Male	43.1(35)	46.6(62)	53.4(31)	53.7(43)	44.3(53)	47.2(43)
Female	49.0(14)	48.4(13)	61.4(17)	62.1(16)	62.1(13)	45.5(2)
Schooling						
Did not go to school	25.0%	9.3%	4.7%	4.4%	4.3%	3.6%
Primary	50.0%	57.3%	39.1%	20.0%	95.7%	91.1%
Secondary	25.0%	26.7%	37.5%	51.1%	-	1.8%
High school	-	5.3%	17.2%	15.6%	-	-
Vocational	-	1.3%	1.6%	6.7%	-	3.6
Bachelor degree	-	-	-	2.2%	-	-
HH profile*						
HH size	3.2	4.0	4.2	4.8	3.1	3.9
Adult equivalent	2.4	3.1	3.3	3.9	2.3	3.1
Labour force	2.67	3.4	3.3	4.0	2.27	3.44
Remittances	0.02	0.19	0.25	0.22	0.07	0.22
HH member age distribution						
60 years +	0.06	0.07	0.29	0.17	0.27	0.20
18 – 59	1.45	1.84	2.56	3.22	1.55	2.20
12 – 17	0.69	1.14	0.49	0.54	0.45	0.98
6 – 11	0.77	0.74	0.51	0.43	0.41	0.38
0 – 5	0.26	0.16	0.33	0.41	0.45	0.11

* Values of household profile correspond to number of individuals.

Headship

Households in the three sites were generally headed by men regardless of the well-being of the household (Table 3.3). Among the three sites, NET had the highest percentage of female headed households (35% and 27%, poor and better-off households respectively). In contrast, RRD had the lowest percentage of female headed households (19%, 4%, poor and better-off households respectively).

Age of household head

The average age of the household head varied significantly by site ($P < 0.001$); household heads in NET are generally older than elsewhere (55 years old ± 13.6 SD). The difference in age between male and female household head was also found to be highly significant ($P < 0.001$); female heads are usually older (54 years old ± 13.3 SD). There was no significant difference between well-being groups ($P > 0.05$).

Education of household head

There were five levels of education identified during the background survey, namely primary, secondary, high school, vocational and bachelor degree. In SEC, more than 50% of the household heads completed primary level and only about 25% completed secondary level. A larger percentage of household heads were not formally educated at all in SEC, particularly among poor households (25%). In NET, most of the household heads were able to go to school, with only 4.7% and 4.4% not attending school, among poor and better-off households respectively. Bachelor degree was the highest educational level attained by a few better-off households (2.2%) while vocational level was the highest for a small minority of poor households (1.6%). The majority of the household heads in NET completed secondary level (37.5% and 51.1% in poor and better-off households respectively). The percentage of household heads that did not go to school was also low in RRD (4.3% and 3.6% in poor and better-off households respectively). The majority of household heads completed primary school (95.7% and 91.1% in poor and better-off households respectively) but only 3.6% of the better-off household heads were able to complete vocational school.

Profile of households

Household size

The average household size was found to be significantly different between sites ($P < 0.001$) and between well-being ranks ($P < 0.05$). However there was no interaction found between site and well-being rank ($P > 0.05$). Household size in NET was higher (4.8) than SEC and RRD, which had similar average household sizes (3.4). In general, better-off families are larger than poor families (4.1 and 3.4 in better-off and poor respectively).

Adult equivalent unit (AEU)

The number of resident adult equivalent units (AEU) in NET was significantly higher than in SEC and RRD ($P < 0.001$). NET has an average AEU of 3.5 and maximum of 7.99. There was also significant difference between well-being group on the average AEU ($P < 0.001$); better-off households had a higher average of AEU (3.3) at all three sites.

Age distribution

Five age groups were identified in the background survey; infant (0 – 5 years old), child (6 – 11 years old), adolescent (12 – 17 years old), adult (18 – 59 years old) and senior (60 years or over). The distribution of household members based on the age group is presented in Table 3.3 where the majority of the household members were within the adult group. Poor households of RRD had the highest average number of infants (0.45). On the contrary, better-off families in RRD had the lowest average number of infants (0.11) compared to elsewhere.

Labour force

The average household labour force in NET is significantly higher (3.5) than in the other countries (P <0.05) with a maximum of eight individuals per household. The difference in the mean household labour force of SEC and RRD were not significant (P >0.05). The average number of active household members were also significantly different between well-being groups (P <0.001); better-off families were larger (3.5) than poorer families in the RRD (2.27). Members of the family who are not able to work like young students, those with a disability and seniors (>70 years) were considered dependants in this study.

Health status

Health is an important factor in understanding the overall livelihood of an individual as it contributes to overall human capital (Ellis, 2000b). There are some shocks and trends that may have direct impact to the human capital particularly on health (e.g. epidemic and illness). Monitoring of the general health condition of the household members was also conducted in this research (Figure 3.7) through the longitudinal study. The common types of illness acquired by individuals of different well-being (Table 3.4) and the season where the occurrence of such illness is very common are presented and analysed in this section.

Analysis shows that distribution of the percentage of individuals becoming ill during the season in the three sites is different. However, the percentages of men becoming ill were relatively similar amongst well-being group and sites (25%, 26%, and 28%, SEC, NET, and RRD respectively). The highest percentage of women becoming ill was reported in both well-being groups of SEC (60% for poor and 55% for better-off). However, illness among children in SEC was reported to be the lowest amongst the sites, particularly for better-off families (13%). A higher percentage of children becoming ill was observed from both well-being groups in NET and poor families of RRD (33% and 36% for poor and better-off in SEC respectively; 35% for poor in NET).

Common type of illness in rural areas

There were a number of common illnesses found in individuals from the three study sites. Table 3.4 shows the different types of illness and the distribution of individuals, segregated by well-being group, that had acquired such illness during the monitoring period. In both well-being groups in SEC, a large proportion of individuals who got sick suffered from fever (73% and 69%, in poor and better-off respectively). Additionally, internal illness also showed a high percentage of occurrences in better-off families (19%), while poor families had a higher percentage of individuals with blood pressure problems (11%). In NET, the most common illness was cough and colds, for which both well-being groups had the highest percentage of occurrence (87% and 70% from poor and better-off respectively). In RRD, fever was also identified as the most common symptom by both well-being groups (53% and 66% from poor and better-off groups respectively). Furthermore, illnesses such as body pain, head ache, and internal illness were also found to be common in both well-being groups.

Table 3.4. Most common types of illness (%) acquired by household members by well-being group in three areas of SE Asia. ***Data presented from longitudinal study.***

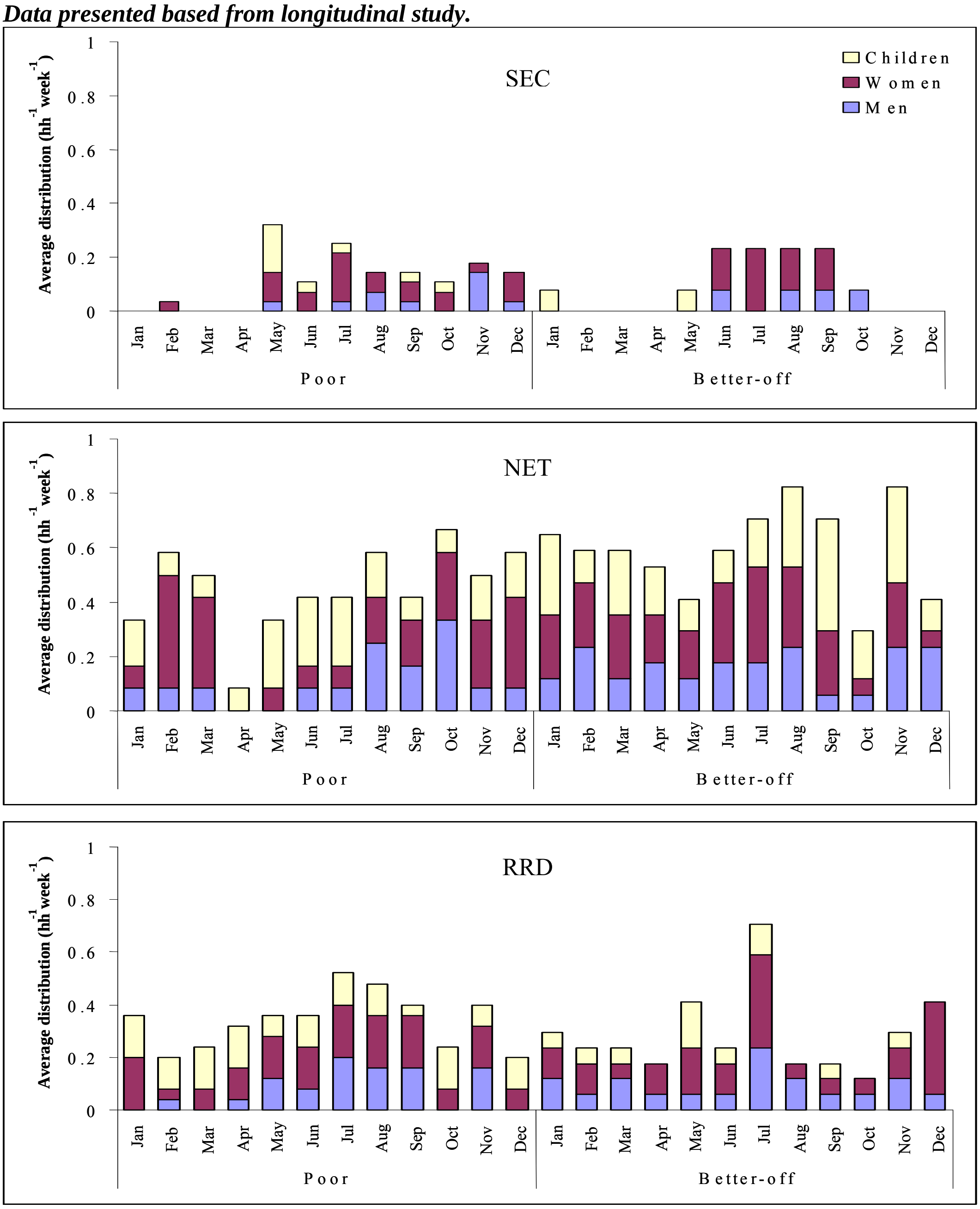
Types of illness	Study sites: SEC		NET		RRD	
	Poor (n=40)	Better=off (n= 15)	Poor (n=75)	Better=off (n= 121)	Poor (n=102)	Better=off (n= 69)
Body pain	0	6.3	0	3.9	11.1	14.6
Colds/cough	2.7	6.3	87.2	70.1	7.4	7.3
Diarrhoea	5.4	0	6.4	7.8	8.6	0
Fever	73	68.7	2.1	5.2	53.1	65.9
Headache	2.7	0	0	1.3	6.2	4.9
High blood pressure	10.8	0	4.3	2.6	0	0
Internal sickness*	5.4	18.8	0	9.1	13.6	7.3

*refers to detected problems with internal organs (e.g. lungs, intestines and kidney)

Seasonality of illness

Seasonal variation on occurrence of illness was significant in SEC and in NET (P <0.05) but not in RRD (Figure 3.7). Children in SEC became ill mainly during the month of May and reported only a very insignificant incidence throughout the rest of the year. For women in SEC, illness is more severe in July for the poor but in June to September for better-off women. There is little illness reported among men in SEC. In NET, seasonal variation in the average number of unwell household members was found in age and gender groups. Children from poor households were more likely to become ill (P <0.05) during the months of June to July while August, September and November were worse for the better-off children. More poor women from NET became ill during February to March and October to December. On the contrary, the number of better-off women falling ill in October and December was very low. In RRD, occurrence of sickness showed no significant differences by season or group (P >0.05).

Figure 3.7 Seasonality on number of individuals hh^{-1} week^{-1} reporting symptoms of illness segregated by well-being and gender during the year in SEC, NET and RRD.
Data presented based from longitudinal study.



3.3.2.2 Natural capital

Scoones, (1998) described natural capital as natural resource stocks and environmental services where useful resources and services are derived. Natural capital is an important class of assets that sustains livelihoods particularly for those people whose main source of income is based on natural resources i.e. farming, fishing and aquaculture (DFID, 1999). In this thesis, focus was given to two main types of natural capital that households in the study sites had access to: land for aquatic and agricultural production and water.

Land

There are three main types of land in the three study areas as presented in Table 3.5. Residential land included land areas where the house, kitchen, storage, livestock, and storage are located. Farm land refers to the land area where agricultural activities are carried out such as rice fields, crop land, and garden area. The 'aqua land' covers all other aquatic systems apart from rice fields. Trap ponds, household pond, ditches and culture ponds were included in this type of land. Among the three land uses, allocation of land for AA production is the smallest in all groups.

In general the average land holding (ha) is significantly different between sites ($P < 0.001$); households in NET had the largest total land area (3.7) and RRD the smallest land area (0.42). The area allocated for farming is generally the largest proportion and significantly greater than both residential and aqua ($P < 0.001$); households in NET had the highest average land holding (4.5 and 3.7, poor and better-off respectively). Differences between well-being groups were only significant in SEC (P <0.05), where better-off families had significantly more land than the poor families.

Table 3.5 Size of land holdings (ha) of households by well-being ranks. **Number in parenthesis indicates standard deviation (SD).** ***Data presented from the longitudinal study.***

Types of land	Sub-sites					
	SEC		NET		RRD	
	Poor	**Better-off**	**Poor**	**Better-off**	**Poor**	**Better-off**
Residential	0.15	0.22	0.09	0.12	0.01	0.01
	(0.1)	(0.1)	(0.1)	(0.2)	(0.01)	(0.01)
Farm	1.45	3	4.5	3.7	0.28	0.37
	(1.3)	(2.1)	(5.1)	(1.8)	(0.1)	(0.1)
Aqua	0.01	0.06	0.02	0.04	0.03	0.13
	(0.01)	(0.1)	(0.03)	(0.05)	(0.05)	(0.2)
Total	**1.61**	**3.28**	**4.61**	**3.86**	**0.32**	**0.51**

Water source

Seven sources of water were identified during the background survey, namely direct rainfall and run-off, canals, reservoir, river, ponds, ground water and lakes or swamps (Figure 3.8). Among the three sites, households from NET had the highest percentage that solely depended on direct rainfall and run-off for their agricultural activities. In contrast, RRD had the lowest percentage of households that solely depended on direct rainfall for their agriculture and there were various sources of water in this site. Sources of water for agricultural activities varied among the three sites. In SEC aside from direct rainfall, a large proportion of the farmers (49%) depend on 'canals' for their agricultural activities. The 'canal' in SEC however, does not refer to engineered irrigation canals but rather waterways or links from rivers or reservoirs. In NET, although a large proportion of households depend solely in rainfall (65%), two common water sources were identified by farmers: river (12%) and pond/ trap ponds (9%). Dependence on rivers as a water source was particularly important for farmers in the LOW area. In contrast, pond/trap pond was more important in the DRY area of NET. In RRD, water coming from engineered irrigation canals was the most important source, with a larger proportion of farmers (34%) reliant on such canals compared to direct rainfall (25%). Additionally, reservoirs and rivers were also considered important in RRD (17%).

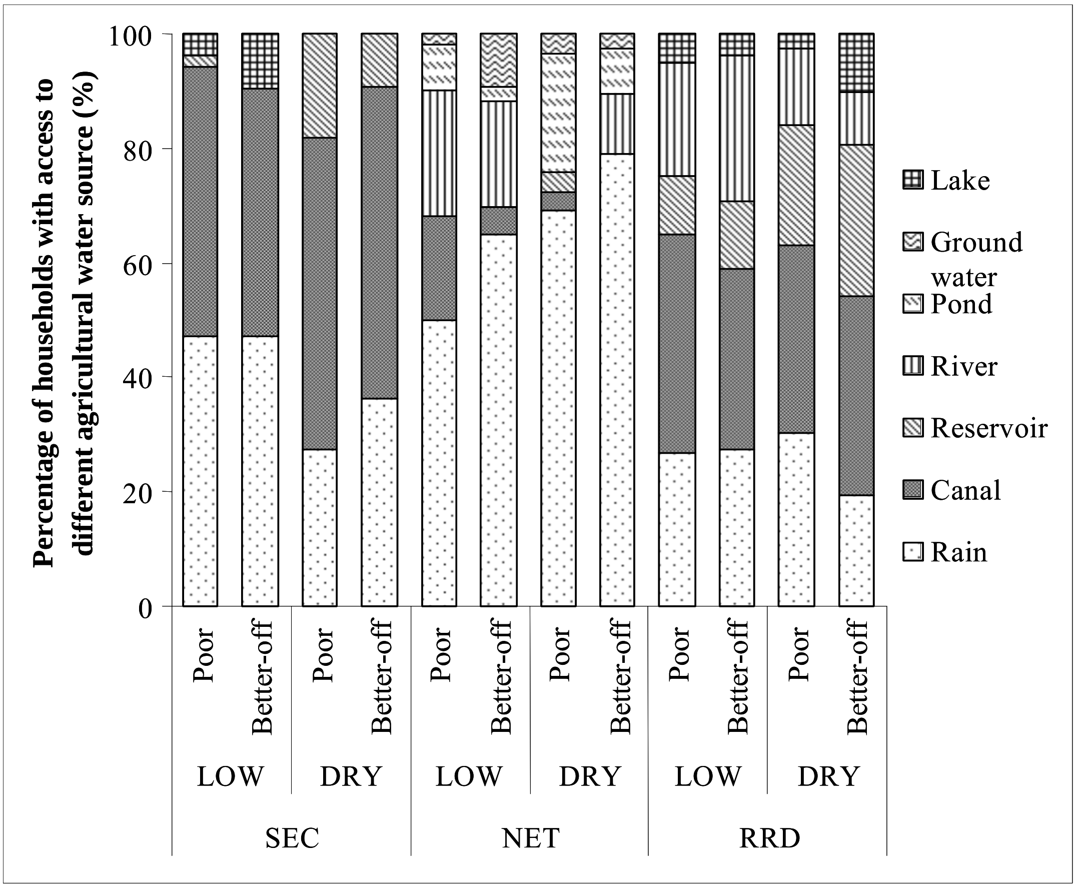


Figure 3.8 Percentage distribution of different sources of water for main agricultural activities by households in different AEZ and well-being ranks. ***Data presented from the cross-sectional survey.***

3.3.2.3 Physical capital

Physical capital is usually infrastructure which supports livelihoods of households/individuals. Assets like shelter, equipment in fishing and farming, machineries, and water sources are some examples of physical capital that households can privately own (Allison and Ellis, 2001; DFID, 1999; Ellis, 2000a).

However, there are other types of infrastructure that are freely accessible to all like roads, rivers, etc. (DFID, 1999). Most of the physical assets are created to produce income; however there are also types of infrastructure that do not have direct economic value but support households requirements for shelter or religious observation (Ellis, 2000a,b).

Housing

There were six types of main materials used in house construction at the three sites (Figure 3.9). In SEC, most of the households use mainly wood (50% and 59%, LOW and DRY respectively) and leaves (30% and 32%, LOW and DRY respectively) in building their houses. The percentage of households using combinations of concrete and wood to build their houses was very low (1.6% and 1.7%, LOW and DRY respectively) and limited to better-off families. Houses in NET were mainly constructed using concrete and wood. However, households from LOW NET mainly used concrete and wood (44% and 73%, poor and better-off respectively) materials while wood was mainly used by households in DRY NET (53% and 42%, poor and better-off respectively). In RRD, two main materials were used to construct houses by households of different well-being groups and locations. Households from LOW RRD built their houses mainly of wood and concrete whereas in DRY RRD the poorer used the same materials whereas the better-off tended to use more expensive concrete alone.

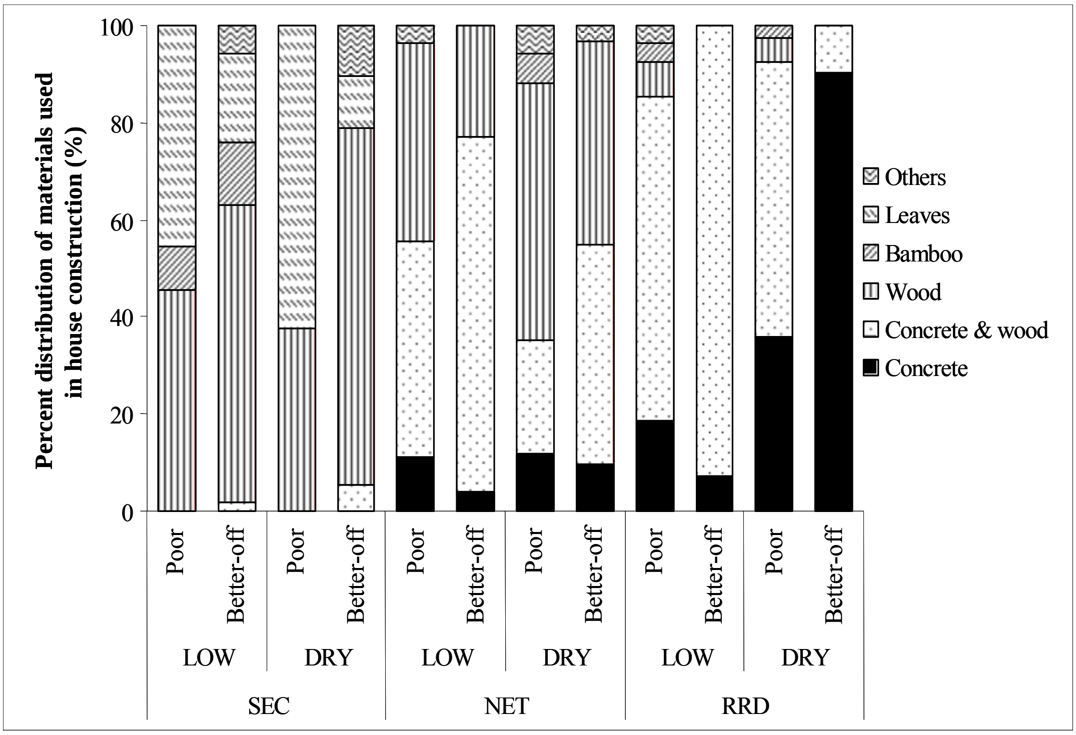


Figure 3.9 Percentage distribution of different materials mainly used (for walls) in building houses by households in different AEZ and well-being ranks. ***Data presented based from cross-sectional survey.***

Livestock

As discussed in section 3.3.1 of this chapter, livestock is one of the criteria used by local people in categorising household well-being particularly in SEC and NET. The percentage of households possessing different types of livestock is presented in Table 3.6. There were four main types of livestock commonly owned by households in the three study sites; cow/cattle, buffalos, pigs and poultry (ducks and chickens). Additionally, in RRD, dogs were considered as livestock.

Poultry were the most common livestock among most households in the study area (100% in each group except poor in RRD). The percentage of households possessing different livestock varies between well-being groups in SEC, but elsewhere the proportions are more or less the same. The percentage of poor households in SEC that possess all categories of livestock is generally less than in the better-off households.

Table 3.6 Percentages of households that possesses different type of livestock and poultry in different well-being ranks. ***Data presented based from longitudinal study.***

Type of animals	Sub-sites SEC		NET		RRD	
	Poor (n=49)	**Better-off (n=75)**	**Poor (n=48)**	**Better-off (n=59)**	**Poor (n=66)**	**Better-off (n=45)**
Cow/Cattle	51.0	54.7	43.8	52.5	27.3	24.4
Buffalos	48.9	65.3	27.1	23.7	15.2	35.6
Pig	75.5	89.3	0.0	3.4	83.3	84.4
Poultry	100	100	100	100	78.8	100
Dogs	0	0	0	0	1.5	13.3

Table 3.7 Mean number of types of livestock possessed by households of different well-being (± SD). ***Data presented based from longitudinal study.***

Sites	Well-being group		Mean
	Poor	**Better-off**	
SEC	2.6 ± 0.7	2.8 ± 0.7	2.7
NET	1.7± 0.5	1.7 ± 0.8	1.7
RRD	2± 0.9	2 ± 0.8	1.9

The number of types of livestock that households possess was not different between well-being groups (P>0.05). However, differences were found to be significant between sites; households in SEC generally had a greater variety of livestock than elsewhere (Table 3.7). The average number of livestock by type and age is presented in Table 3.8. Individual comparison of mean holdings by livestock type and age were carried out to understand the variation among site and well-being groups. Among the four main types of livestock, only poultry did not show any significant difference in terms of the average number of livestock of different household groups at the three sites.

Table 3.8 Average livestock and poultry holding size by households of different well-being ranks (± SD). ***Data presented based from cross-sectional survey.***

Type of animals	SEC Poor	SEC Better-off	NET Poor	NET Better-off	RRD Poor	RRD Better-off
Cow/Cattle						
Adult	0.8 (1.0)	1.2 (1.4)	1.3 (2.0)	1.5 (1.7)	0.2 (0.5)	0.2 (0.4)
Calves	0.5 (0.7)	0.6 (1.0)	0.7 (0.9)	0.5 (0.7)	0.0	0.1 (0.3)
Buffalos						
Adult	1.1 (1.2)	1.6 (1.4)	0.7 (0.9)	0.4 (0.7)	0.2 (0.4)	0.2 (0.4)
Calves	0.5 (0.7)	0.4 (0.6)	0.3 (0.5)	0.1 (0.5)	0.0	0.0
Pig						
Adult	0.4 (0.7)	0.9 (0.9)	0.0	0.0	0.9 (0.9)	1.5 (1.7)
Juvenile	0.9 (0.9)	1.1 (1.6)	0.0	0.0	1.3 (3.2)	2.7 (5.3)
Poultry						
Adult	4.7 (9.7)	10.2 (14.1)	9.9 (12.3)	12.8 (12.7)	8.5 (19.5)	16.2 (43.2)
Juvenile	2.2 (4.6)	2.4 (5.8)	12.5 (13.9)	28.0 (48.8)	6.4 (8.4)	14.5 (17.3)

There were significant differences in average number of adult cattle possessed by households between sites and well-being groups, but no significant interaction between site and well-being. Households in NET generally possessed a greater number of adult cattle (1.8 ± 2.3 SD) as compared to elsewhere ($P < 0.001$). Poor families tend to have fewer cattle (0.7 ± 1.2 SD), ($P < 0.05$). The average number of adult buffalo possessed by different groups of households was found to be significantly different between sites ($P < 0.001$); households in SEC had more adult buffalos (1.2) than all other groups. There were no significant differences between well-being groups ($P > 0.05$).

There were significant differences in the average number of pigs raised by different groups at the three sites ($P < 0.001$) and between well-being groups ($P < 0.05$). Among the three sites, households in RRD had the highest mean number of pigs

(1.2) while SEC households (0.5) had the lowest number of pigs. In general, better-off families had more pigs than poor families (0.8 and 0.5 in better-off and poor respectively).

The average holding of juvenile livestock was also analysed and presented in Table 3.8. The differences found with the mean number of adult livestock holding were also similar with the calves/juveniles. Additionally, significant differences (P = 0.001) were found between the mean holding of juveniles of poultry (ducks/chickens) where households from NET generally had more juvenile poultry while households in SEC had the least.

The distribution of households possessing different number of large livestock (i.e. cattle and buffalo) is presented in Figure 3.10. The distribution of households showed great variation between sites and between AEZ, particularly in SEC and NET. In SEC, better-off household in DRY areas were more likely to (75%) possess at least 3 – 5 large livestock. On the contrary, in NET, poor households (60%) had a greater percentage of large livestock. A very small percentage of households possessed 6 or more large livestock. In RRD most of the households possessed less than 2 large livestock or none at all.

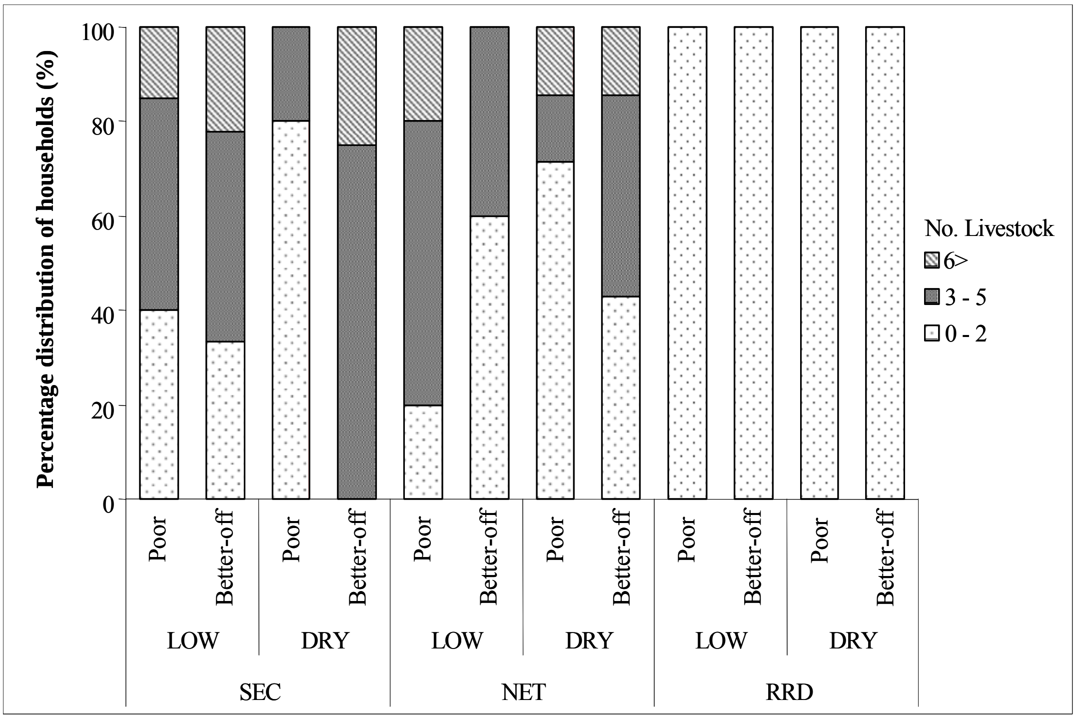


Figure 3.10 Percentage distribution of households possessing large livestock (cattle and buffalo) from different AEZ in SEC, NET and RRD. ***Data presented based from longitudinal study.***

Equipment

Households from the study area used several types/ kinds of equipment in pursuit of different livelihood strategies. This section presents the three main types of equipment being used by different groups of people in the community; for farming, fishing and transportation (Table 3.9).

<u>Farming equipment</u>

The possession of agricultural equipment by household differs by site and well-being group. In SEC, the most common equipment is rice transport (93% and 76.9%, better-off and poor respectively) which is used for transporting agricultural inputs (seed and fertiliser) and also harvested products to and from their houses. NET has the most modern farming equipment compared to other sites and a large proportion of households have two-wheeled tractors (27.1% and 76.3% in poor and better-off respectively) used for ploughing the field and also for transport. Water pumps were also available in SEC where more than 45% of the better-off families possessed this type of equipment. In RRD, most of the farming equipment was available apart from the two wheel tractor (Table 3.9). Better-off farmers possessed a greater variety of farming equipment.

Table 3.9 Percentage of households that possess different equipment by well-being rank. ***Data presented based from cross-sectional survey.***

Type of equipment	Sub-sites SEC		NET		RRD	
	Poor (n=49)	Better-off (n=75)	Poor (n=48)	Better-off (n=59)	Poor (n=66)	Better-off (n=45)
Farming						
2 wheel tractor	0	0	27.1	76.3	0	0
Rice machine	0	0	0	5.1	47.0	77.8
Water pumps	0	0	22.9	45.7	7.6	35.6
Rice transport	79.6	93.3	0	0	72.7	73.3
Simple tools*	2.0	17.3	0	0	18.2	28.9
Fishing						
Gill net	46.9	41.3	45.8	61.0	0	0
Cast net	2.0	8.0	56.3	72.9	3.0	8.9
Drag/seine net	8.2	8.0	2.1	0	1.5	20.0
Fishing rod/line	34.7	29.3	70.8	72.9	1.5	0
Traps	71.4	69.3	37.5	50.8	3.0	0
Lift net	0	0	22.9	32.2	7.6	15.6
Scoop net	26.5	26.7	0	0	0	0
Transport						
Motorcycle	0	0	47.9	79.7	1.5	8.9
Bicycle	0	0	72.9	86.4	12.1	57.8

*Simple tools includes rake, hoe, plough and the like

<u>Fishing equipment</u>

The ownership of important fishing equipment is shown by site and well-being group in Table 3.9. Poor households in SEC have a greater percentage of different fishing equipment than better-off households. Better-off families in NET and RRD tend to possess more diverse fishing equipment than poor families. In SEC, traps (bamboo traps, 71.4% and 69.3% in poor and better-off respectively) and gill nets (46.9% and 41.3% in poor and better-off respectively) were most common among both well-being groups. In NET households from both well-being groups mostly possessed fishing line (70.8% and 72.9% in poor and better-off families respectively) and cast nets (56.3% from poor and 72.9% from the better-off families). Gill net and traps were also common in this site. In RRD, very few households owned fishing equipment of any type. Lift nets (7.6% and 15.6% from poor and better-off respectively), cast net and drag net were most commonly reported types of gear owned at this site.

Transportation

Households from the three sites differed in terms of possession of a means of personal transportation as shown in Table 3.9. Households in SEC had no household-owned means of transportation. In both NET and RRD, a large percentage of households had bicycles and even motorcycles, particularly among the better-off. Trucks and cars were also noted in NET as a form of transport; however none of the study households possess such types of personal transportation.

3.3.2.4 Financial capital

This type of asset refers to financial resources of the households, the capacity to save money, and levels of household debt (Allison and Ellis 2001) and other economic assets that are essential to support a livelihood strategy (Scoones, 1998). Information presented in this section was based on the cross-sectional survey. The financial capital of households in rural areas is derived from direct income of the family or any other that is liquidated to cash particularly from the livestock.

Household income

During the longitudinal study, more detailed information regarding the average income of the family per week was obtained. Estimating agricultural production including aquatic crops and livestock by household per season was the method used in this analysis. Based from the reported production, estimated values for each production were determined. Other sources of income such as off-farm sources were not included in this section; however, information related to off-farming is presented in section 3.3.3.

The average production value of households from different AEZ and by well-being in the three study sites is presented in Table 3.10. Four types of production were identified in this study; the main agricultural crop (rice), secondary agricultural crops, aquaculture and fishing, and livestock. Analysis showed that there was significant two way interaction between incomes related to AEZ and farm product ($P < 0.05$), AEZ and well-being ($P < 0.05$), site and AEZ ($P < 0.001$), and site by farm product ($P < 0.001$). Amongst the different components of agricultural income, livestock make the highest cash contribution to households followed by the main agricultural crop. The production value of aqua and fishing is only the third most important contributor to revenue. Although the order of importance of the different components is the same, the average value per households differs between sites. In general, the value of aqua/fishing production is relatively higher in LOW as compared to DRY area ($73.1; $45.5, LOW and DRY respectively). The production value of secondary crops was also found to be significantly different between AEZ. DRY areas had a higher value than LOW (28.0, 7.4; DRY and LOW respectively); however, the main crop value did not show any significant difference in value between AEZ.

Table 3.10. Estimated average annual farm (livestock, rice and crops, aquaculture + fishing) production value by households of different well-being ranks. Values in ($) US dollars (± SD). ***Data presented based from cross-sectional survey.***

	Farm product				
	Farming				
Sites	**Main crop**	**Secondary crop**	**Aqua & fishing**	**Livestock***	**Total**
SEC					
LOW					
Poor	150.9 ± 112.3	3.4 ± 3.8	19.7± 18.5	541.8 ± 269.8	715.7 ± 343.8
Better-off	347.4 ± 225.6	3.4 ± 3.1	44.5± 27.7	672.4 ± 358.4	1067.6 ± 521.8
DRY					
Poor	73.2 ± 39.7	8.0 ± 5.3	2.4 ± 3.9	206.1 ± 138.7	289.7 ± 171.3
Better-off	102.7 ± 48.1	10.5 ± 16.6	19.9 ± 20.2	593.8 ± 178.7	726.9 ± 213.0
NET					
LOW					
Poor	754.8 ± 884.7	0	150.7 ± 280.9	1292.1± 837.6	2197.6 ± 1879.1
Better-off	575.2 ± 457.1	0	47.7 ± 55.3	464.4 ± 435.4	1087.3 ± 715.8
DRY					
Poor	386.7 ± 121.2	0	26.6 ± 20.0	528.4 ± 551.1	941.6 ± 586.8
Better-off	893.3 ± 369.1	26.1 ± 50.9	48.0 ± 35.0	642.5 ± 658.7	1609.8 ± 895.0
RRD					
LOW					
Poor	243.1 ± 132.5	17.3 ± 21.6	79.0 ± 84.7	167.4 ± 201.5	506.8 ± 241.2
Better-off	352.1 ± 200.7	26.7 ± 30.3	192.7 ± 326.5	476.9 ± 634.7	1048.3 ± 906.5
DRY					
Poor	216.1 ± 99.2	23.2 ± 31.8	37.0 ± 60.3	248.4 ± 175.5	524.7 ± 282.7
Better-off	344.1 ± 119.3	78.1 ± 86.9	59.3 ± 55.7	515.4 ± 426.5	996.9 ± 496.6

*Value of present livestock and poultry holdings were estimated based on current price of animals. Large animals were not being sold annually, however just for the basis of comparison, all livestock and poultry were estimated to be sold during the year of the research.

Sources of income of household head

In general, the number of sources of income by household head is significantly higher in SEC than elsewhere ($P < 0.001$), averaging 2.8 different sources (Table 3.11). Households in NET had fewest income sources (1.2). Male household heads were also found to have more sources of income than female heads (1.9, 1.7, male and female respectively) ($P < 0.05$). There was no interaction effect between well-being group and gender ($P > 0.05$).

Table 3.11. Mean number of sources of income of households in the study areas (SEC, NET and RRD) segregated by gender. ***Data based from background survey.***

No. of income sources	SEC		NET		RRD	
	Poor (n=49)	Better-off (n=75)	Poor (n=48)	Better-off (n=59)	Poor (n=66)	Better-off (n=45)
Male	2.9	3.0	1.4	1.0	1.4	1.6
Female	2.7	2.7	1.6	1.5	0.9	1.1

Primary sources of income by household head

Rice farming was inevitably the primary source of income of most household heads at all study sites (Table 3.12). However, there were other important sources of income; livestock, wage labour, government employment including teaching, self-employed, and migrant labour (local/district and overseas). There were also some household heads with no direct source of income, particularly in NET, that survived on other family members' remittances.

Table 3.12 Main source of income of household head from different well-being groups in SEC, NET, and RRD. ***Data presented based from cross-sectional survey.***

Main sources of income	**SEC**				**NET**				**RRD**			
	Poor		**Better-off**		**Poor**		**Better-off**		**Poor**		**Better-off**	
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Rice farming	100	100	98	90	91	76	91	94	87	92	88	100
Livestock				10								
Wage labour					3	6					5	
Government employee			2				2					
Self-employed					3				11	8	7	
Overseas									2			
No work					3	18	7	6				
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: M = male; F = female

<u>Remittances</u>

The average number of household member remitting income to the family was generally low (Table 3.3). Poor households in SEC had the fewest household members remitting money (0.02). There was no significant difference found between sites in terms of the number of members remitting cash to the family (P >0.05). However, a significant difference were found between well-being ranks (P <0.05). Better-off families generally had more household members remitting cash to the family (0.3).

3.3.2.5 Social capital

This type of asset includes the range of social resources (social organization, networks, social claims, relations, affiliations, associations) that people draw on in order to carry out different livelihood strategies (Scoones, 1998; Brock, 1999; Ellis, 2000b; Allison and Ellis, 2001; Krishna, 2004) as well as increase trust among each other (Adato and Meinzen-Dick, 2002) and create mutual benefits (Krishna and Shrader, 1999). The resources include relationships of people based on kinship, formal and informal networks (Brock, 1999; Cattell, 2001; Krishna, 2004; Lochner *et al*., 1999). Falk and Kilpatrick (2000) and Narayan and Cassidy (2001) stated similar definitions of social capital with the Social Capital Assessment Tool (SCAT) (Krishna and Shrader, 1999) i.e. that social capital encompassed the norms and networks in the community which subsequently lead to collective action and mutual benefits. Morrow (1999) suggested that social capital has a complementary role in building human capital. Measuring the level of social capital is inevitably difficult to measure as it takes a very lengthy analysis and simply counting the number of groups in the community is not enough (DFID, 1999). Furthermore, measurement of such capital may vary in different context as communities are not all alike (Krishna, 2004). Due to time and logistic limitations, this thesis measured the social capital of individual households through membership of various types of organizations/groups that were operating in the community as presented in Table 3.13. However, it needs to be noted that information from counting the density of people who are members of an organization is only a proxy measure of social capital as it does not directly provide information regarding the relations (e.g. norms and trust) amongst members. Moreover, such capital is not directly observable and what one can observe or measure, i.e. involvement in organizations, are just manifestations or consequences of it (Krishna, 2004).

There were major differences between sites regarding the membership/affiliation of households to various organizations in their respective areas. The majority of the households in SEC (87%) are not members of any group or organization particularly the poor female-headed households (100%). On the contrary, in NET, a high percentage of households (80%) were involved in such organizations. Both male and female headed households were involved with various types of organizations that were livelihoods, savings and credit related. More better-off women were involved with organizations than any other groups in NET (50%). None of the households in NET were involved with organizations relating to political agendas or activities. In RRD, the percentage of households which had membership of organizations was generally low (<40%). Men in RRD were less likely to be involved with organizations (89% had no involvement).

Table 3.13 Average percentage of households with involvement with different institutions/organizations by different gender of household head and wealth-ranks. ***Data presented based from cross-sectional survey.***

Sub-sites and gender	Type of organizations						
	Livelihoods & credit	Credit	Savings & credit	Social	Political	Health	None
SEC							
Poor Men (n=21)	0	4.8	0	0	4.8	0	90.5
Poor women(n=8)	0	0	0	0	0	0	100
Better-off Men(n=11)	0	0	18.2	0	0	0	81.8
Better-off Women(n=3)	0	0	0	0	0	33.3	76.7
NET							
Poor Men (n=12)	41.7	58.3	58.3	8.3	0	8.3	16.7
Poor women(n=0)	0	0	0	0	0	0	0
Better-off Men(n=15)	53.3	33.3	80	6.7	0	13.3	13.3
Better-off Women(n=2)	0	0	50	0	0	0	50
RRD							
Poor Men (n=19)	5.3	0	0	0	5.3	0	89.5
Poor women(n=6)	0	0	16.7	16.7	0	0	66.7
Better-off Men(n=17)	5.9	0	0	0	5.9	0	88.2
Better-off Women(n=0)	0	0	0	0	0	0	0

3.3.2.6 Discussion on livelihood assets

The five livelihood capitals (human, natural, physical, financial, and social) as described by DFID (1999), Ellis (2000a,b), and Scoones (1998) were broadly explored in this chapter to be able to understand their role to the overall livelihoods. Several indicators in each asset were compared between different groups and sites to determine the causes of variations, limitations, as well as vulnerability. In general, the state of the different livelihood assets/capital varied depending on the site and socio-economic group.

Human capital

Human capital underpins other capitals of households, although all the five capitals were necessary to sustain livelihoods (DFID, 1999; Ellis, 2000b). Several indicators of human capital were presented in this chapter and amongst these indicators, profile of households (headship), the labour forces, skills to get diversified activities, and health were considered important. In general, household heads are the main economic providers within households and their status therefore affects the overall status of the household. However, there are also household heads that were dependent on other household member due to illness or age. This case was found in Thailand where the oldest member of the household is still considered the head of the family especially males. This finding supports the earlier claim of Handa (1994) that head of household as reported in surveys may not always be the main economic provider. However, in this study particularly in the well-being ranking, the overall staus of the household was linked to the status of the household head which is similar to other studies (Chant, 1997; Dinh and Feeny, 1999; Handa, 1994). Among the three sites, Cambodia has the biggest percentage of females (<25%) heading the family as a result of the death of a husband through civil strife, disability or illness. Catalla and Catalla (2002) had a relatively similar finding of the high incidence of female headed households. The percentage of women (>50%) heading the family was high in the poor group in all three sites which conformed to the findings of Chant (1997) and Ellis (2000a) that generally women are poorer than men and therefore female headed households are generally the poorest households. On the contrary, in Thailand and Vietnam where patriarchy is predominantly observed, the percentage of women heading households was small (~10%). ADB (2002) related this to the situation of women in a patriarchial society where women must defer to their parents, husband, or eldest son. Level of education as well as age can also influence finding good opportunities (e.g. getting a better job) and is therefore an important part of household head's characteristics.

Household size and the adult equivalent is an important factor determining livelihood status of the household. A larger number of adults would implythe likelihood of more income providers in the household (Pollock, 2005). However, average consumption (expenses) may also be higher (General Statistical Office, 2000; Lanjouw and Ravallion, 1995; White and Masset, 2003). This supports the findings of this research where better-off families are generally larger in terms of household size and labour force than poorer households. The average household size in Thailand (>5 person) resulted in a higher adult equivalent and also greater likelihood of having a member in the family sending remittance as a result of rural – urban migration (Demaine *et al.,* 1999). In a study of farms manging integrated agriculture- aquaculture in the same region of Thailand, a similar mean household size was observed by Pant (2002). Pholweing (2001) reported similar figures in a study conducted in Yasothon province where one of the sub sites of this research was conducted. In other parts of NET, both AIT/AO (1998) and Phromthong (1999) found similar average sized households (>5 person per household). In Vietnam, the result of this research was relatively similar with that reported by the living standard survey of the Red River Delta area (4 person/ household) (General Statistics Office, 2000). This figure, however, was considered the lowest in the country with an overall average of household size 4.7/ household. Demaine (2000) however, reported a slightly higher average household size (>5 person/household) but this maybe due the selection process of the research wherein it only targeted household practicing the VAC system. The small average household size of Cambodia and Vietnam may be related to the effect of civil strife and war which both countries suffered respectively (Turton, 2000) and also by the inter province or rural urban migration as reported in the living standard survey in Vietnam (General Statistics Office, 2000).

In the rural areas where most of the economic activities need physical strength, larger household size can be an advantage by increasing available labour. Campbell *et al.* (2005) reported that health is an important asset as it influences the livelihood strategies and outcomes of individual households. This also supports the criteria used in the well-being ranking i.e. being poor because the household head is ill. The greater the number of adult equivalents in the family means more chance of getting more income and diversified livelihood activities. Campbell *et al.* (2005) identified similar findings in a research conducted in Cambodia that diversity and outcome of livelihood strategies are often linked with the age and the size of the household. However, this may not always be the case as in Vietnam where the average adult equivalent is very low and yet the agricultural production is still high. This may be the influence of a society that is more market oriented (Campbell *et al.* 2005).

Children's contribution to the household as human capital was particularly significant in Cambodia. Children played a very important role in foraging for food i.e. harvesting aquatic animals, managing aquatic systems and household chores.

The average number of children per household was higher in SEC which is maybe the reason why children's contribution is higher. Additionally as related to the wellbeing characteristics, households in NET and RRD give more importance to education and therefore children have more opportunity and social pressure to study, whereas in Cambodia where educational infrastructures are less developed, access is inevitably more limited and children are more likely to be absorbed into household labour (Catalla and Catalla, 2002). Turton (2000) reported similar facts regarding health and education of chidren – generally low and that women and children shoulder relative amount of responsibilities on agricultural work.

Natural capital

The physical and social dimensions (i.e. ownership and access) of the natural capitals available for the households were broadly understood. In most agricultural countries of Asia, natural resources are a very important type of capital because they provide the foundation for food security, source of income and employment, and also an essential 'safety net' for the rural poor (McKenney and Tola, 2002; Ramamurthy *et al.*, 2001; Rigg, 2006; STREAM/CFDO/SCALE, 2002). Private agricultural land, and communal land like forest and water bodies are very important. The two main indicators that were presented in this thesis are the area of land owed (land rights in Vietnam) and the main source of water for agricultural production.

During the wellbeing stratification, land was found to be one of the most important criteria for wellbeing as it was considered as the source of income and most of the ranking criteria were associated with money (Heady and Wooden, 2004). The differences in land holdings between wellbeing groups varied amongst sites. In Cambodia for example, the better-off households owned double the amount of the land compared to poorer households, which simply means that the poor farmer had less chance of producing enough rice and therefore posing a threat to the household's food security. This finding also indicated that the indicator that was used in Cambodia during the wellbeing activity was relatively accurate. The number of poor households in Cambodia with small land holdings or becoming landless is increasing. Farmers are using their land as collateral during their difficult times. Catalla and Catalla (2002) made similar reports on confiscation of land among the poor by the rich and the powerful. However, Thailand and Vietnam are different cases in this regard. Households with the smallest land area in Thailand were not necessarily poor as other households especially the better-off have diversified into non-farm activities and therefore land holdings were less of a critical reflection of overall wellbeing. This was also observed and reported by Rigg (2006) that non-farm opportunities have expanded and therefore livelihoods are becoming divorced from farming land (Rigg, 2006). Conforming to previous report of Demaine *et al.* (1999) rural-urban migration was also another reason why agricultural land was less important to rural households in Thailand as compared to Cambodia. In the case of Vietnam, the insignificant differences in land holding were the outcome of the existing policy on land distribution where all households had more or less similar sizes of land for cultivation (Resolution 10) (Rigg, 2003). The cases of farmers in Vietnam cultivating larger land holdings were related to the practice of mortgaging land by other farmers i.e. farmer give their land for cash loan on long term basis. The importance of land ownership in Cambodia was illustrated in this research and and a high dependency on agriculture as the main source of livelihood. Several researchers have reported similar findings in Cambodia (McKenney and Tola, 2002; Murshid, 1998; Ramamurthy *et al.,* 2001). Rigg (2003) also reported that more than half (51 – 78%) of the people living in the rural areas of the south were involved in agricultural work

Land allocation for different uses is mainly divided into three types; residential, aqua farming, and farm land which are mainly the largest proportion (90%, 96% and 80% from SEC, NET and RRD respectively). Pant (2002) reported similar allocations of land by farmers in the northeast of Thailand who were practicing integrated agriculture – aquaculture. However, the land allocation found in the study site in northeast Thailand was less than that recommended by the Royal Development Project Board 1997 (Pant, 2002) which is 30% for the rice fields; 30% for pond and reservoir; 30% for field and horticultural crops and 10% for the homestead. In the Red River Delta,Vietnam however as reported by Demaine (2000), land allocation for aquatic production was typically more than 25%. Amongst the different uses of land for farming, rice fields is the most important in all sites as the bulk of their livelihoods depend on this system (McKenney and Tola, 2002; Paxson, 1993; Rigg, 2006). This finding is similar to other research conducted in the region (Amilhat, 2006; Demaine, 2000; Gregory and Guttman, 2002b; Gregory *et al.,* 1996; Pant, 2002; Shams, 1998). The majority of households at all three sites were predominantly rice farmers, although some farmers in RRD grew other types of crops (Thanh *et al.,* 2005) particularly those practicing the VAC system (Demaine, 2000; Luu *et al.,* 2002). An interesting finding in this thesis was the difference in the proportion of land allocated for deeper aquatic systems (household, culture, and trap ponds). Although Vietnam had the smallest land area, it had the highest allocation for deeper systems i.e. household ponds (<20% of the total land area). This finding is relatively smaller than the average percentage reported by Demaine (2000). The difference however, may be due to the exclusion of the land allocated for homestead in Demaine's report. Furthermore, a large proportion of households in Vietnam have deeper aquatic systems compared to Cambodia and Thailand. This suggests how aquaculture is important in this area and supports the initial assumption during the site selection process i.e. that the site be well established in terms of conventional aquaculture. Again, this finding in the Red River Delta Vietnam of having aquaculture as an important livelihood strategy may be due to the government policy institutionalising the practice of VAC system in order to improve the economic situation (Demaine, 2000).The limited number of households having deeper aquatic systems in Cambodia confirmed its status in terms of limited and relatively recent aquaculture development as reported by other workers (ARMP, 2000; Gamucci, 2002)

Water source is another important resource related to household livelihoods dependent on agricultural production. Aside from rain, perennial water bodies are the main sources of water in the rural areas in both agro-ecological zones; however such type of water resource may not always be available and accessible particularly in the drier or elevated areas. Turton (2000) reported that many factors constrain access to water irrigation in Cambodia. Relying on rainfall or water from local man-made water impoundments are the only options for farmers or households with water resource problems. In some areas like Cambodia and Thailand, local communities use water from other aquatic systems like dug out ponds, small canals, swamp, and lakes. In Northeast Thailand as reported by AIT/AO (1998), aquatic systems are usually limited to streams, ground water and low-lying areas of ricefields. The creation of trap ponds in both Cambodia and Thailand also plays an important role in prolonging the water availability for agricultural production (AIT/AO, 1998). Vietnam generally has established irrigation systems which explain its high agricultural productivity.

Physical capital

Various physical assets were described in this chapter (housing, various types of equipments, and livestock). All of these physical assets influenced the implementation of different livelihood strategies (DFID, 1999; Ellis, 2000a,b) or from another point of view, they can be considered a livelihood outcome. In any case, possession of these assets reflected the overall livelihood status and therefore a good indicator of a wellbeing exercise which was observed in this research. Similarly, other researchers who implemented wellbeing ranking reported the importance of physical assets as an indicator of wealth (Beaton, 2002; Conway, 1999, Garaway, 1999, Islam 2007; Karim, 2006; STREAM/CFDO/SCALE, 2002). Amongst the physical assets, the differences in livestock holdings and value were very interesting. During the wellbeing ranking, aside from land ownership, livestock was mostly used to determine wealth particularly in Cambodia and Thailand where large ruminants are mainly used for agricultural production (cultivation and transportation). They are also valued for their liquidity value as a source of almost immediate cash for the households especially for the poor who are most vulnerable to shocks (Demaine *et al.,* 1999; Pant, 2002). Tana *et al*. (1994) and Ramamurthy *et al*. (2001) suggested that raising livestock is an integral part of farming system in Cambodia and a very significant asset. Large livestock (buffalo and cattle) were being utilised for draft power in all agricultural activities (e.g. ploughing, transporting of seed and harvests) (Tana *et al.,* 1994). In Vietnam however, livestock (large and small) were mainly raised for cash production (Suzuki *et al.,* 2006). Possession of large livestock may be influenced by the size of land-holding available for grazing (Ramamurthy *et al.,* 2001). In Cambodia and Thailand where common property pasture is commonly available, a large proportion of households has more than three or six large livestock. The situation is different in Vietnam as community grazing is very limited and therefore the number of large livestock that can be kept is constrained. Demaine *et al.* (1999) and Pant (2002) had similar conclusions that in areas where agricultural land where irrigated and that multiple cropping is possible, shortage of pasture was an issue and therefore limiting the rearing of large animals. However, other types of livestocks are common and important in Vietnam – pig and poultry, for example are livestock that do not require a large area for grazing. Pigs are typically penned adjacent to the household pond in Vietnam, serving as a critical nutrient source for maintaining pond productivity (Demaine, 2000; Luu *et al.,* 2002). The average number of livestock reported in this thesis was relatively low compared to the existing literature (AIT/AO, 1998; Demaine *et al.,* 1999; Pant, 2002). This could be due to the sampling procedure employed in this research whereby at least 2/3 of the respondents were randomly selected regardless of the farming system being practiced. On the contrary, the respondents of Pant (2002) were all practicing integrated agriculture and aquaculture where livestock rearing was one of the components and therefore there was a greater chance of identifying respondents that kept livestock.

Doney and Wroe (2006) reported that in Vietnam one of the indicators used in determine household wellbeing status is the presence of motorbikes. Possession of a motorbike suggests that the household has a certain level of wealth. Common physical assets that provide better opportunities to the whole community are also important. Established irrigation systems, roads and electricity are some of these common physical assets. This research also found the negative impacts arising from damage to basic infrastructure (roads and water supplies) and destruction of irrigation systems described by Turton (2000). In RRD such public capital is generally available in most agricultural areas which support more sustainable and less seasonal production. In contrast, SEC and NET suffered from very seasonal production as access to irrigation supplies is limited and therefore agricultural land is mainly rainfed. Such limitations to this type of capital also undermine any improvement of farming aquatic animals in areas like SEC and NET. This may also the reason why households in both Cambodia and Thailand excavated an area of their rice fields (trap ponds) in order to keep water and mitigate water scarcity.

Availability of different equipment for different livelihood activities varied between sites and socio-economic groups. Different equipment also characterised the status of the main livelihood activities in the area. For instance in Cambodia, agricultural technologies are still yet to develop hence modern and high technology equipment is lacking unlike in Thailand and Vietnam where more modern equipment is available (e.g. two-wheeled tractor, rice machine – thresher, water pumps, etc.). The availability of various fishing equipment with households in Cambodia and Thailand obviously illustrated their dependency on fishing as an important livelihood activities. This finding agrees with the report made by AIT/AO (1998) that fishing is a common activity in northeast of Thailand (particularly in Srisaket and Roi-et province) with more than 83% of the respondent claimed fishing as their main livelihood activity.

Financial capital

Estimates of financial assets are some of the most critical information collected and most prone to inaccuracy either because of difficulties in recall or because of intentional misreporting (Macours, 2003). Demaine *et al.* (1999) suggested that establishing income levels using a survey was both time consuming and fraught with difficulties. These issues however were taken into account when planning the research and managed to minimize the problem; substantial information was generated to describe financial capital of households in the rural areas. Building rapport with respondents during the research process, particularly during the previous activities in the community (PRA, village workshops), sought to reduce these inaccuracies. Generally, financial assets in rural areas of Asian countries are derived from livelihood activities, and in most cases, farming (ADB, 2004). Sales of farming and aquatic production and the value of livestock are the main source of cash assets in the study sites. Generally, the value of agricultural production accounts for more than 50% of the total financial assets in rural areas across all wellbeing groups, AEZ and sites. Demaine *et al.* (1999) reported that sources of financial capital were mainly dominated by agriculture in northeast Thailand. An average of 84% of income was contributed by sales of agricultural crops. In Cambodia, aside from the earnings from agricultural crops, sale or the retained value of livestock were the main sources of financial capital. Although a significant proportion of the population had no land or was nearly landless, there are other opportunities that household can depend on in order to develop financial capital (Ramamurthy *et al.,* 2001). In general, there were few options available for households in Cambodia to get financial capital (Turton, 2000). The contribution of livestock (value) is high in Cambodia which again supports the findings in the wellbeing ranking activities (i.e. number of livestock indicates wealth). The tangible or direct contribution of aquaculture and fishing to the financial asset is very small in Cambodia where such activity is generally considered subsistence (ARMP, 2000; Phillips, 2002; Touch, 2000). However in Thailand and Vietnam, such activity is considered as a form of cash cropping and therefore contributes significantly to the overall financial assets of the household. Meanwhile in Vietnam, aside from the agricultural sources of financial capital, wage employment and household enterprises (self-employment) was a major contributor of financial assets. This is similar to the findings of the Vietnam Development Report (2004) which found the majority of the household members (53%) were either engaged in wage labour (private sector) or conducting their own enterprise.

Another important contributing factor to the financial capital of households was the remittances coming from household members working in non-farming activities in other provinces/city. However, the findings of this study showed a very low percentage of household membes sent remittances to their family. This finding contradicts with the report of Pant (2002) in which he indicated that the majority of households in northeast Thailand diversified their income through employment earnings from off- and non-farm activity which included working in the city, other provinces and even abroad. Sheriff (2004) also found remittances were important in fisher households in southern Thailand. In Vietnam, Thanh *et al.* (2005) reported that remittances from migrant workers contributed a very significant amount to the total financial assets of households in one village in the Red River Delta. Aside from the direct impact of remittances to the financial capital of the family and therefore creating other opportunities, remittance can also be use as an indicator for social and human capital. The differences on the indicator found in this current research varied from other works and this may be due to the approach used were respondents were allowed to provide their own criteria.

Although credit providers are available in rural areas, not everyone had access to such resources especially poorer households in Cambodia and Vietnam where the only creditors that provide credit to them were NGOs and private lenders. Turton (2000) reported that majority of the households in Cambodia were forced to take loans from informal lenders (e.g. neighbours, private lenders) at high rates of interest. In Vietnam, contrary to the findings reported here, several sources of credit exist that even the poor in the rural areas can access including the Vietnam Bank for Social Policies (VBSP) and Vietnam Bank for Agriculture and Rural Development (Vietnam Development Report, 2004). Meanwhile, most households in Thailand have access to multiple credit providers such as commercial banks, government banks (BAAC), NGO's (cooperatives) and private lenders. Most of people in rural areas believe that they need physical assets in order to access to such credit (i.e. land titles, house and even livestock). Amongst the three sites, communities in NET have more access to credit particularly from the Government agricultural bank (BAAC) and private lenders. These findings are similar to those of Sherrif (2004) in the southern part of Thailand. Pant (2002) and AIT/AO (1998) also reported the importance of BAAC to the financial capital of households in northeast Thailand.

Such programmes are lacking in Cambodia and Vietnam. Non government organizations and people's organization are most common in these two areas. However, access to credit may not always lead to improvement of financial assets. In some cases (Cambodia and Thailand), creditors provide other forms than monetary (i.e. agricultural inputs, rice for consumption, other equipments).

Social capital

The ability of individual persons to network and to become accepted within a group is considered to be a type of social capital as described by Ellis (2001). Krishna and Shrader (1999) described social capital as features of social organizations which include networks, norms and social trusts that facilitate coordination and cooperation for sharing benefit in other words relationships among individuals and groups (Flora, 2004). This capital is one of five types of capital that underpin overall livelihoods as it can be used to access resources necessary in the implementation of livelihood strategies (Cattell, 2001; Fall and Kilpatrick, 2000; Lochner *et al*., 1999; Serageldin and Grootaert, 1996). DFID (1999) considered this type of capital as a "resource of last resort" as it can be used as a buffer that helps households, especially when they experience shocks. This capital can be used in acquiring finance, farming equipment, medicines, labour, and even just company. However, among the five capitals, only this type was not included as a local indicator of well-being. This maybe due to the fact that there was limited tangent indicators for such behaviour, evaluation of people in the village working together and building trust to one another was not part of this research. However the SRS project did looked at this issue on its intervention phase of the project (Little *et al.,* 2004).

Since social capital has been identified and used as an indicator several measurement tools have been developed for its assessment such as Social Capital Assessment Tool (SOCAT) of the World Bank (Krishna and Shrader, 1999). This tool focuses on the structural and the cognitive social capital at the micro level, its interactions at the community, household and institutional levels. Between the two (structural and cognitive), structural capital is easier to measure as it deals with organizational density, mutual support organizations, measures household members affiliation with local level institution (both formal and informal). On the other hand, cognitive social capital deals with solidarity, trust, reciprocity and cooperation (Krishna and Shrader, 1999). Indicators of structural social capital were only measured in this research – membership of household members to different organizations.

To describe social capital, the capacity of individual to be involved with different organizations was the only information generated in this research, altough there were also researcher and field staff's observations regarding the social dynamics in each site. For instance, the role of village headman, health worker, and local teachers were very important in facilitating collective activity in the rural areas. Each one of these individuals has a social role/status that local people in the village look up to and follow. STREAM/CFDO/SCALE (2002) reported from the community appraisal conducted in Cambodia in which they found out that local leaders, health workers were being recognized and their advice followed within communities. Similarly, this scenario was also observed in other sites, Thailand and Vietnam. Villagers in rural areas contribute to road construction, during the occasion of celebrations (religious ceremony), building houses, etc. (STREAM/CFDO/SCALE, 2002).

Stolle and Rochon (1998) suggested that actual membership in associations/ organizations creates generalised interpersonal trust which can be used as ‘lubricating agents’ to various forms of social interactions and cooperation. Although there are several types of organization, a large proportion of the individuals in the rural areas of Cambodia and Vietnam do not belong to any formal organization which only indicates the low level of social networks, particularly of poorer men and women. This suggests that this approach to estimating social capital is inadequate. However, amongst the three sites, such organisational networks appear to be better developed in Thailand, perhaps reflecting longer term social and economic stability. Viewed in these terms, social capital in Thailand can be considered to be relatively high as only 30% of the population were not involved in any organization. There are some possible reasons for the non-involvement of rural people in an organization especially by the poorer households. This non-involvement can be linked to the nature of livelihoods activities of individuals who are working most of the time and therefore have no time to network with other villagers unless really needed i.e. support in labour. Membership fees can also contribute to the non-involvement of most poor farmers since most of them do not always have money on their hand and if they do, priorities are towards meeting the household’s immediate needs.

Collective action has been going on in the different sites particularly in relation to aquatic resource management like community-based fisheries and pond-refuge management in Cambodia as reported by Meusch and Viseth (2001) and Viseth *et al*. (2002). Turton (2000) suggested that collective action in Cambodia can be successful when it is genuinely participatory during the planning and implementation process which was what the above research did as part of the Aqua Outreach programme of the Department of Fisheries in Cambodia. In Thailand, village fishponds managed by the community are becoming popular in the northeast. Meanwhile in Vietnam, people's involvement in managing irrigation is one example of collective action (Dat, 2001).

3.3.3 Institutions and access

Institutions are described as social cement that connects different stakeholders (Scoones, 1998) or a regularised pattern of behaviour structured by rules that have important functions in the development in the society (Ellis, 2000b). Furthermore, institutions influence how people utilise and access their resources which include assets, markets, livelihood strategies and vulnerability (Adato and Meinzen-Dick, 2002; Johnson, 1997). Organizations and institutions need to be understood in order to develop interventions which will improve the livelihoods of the community (Scoones, 1998).

3.3.3.1 Organizational membership/affiliation

The different organizations that were present in the community were categorised based on affiliation; government organization (GO), non-government organization (NGO), and local or mass organisations such as farmers' union, women's union etc. Amongst the three categories of organization, local/mass organizations had the largest number of members in the community, particularly in NET (Figure 3.11). In both SEC and RRD, although memberships were very low, GOs and NGOs were more important. In SEC, a very few number of both poor and better-off families were involved with GOs and NGOs (Figure 3.11). However, better-off families were also involved with some local organizations/groups. In NET, the majority of households were involved with local organizations, particularly the better-off. Involvement in GOs is similar among the better-off and poor households. Only better-off households were involved with NGOs in NET. In RRD, in contrast to SEC and NET, poorer families were more involved with community, particularly local, organizations as shown in Figure 3.11. Neither the poor nor the better-off families were involved with NGOs in RRD.

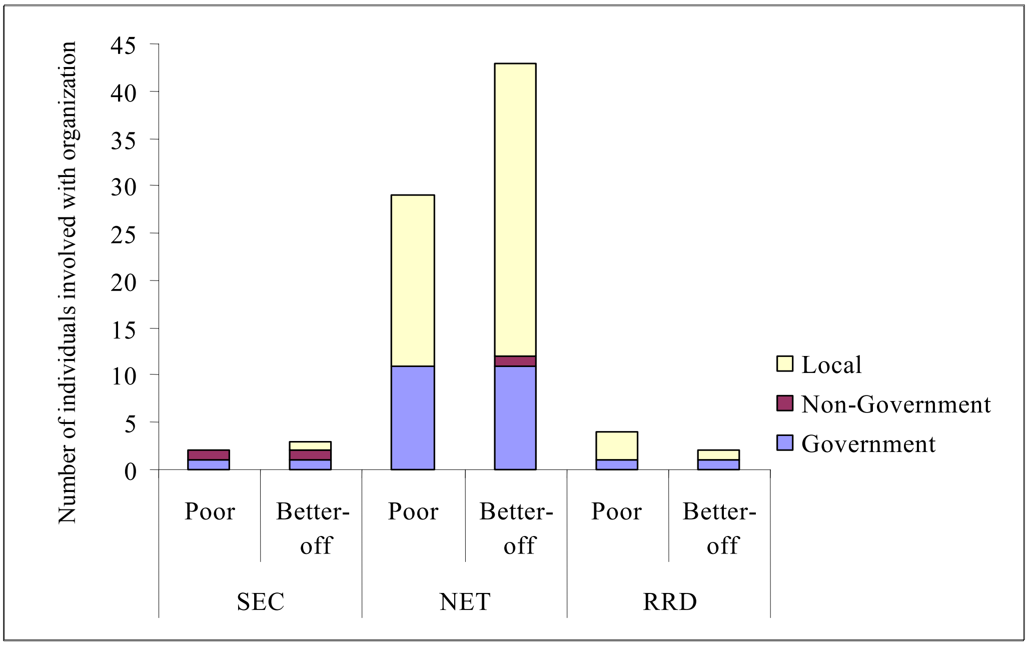


Figure 3.11 Involvement of individual villagers of different well-being ranks in different types of organization. *Data presented based from cross-sectional survey.*

3.3.3.2 Benefits from membership of organizations

The main reason for being involved with any organization or group is the expectation of benefits. The following section discusses the different types of benefits that individuals received from different organizations. Figure 3.12 grouped the different benefits into four categories; benefits related to agricultural production, and improved access to financial, human and social capital. The most common benefits that an individual gains from being involved in the organizations is financial. These organizations were mostly involved in providing credit and other livelihood opportunities to their members.

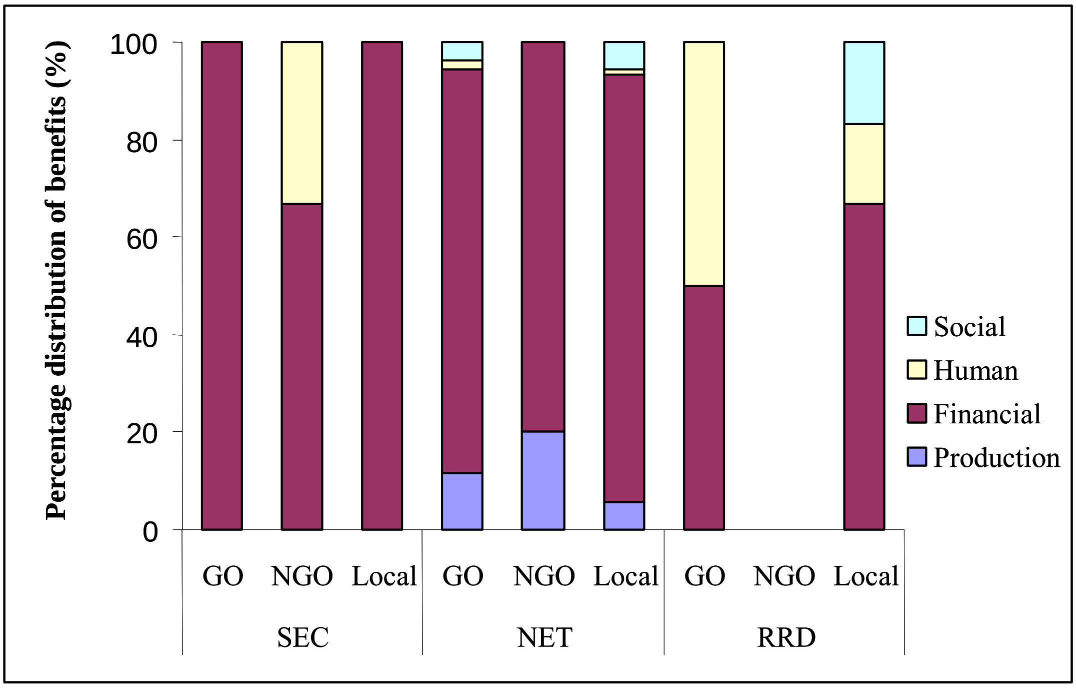


Figure 3.12 Percentage distribution of benefits from different types of organizations/ institutions. *Data presented based from cross-sectional survey.*

In SEC, amongst the three types of organizations, only NGOs provided benefits other than financial, that is human capital i.e. knowledge through training, medicines, and even rice for family consumption especially during the lean season. In NET, organizations also provide other types of benefits to members; benefits related to production (e.g. agricultural equipment, fertiliser, seeds, and even livestock breeders) were being provided by the three groups of organizations in NET, where NGOs have a higher profile among different types of organization. The least benefits which the organizations in NET provide to beneficiaries are related to human capital (e.g. training and medicine). In the RRD, particularly the government organizations give equal importance to both financial and human capital, whereas benefits relating to social capital were provided by local organizations.

3.3.3.3 Credit access

Households from the three study sites had access to various types of credit provider. However, a significant number of poor households in SEC and RRD did not have access to such services (27.6% and 32% of poor households from SEC and RRD respectively) (Table 3.14). The different credit providers were banks (government banks and commercial), government organizations, non-government organizations, and private lenders. Poor households from SEC did not have access to government and commercial organizations providing credit. A larger percentage of poor households in SEC obtained credit from NGOs (44.8%) and private lenders (31%). In NET, credit was more widely and equitably available from a large range of sources from the government bank, BAAC (91.7% and 94.1% of poor and better-off households respectively) and other government organizations (91.7% and 82.4% of poor and better-off households respectively). All of the sampled households had access to at least one type of credit institution.

Table 3.14 Percentage of households who have access to different credit organizations/ institutions by different gender of household head and well-being ranks. ***Data based from cross-sectional survey.***

Sub-sites &	Credit provider

wellbeing	Comm. Bank	Gov't. Bank	Gov't org.	NGO	Private lenders	No access
SEC						
Poor	0	0	0	44.8	31.0	27.6
Better-off	14.3	0	7.1	71.4	21.4	0
NET						
Poor	25	91.7	91.7	0	58.3	0
Better-off	23.5	94.1	82.4	23.5	29.4	0
RRD						
Poor	0	36.0	0	28.0	20.0	32
Better-off	0	64.7	0	29.4	17.6	0

In RRD, households mainly accessed three types of credit institution i.e. government bank, NGO, and private lenders. Amongst these credit institutions, more households accessed credit from the government bank (36% and 64.7% of poor and better-off household respectively). None of the sampled households in RRD reported having access to commercial banks or government organizations.

Forms of credit

Cash was not the only form of credit that households acquired from the different institutions mentioned in the previous section. Other forms of credit were equipment, inputs and even rice for household consumption (Figure 3.13). In SEC, more than 20% of poor households acquired rice for consumption as a form of credit. Meanwhile, almost 30% of the better-off households acquired inputs on credit. In NET, the majority of households from both well-being groups acquired cash as credit, however equipment was also rented by some households (5.3% and 3.8%, poor and better-off households respectively). In RRD, sampled households accessed only cash from credit institutions.

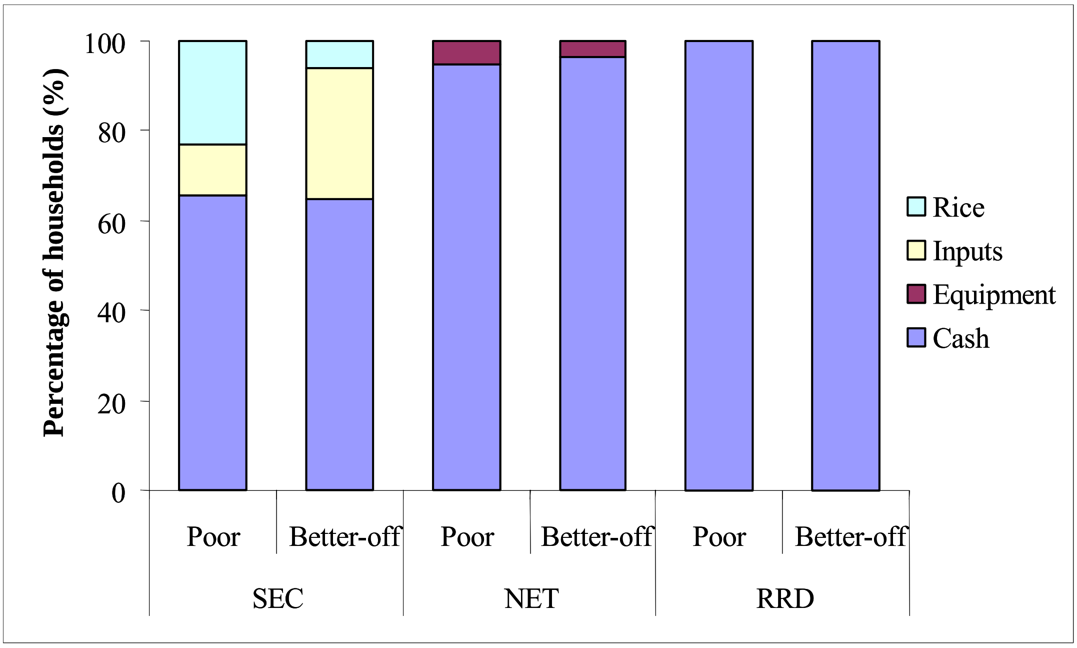


Figure 3.13 Different forms of credit acquired by households of different well-being in SEC, NET and RRD . ***Data presented based from cross-sectional survey.***

Credit rules

This section includes not only the mechanism for paying off loans but the requirements for households to obtain credit. These rules determine households' access to credit by different credit providers (Table 3.15). Loans from NGOs are most commonly repaid after harvesting the main agricultural crop in SEC. Payment of high interest rates is required by most credit institutions in SEC even those identified as NGOs. Having land as collateral is also an important requirement for most credit providers. The use of collateral in acquiring loans is the most common rule among credit providers in NET. In RRD, the most common rule for acquiring credit is the capacity of the households to repay the high interest rates levied by both government banks and private creditors. Aside from paying the interest, credit providers also require collateral such as land or house deeds from the households seeking loans.

Table 3.15 Different rules being implemented by different credit providers in SEC, NET and RRD. ***Data presented based from cross-sectional survey.***

Sites	Types of Credit provider	Rules*	Freq.
SEC	Commercial bank	Pay high interest	2
	NGO	Payment should be done on time	1
		Loan should be used for agriculture purpose only	1
		Payment after harvest	11
		Know someone from the organization	1
		2% interest per month	2
		Use land as collateral	5
		4 months interest upfront	2
		Member of group	5
	Private	Pay high interest (2x higher from commercial bank)	2
		Should be known very well	2
NET	Commercial bank	Use land as collateral	6
	Government bank	Use land as collateral	
	Government org	Use land as collateral	2
		Should have a guarantor	1
	NGO	Should be a member of a group	1
	Private	Use land as collateral	4
RRD	Government bank	Use land as collateral	2
		1% interest per month	12
		House as collateral	
	NGO	Member of group	2
	Private	Pay interest – normal rates	15
		Need collateral	2

* Note that not all of the respondents were aware of the rules implemented by different credit providers.

3.3.3.4 Access to aquatic resources

Access is defined by the rules and social norms that determine the differential ability of people in rural areas to own, control, otherwise claim, or make use of the resources such as land and common property (Ellis, 2000a,b; Scoones, 1998). It can also be the ability to participate in, and derive benefits from, social and public services provided by the state such as education, health services, roads, water supplies and so on. In this thesis, an understanding of peoples' access to both owned and common property was assessed through focus group discussion and one-on-one interviews. Access was determined based on the different level as discussed by Buenavista *et al.* (1994), Ellis (2000a,b) and Scoones (1998).

This section presents three main types/level of access to aquatic resources (Buenavista *et al.,* 1994). Furthermore, differentiation within households regarding access to resources by gender and age is also highlighted in this section (Table 3.16). The first type of access is related to control i.e. the individual deciding on what to do with the resource. The second relates to the individual responsible for using the resource and the third, the person in the household that controls the outcome of the production that results.

Table 3.16. Ranking of the different types of access by different age-gender group to different types of aquatic resources in the rural areas of SEC, NET and RRD

Country	Resource group	Decision			Use resource			Control benefits		
		M	W	C	M	W	C	M	W	C
SEC	Individual	1.28	1.81	-	1.15	1.93	2.64	1.75	1.25	3
	Community	1.38	1.87	-	1.31	1.80	2.81	1.69	1.31	3
NET	Individual	1.31	1.60	2.88	1.20	2.14	2.52	1.36	1.31	2.83
	Community	1.16	1.74	2.60	1.17	1.95	2.53	1.43	1.24	2.92
RRD	Individual	1.30	1.61	2.71	1.67	1.48	2.77	1.86	1.13	3
	Community	1.40	1.50	3	1.65	1.47	2.87	1.73	1.19	3

Note: M = men; W = women; C = children; 1 highest rank

As presented in Table 3.16 there were two types of resources used in this analysis: (1) individual resources or the privately owned aquatic resources such as ponds (trap pond, ditch, household pond/culture pond) and rice fields; (2) community resources such as village fishponds, reservoirs, swamp and canals. Friedman tests showed a significant difference in ranks relating to decision making between genders (P <0.001) where men (ranked 1st) generally controlled the decision making on what to do with the resources. Women had secondary decision making powers. In both NET and RRD, children also decided on what to do with resources, however, this only happened if both men and women were not present. Children in SEC do not have such type of access (i.e. decision making) to either household or community resources. Men also ranked first in both SEC and NET regarding the use of aquatic resources and women and children ranked second and third respectively. On the contrary, in RRD, women were most likely to use the resource for production followed by men and children as second and third respectively. In controlling the benefits gained from the resources, women were ranked as the main controller of benefits (mostly cash) at all sites. Men and children were ranked second and third respectively in controlling the benefits.

The ranking activity was carried out by a group of both men and women and the Spearman rank-order correlation showed a highly significant positive correlation by gender ($P < 0.001$) which means ranking results of the two groups were similar. Friedman test did not show any significant difference ($P = 0.502$) between individual and community resources which means that the gender group that decided, production and controlled benefits of resource use was the same for both types of aquatic resource.

3.3.3.5 Discussion on institutions and access

Organizations that provided support for livelihoods, health, credit and savings for individuals in Asian rural areas were most common. In contrast institutions or organizations that provide support specifically for aquaculture or fisheries were lacking in most of the communities studied. However, this may be the result of the selection process of the SRS project; communities that were involved with the AIT outreach project were avoided. Generally, institutional support to the communities studied was found to be minimal and the involvement of the local community was also minimal. Most of the organizations were particularly interested in agricultural production i.e. rice farming, otherwise, the focus is on non-farming livelihood activities (e.g. small entrepreneurship).

As defined by several researchers and development organizations (DFID, 1999; Ellis, 2000b; Garaway, 1999; Scoones, 1998), the concept of institution is the analysis of rules that govern behaviour of those that were involved and not the organization *per se*. The organisations which are commonly synonymous to institutions (Garaway, 1999) are the players in this context that implement the rules (Scoones, 1998). However, the information presented in this thesis mainly focuses on the institutions referring to the player with whom rural households have involvement and very minimal on the set rules. The effectiveness of the different rules and norms as well as the impact were not evaluated in this research due to logistic and the main focus of the project.

Various organizations were identified in the study sites with which households have involvement, however, involvement or the number of households involved in any type of organization was very low. Importance of the different types of organizations was found to be site-specific. Involvement of the different gender groups was shown in Cambodia, where men were involved with livelihoods, politics and credit-related institutions while women, particularly the better-off group, were involved with organizations focusing on health improvement in the area. The high proportions of households in Cambodia that did not have access to any institution or organization, especially the poor women, clearly illustrated the lack of social capital of this group. Similarly, Turton (2000) suggested that the social networks have been severely disrupted due to civil strife and the movement of household to and from the village after the Democratic Kampuchea regime. In Thailand, organizations that focused on livelihood activities, savings and credit were common, particularly servicing men. Some of the organizations identified in this research in the area of Thailand were also identified by Pant (2002) who was working on the promotion of integrated agriculture aquaculture. Involvement of women was also limited in NET. This finding however is contrary to the situation in RRD, where women are more involved in organizations, particularly the Women's Union. From various organizations in the study sites, the main benefits that members can get are mostly support to improve their financial and human capital, particularly in SEC and RRD.

The most common requirements for accessing credit are for the borrower to have collateral (e.g. land title, house, and livestock). Land title as collateral is very common even among the private lenders, this is mainly the reason why other farmers lost their land in Cambodia and rights to farm in Vietnam as discussed in the wellbeing section of this report. This explains the skewed land holdings in Vietnam in spite of the equal land distribution policy (Rigg, 2003). Payments of interest in advance and on time are the most common rules from creditors to the borrowers. Pant (2002) have identified several organizations/institutions supporting the farmers in the northeast practicing integrated agriculture-aquaculture and have identified similar organization like the BAAC that provide loans to group of farmers as well as individual farmers. Aside from BACC, Pant (2002) also identified government and non-government organizations that provide several types of support to the farmers in the rural areas of northeast Thailand. In Cambodia, several NGO's were identified that played a major role in providing support of basic social services especially in the rural areas (Catalla and Catalla, 2002)

The issue on access to aquatic resources was also analysed in this research where seasonality, well-being, and gender influenced the accessibility to such resource. Among the three types of access presented in this research, most of them were male dominated particularly in decision making or control to the resource may it be private or publicly own resource. Womens' access to resources was only limited to using the resource to produce products or in other words labour, however these are usually influenced by man. However, men's decision on what to do to the resource in order to produce output is not always the case particularly in Vietnam where women were found to be more in charge in the production side of the farm. This observation illustrates the suggestion of Buenavista *et al.* (1994) that in a household men have considerable power in the "public" sphere (male labourers are the main household provider and therefore decide for the whole households), however, women have important power in the "private" sphere particularly in the decision for the household livelihoods strategies.

In rural areas, at least in the three study sites, common or public properties were numerous especially aquatic resources (e.g. lakes, swamp, river and reservoir). Most of these resources were open access to everyone and used for small scale fishing, pasturing livestock and rearing ducks. Additionally in Cambodia and Thailand, additional resource was considered public during the rainy season – rice fields.. Several researchers reported similar observations regarding this seasonality of accessibility to rice fields (AIT/AO, 1992 and 1998; Amilhat, 2006; Beaton, 2002; Gregory, 1997; Gregory and Guttman, 1996; Gregory and Guttman, 2002b). In Vietnam, formerly open access waterbodies can become closed when individuals or private groups rent water bodies for stocking of culture species after auctioning of rights – so called ‘bid-rent’ ponds. The setting of rules for accessing aquatic resources varies locally, often on a case by case basis. For instance, the rice fields in northeast Thailand and southeast Cambodia, prohibition of other farmers to access the rice fields after the rainy season was done by individual owner of the system. Villagers are putting some obstructions to their field in order to discourage other farmers to get into the field (e.g. branches of bamboo tree, leaves of nipa tree). Additionally this also detracts large livestock grazing into individual land. Turton (2000) reported that the institutional capacity of the Cambodian government to resolve issues affecting people i.e. land access and distribution was lacking. In Vietnam, access to aquatic resources was determined by the local authority.

3.3.4 Livelihood options and strategies

The aim of this section is to assess the different options that households of different well-being level in the three study sites have to sustain their livelihoods. Furthermore, this section also discusses the various livelihood strategies demonstrated. The composition of the activity portfolio may vary at different times of the year which subsequently affects income or security among households (Adato and Meinzen-Dick, 2002). Ellis (1999) stated that the process by which families in rural areas construct a diverse portfolio of activities and social support capabilities in order to survive and pursue sustainable livelihoods constitutes a form of ‘livelihood diversification’. Information presented in this section was generated through the PRA, cross-sectional and longitudinal studies.

3.3.4.1 Livelihood activities

At the community level, a range of activities that are important to different well-being and gender groups were identified through scoring techniques (Chapter 2). There were nine main activities identified and scored by the four different gender and well-being groups at the three sites: farming (predominantly rice cultivation), livestock raising, fishing, raising fish (aquaculture), trading or small business, wage labour, income generating activities (mostly handicraft), social and religious activities and household chores.

The different activities identified in this research can be classified in two ways: based on its outcome (i.e. productive and non-productive) and its location and/or relationship to farming (i.e. on-farm, off-farm, and non-farming) (Table 3.17)

Table 3.17 Classifications of livelihood activities

Activity classification	Descriptions	Activities
Based on outcome		
Productive	Any activities that lead to production or yield; mostly related to monetary value i.e. economic activities	Farming (on and off site); trading; wicker works; producing local products (e.g. wine)
Non-productive/ reproductive[2]	Activities that do not lead to direct yield	Household chores; social; religion
Relation to farming		
On-farm	All activities related to agriculture and aquaculture carried out on own farm	Planting, harvesting, livestock, aquatic management
Off-farm	All activities related to agriculture and aquaculture carried out in places outside their own farm (other people's land; common property)	Planting, harvesting, livestock, fishing
Non-farm	All activities that do not include any agriculture, aquaculture and capture fisheries	Household chores; social and religion; trading; wicker works; wine making; construction works

[2] term used based from Buenavista *et al.* 1994

Figure 3.14 shows the average scores for the main activities that are important at the three study sites where 'farming' was scored as most important and the highest among well-being ranks, gender, and AEZ in each sites (P <0.001). Analysis showed a significant interaction effects between site*AEZ*activity (P <0.001); site*well-being*activity (P <0.001); site*gender*activity (P <0.001).

The interaction between site*AEZ*activity explains differences in scores between particular activities by gender and group at particular sites. In SEC, activities that are more important in LOW areas include income generating activities (e.g. wicker work and making wine), raising fish and trading. On the contrary, farming, livestock rearing, household chores (preparing food, washing clothes, looking after young members of the household, etc.) and social activities were more important in DRY SEC. In both AEZ, fishing was scored at the same level of importance. Important activities in different AEZ in NET were similar to SEC where farming scored higher in the DRY area, raising fish was only scored in the LOW area and fishing was of similar importance at both AEZs. In RRD, only farming and rearing livestock were scored higher in the DRY area, while other activities were more important in the LOW RRD.

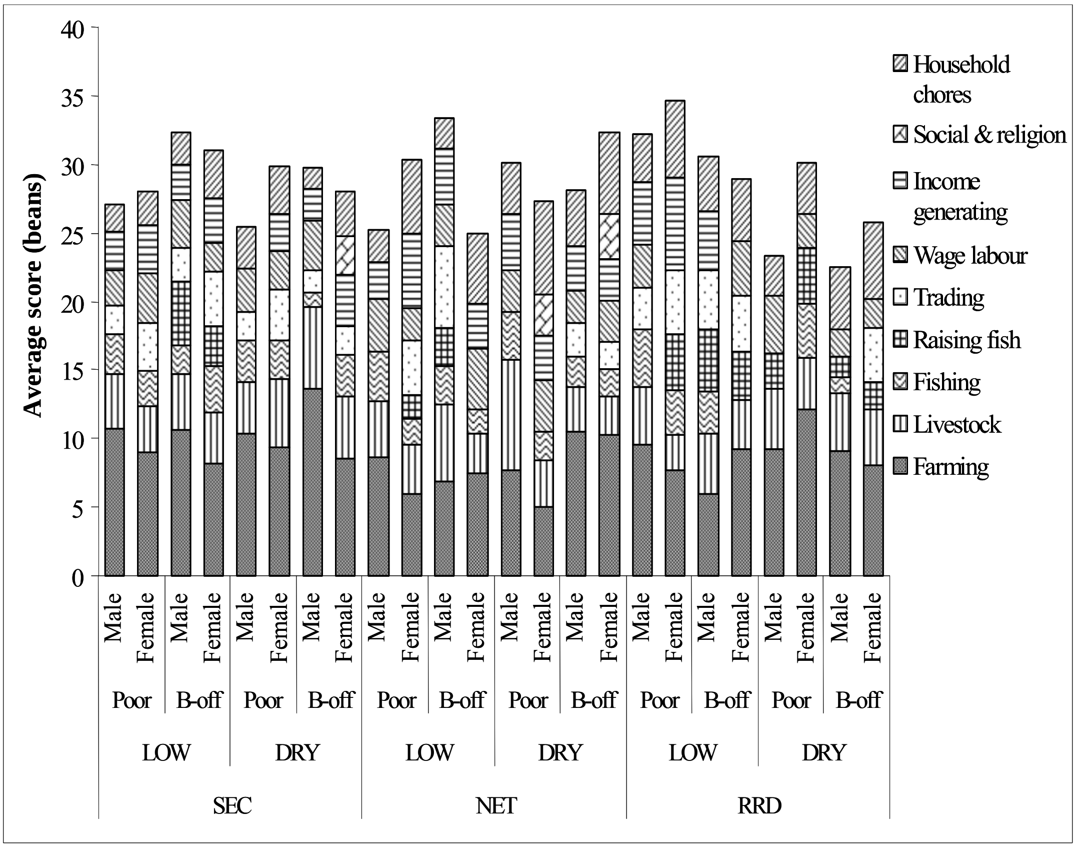


Figure 3.14 Average scores of different activities by different well-being and gender groups in AEZ of SEC, NET and RRD (B-off = better-off). ***Data presented based from PCA exercise (activity scoring).***

In comparing the important activities between well-being groups, significant differences were found (P <0.05). In SEC, only better-off groups included fish culture and social activities amongst the important livelihood activities. Raising fish was ranked third most important after farming and livestock rearing respectively. In NET, most of the activities were of similar importance between well-being groups apart from raising fish and fishing; poor groups were more engaged in the latter. Better-off people considered the two activities of equal importance. In RRD, both well-being groups identified farming and income generating activities as the most important livelihood activities in the community. However, a difference in the relative importance of raising fish and fishing was observed; whereas poor groups considered fishing more important than raising fish, the better-off had the opposite view.

In comparing priorities by gender, farming and other productive activities (directly earning income) were considered more important by men at all sites. However, household chores were always ranked more importantly by women than by men. Social activities were included by female groups in SEC and NET but scored very low. The importance of fishing and raising fish were different between sites: raising fish was considered by better-off households in SEC, particularly in the LOW area, as more important than fishing. In NET, this level of importance was reversed where both gender and wellbeing groups ranked fishing as more important than raising fish. Both activities were considered to be of similar importance by both gender groups in RRD.

Farming

This livelihood activity includes all aspect of farming: ploughing and seed bed preparation; planting/ transplanting; growing; harvesting; and even post harvest activities such as milling. Rice dominated crop production, however in NET and RRD, other crops were also grown (chilli and onions in NET; bean and other root crops in RRD). Among other activities, farming was ranked the most important by different groups ($P < 0.001$).

Livestock raising

This activity involves raising of large ruminants (cattle and buffalos), poultry (chicken and ducks) and pigs. This includes feeding or pasturing, providing places to stay i.e. pigsty and pens. Gathering of food for these animals is also part of this activity. Overall, this activity was the second most important in SEC and in RRD.

Fishing

This activity covers only the collection of aquatic animals from open water bodies (OWB) and farmer managed aquatic systems (FMAS). Preparation or repairing of harvest equipment and setting fish traps are part of this activity. Generally, this activity was given a low score by most of the groups, however, the fact that it was included in the list by all groups in SEC and NET showed its relative importance, particularly among poor men of SEC and NET. In RRD, better-off women in both AEZ and poor men in DRY areas did not consider this activity as important.

Raising fish

This livelihood activity covers all activities related to growing fish and other aquatic animals: improvement or building facilities/environment for raising fish, sourcing and stocking fish seed, sourcing food and feeding, water management and harvesting. In general, this activity was scored relatively higher in the RRD than any other sites; all groups from both AEZ included this activity apart from the poor men in the LOW area of RRD. In contrast, raising fish was considered less important in SEC and NET as the majority of the focus groups did not include it at all in their activity identification or ranking; only better-off men and women from the LOW areas of SEC and poor women and better-off men from the LOW areas of NET scored aquaculture as being important.

Trading

This activity refers to activities of households which involve buying and selling of all sorts of merchandise which are mainly for household needs or materials needed for other livelihood activities (e.g. raw materials for making mats, wine, etc). In most cases, this activity is being done in or from their house as some households had built retail outlets adjacent to, or as part of, their house. Most of the merchandise being traded was basic necessities. In some areas, fishing and farming equipments were also sold. This activity was considered important particularly among the better-off groups in RRD (male and female). The female group in SEC ranked this activity higher than the male group. In NET, poor men did not include trading as an important activity.

Wage labour

This activity refers to the act of individuals within households working for other people to earn money or goods. Wage labour is not limited to farming but includes non-farming activities such as construction work, making bricks, carrying stones, factory worker, household helper, etc. This activity was considered more important by poor households in NET and RRD, however; in SEC, the importance of this activity was similar between well-being groups.

Income generating activities

This activity refers to small enterprises for additional income undertaken within the household. These include handicrafts and home industries such as wicker work (making mats, basket, etc.) and making wines etc. This activity was generally lower in importance among men than women, except better-off men in NET and RRD.

Social & religious activities

Visiting pagodas or temples to pray and provide food for the monks is a common religious activity. Attending local festivals and ceremonies (weddings and funerals) were also included in this activity. This activity was ranked the least important activity by better-off women in SEC, and NET, which were the only groups that included this activity.

Household chores

Activities such as preparing food, cleaning, repairing part of the house, cleaning the dishes and collecting water were all considered household chores. In some cases, looking after children and the elderly were also included in this category. Generally this activity was more important to women regardless of well-being level at all sites.

Fishing vs. Aquaculture

Fishing was found of greater importance compared to raising of fish by different well-being groups in both AEZ in SEC and NET, apart from the better-off households in the LOW area at the two sites. However in RRD fishing was less important than aquaculture except among poor households in the DRY area (Figure 3.15).

Aquaculture has generally increased in importance in Thailand when the Department of Fisheries started promoting it in the northeast of Thailand with the assistance of FAO (ADB, 2005; Demaine *et al.*, 1999; Pant, 2002), but this research suggests that in the research areas stocking of hatchery seed is currently having little impact and fishing was still more important to most of the groups, particularly to the poor. In SEC, only better-off families in the LOW area ranked and considered raising fish more important that fishing. Generally, fishing was more important to the poor at all sites.

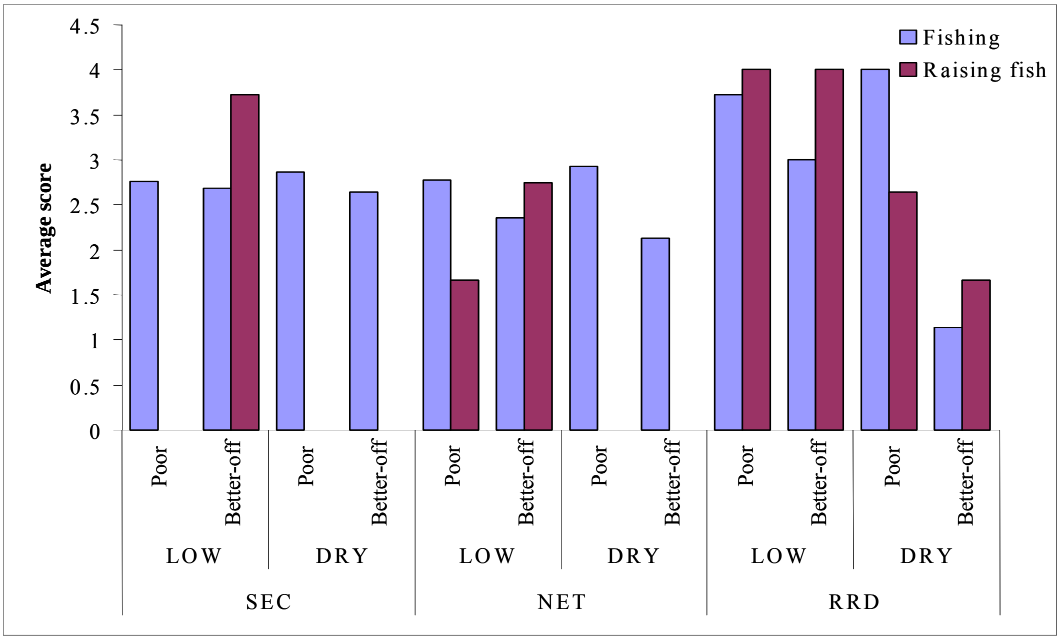


Figure 3.15 Comparison of ranking between fishing and aquaculture by households in AEZ of SEC, NET, and RRD. ***Information based from PCA exercise (activity scoring).***

3.3.4.2 Livelihood diversity

A diversified portfolio of activities can be interpreted in two ways; a choice or a coping mechanism to the surrounding issues, trends (e.g. scarcity of resources) and shocks (crises) that households face. Diversified livelihoods may not only mean the number of different types of activities i.e. the combination of farming activities with non-farming activities. Farming activities can be diversified by growing several crops or by producing other products from the original production (Campbell *et al.*, 2005; Trakoontivakorn, 2002). Diversification can also occur at different levels. As stated by Campbell *et al.* (2005), diversification can be considered at the individual level, i.e. the same household member having several activities or at the household level where the household as a whole has several sources of income. This is affected by the number of adults in the household and the range of their livelihood activities.

Mean number of livelihood activities

As presented in the previous section, farming was the most important livelihood activities in all groups of households in the community being studied. However, there were also other options for the households in order to improved or sustained their livelihoods. Table 3.18 shows the average number of activities taken up by households as a strategy in maintaining their livelihoods. However, the number of activities alone does not necessarily show diversity. There are several factors that need to be considered in determining diversed activities i.e. hour spent, frequency.

Analysis demonstrated that there was interaction between site, well-being, and gender groups for the number of livelihood activities (P = 0.004). Significant interaction also occurred between site, AEZ and gender group for the average number of livelihood activities (P = 0.019). Amongst the groups, better-off females from NET had the highest average number of livelihood activities (6.9 ± 1.1) whilst poor women in RRD had the lowest number of livelihood activities (4.2 ± 0.7). Women from the LOW area of NET had the highest mean number of livelihood activities (7 ± 1.1) and men from DRY area of SEC had the least (3.9 ± 1.3).

Table 3.18 Average number of livelihood activities of villagers of different well-being and gender groups by AEZ of SEC, NET and RRD (±SD)[3]. ***Data presented based from the PCA exercise.***

			Gender group	
Sites	**AEZ**	**Well-being**	**Male**	**Female**
SEC	LOW	Poor	5.1 ± 1.4	5.2 ± 1.6
		Better-off	5.0 ± 1.4	5.3 ± 0.9
	DRY	Poor	5.2 ± 1.0	4.7 ± 1.7
		Better-off	3.3 ± 1.1	5.6 ± 1.6
NET	LOW	Poor	5.7 ± 2.1	7.1 ± 1.2
		Better-off	5.4 ± 1.3	6.9 ± 1.1
	DRY	Poor	5.4 ± 1.1	6.6 ± 1.2
		Better-off	5.9 ± 1.4	5.6 ± 1.1
RRD	LOW	Poor	4.7 ± 0.9	4.5 ± 1.2
		Better-off	5.1 ± 0.5	4.6 ± 1.4
	DRY	Poor	5.0 ± 0.4	4.2 ± 0.7
		Better-off	5.3 ± 0.9	5.5 ± 0.8

However, taking into account the number of livelihood activities which were combined, many were ‘similar activities’ i.e. gardening, citrus production and planting other crops into farming. In RRD for example the growing of several different field crops rather than only rice was more common than in SEC and NET. They therefore had less time or no time at all for other, different types of activity, hence, livelihoods were more dependent on agriculture and overall, less diverse.

[3] There are other ways of presenting diversity i.e. biodiversity indices.

Distribution of occupation

Members of each household from the three study sites were grouped according to their occupation or livelihood activities. There were four types of individual in the study area: those who were mainly earning a living through farming; individuals who had occupation other than farming (non-farming); individuals who did not have work; and there were also some who could not work and were mainly depending on other family members for their livelihoods (Figure 3.16). Members of the household who could not work were mainly those young members of the households (infants and children), grandparents (too old) and those who are ill or with disability problems.

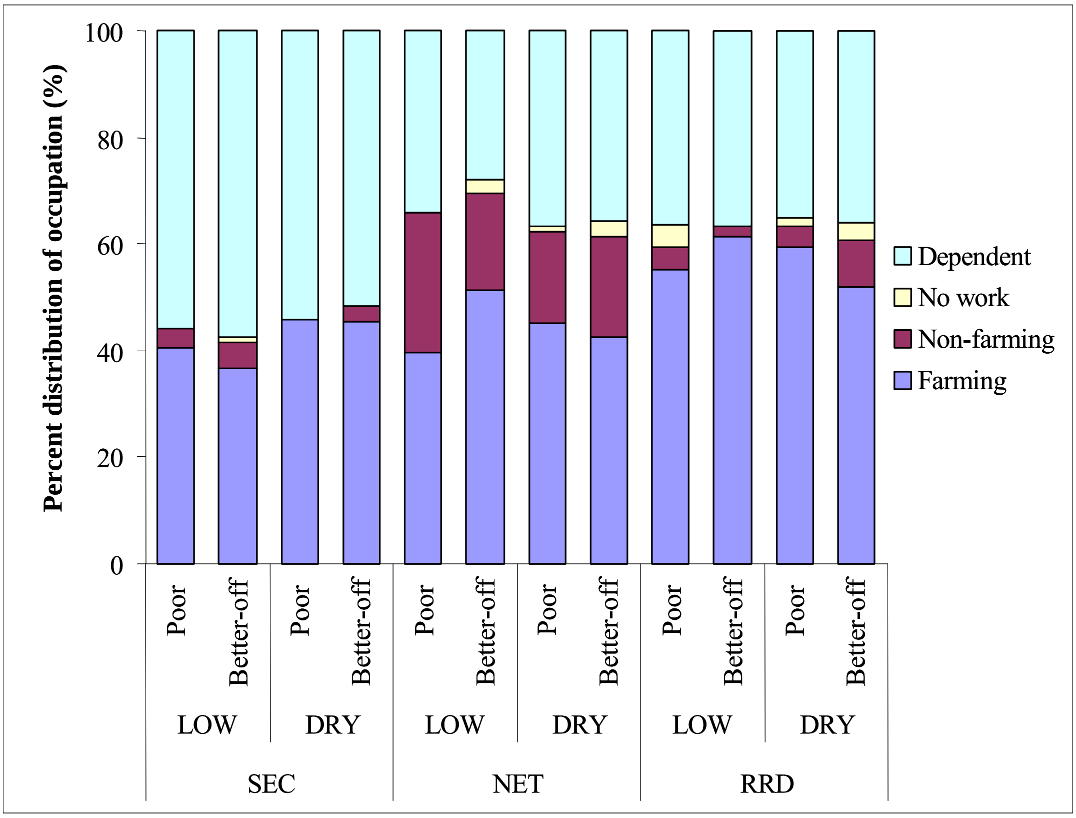


Figure 3.16 Percentage distribution of occupation by individuals of different well-being groups in AEZ of SEC, NET and RRD. ***Data presented based from the cross-sectional survey.***

As presented in Figure 3.16, the proportion of the population working was similarly high in RRD (65%) and NET (64%) while SEC had the lowest proportion (44%) of the total population who were working. The majority of the population in the study areas earned their living primarily through farming regardless of their level of well-being. Among the three sites, RRD had the largest proportion (60%) of the population that farmed. In contrast, SEC had the lowest percentage (40%) of the population that farmed. The proportion of the population doing non-farming activities was higher in NET (20%) compared to the other sites.

Variations within sites i.e. AEZ and wellbeing also occurred (Figure 3.16). In SEC, the percentage of individuals dependent on farming was slightly higher in DRY areas than in LOW area (38% and 46% in LOW and DRY respectively). In NET, the proportion of individuals undertaking farming was relatively similar between AEZ (44%), however, the percentage of better-off individuals from the LOW who farm tended to be higher amongst all other sites. In RRD, the proportion of individuals engaged in farming was relatively high compared to the other two sites (SEC and NET); more than 50% of the population in the study area were farming, particularly the better-off individuals in LOW area (61%).

The proportions of individuals engaged in non-farming activities were not similar between sites, AEZ and well-being groups (Figure 3.16). Amongst the three sites, NET had the largest proportion of individuals engaged in non-farming activities whilst SEC had the least. The proportion of better-off individuals from SEC and NET that carried out non-farming activities to earn their living was higher than among the poor individuals. However, in NET, the proportion of individuals engaged in non-farming activities was relatively similar between well-being groups.

The proportion of households that had non-working members was high in RRD, particularly from poor households in the LOW area (4.4%). Amongst the three sites, SEC had the least number of individuals that were not working (0.4%). However, the percentage of dependants was higher in SEC compared to elsewhere, where more than 55% of the population not working and mainly receiving support from other members of the family. NET had the lowest percentage of individuals who were considered dependents (34%).

Mean time spent on different livelihood activities

The different activities being carried out by individuals were categorised as on-farm, off-farm and non-farm (Table 3.17). Both on-farm and off-farm could include farming activities such as rice cropping, vegetable and other crop, livestock and aquaculture. The last category (non-farm) refers to all activities that are not related to farming (but can be done either on or off-farm) such as construction work, handicrafts, small business/trading, household chores and social activities. The distribution of time spent by different age and gender groups of different well-being groups from AEZ of SEC, NET and RRD is presented in Figure 3.17.

Analysis showed significant differences in the time spent (hrs) by age and gender in doing different activities at particular sites ($P < 0.05$). The well-being of households was not a significant factor on the time spent in securing livelihoods ($P > 0.05$). In general, adult men in NET spent more time (191.4 hrs ± 148.5 SD) conducting productive activities than other groups from all sites over a period of 12 months. Women in RRD on the other hand spent more time undertaking livelihood activities compared to women in SEC and NET. Only children in SEC spent significant time supporting household livelihoods. Women spent more time in SEC and RRD compared to men and children in carrying out on farm activities but; in NET, the opposite was the case. The contribution of children in SEC in doing on farm activities was also significantly higher than the children in NET and RRD. Off-farm activities were dominated by men in all groups in the three sites. Non-farming activities are also dominated by men, however in NET, women spent more time doing this activity compared to men and children. Children from RRD contribute least towards securing household livelihoods.

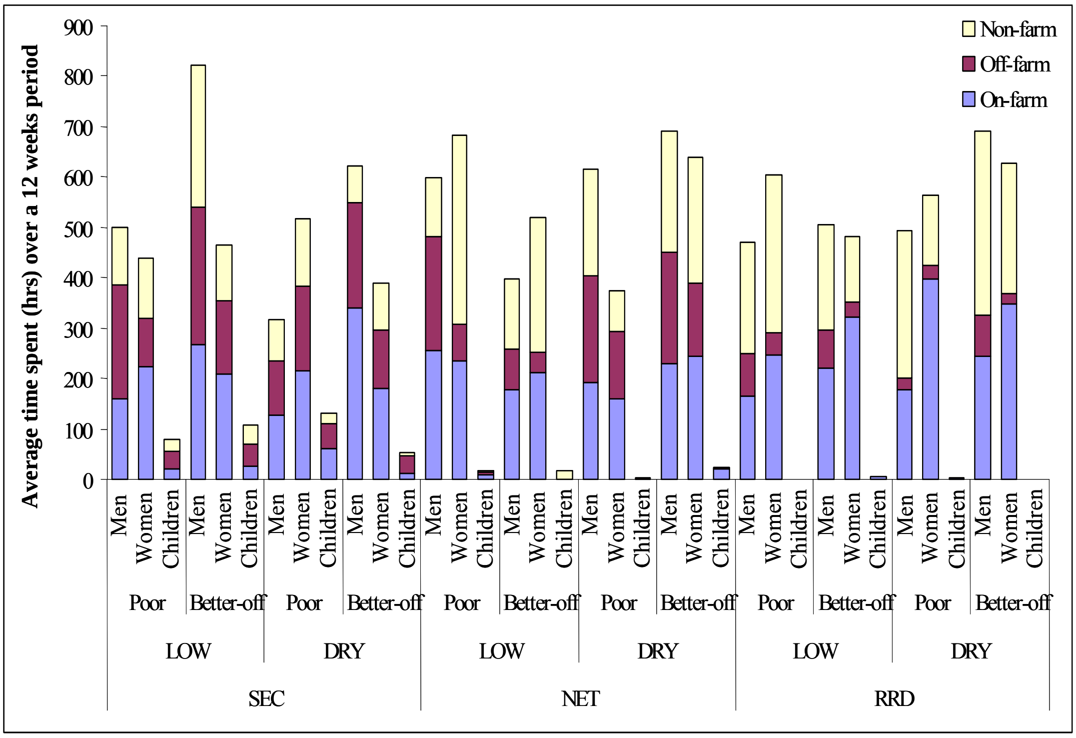


Figure 3.17 Average distribution of time spent on livelihood activities by different age and gender group of households with different well-being ranks. ***Data presented based from longitudinal study conducted over a 12 months period.***

Time spent in fishing and aquaculture

Households spent more time fishing than undertaking aquaculture activities ($P < 0.05$, Figure 3.18) at all sites. There were exceptions such as better-off households in DRY areas of SEC whose members spent more time undertaking aquaculture activities (>100 hrs over 12 months ± 124.3 SD); the majority of this time was spent physically enlarging the system.

The average time spent for fishing and aquaculture was significantly different between AEZ ($P < 0.05$). Households in LOW areas spent more time in both activities as compared to those located in DRY areas particularly in SEC and RRD. Better-off households, especially in DRY areas spent more time engaged in aquaculture than poor households elsewhere. Well-being level did not affect the time spent fishing ($P > 0.05$).

The amount of time spent by different age and gender groups fishing or culturing fish is significantly different ($P < 0.05$). Men spent more time in doing both activities compared to women and children. The contribution of children in fishing was only significant in SEC. Children at the other sites did not participate in either fishing or aquaculture activities. The contribution of women in undertaking aquaculture and fishing activities varied between sites. In SEC, women spent more time on fishing than aquaculture, which was similar to NET except for better-off women in DRY areas. In RRD, women generally spent more time on fish culture than fishing except for poor women who spent more time fishing (Figure 3.18).

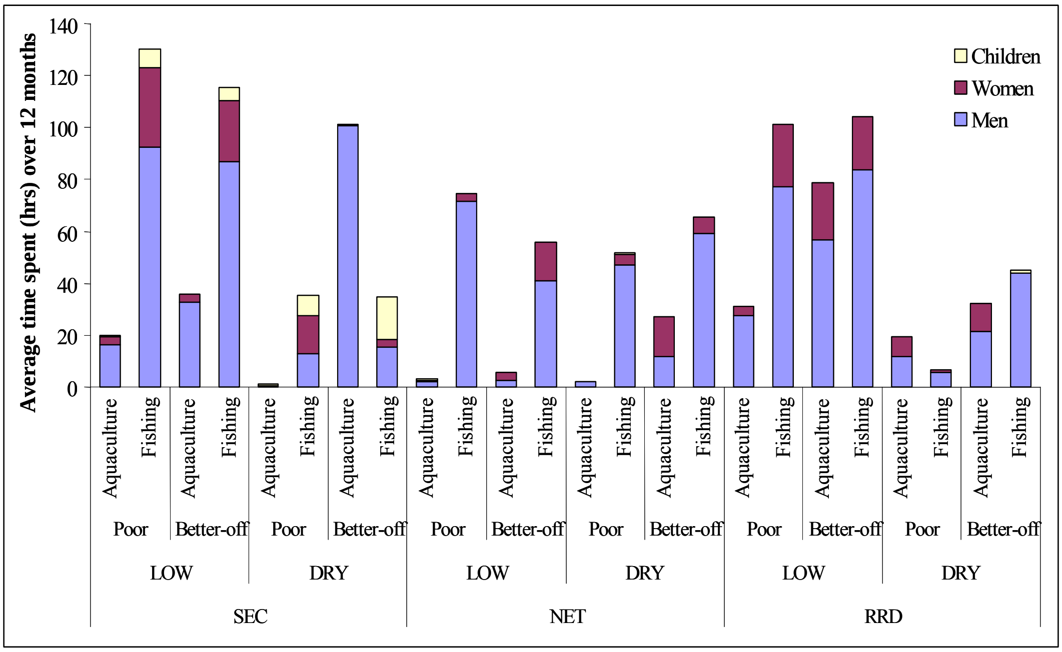


Figure 3.18 Comparison of time spent (hrs) in aquaculture and fishing by age-gender group of different well-being levels in AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

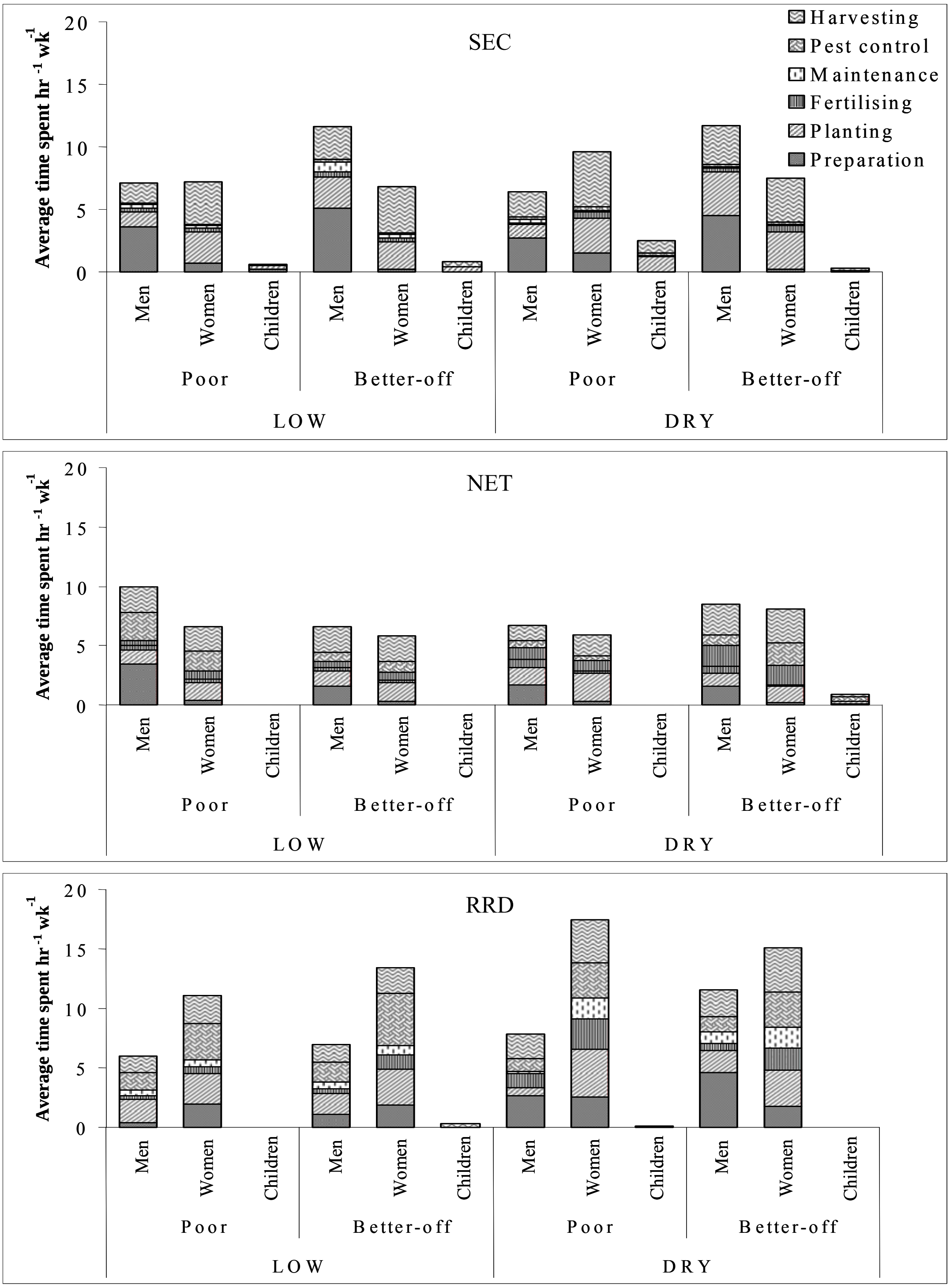
Farming activities

Activities in farming include preparation, planting and transplanting, fertilization, regular maintenance or the monitoring and water management, pest control, and harvesting. In SEC, better-off men spent more time farming compared to women generally and poorer men. However, poor women groups (both in LOW and DRY area of SEC) spent a similar amount of time farming as men. Participation by children in farming is very significant in poor households in the DRY areas, mainly in Cambodia. In NET, the overall time spent by men and women on farming activities was not significantly different. However, specific activities were found to be dominated by men particularly land preparation (Figure 3.19). A similar pattern emerged with men in SEC. In RRD, farming activities of all types, including land preparation, were mainly dominated by women. Figure 3.19 shows the distribution of time spent by individual members in different farming activities segregated by age-gender, well-being and AEZ.

There were significant differences in time spent farming by site ($P < 0.001$), well-being of households ($P < 0.05$), and type of activity ($P < 0.001$). In general, differences in the time spent between men and women were location-specific. Across the three sites, AEZ did not affect the overall time spent on farming ($P > 0.05$). In general, households in RRD spent more time farming compared to Cambodia and Thailand, reflecting the intensive nature of agriculture. Women have also had a considerably higher labour investment than men (almost double) in contrast to NET and SEC.

Three way interactions between site, AEZ, farming activities ($P < 0.001$); sites, well-being ranking, AEZ ($P < 0.05$); sites, gender, farming activities ($P < 0.001$); sites, AEZ, gender ($P < 0.05$); were found to be significant. In SEC, better-off men spent more time farming compared to women generally and poorer men. Participation by children in farming is very significant in poor households in the DRY areas, mainly in Cambodia. In NET, the overall time spent by men and women on farming activities was not significantly different. However, specific activities were found to be dominated by men particularly land preparation (Figure 3.19). A similar pattern emerged with men in SEC. In RRD, farming activities of all types, including land preparation, were mainly dominated by women.

Figure 3.19 Distribution of average time spent (hr) by different age-gender groups of SEC, NET, and RRD on doing agricultural activities. ***Data presented based from longitudinal study.***

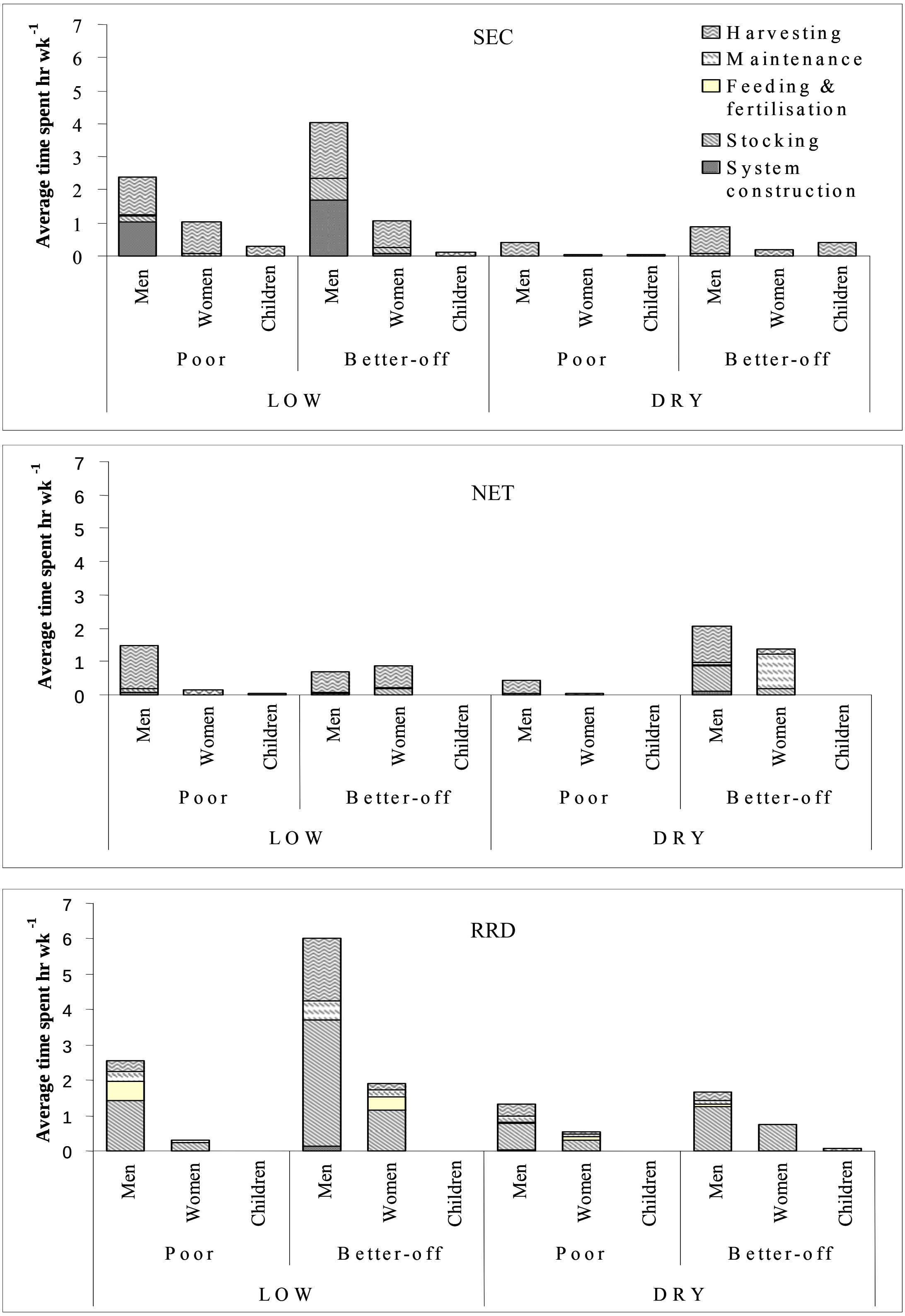


Aquatic system management activities

Five main activities relating to aquatic system management were identified in this study: system construction/improvement, stocking, feeding, maintenance and harvesting. The system construction/improvement usually involves the deepening of the system by excavation (manual) or increasing dike height. Creation of habitat (brush parks) and providing paths to the system (inlet/outlet) for AA are also included in this activity. In this study, stocking was not only limited to hatchery produced seed but also those that were caught from other systems and re-stocked into their own system. Feeding activities also included the act of finding, collecting, and preparing food for stocked AA. Checking, replenishment, changing of water and the usual monitoring of the system were all considered as part of maintenance. The harvesting activity includes the act of collecting AA from the system and the preparation of gears/traps in collecting AA. Figure 3.20 illustrates the distribution of time spent in doing such activities by individual household member of different age-gender groups, well-being and from different AEZ in the three sites.

Analysis of the time spent in doing activities related to aquaculture and fishing shows significant differences between individual activities ($P<0.05$), with harvesting, stocking and system improvement/construction occupying most time. However, within sites, time spent in doing such activities differed between AEZ ($P<0.05$). Age-gender difference in terms of time spent on aquatic system management was found to be significant ($P<0.05$) where men spent more time managing aquatic systems in general. Participation of children in the management was only significant in SEC.

Figure 3.20 Distribution of average time spent (hr) by different age-gender groups of SEC, NET and RRD on activities related to aquaculture. ***Data presented based from longitudinal study.***



3.3.4.3 Migration

Migration is one of the broader clusters of livelihood strategies described in the livelihood framework (Scoones, 1998). This is seen as one of the options for rural people to be able to improve their livelihoods. Migration can be classified into duration and location. Some people move from one place to another seasonally, short term or permanently. People in rural areas can also migrate or move from their village to another village or nearby province (internal migration), however, there are also some people that move outside the country (international migration) (Deshingkar and Start, 2003; McDowell and Haan, 1997). Deshingkar (2006) reported that there were many driving factors for such movement and amongst these factors under employment in rural areas and the spread of labour intensive industries were common.

In this thesis, migration patterns were established in the three study sites using the seasonal calendar technique during the PCA. In general, the mean number of months (5 months ± 0.9 SE) people migrate or move to another place temporarily did not vary among the sites ($P > 0.05$). However, interaction between AEZ and wellbeing showed significant differences ($P < 0.05$) where better-off households in the DRY area undertake longer migration (7.2 months) than poorer households (3.5 months). Differences in the duration of migration between gender groups were not significant ($P > 0.05$).

Table 3.19. Average number of months villagers migrated to other places to work.
Data presented based from seasonal calendar carried out during the PCA.

Site	AEZ	Wellbeing	Gender	
			Male	**Female**
SEC	LOW	Poor	5.3	4.5
		Better-off	6.3	6.5
	DRY	Poor	3	3.5
		Better-off	5.5	8
NET	LOW	Poor	6.7	4
		Better-off	7.7	2
	DRY	Poor	4	3.7
		Better-off	6.7	6
RRD	LOW	Poor	6.3	4
		Better-off	0	6.7
	DRY	Poor	3.7	3
		Better-off	8.7	8

In SEC, generally, rural households undertake seasonal migration for 5.4 months (Table 3.19). Households from the DRY area had the shortest period of migration of 3 to 3.5 months duration, for males and females respectively. However, better-off females on the same AEZ work outside the village for most part of the year (8 months). Households in NET had a similar duration of seasonal migration (5.1 months) to SEC. Aside from the fact that people from poor households from the DRY area migrated for shorter periods than in better-off households, it is also interesting that females generally moved away from the village for shorter periods than men (half of men's time) particularly in LOW areas of NET. On the contrary, in RRD, men generally undertook seasonal migration for shorter periods than women (4.7 and 5.4 months, men and women respectively). Better-off women in RRD migrated seasonally for longer than any other groups in these villages (7.3 months).

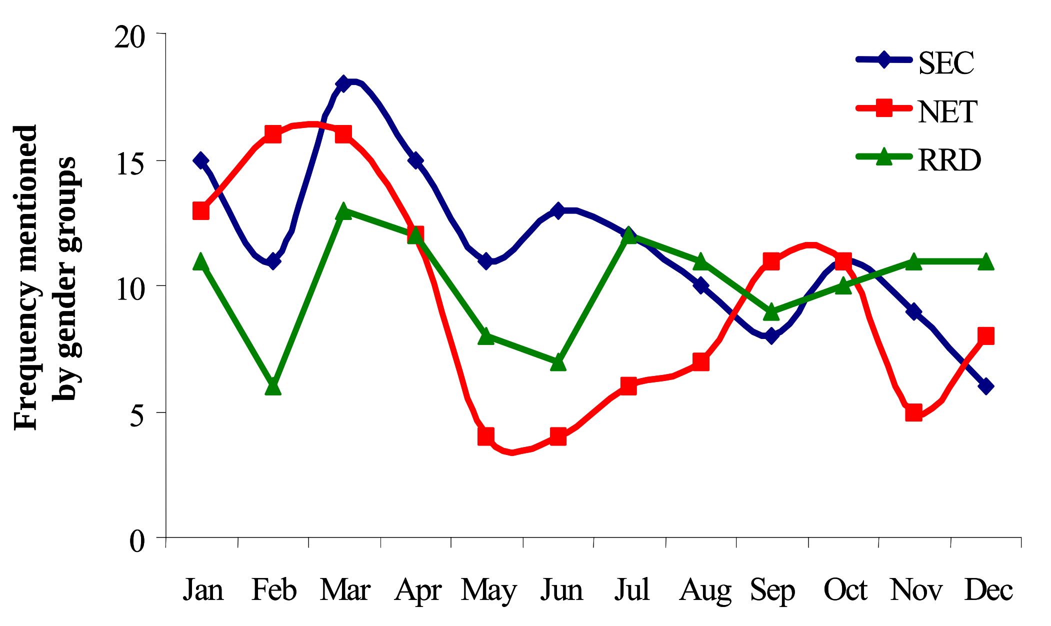


Figure 3.21. Common months of the year where migration take place in the three study sites (SEC, NET and RRD). ***Data presented based from seasonal calendar of PCA.***

Migration in the three study sites occurred in different times of the year. Figure 3.21 shows when most groups migrate to other places for work. The months of March and April are the peak periods for migration when a large proportion of the community temporarily moved to another place (e.g. near Vietnam and Thailand border for households in Cambodia, cities and urban areas) for work. The most common activities that these people did when they moved to another place during this period were non-farming activities like construction (mainly for men) and factory work (mainly for women). In contrast, the months of May, June, November and December are the periods of least migration. The periods when migration was less coincided with the main agricultural work; planting season (May to June) and harvest season (November to December).

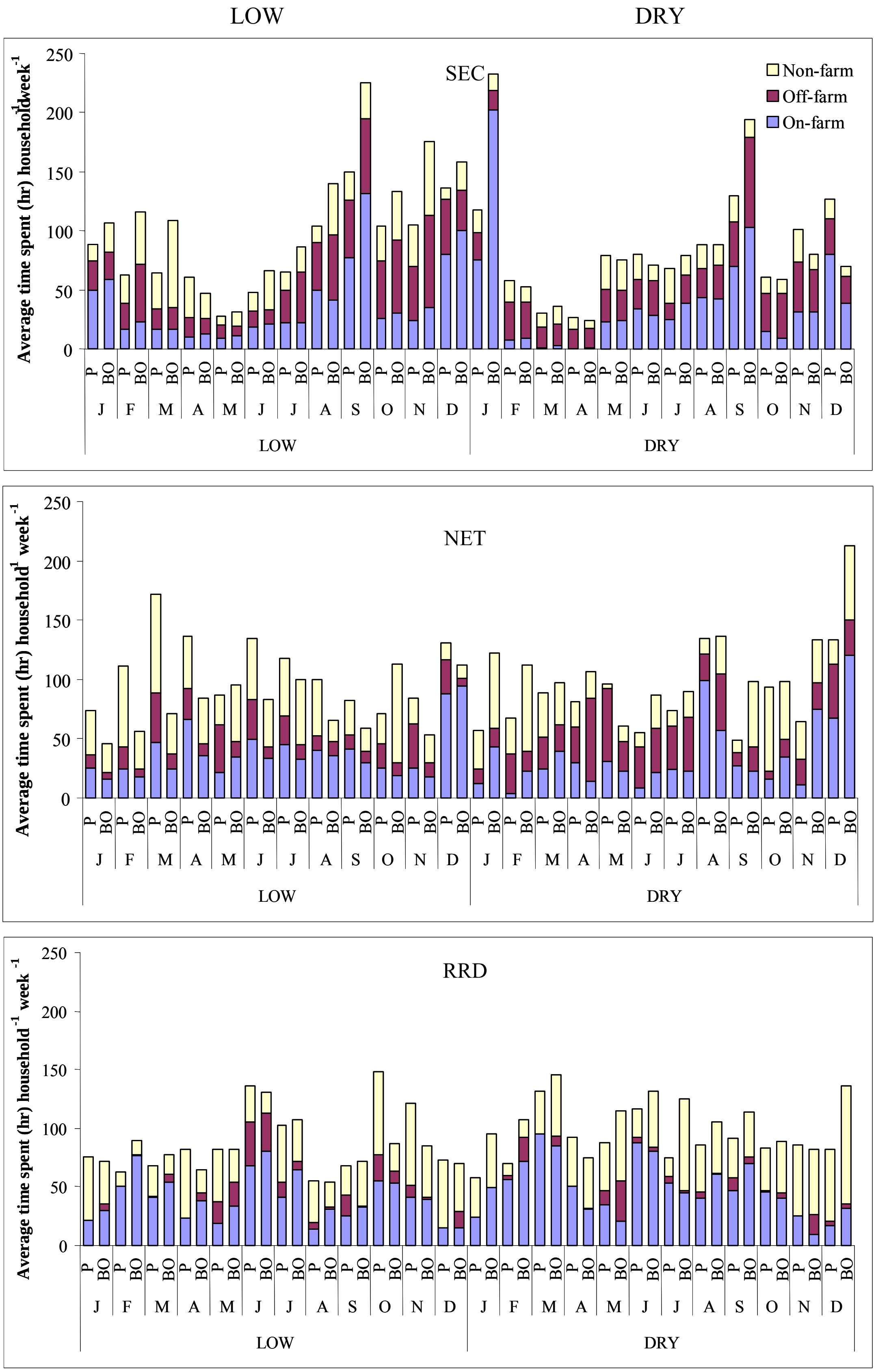
3.3.4.4 Seasonality of livelihood strategies

In general, seasonality has a great influence on overall livelihoods of the people in rural areas (Agarwal, 1990; Ellis, 1999, 2000a, b; Gill, 1991; Thanh *et al.,* 2005), considering that the main 'economic livelihood activities' of most households in the study sites are dependent on their human and natural capital. Common seasonality that impacted or influenced livelihood diversification were the availability of water (drought and floods) and also intensity of farming activities. The influence of such seasonality may increase or decrease vulnerability of people living in the community (DFID, 1999; Ellis, 2000b). The focus of this section is to present a picture of the seasonality of diversified livelihood strategies. The seasonality of overall activities in each study sites are presented first. The subsequent sub-sections will consider the specific seasonality related to fishing and aquaculture and finally, seasonality of the available labour is also presented. The information from this section was mostly generated from the longitudinal study.

Seasonality of activities

Seasonality analysis, based on the time spent (hr household $^{-1}$ week $^{-1}$) on different types of activities (i.e. on-farm, off-farm and non-farm) attempted to clarify the influences of seasons (Figure 3.22). The time spent by households in doing such activities was found to be significantly variable by season in all three sites ($P < 0.05$). SEC was found to have the greatest seasonal effects on overall labour expenditure (<30 - >200) while RRD had the least (>50 - <140). Furthermore, within-site variation in AEZ and wellbeing and type of activities were also significant ($P < 0.001$).

Figure 3.22 Seasonality of households labour expenditure on different types of activity by well-being level and AEZ. ***Data presented based from longitudinal study.***



P = poor; BO = better-off

In SEC, the months with least time spent supporting livelihoods varied by AEZ; from April to June both poor and better-off families spent less time doing livelihood activities in the LOW while in the DRY area the months of February to April were the critical period. In NET, critical months were also different among AEZ; the months of January, August and September were the lean months for activities in the LOW while June – July and September – October were found to be the lean periods in the DRY area. Variations in lean periods in the AEZ of RRD were also found; August – September and December to January were the lean period in the LOW while January, April, and October – November were considered lean in the DRY areas.

Important activities that contributed to the peak of time spent by households differ within well-being groups at particular sites ($P < 0.001$). In SEC, the peak of time spent was related to on-farm activities except during the month of March when better-off households spent more time doing non-farming activities. In NET, the amount of time spent on on-farm and non-farm activities were complementary; when on-farm activity was least (i.e. February) non-farming activity was high (Figure 3.22, NET). This trend was also found in RRD, however; on-farm activity dominated time budgets in RRD.

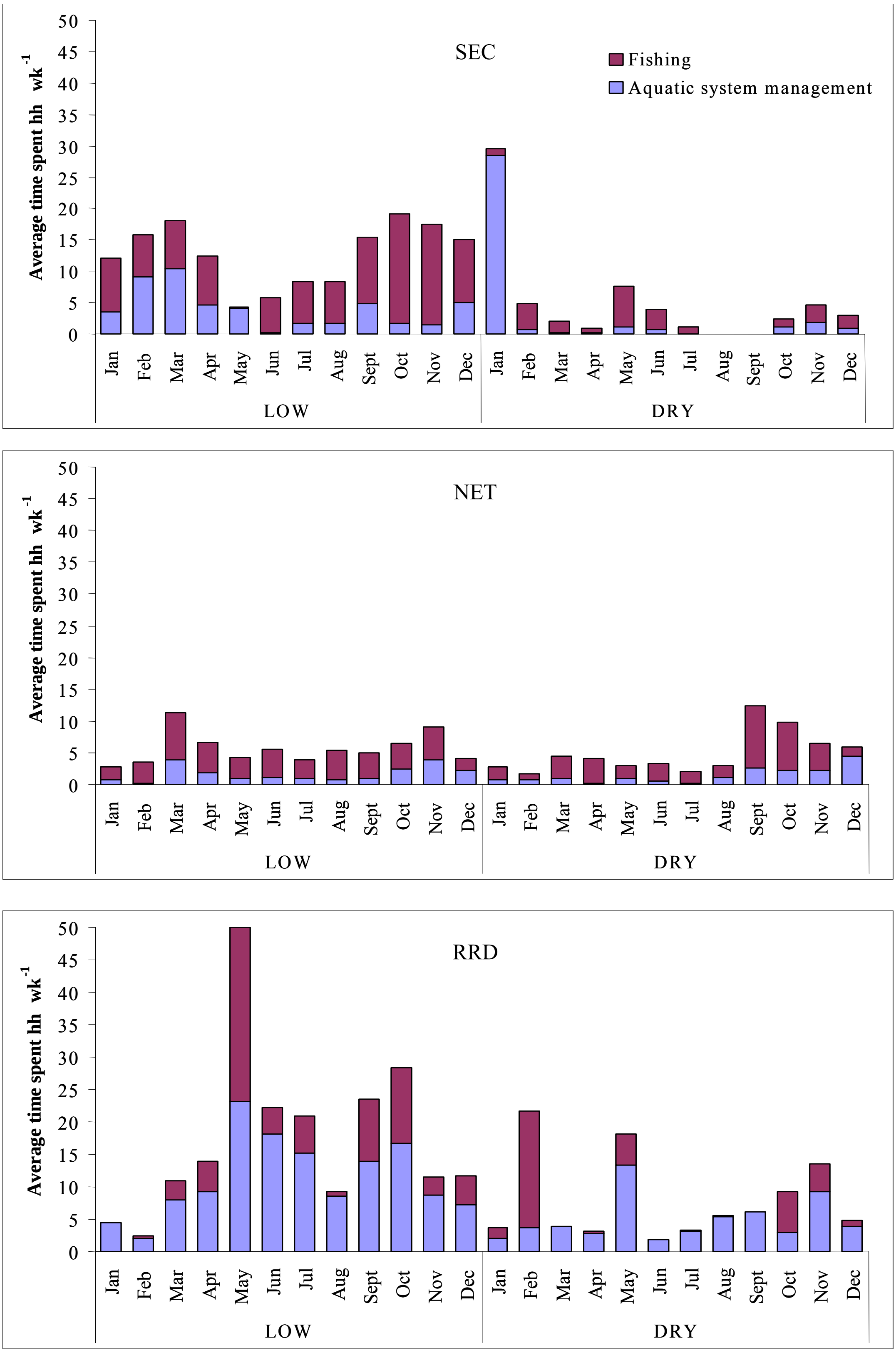
Seasonality of aquaculture and fishing

As described in section on Livelihood activities, aquaculture or aquatic system management refers to all human interventions in order to increase aquatic production, and is not limited to stocking hatchery produced seed. Fishing, on the other hand, was defined as the collection or harvesting of aquatic animals from open water bodies such as lakes, rivers, and swamps that households are not managing. A comparison between the time spent by households in different AEZ on managing aquatic systems and fishing was analysed and presented in Figure 3.23. Among the three sites, NET spent the least time in carrying out both fishing and management activities and had least seasonality (>2 - <15 hr week $^{-1}$) while RRD spent the most time and had the largest seasonal effect (>2 - >50 hr week $^{-1}$)

Variation in the time spent by household was found to be significant and explained by site*AEZ*activity type interaction (P <0.05). In SEC, particularly at LOW sub-site, households spent more time fishing than on aquaculture, however in some months, households spent more time in aquaculture activities such as in the months of February and March. In the DRY area of SEC, households mostly fish and insignificant time was spent on aquaculture activities apart from the month of January when the hours spent were very high (P <0.05) (Figure 3.23) as this was the start of clearing and harvesting their aquatic systems (trap and household ponds).

In NET, generally households in both AEZ spend more time on fishing than culture-based activities (Figure 3.23, NET). Seasonal variation in the overall time spent fishing by households located in different AEZ was significant (P <0.05). Fishing peaked during the months of March and November in the LOW area while the months from September to October were more important in the DRY area. Relatively little time was spent on aquatic system management, particularly in the DRY area.

Figure 3.23 Seasonality of time spent in managing aquatic system and fishing by households from different AEZ. ***Data presented based from longitudinal study.***



In contrast, aquaculture was relatively more important than fishing in RRD (Figure 3.23, RRD). The amount of time committed by households did vary by AEZ; households in the LOW area spent considerably more time on management (and fishing) than those in the DRY areas. Both fishing and aquatic system management showed seasonal variation in intensity of labour use. In the LOW area, least time was invested in aquaculture from the beginning of December until early March. Less time was spent in the DRY area except during the months of May and November. There were also peaks of fishing activity in terms of time spent observed in both LOW and DRY areas of RRD (May, September, October and February, May, October, November in LOW and DRY respectively).

Seasonality of labour force

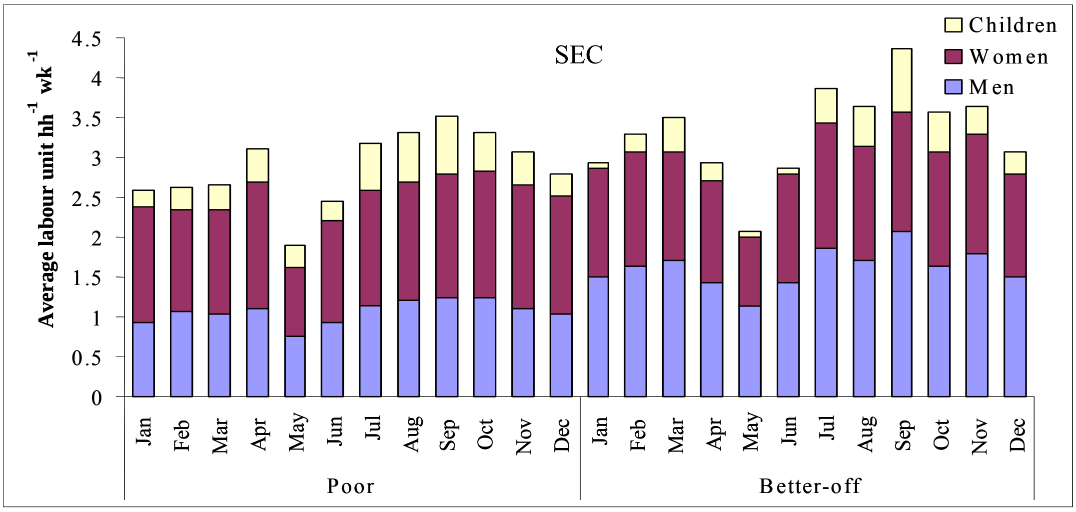
The variation on the effect of seasonality to the total labour force is presented in Figure 3.24. Amongst the three sites, SEC has the highest average labour (3 labour units) and seasonal variation on labour availability (>1.5 - 4 labour units). In contrast, RRD has the least amount of labour per household (2.5 labour units) and also least seasonal variation (>2 – 3 labour units).

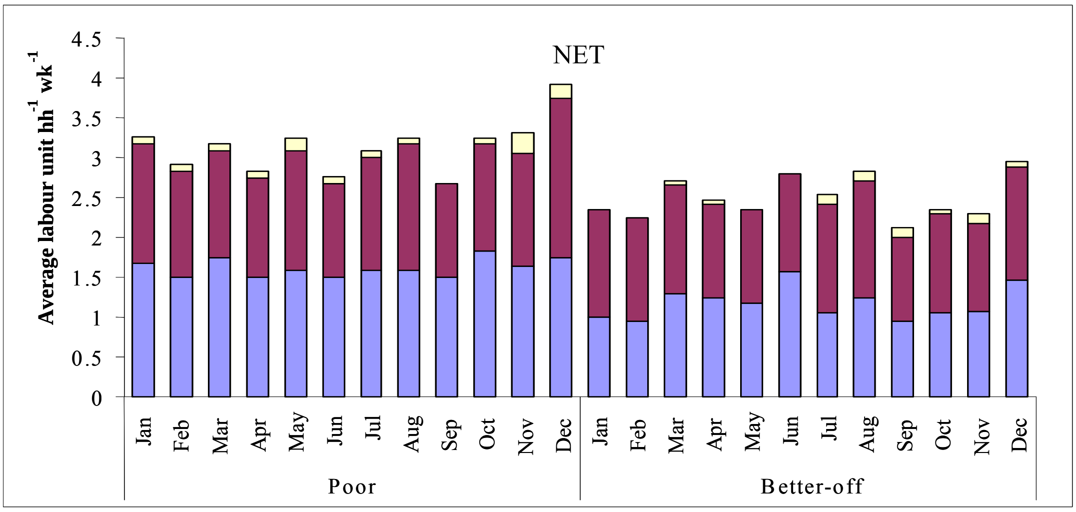
Available intra-household labour was analysed for seasonal variation and results are presented in Figure 3.24. Contribution by different age-gender groups was found to be different between sites (P <0.05). Children only contributed significant inputs in SEC. The number of individuals by age-gender also shows seasonal variation (P <0.05) as shown in Figure 3.24. Labour inputs occurred year round but were concentrated during the rainy or wet season when they constituted up to 20% of the total household labour. Female labour was also greater in SEC than in NET and

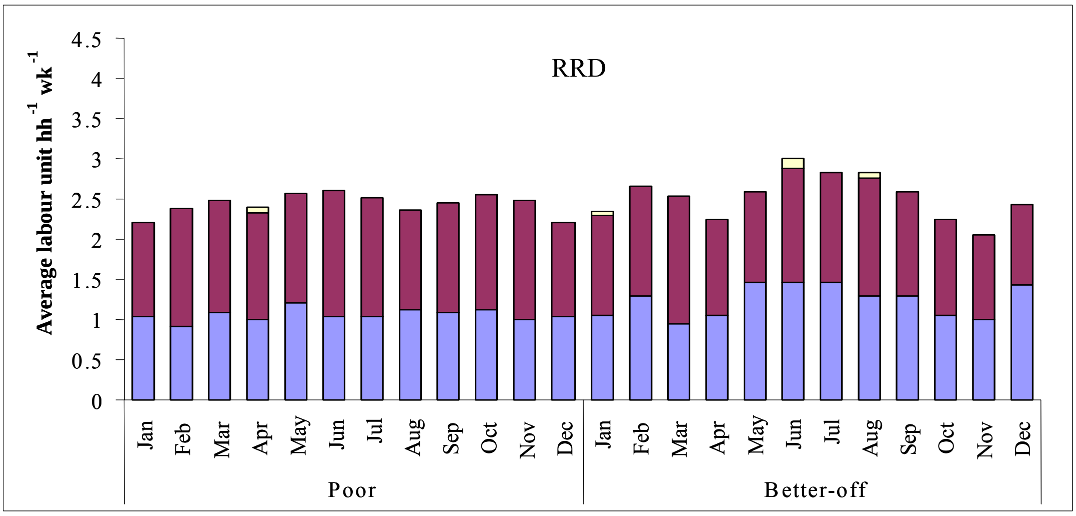
RRD. However, the average female labour force was more than men in RRD, especially in the poorer households.

The limited total labour force in some parts of the year was observed clearly in SEC but not in NET and RRD. Seasonality on the labour force may relate to the seasonal migration of households especially during the dry season (May – June) when opportunity is limited for on-farm activities. During this period, other villagers tended to do non-farming activities outside the village (e.g. city, nearby province). The available labour in the household in SEC, in both well-being groups is low during the months of May and June while during the period of July to December, the available labour force in the households were high. The contribution of women in SEC, particularly in the poor group, was higher than by men and children. In NET, labour available during the season among poor households is relatively higher than the better-off households. The labour force available for households in RRD during the season did not show significant seasonal variation and is relatively constant during the season (2.5 labour force hh^{-1} wk^{-1} ± 1.1 SD). Moreover, the average size of the household labour force in RRD for both well-being groups is low compared to SEC and NET (3 ± 1.4 labour force hh^{-1} wk^{-1} and 2.75 ± 1.3 hh^{-1} wk^{-1}, SEC and NET respectively).

Figure 3.24 Seasonality of available labour units for carrying out livelihood activities (on-, off-, and non-farm) in SEC, NET and RRD, segregated by age-gender and well-being. ***Data presented based from longitudinal study.***







3.3.4.5 Comparison between qualitative and quantitative data

Data was collected for this thesis using two approaches (qualitative and quantitative). The purpose of this section is to present the similarities and differences of information collected using PRA and survey data with regards to important activities and livelihood diversity.

Important activities

During the early stage of the research, important activities of different social groups were identified using preference ranking (scoring). Furthermore such activities were again identified during the household longitudinal study where the amount of time spent by individual households was recorded. For the sake of comparison, the amount of time spent was used in this section as an indicator of the importance of a particular activity to the individuals of different social groups.

Table 3.20 Important activities identified using different research approaches. (Activities were arranged based on importance)

Sites	Social group		Research approach: Qualitative (PRA-scoring)	Research approach: Quantitative (HH Monitoring-time spent)
SEC	Poor	Men	Farming	Farming
			Livestock	Livestock
			Planting crop	Fishing
			Fishing	Non-farm income
			Wage labour	Household chores
			Income generating act	Education
		Women	Farming	Farming
			Livestock	Livestock
			Trading	Household chores
			Planting crop	Non-farm income
			Income generating act	Fishing
			Wage labour	Education
	Better-off	Men	Rice farming	Farming
			Livestock	Livestock
			Raising fish	Non-farm income
			Planting crop	Fishing
			Wage labour	Raising fish
			Income generating act	Household chores
		Women	Rice farming	Farming
			Livestock	Livestock

Sites	Social group	Research approach	
		Trading Household chores Income generating act Fishing	Household chores Non-farm income Social and religious act Fishing
NET	Poor		
	Men	Rice farming Livestock Wage labour Fishing Income generating act Planting crop Household chores	Farming Non-farm income Livestock Fishing Household chores Social and religious act Raising fish
	Women	Household chores Income generating act Trading Rice farming Livestock Social act Planting crop	Farming Non-farm income Livestock Household chores Social and religious act Fishing Raising fish
	Better-off		
	Men	Rice farming Livestock Planting crop Income generating act Trading Household chores Raising fish	Farming Non-farm income Livestock Fishing Household chores Social and religious act Raising fish
	Women	Household chores Rice farming Planting crop Wage labour Social activities Income generating act Livestock	Farming Non-farm income Livestock Household chores Social and religious act Fishing Raising fish
RRD	Poor		
	Men	Planting crop Rice farming Income generating act Livestock Fishing Wage labour Household chores	Non-farm income Farming Fishing Raising fish Livestock Social and religious act Household chores
	Women	Rice farming Income generating act Trading Household chores Planting crop Raising fish Livestock	Farming Non-farm income Fishing Raising fish Livestock Household chores
	Better-off		
	Men	Rice farming Trading Livestock Household chores Income generating act Planting crop Raising fish	Non-farm income Farming Fishing Raising fish Livestock Household chores
	Women	Household chores Rice farming Trading Planting crop Livestock Wage labour Raising fish	Farming Non-farm income Raising fish Fishing Education Household chores Livestock

As presented in Table 3.20, both approaches identified a similar list of important activities although the order of importance is slightly different. In SEC, some activities were additionally identified during the monitoring activities such as education in poor group and social/religious activities in the better-off groups. In NET, raising fish was additionally identified important particularly in poor groups and better-off women. Activities in RRD in both approaches were relatively similar.

Livelihood diversity

The diversity of livelihoods by different groups of households from the study areas was described using both approaches (qualitative and quantitative) (Table 3.21).

Table 3.21 Mean number of livelihood activities identified using different research methods

Sites	Social group		Research approach: Qualitative (PRA)	Research approach: Quantitative (HH Monitoring)
SEC	Poor			
		Men	5 ± 1.3	8
		Women	5 ± 1.6	8
	Better-off			
		Men	4 ± 1.5	8
		Women	5 ± 1.1	7
NET	Poor			
		Men	6 ± 1.6	7
		Women	7 ± 1.2	7
	Better-off			
		Men	6 ± 1.3	7
		Women	6 ± 1.2	7
RRD	Poor			
		Men	5 ± 0.7	7
		Women	4 ± 0.9	6
	Better-off			
		Men	5 ± 0.8	6
		Women	5 ± 1.2	7

During the PRA stage, the diversity of livelihoods was identified using preference ranking techniques whereby group of villagers identified the different activities and ranked/scored them. In the longitudinal study, the diversity of livelihoods was determined by recording the different activities carried out by households during the season to sustain their livelihoods. As presented in Table 3.21, the mean number of livelihoods is relatively similar apart from SEC where the number of activities identified during the monitoring was slightly higher than those from the PRA.

3.3.4.6 Discussion on livelihood strategies

Livelihood strategies refer to the way in which the portfolio of activities based on different assets sustain and develop livelihoods (Carney *et al.,* 1999; Ellis, 1999), in other words, how people make a living (Turton, 2000). This portfolio of activities can be grouped into three distinct elements as suggested by the literature (Allison and Ellis, 2001; Carney *et al.,* 1999; DFID, 1999; Ellis, 1999; Ellis and Freeman, 2005; McDowell and de Haan, 1997; Scoones, 1998): agricultural intensification/ extensification, diversification and migration. All of these categories were observed and analysed in this research. However, greater emphasis was placed on the last two – diversification and migration. As livelihood strategies are considered as a way to make a living, there are several factors that can influence or allow it to happen and assets or capitals were amongst those factors (Allison and Ellis, 2001). The scope of strategies will depend on individually owned resources and resources that were not owned but could be accessed, in other words, the status of their assets (human, physical, financial, natural, and social). Scoones (1998) suggested that strategies can be described in different scales i.e. individual, household and village level and even regional or national level. In this research, most of the livelihood strategies described and analysed were on the level of the individual and household. There were two types of classification for the different activities that were established in this research: (1) based on outcome and (2) relationship to farming. Productive and reproductive (Buenavista *et al.,* 1994) were used as the basis for classification of activities related to outcome based while on-farm, off-farm and non-farm were the sub-classification of activities under the farming-based activities.

In general, the productive activities (market production with exchange value or home/ subsistence production, Buenavista *et al.,* 1994) were relatively more important among men. In contrast, reproductive activities (non-remunerated and primarily performed within the private sphere of the household i.e. not translated into economic value) were generally more important among women especially in better-off households in Cambodia and Vietnam. These conclusions are based on the outcomes of the scoring activity during the PCA. However, if time and frequency be considered as well as seasonality, productive activity by women may be as important as of the men especially in the rural areas of Vietnam. It is important to mention therefore that men have limited non-productive (reproductive) activities as compared to women. Eisses and Chaikam (2002) reported that women have significant responsibility for agricultural production in organic farming in the northern part of Thailand (e.g. women were in charge of the maintenance of crop while men are away for seasonal migration).

The relative importance of farming-based activities was elucidated in this chapter. Generally, on-farm activities are the most important livelihood activities in all sites (>40%) which illustrated the dependency of the three study sites in agriculture. Rigg

(2003) reported that majority of the people living in rural Asia were mostly farmers. Baulch (1996) on the otherhand described Southeast Asia as the 'region of farmers'. The average percentage of the population involved in on-farm activities however can be considered small compared to the ADB (2004) report for 2002 i.e. ~ 70% in Cambodia, >40% in Thailand and missing data in Vietnam. However the difference between the research and the ADB report may be due to the big variations between sites. The average percentage in Thailand was however similar with the ADB (2004) national average. In Cambodia, agriculture or farming is central to the economy of Cambodian households (Tana *et al.,* 1994; Turton, 2000) and more than 90% of the rural Cambodians were farmers. In the Red River Delta as reported by Demaine (2000) and Thanh *et al.* (2005), the area was predominantly agricultural i.e. rice producing area with approximately 80% of the population has farming as their primary occupation. Meanwhile in northeast of Thailand, as reported by AIT/AO (1998), more than 80% of the respondents reported farming as their primary occupation. However, off-farm activities are generally important for poorer people at all sites compared to better-off people, suggesting that this is due to the limited land holdings that the poor own and manage and their need to work off-farm to support their livelihoods. The high proportion of time spent on off-farm activities in Cambodia suggests the limitation of land holdings for the households in Cambodia and the need to gain additional income from working for another farm. Both women and children in general spent more time doing on-farm activities (>50% of their total time), however, men had to split their time between working on-farm and non-farming (38% and 35%, respectively). Amongst the three sites, only children in Cambodia spent a large proportion of their time working off-farm (>40%).

Among the on- and off-farm activities, rice farming dominated the total time spent by households in all sites, especially in Vietnam (>45% of the total time sent). Following rice farming is livestock rearing, although the percentage contribution is very low in Vietnam (0.3%). The importance of fishing and aquaculture were also elucidated in this chapter. Amongst the sites, Cambodia has the most time spent in fishing but less in aquaculture. In contrast, Vietnam spent more time in aquaculture and the least in fishing. This finding supports the assumption made during the selection of sites for this research i.e. Vietnam had relatively well established aquaculture. Moreover, the amount of time spent in different activities coincides with the result of the ranking of activities during the PCA exercises.

Ellis (2000a, b) defined livelihood diversification as the process by which rural households construct an increasingly diverse portfolio of activities and assets in pursuit to improve and sustain livelihoods. Diversity and diversification of livelihoods by households in rural areas of Southeast Asia was presented in this chapter in which the seasonal effect was highlighted. Diversified livelihoods usually refer to the combination of different types of activities in order to contribute to the total cash flow of the households. These activities included various types of productive activities such as on-farm, off-farm, and non-farming activities. It is very common in the rural areas for the household head to have more than one sources of income. In this study, it was found that better-off men in Cambodia had more diversed livelihoods than women. In contrast, women in Thailand had relatively high diversified livelihood activities. However, if diversity implied the combination of on, off and non-farming activities, this may not always be true in the case of Vietnam where women spent more time doing on-farming activities. Farming in

Vietnam does not solely mean rice farming, since most households in Vietnam are engaged in diverse agriculture i.e. growing different types of crops such as vegetables, cereals, and root crops. As a result of this practice, in Vietnam, the overall livelihoods were less diverse (based from the main activity grouping), however, the agricultural activities alone were considered diverse due to the different crops grown by individual farmer on farm and homestead. It is therefore necessary to consider such complexities when determining the diversity of livelihoods and counting the main type of activity alone does not reflect the real scenario.

However, the number of livelihood activities being carried out by individuals may not always be indicative of the level of vulnerability or sustainability of the individual; more diverse or less diverse activities may have different outcomes. Furthermore, changes in livelihoods have various and complex reasons. These changes can be due to a crisis or distress that pushes individuals to engage in different or more works. However, changes can also be due to demand of the existing society i.e. development in the society that brings new opportunities (Campbell *et al.,* 2005). For instance, poor families tend to have diverse activities because of necessity. Foraging and working to earn a daily living would normally result in a portfolio of various activities in order to provide their needs for the day. On the contrary, there are households that have limited livelihood activities because the main activity is so time intensive, and they do not have enough time to embark on other activities. This appears to be the case among some households in RRD. Moreover, the income or production is high enough for the household in relations to their needs. The value addition to the main product of agriculture and the 'intra' and inter cropping can also be the reason for a lower number of other activities (Campbell *et al.,* 2005). In both scenarios, there is a risk and the resource poor are the most likely to be vulnerable to different shocks that might happen as their daily of living is directly affected. The differences in livelihoods strategies between sites, agroecological zones and well-being levels may have accounted for the environmental factors affecting mostly the agricultural activities i.e. land use and access to water resources (Suzuki *et al.,* 2006). In addition to these factors, Campbell *et al.* (2005) identified other factors affecting such diversification of livelihoods: household's social resources i.e. network of the family, friends, neighbours and employers that surround them, mobility and location i.e. proximity to markets and urban areas.

Both female and male members of households have diverse livelihood activities regardless of wellbeing rank; however location appears to influence the diversity of livelihoods. This can be related to the available opportunities in the area and access to resources (Campbell *et al.,* 2005). Edwards *et al.* (1993) and Sivakumar and Valentin (1997) suggested that site-specific factors such as climate, soil, water and even socio-economic preferences are present in specific agroecology and thus need to be considered for a more sustainable production system. Female members of households in Thailand generally have more non-farming activities than men, such as weaving, etc. The number of groups of activities is similar between women and men in Vietnam. However the individual activity might be higher than men because women have several responsibilities. For example in farming, men in Vietnam are mainly involved in rice cropping as the major agricultural activity, however, women tend to produce several different crops (3 – 5 crops) around the homestead in addition to their involvement in rice production, each of which needs a different level of management.

As described by Ellis (2000a, b) and other literature (Alderman and Sahn, 1989; Ellis, 1999; Messer, 1989; Paxson, 1993), seasonality is an inherent feature of rural livelihoods particularly in rural Asia where the vast majority rely on agricultural production as their main livelihood income. Delayed rains impact on agricultural as well as the aquatic production especially in rainfed areas of NET and SEC where irrigation is lacking. However, seasonality does not only apply to households with land but also to the landless as they are mainly dependent on agricultural labour markets (Ellis, 2000b). Moreover, seasonality can be considered as one of the determining factors in livelihood diversification as suggested by Ellis (2000a). On the other hand, diversification can also lessen the impact of seasonality.

The seasonal variation in labour expenditure on livelihood activities was more significant in SEC, particularly amongst households in the LOW agroecological zones (28 – 171 hr household $^{-1}$ week $^{-1}$) in the period from May to September. In SEC, May is mid-summer, when activities in the village are limited due to lack of water, whilst November is usually the start of the harvest season. Similarly, Campbell *et al.* (2005) reported the same observation in Cambodia that seasonality affected major livelihood activities in the area i.e. agriculture and fishing. However it was also considered as major driving force for rural SEC to diversify their activities. This result was similar to Paxson's (1993) report that the majority of farmers in Asia rely on seasonal agriculture, especially those in rainfed and non-irrigated areas. Most of the agriculture-related activities in Cambodia start at the beginning of the rainy season (June – July) and greatly intensify in September which is usually the time for planting and transplanting rice. The variation in the amount of time spent in doing different activities in SEC may be accounted for by the the amount of labour force available in the households particularly during summer where some member of the households do seasonal migration, hence, less members are contributing to the total amount of time spent doing the various activities. At harvest time household labour increased susbstantally as migrants returned home.. However in NET, seasonality has less influence on household labour expenditure (>65 - <160 hr household $^{-1}$ week $^{-1}$). Activities peaked during the rice harvest in December while June to September are considered the lean season as most farmers have finished planting rice and therefore less labour was used. RRD however has a different seasonality of activities compared to SEC and NET mainly because of the different weather pattern in RRD, the availability of irrigation and the mixed cropping practiced. The seasonal variation on time spent by household in RRD ranges from more than 60 to 135 hr household $^{-1}$ week $^{-1}$. Periods of maximum and minimum labour expenditure varied with AEZ and this may be the result of the variations in the crops being farmed in both zones. In general activities and labour requirements are low in rural areas during the dry season mainly because there was no activity in the field and most men have migrated to other places (Paxson, 1993).

Migration is described by literature as the spatial separation between the location of a resident households or a family from their original place (Ellis and Freeman, 2005). Scoones (1998) reported that migration maybe brought about by several potential causes (e.g. voluntary or involuntary movement, effect of reinvestment in agriculture, enterprise, etc.). Seasonal migration or the movement of household members from their residence to another place was a necessity in order to support their individual and the whole household's livelihoods (Ellis, 2000a; Rigg, 2003). In this research, migration was seen and understood mainly as a coping strategy of households. The beginning of the year (January to March) was the peak of migration in the three study sites, however, July and October can be also considered the period of seasonal migration particularly in SEC and RRD. The period of the peak of migration coincided with the period of minimal work in the farm as it was during the dry season (January to March) where most of the agricultural land has been harvested already and during the period when planting season was over (July to October). Majority of the households from the rural areas tended to migrate (seasonally) to urban areas (other province or cities) for work in factories and construction. In Thailand, the northeast region has been known for the out migration phenomenon to urban areas to find employment on either a semi-permanent or seasonal basis in order to send remittances to support their families (AIT/AO, 1998). Phromthong (1999) reported that seasonal changes in the household size and labour force were caused by the migration of household members for all sorts of reasons wherein seeking job opportunities were the most common. Moreover, Demaine *et al.* (1999) also reported that majority of the younger people in the village usually migrate for employment during the dry season. The popularity of migration (rural-urban) however is posting a negative impact on the agricultural development as well as aquatic resources management in the rural areas as the available labour force is decreased leaving very young and older people in the village. Pant (2002) also reported that more than half of the households practicing integrated agriculture – aquaculture in northeast Thailand had at least one family member working away in order to augment their rural livelihoods. Murshid (1998) and Catalla and Catalla (2002) both reported that in Cambodia, one of the coping strategies of the poor particularly in the rural areas where there was little or no opportunity to generate income for the family, short-term migration or even crossing the border (legal and illegal) was an option. Meanwhile in the RRD, seasonal migration was also seen as one of the rural people's option in diversifying their livelihoods (Thanh *et al.,* 2005). Aside from diversifying livelihoods, the GSO (2000) also reported other reasons for migration: natural disaster, family reason and schooling. Migration due to economic reasons accounted for 17% of all migration in Vietnam. However out migration from rural to urban and even abroad is a general phenomenoen in Southeast Asia (Rigg, 2003).

3.3.5 Livelihood outcomes

Livelihood outcomes are the results of the different strategies undertaken by households or individuals in pursuit of sustainable livelihoods (Adato and Meinzen-Dick, 2002; Ellis, 2000a, b; Ellis and Freeman, 2005; DFID, 1999; Scoones, 1998). This section demonstrates the variation of outcomes by well-being level as well as the type of households (stocking and non-stocking AA). The importance of seasonal variation on income, expenses, and food consumption are highlighted in this section.

3.3.5.1 Gross income

The average gross income generally varied amongst sites. Households in NET had the highest (<\$30 - >\$100 hh^{-1} $week^{-1}$) while SEC had the lowest average income

(>$5 - <$20 hh^{-1} $week^{-1}$) (P <0.001). Furthermore, the gross income of households in NET had large variations compared to the other two sites. AEZ was also found to contribute to the variation; households in the LOW zone generally earned more income than in the DRY area, especially in NET (P <0.05).

Seven main sources of income were identified in this study; income from crop production, from aquatic production (aquaculture and fishing), livestock, wage/paid labour, small business or trading, remittances and other sources. Figure 3.25 shows the mean contribution of each source to the total income of households aggregated by well-being level from two different AEZ located in the three sites. Income from livestock is very important in SEC and RRD where it contributed more than 70% and 44% of the total income respectively. In contrast livestock contributed less than 10% to the total income of households in NET. The main contributors of income in NET are agriculture and wage labour (>30% and >25% respectively).

Variation in the contribution of the different sources of income in NET and RRD was found to be related to wellbeing and AEZ interaction (Figure 3.25) (P <0.05). In NET, the contribution of wage labour was only high in poorer households in the LOW and DRY area (33% and 36% respectively). Remittances were more significant among the better-off households than poor groups in NET. In RRD, livestock and aquaculture made important contributions (>60% and >20% respectively) to the total income of better-off households in the LOW area.

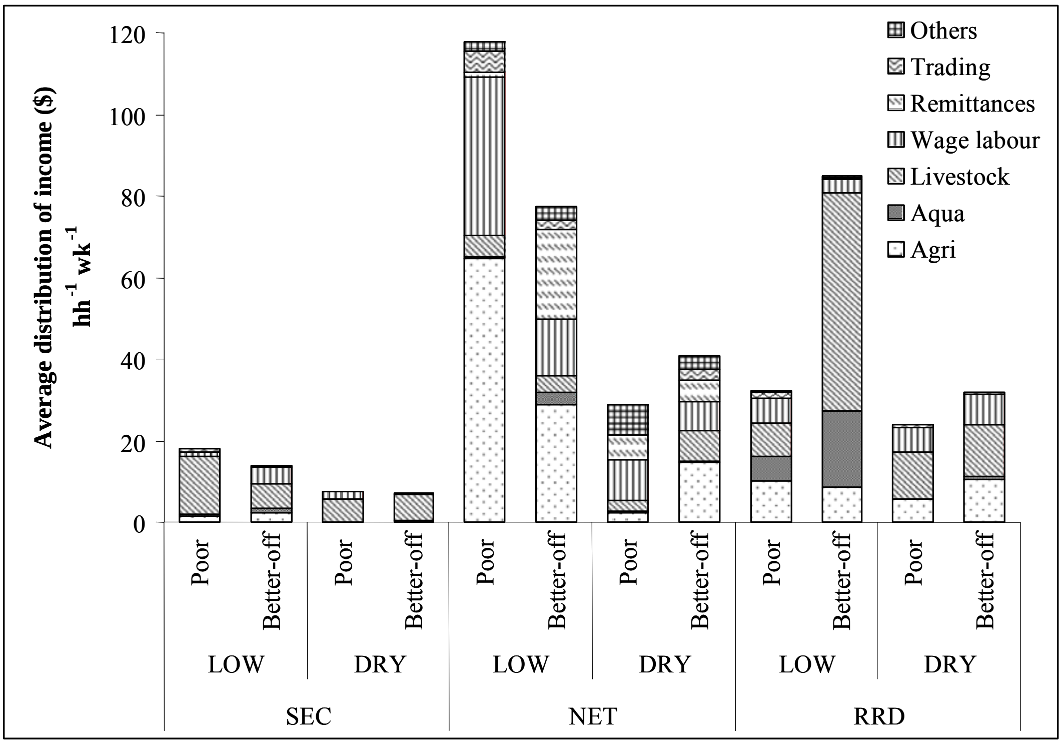
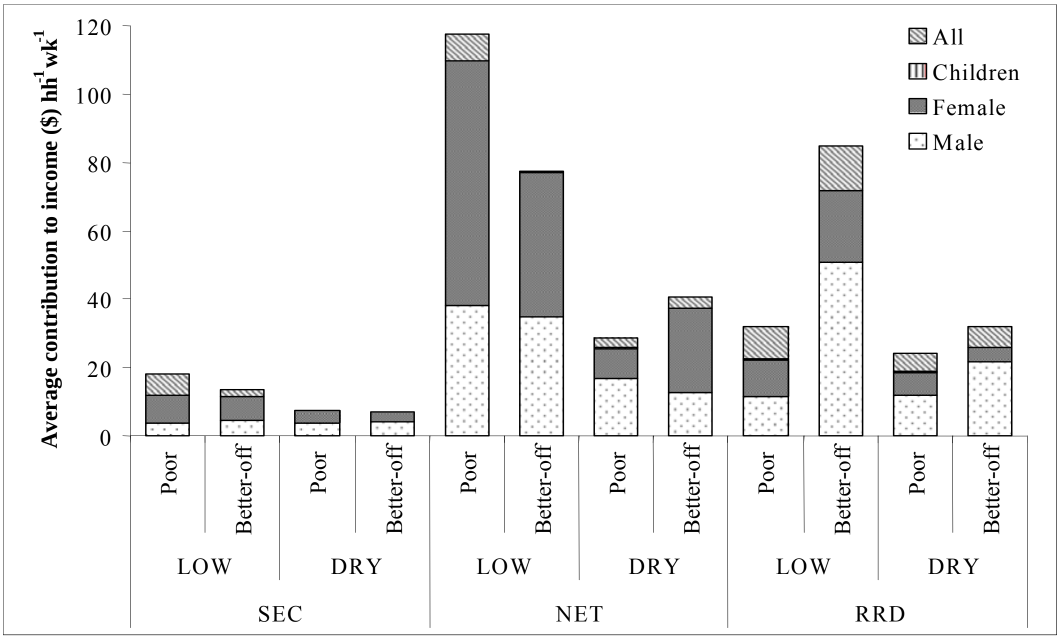


Figure 3.25 Contribution of different sources to gross income in 12 months by households of different well-being ranks in SEC, NET and RRD. ***Data presented based from longitudinal study.***

The contribution of the different household members to the total income was also analysed and the average contribution of each gender group is presented in Figure 3.26. The results shows that the contribution of each gender group varies between the AEZ of each site (P <0.001). Furthermore, the well-being level also influenced the contribution of a particular gender group to the total income of the household (P <0.001). Variations were found regarding the contribution of the different age and gender groups to the total household income (P <0.05). The contribution of women was generally high, especially in NET where women contributed more than 50% of the total income. In contrast, women in RRD had the lowest contribution to the total household income (< 25%). In SEC, female members of the household particularly in the LOW area contributed significantly more than men.



Note: "All" refers to combination of all member of the family; however it is mostly adult male and female members of the household.

Figure 3.26 Contribution of different age-gender group of different well-being to the weekly income of households in different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

Similarly in NET, females in the LOW area and from the better-off households in DRY sub-sites contributed a relatively high proportion to the total income of the households. In the RRD, it was generally the male member of the household who contributed most to total household income. A significant amount was also derived from the whole household working together i.e. male and female members of the household including the children. Very insignificant amounts of income were contributed by children alone (0%, 0.1%, and 0.2% from SEC, NET, and RRD respectively).

3.3.5.2 Expenses

The different sources of expenditure by households were also identified and assessed in this study. Among the different sources identified were; agricultural expenses, expenses related to the management of the aquatic system, expenses related to livestock rearing i.e. feeds and medicines, food for household, expenses in maintaining the house, medical expenses, expenses related to children's education, social and religious activities and others. Figure 3.27 shows the contribution of each source to the total expenditure of households with different wellbeing from two AEZ in the three study sites.

Analysis showed significant differences on the average expenditure of households from different AEZ at the three sites ($P < 0.001$) where households from the DRY area of SEC had the lowest mean expenses (7.5\$ $hh^{-1}week^{-1}$ ± 23.4 SD) while households from LOW areas of NET had the highest expenditure (79.2\$ $hh^{-1}week^{-1}$ ± 188.7 SD). There were no significant differences in the average expenditure between households of different well-being levels ($P > 0.05$). Within-site analysis found that expenditure of different types varied amongst households by well-being group and AEZ. In SEC, expenditures were generally different between better-off and poorer ($P < 0.05$). Richer households spent more than the poor (\$14.5 hh^{-1} $week^{-1}$ ± 42.8 SD and \$6.9 $hh^{-1}week^{-1}$ ± 22.9 SD for better-off and poor respectively). While better-off families spent more on farming than food, poor households in RRD spent relatively more of their earnings on food. Livestock and farming were the next most important sources of expenses for poor families. Both well-being groups spent relatively little on their aquatic system management, however poor families spent more than the better-off.

In NET, expenditure was significantly affected by well-being and AEZ. Moreover, the amounts spent on particular categories was significantly different ($P < 0.05$). Poor families in the DRY area had the lowest expenditure (3.3\$ $hh^{-1}week^{-1}$ ± 27.6

SD). In contrast, poor families from LOW areas had the highest average expenditure (11.2$ $hh^{-1}week^{-1}$ ± 61.5 SD). Farming needs, schooling, food, and maintenance were the four main types of expenditures in NET. Poor households from the LOW area spent the most on farming inputs and schooling/education. Expenditure on food however was high among better-off families in DRY area of NET. All groups spent little on aquatic system management (0.3$ $hh^{-1}week^{-1}$ ± 1.6 SD).

In RRD, expenditure is generally similar in all groups apart from the better-off families in LOW area where the average weekly expenses were found to be significantly higher ($P < 0.05$) ($40 $hh^{-1}week^{-1}$ ± 22.3 SD). The main expenses were for livestock, food purchases and farming inputs. Expenditure for aquatic system management was relatively low, and the highest mean was $1.3 $hh^{-1}week^{-1}$ (± 8 SD) by better-off households in the DRY area.

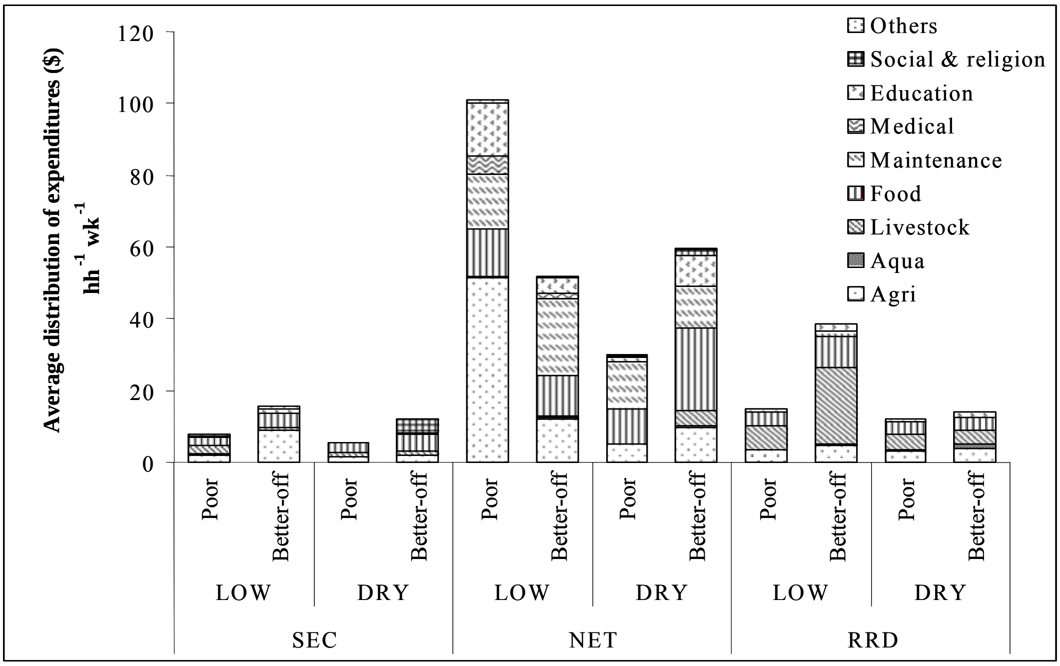


Figure 3.27 Total expenditure by category for households in SEC, NET and RRD by different well-being ranks. ***Data presented based from longitudinal study.***

3.3.5.3 Net income

Figure 3.28 shows the average weekly net income of households from different well-being groups at the three sites. The average weekly income in general was significantly different amongst sites (P <0.001); households in the RRD had the highest net income (18.9 \$ household^{-1}week^{-1} ± 80.33 SD). Furthermore, all sampled households in RRD had positive net incomes, unlike in SEC and NET where some households had negative net income particularly among better-off groups. Households in SEC had the lowest average weekly net income (4.3\$ household^{-1}week^{-1} ± 37.2 SD). In general no significant difference was found between well-being groups (P >0.05).

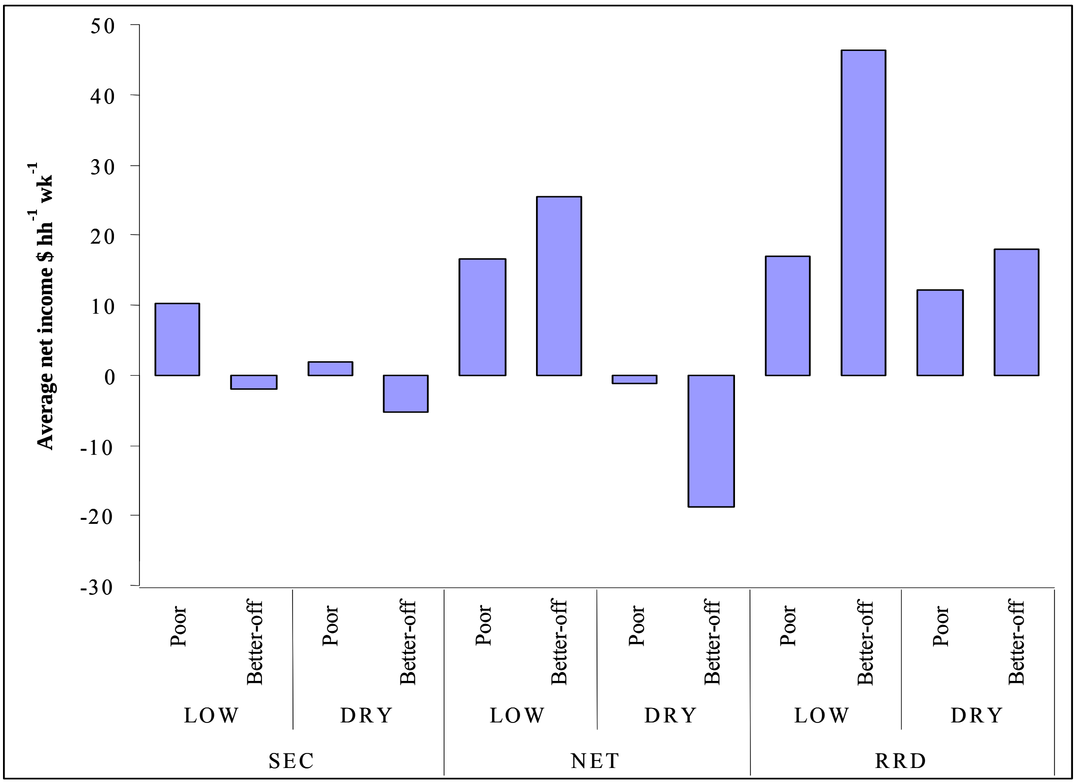


Figure 3.28 Average net income of households with different well-being from AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

Seasonal variation of net income was found to be significantly different in general ($P < 0.05$) and Figure 3.29 shows such variation. Amongst the three sites, households in SEC had the least variability in weekly net income. On the contrary, households in NET had the biggest variation month to month. The net income in SEC was greatest during the months of February, May and August (9.4 ± 36.1, 7.9 ± 38.5, 11.4 ± 34.2, respectively) but was minimal for the rest of the year. The variation was caused by the seasonality of work off-farm and non-farm. Non-farming activities were found to be high starting the month of February while May and August coincides with the agricultural activities i.e. land preparation, transplanting and harvesting. In NET, household net income peaked in January, July and November (40.1 ± 186, 55.6 ± 246, 37.8 ± 106, respectively). Net income was greatest in the months of June, September and October (42.8 ± 85, 29 ± 47; 29.4 ± 122, respectively) in RRD. The leanest month where households had no income at all in NET was found to be during the month of June (-41\$ $hh^{-1}week^{-1}$ ± 265 SD). In RRD, July was the leanest month (-3.1 \$ $hh^{-1}week^{-1}$ ± 95 SD).

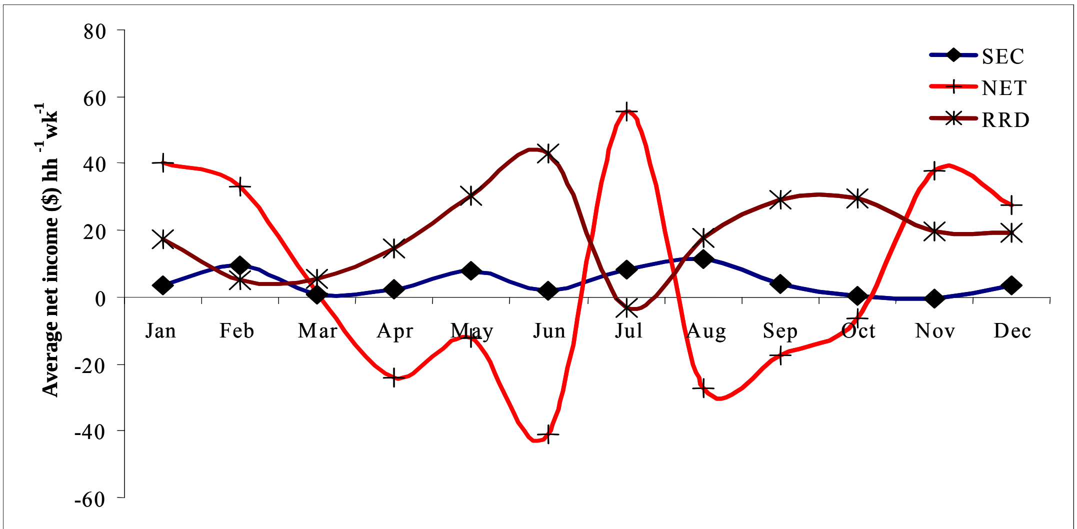


Figure 3.29 Average weekly net income of households from SEC, NET and RRD. ***Data presented based from longitudinal study.***

3.3.5.4 Seasonality of income and expenses

Although the total income and expenditure were already presented in the previous section, this section illustrates how income and expenses vary throughout the seasons. Furthermore, comparison between different well-being groups throughout the seasons was highlighted in this section. Figure 3.30 illustrates the seasonality of income and expenditure by households of different well-being in the three sites.

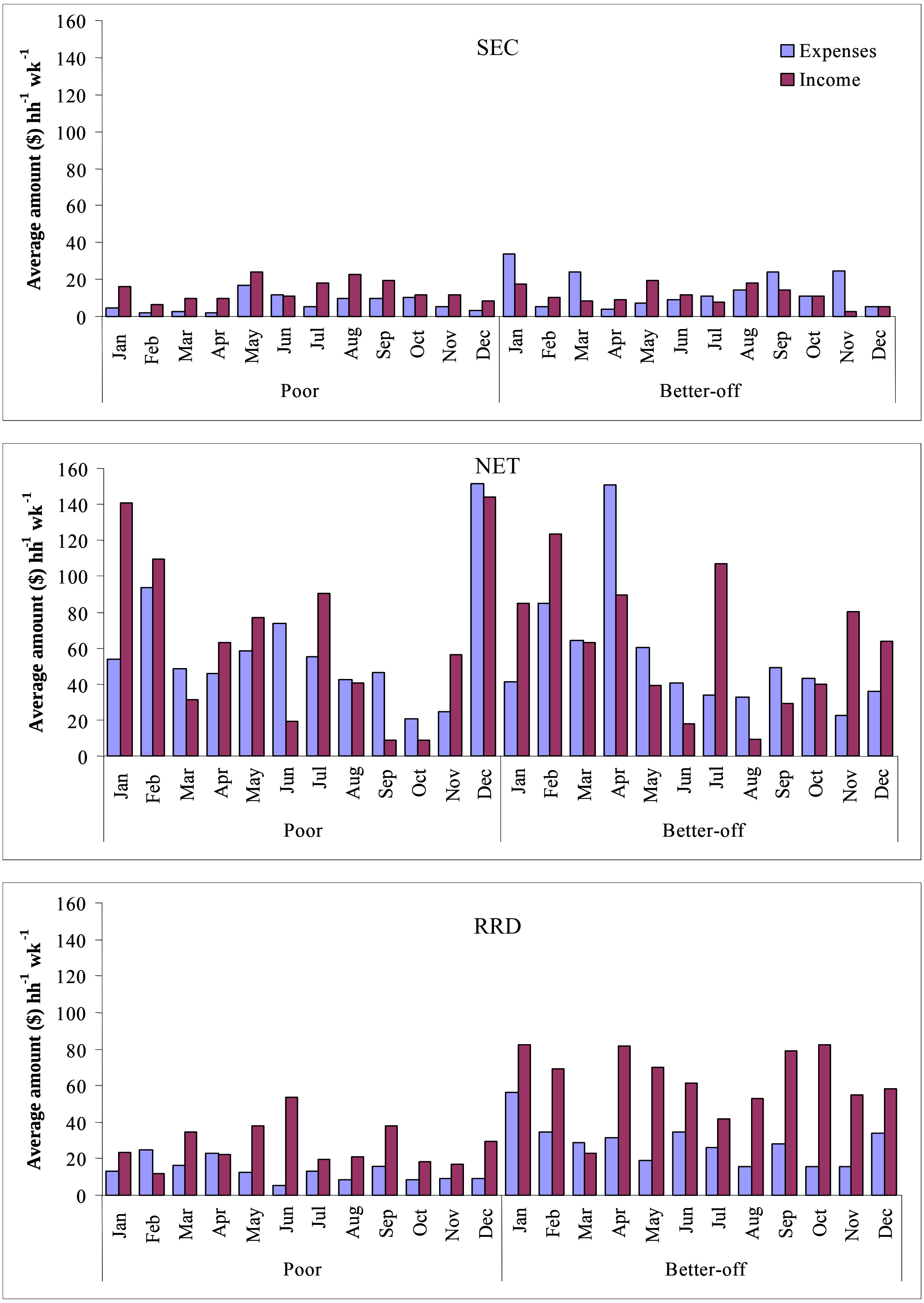
The analysis revealed that differences in the seasonality of income and expenses between site and well-being group were significant ($P < 0.001$). As shown in Figure 3.30 variation in income and expenditure of households of both well-being groups is highly affected by season in NET (<\$10 - >\$150 hh^{-1} $week^{-1}$). In contrast, SEC has least seasonal variation in income and expenditures (<\$2 - >\$30 hh^{-1} $week^{-1}$). Seasonal variation in RRD is intermediate (>\$5 - >\$80 hh^{-1} $week^{-1}$).

Marginal seasonal variation within-site was found amongst wellbeing groups ($P = 0.05$). The critical period, when poor households in SEC had incomes of less than \$10 hh^{-1} $week^{-1}$, occurred only during the months of February, April and December. In contrast the critical period for better-off households extended over five months (March – April, July and November - December). Income peaked during the months of May and August - September for poorer households while January, May and August for the better-off households. During this period households earned more than \$20 and \$15 hh^{-1} $week^{-1}$ for the poor and better-off respectively. Expenditure of poorer households was high (>\$10 hh^{-1} $week^{-1}$) during the months of May – June and October while the months of January, March, September and November were the periods of high expenditure among better-off households (>\$20 hh^{-1} $week^{-1}$).

Critical months in NET also varied between well-being groups; poorer households earn less than \$10 hh^{-1} $week^{-1}$ during the months of September – October while it was only during the month of August that better-off households experienced low incomes. Both wellbeing groups earned more than \$100 hh^{-1} $week^{-1}$ during the months of December – January for poorer households and February and July for the better-off. Expenses, however were high during the months of February and June for the poorer households and in April for the better-off. Expenses during this period reached over \$90 hh^{-1} $week^{-1}$ and \$150 hh^{-1} $week^{-1}$ for poor and better-off households respectively.

In RRD, the critical periods where households earned less than \$15 hh^{-1} $week^{-1}$ and \$30 hh^{-1} $week^{-1}$ (poor and better-off respectively) were during the months of February (poor) and March (better-off). The peak season also varied between the wellbeing groups; poorer households earned most (>\$50 hh^{-1} $week^{-1}$) only in June while the periods over which the better-off earned more (>\$80 hh^{-1} $week^{-1}$) were longer in total and distributed through the year (January, April and October). The peak of expenditures also varied between well-being groups. Whereas poorer households spent more than \$20 hh^{-1} $week^{-1}$ during the months of February and April, better-off households spent more than \$50 hh^{-1} $week^{-1}$ in January. However, expenses were low in general during the months of August and October – November.

Figure 3.30 Seasonality of income and expenses of households with different well-being ranks in SEC, NET, and RRD. ***Data presented based from longitudinal study.***

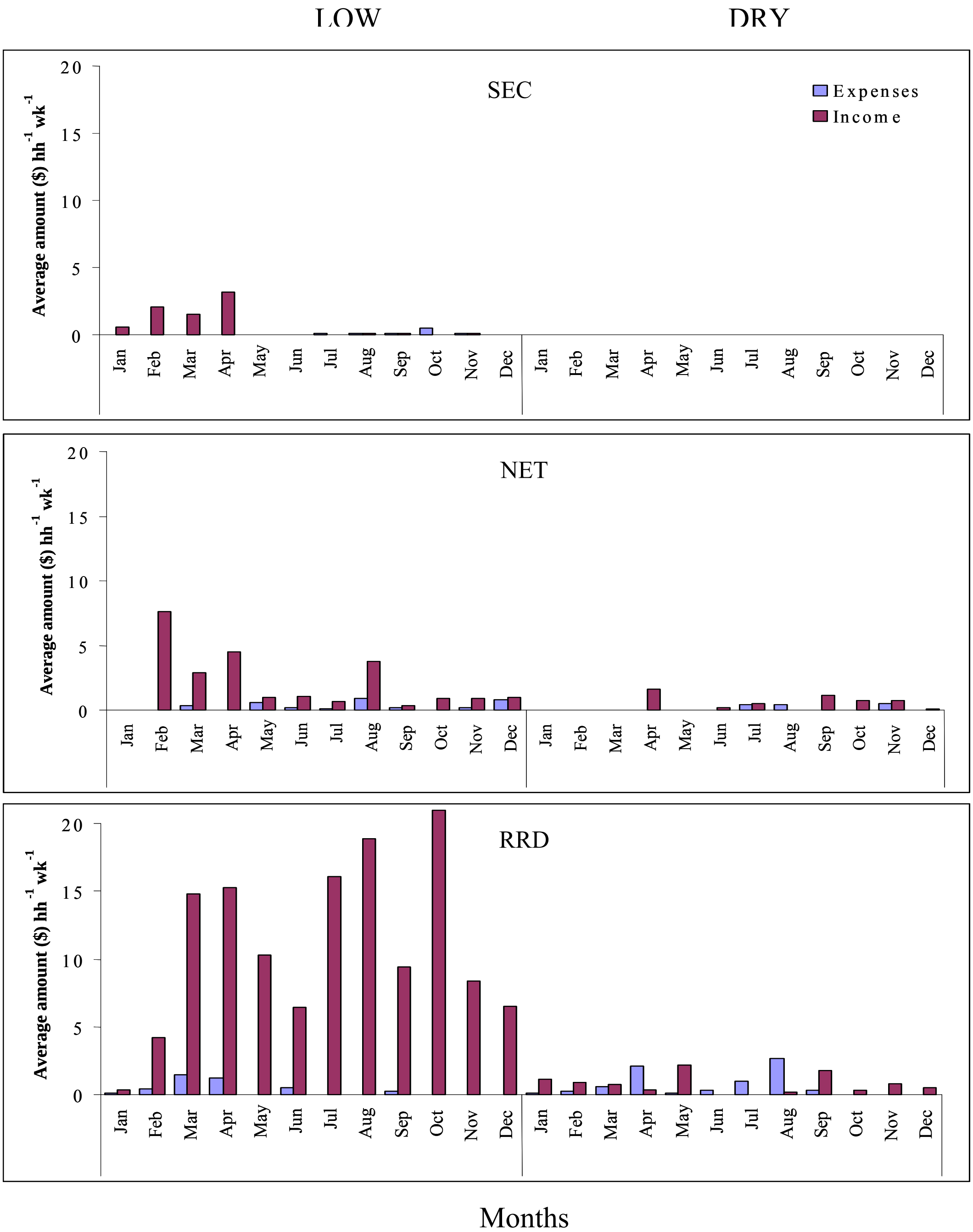


3.3.5.5 Seasonality of income and expenses in aquatic management

Statistical analysis of the seasonal variation on income and expenses from aquatic management was not possible due to the limited information available. Very few households incurred expenses and gained income from aquatic management, hence the limitation of data for deeper analysis i.e. including all variables that were used in previous analysis. However, as presented in Figure 3.31, a general comparison between sites and AEZ in each site can still be done.

Profitability is obviously highest among households in RRD particularly in the LOW areas (\$20 hh^{-1} $week^{-1}$). The peaks of income were experienced during the months of March – April, July – August and October. In contrast, households in SEC had the least income (\$3.2 hh^{-1} $week^{-1}$) and only during the months of January to April. Income from aquatic systems of households in NET was intermediate where February to April and August were the periods of high income. Aquatic systems in the DRY areas of all sites were relatively less profitable, especially in SEC.

Figure 3.31 Seasonality of the average income and expenses from aquatic system of households from different AEZ in SEC, NET, and RRD. ***Data presented based from longitudinal study.***

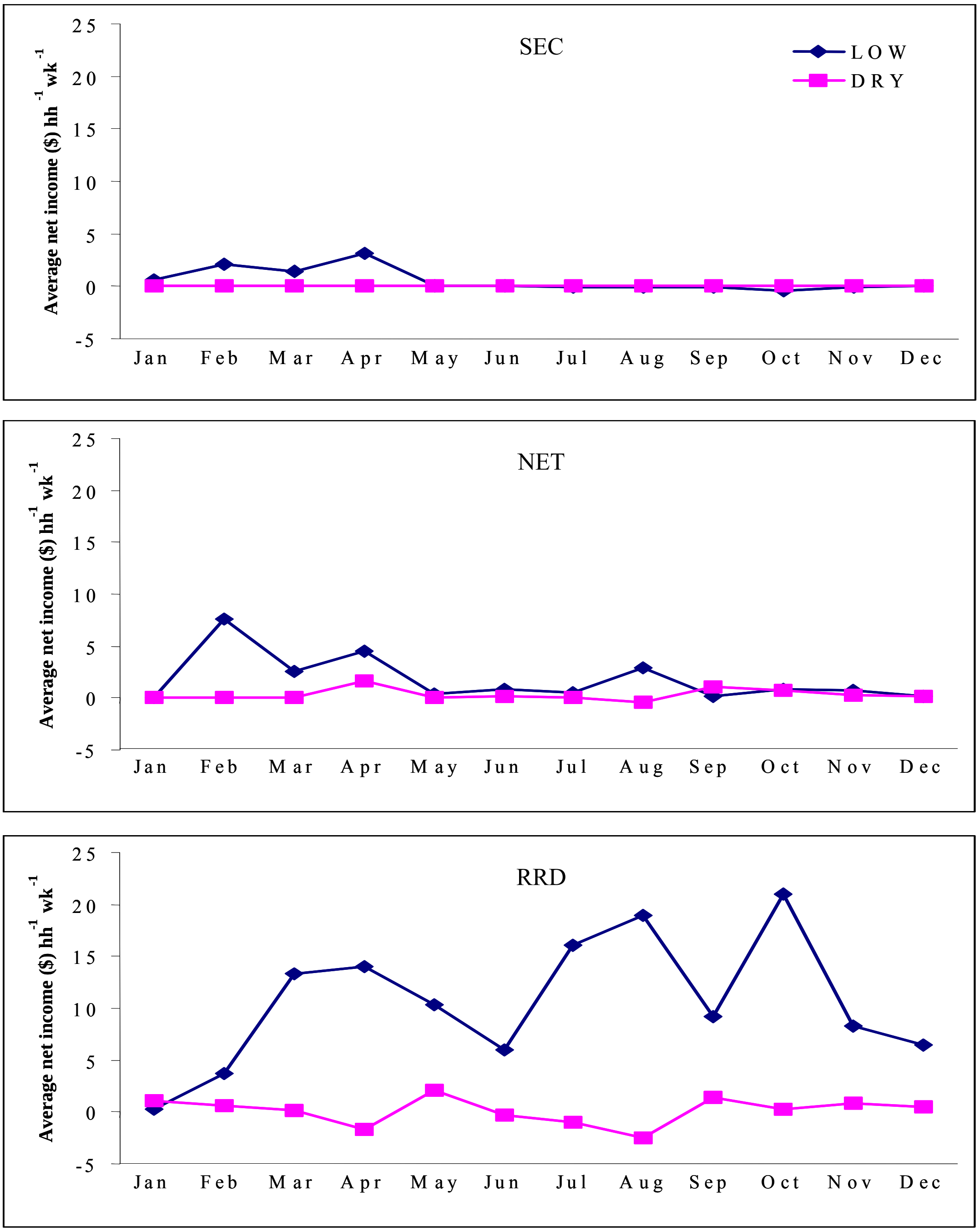


3.3.5.6 Net income from aquatic systems

The average net income was analysed and presented in this section. Figure 3.32 shows the seasonal variations in average net income among sites and AEZ ($P < 0.05$). Among the three sites, the income from aquatic systems had considerable seasonal variation in RRD (-\$2 - >\$20 hh^{-1} $week^{-1}$). In contrast net income among households in the SEC area had the least variation (\$0.3 - >\$7 $hh^{-1}week^{-1}$).

However, variations were also noticeable within sites i.e. AEZ. In SEC, net income by household in the LOW area ranged from -\$0.03 - >7 hh^{-1} $week^{-1}$. The critical months at this site were July and August when net incomes were negative. May to June is the period considered to be 'safe' as households did not lose capital. In NET, seasonal variation is high in the LOW area (\$0.13 - >\$7 hh^{-1} $week^{-1}$) compared to the DRY area (-\$0.4 - <\$2 hh^{-1} $week^{-1}$) and even the period where net income was high was different between AEZ (February and April, LOW and DRY respectively). In RRD, seasonal variation between AEZ was also significant. Variation in the LOW area is higher (\$0.2 - >\$20 hh^{-1} $week^{-1}$) than DRY (-\$2 - \$2 hh^{-1} $week^{-1}$).

Figure 3.32 Average net income from aquatic system of households with different well-being from different AEZ in all sites. ***Data presented based from longitudinal study.***



3.3.5.7 Food consumption

One of the most important outcomes of a livelihood strategy is to maintain or improve food consumption of households. This section describes the behaviour of people disaggregated by well-being and AEZ at three sites in terms of food consumption. The different types of food consumed, seasonal variations in the amount and the sources of such food were highlighted in this section. More detailed information regarding aquatic animal consumption is discussed in the next chapter (Chapter 4). The comparison of food consumed was only based on the raw weight of food consumed and that shell and bones were also included. Moreover the researcher was not able to convert the amount consumed into kilocalories (kcal).

Average food consumption

Analysis shows that there were significant differences between the average food consumption between the three sites ($P < 0.05$); households in SEC consumed the most (7678 g $capita^{-1}week^{-1}$) while households from RRD had the lowest consumption (5364 g $capita^{-1}week^{-1}$) and households in NET were intermediate (6231 g $capita^{-1}week^{-1}$) (Figure 3.33). The amount of food being consumed at the three sites also shows seasonal variation ($P < 0.001$) and will be discussed later in this section.

Food composition

In general, there were nine food groups identified in this study; freshwater aquatic animals which includes fish and non- fish species, meat (pork, beef, goat and dog), poultry (ducks and chicken), vegetables, rice, processed food (e.g. tofu), marine (fish and crustaceans), insects and others (Figure 3.33). The contributions of the various food groups show significant difference among sites and wellbeing groups ($P < 0.05$).

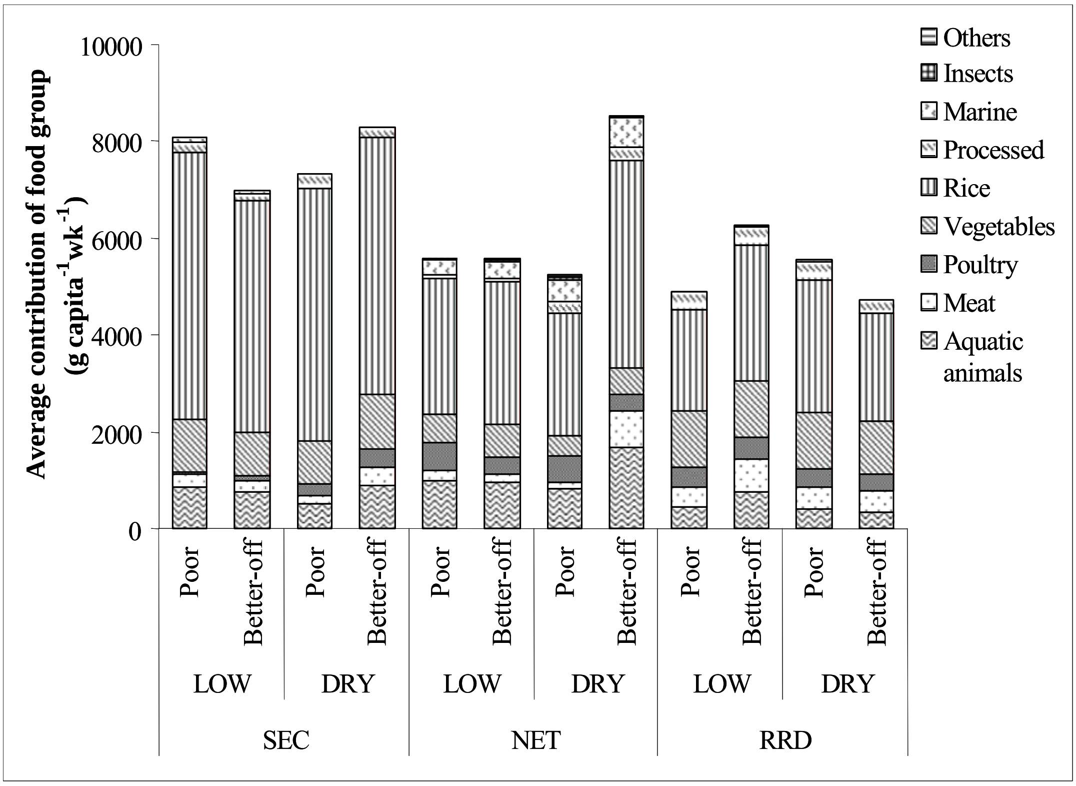


Figure 3.33 Contribution of different food groups to the total food consumption in 12 months by households of different well-being ranks in SEC, NET and RRD. ***Data presented based from longitudinal study.***

Amongst the nine food groups, rice was the most important in all three sites and households in SEC consumed the highest percentage of rice in the diet (<70%). In contrast least rice was present in the household diet (<50%) in the RRD. The percentage contribution of AA was significantly different among the three sites; the highest percentage contribution of AA to total food consumption was found in NET (17%, 1114 g capita^{-1}week^{-1}) while households in RRD consumed the least proportion of AA (9%, 492 g capita^{-1}week^{-1}). Meat was also an important food group in the three sites; RRD had the highest ($P < 0.05$) proportion of meat being consumed by households (>9%, 493 g capita^{-1}week^{-1}) while households in SEC had the least proportion (3%, 270 g capita^{-1}week^{-1}). Vegetables were another important food group and the percentage contribution was significantly different among the three sites ($P < 0.05$); more than 20% (1143 g capita^{-1}week^{-1}) of the food consumed in RRD was vegetables which was the highest proportion compared to SEC (13%, 1007 g capita^{-1}week^{-1}) and NET (9%, 544 g capita^{-1}week^{-1}). The contribution of marine food (Figure 3.33) was highest in NET (7%, 412 g capita^{-1}week^{-1}) but very low in SEC (0.7%, 56 g capita^{-1}week^{-1}) and RRD (0.3%, 16 g capita^{-1}week^{-1}).

Within-site variations were also found in the analysis (Figure 3.33). In SEC, the amount contributed by each food group to the total consumption of households from different AEZ was found to be significantly different ($P < 0.001$). Amongst the different food groups, rice dominated the composition of food being eaten by households in SEC in general. On average, households from LOW and DRY consumed approximately 5197 g capita^{-1}week^{-1} of rice. This amount made up 67% of the total food consumed by households in both AEZs. Other than rice, vegetables and AA were major components of diet. Households from LOW and DRY consumed 803 g capita^{-1}week^{-1} and 704 g capita^{-1}week^{-1} AA respectively, which contributed 11% and 8% of the total food consumed. Differences in the contribution of each food group between well-being groups were also found to be significant ($P < 0.05$). Poor families consumed more rice and processed food (mainly fermented AA) than better-off families. On the contrary, better-off families consumed more fresh AA, poultry, and vegetables than the poor. The contribution of AA to the total food consumption was lower in poorer households (17%) compared to better-off (21%).There was no significant interaction between AEZ and well-being ($P > 0.05$).

In NET, better-off households particularly in the DRY area consumed more than other groups at the site (8521 g capita^{-1}week^{-1}) ($P < 0.05$). Moreover, differences between AEZ were also found to be significant ($P < 0.001$), although there was no interaction between AEZ and well-being levels ($P > 0.05$). Amongst these food groups, AA contributed the second highest (1018 g capita^{-1}week^{-1} or 19 % and 1148 g capita^{-1}week^{-1} or 18%, LOW and DRY respectively). The only food groups where poor households consumed more than the better-off were poultry and eggs and insects. Aside from rice, the main contributions to total food consumed by poor households were AA and poultry (883 g capita^{-1}week^{-1} and 568 g capita^{-1}week^{-1}, respectively) whilst for better-off families, AA, marine food, and vegetables were the main contributors to the total food consumed (1267, 445, 621 g capita^{-1}week^{-1}; AA, marine food and vegetables respectively).

In RRD, better-off families in the LOW area consumed the most (6253 g capita^{-1}week^{-1}) compared to all other groups within the site ($P < 0.05$). As with the other sites, rice was still was the largest contribution to the diet in all groups with better-off families in the LOW area having the highest mean (2783 g capita^{-1}week^{-1}). After rice, vegetables were the second most important food group in all AEZ and well-being groups (1143 g capita^{-1}week^{-1}). Mean consumption of both AA and meat was significantly higher among the better-off households in LOW area (753 and 688 g capita^{-1}week^{-1} of AA and meat respectively) compared to other groups in the site. Marine products were only consumed in small quantities in the DRY zone of RRD.

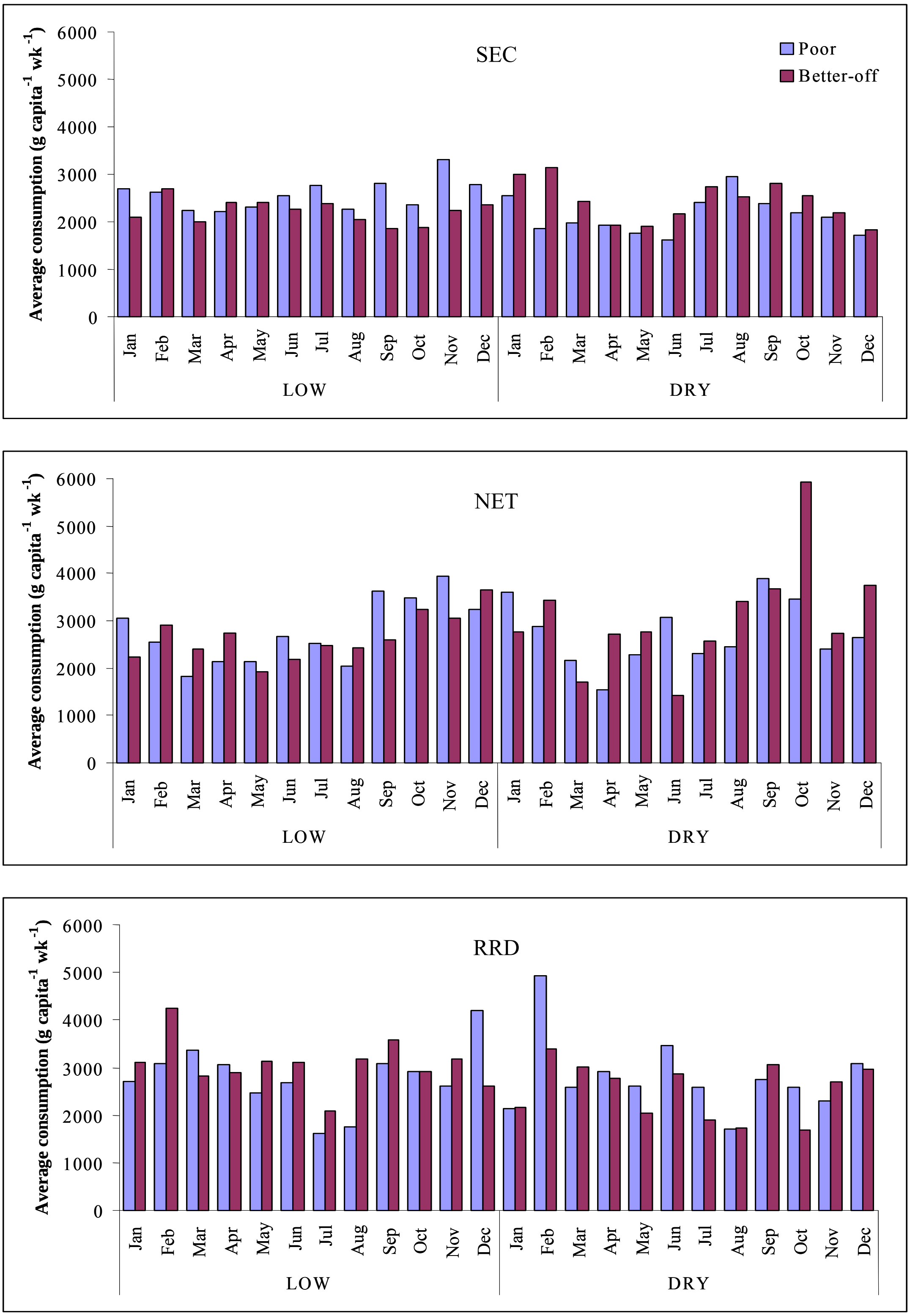
Seasonality of food consumption

Seasonal analysis of the amount of food consumption using the GLM showed significant variation among the three sites ($P < 0.05$). The amount of food consumption (excluding rice) in NET is significantly affected by season especially in the DRY area (241 - 586g capita^{-1}week^{-1}) (Figure 3.34). Food consumption in SEC was the least affected by season especially in the LOW area (264 - 347g $capita^{-1}week^{-1}$) where variation was the least among all groups in the study sites (P <0.05).

The critical months identified in the seasonality analysis varied by site and AEZ (Figure 3.34). In SEC the months of March, August and October were considered lean months (<300 g $capita^{-1}week^{-1}$) in the LOW area while the months of April to June and December were the periods in which households in the DRY area consumed less (<240 g $capita^{-1}week^{-1}$). In NET, the months that were critical, with minimal consumption, in both AEZ (<270 g $capita^{-1}week^{-1}$ and <300 g $capita^{-1}week^{-1}$ in LOW and DRY respectively) were March and May. However, there were also critical months that were specific to particular AEZ; August was critical (<280 g $capita^{-1}week^{-1}$) in LOW area while June was considered lean period (<280 g $capita^{-1}week^{-1}$) in the DRY. In RRD, July (230 and <310 g $capita^{-1}week^{-1}$ in LOW and DRY respectively) and August (307 and <220 g $capita^{-1}week^{-1}$ in LOW and DRY respectively) were the critical months for both AEZ.

Seasonal effects on the amount of food consumed by households with different wellbeing levels were also found to be significantly different in the three study sites (P <0.05). In general, food consumption of households in NET was more affected by season compared to SEC and RRD. This may have been due to the large variation particularly with the better-off in the DRY area (175 - 740 g $capita^{-1}week^{-1}$). In contrast, consumption of households in the LOW area of SEC (both poorer and better-off) was the least affected by season (213 - 337 g $capita^{-1}week^{-1}$).

Figure 3.34 Seasonal variation in household consumption of dietary items excluding rice by well-being and AEZ. ***Data presented based from longitudinal study.***



In the LOW area of SEC, poorer households consumed less than 300 g capita^{-1}week^{-1} for five months of the year (March - May, August and October) and it was only during November when consumption increased to more than 400g capita^{-1} week^{-1}. In the DRY area of SEC, poorer households consumed less than 300g capita^{-1} week^{-1} for most of the year (10 months). In NET, poor households consumed least food during the periods of March – May and July – August. In RRD, however, poorer households consumed less than 300g capita^{-1}week^{-1} for four months and three months in the LOW and DRY AEZ respectively. The common lean months for both AEZ were January and August.

Seasonality of fresh and processed food

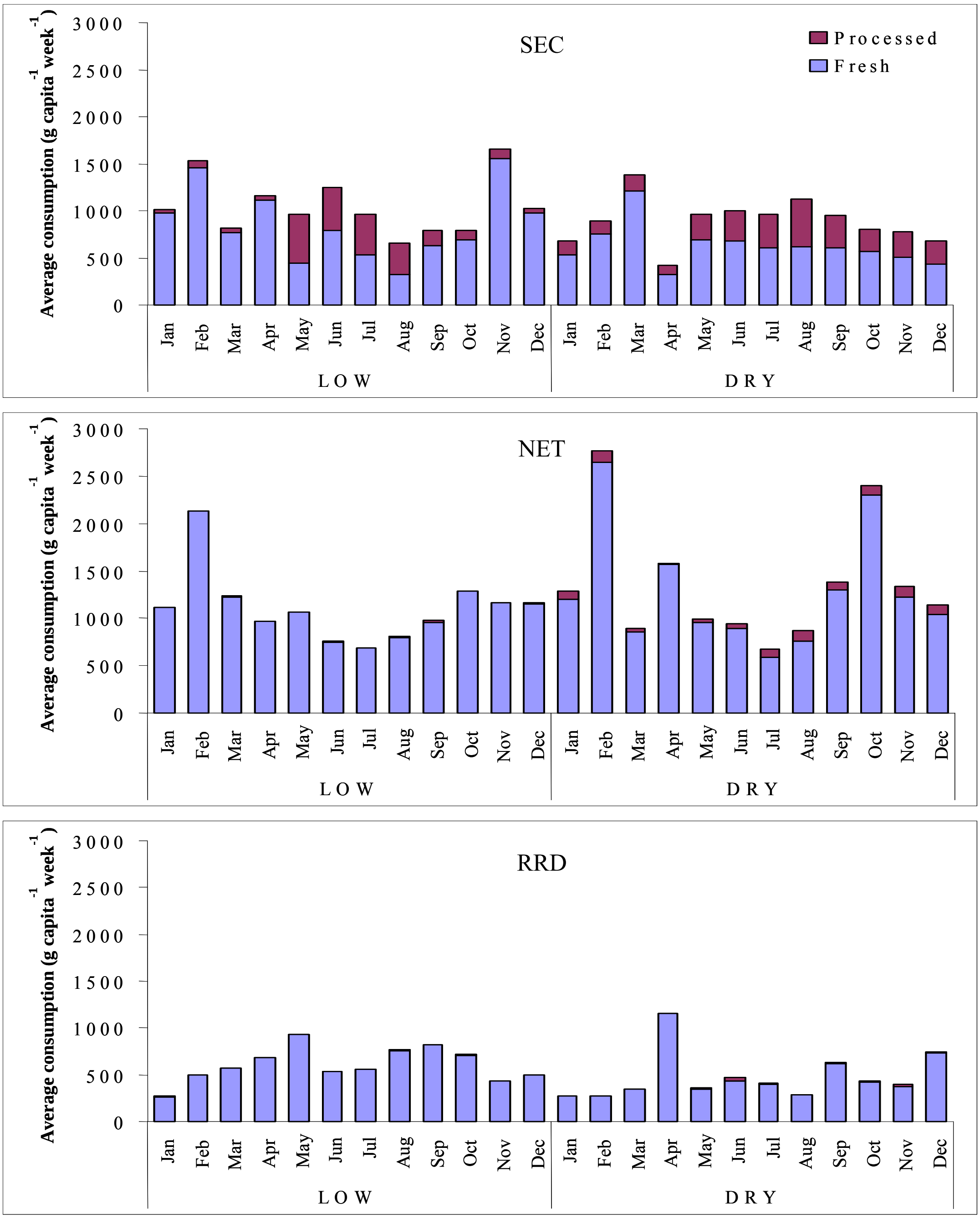
AA are consumed both fresh and processed at all three sites. 'Fresh' fish is collected or bought from the market, cooked and consumed directly. Processing of AA was a coping strategy for smoothing consumption particularly during critical periods of the year. Such forms are being consumed as a substitute for fresh AA especially in the DRY areas where fresh AA are usually limited. AAs are also processed in a number of forms such as salted, dried or fermented. Figure 3.35 shows the seasonality (g capita^{-1}week^{-1}) of the two forms of AA (fresh and processed) consumed by different well-being groups in the three sites throughout the seasons.

Seasonal variation in the processed AA consumed was found to be AEZ- and site-specific ($P < 0.05$). Furthermore, such variation was not influenced by the well-being of the household ($P > 0.05$). In Figure 3.35, the amount of processed AA consumed was only significant in SEC (217 g capita^{-1}week^{-1}); only very minimal quantities were consumed in NET (41 g capita^{-1}week^{-1}), and even less in RRD (36 g capita^{-1}week^{-1}). However, there was large variation of the data that needs to be considered.

In SEC, seasonal variation in the amount of AA forms being consumed was found to be significant within AEZ (P <0.001). In general, households from the DRY area consumed more processed AA than those from the LOW (259 g capita^{-1}week^{-1} and 196 g capita^{-1}week^{-1} in DRY and LOW respectively), however there were at least three months when households from LOW sub-sites consumed more processed AA than in the DRY sub-sites (May to July). The month with highest processed AA consumption was found to be May in the LOW area (520 g capita^{-1}week^{-1}) and August in the DRY area (508 g capita^{-1} week^{-1}).

The influence of well-being on the seasonal variation was not found to be significant (P >0.05). In NET, neither AEZ nor well-being influenced the seasonal variation on the amount of the different forms of AA, however significant differences were found (P <0.05) between AEZs where mean consumption of processed AA was higher in the DRY as compared to the LOW area (77 g capita^{-1}week^{-1} and 6 g capita^{-1}week^{-1} in DRY and LOW respectively). In RRD, most of the households consumed fresh AA and intake of processed AA was very rare. In both AEZ, no household reported consuming processed AA during the months of February and March. The highest number of households that consumed processed AA in LOW area was 2 out of 27 during the month of August and 5 out of 27 households in DRY in the month of June.

Figure 3.35 Seasonal consumption of processed and fresh AA by households from different AEZs of SEC, NET and RRD. ***Data presented based from longitudinal study.***



Sources of food

Food consumed were commonly obtained from four main sources by households at the three study sites (Figure 3.36). ‘Own source’ includes the production of food items from the household's own system i.e. farm, garden and aquatic system (FMAS). Common property sources include open water bodies (OWB) such as lakes, rivers and community ponds. Terrestrial systems include grassland, forest and even rice fields during some part of the year (rainy season). Other food items were acquired by households through exchanges for service rendered in working on-farm or even as gifts from relatives and friends in the community. Purchase from markets was also another means of acquiring food by households. A more detailed discussion regarding the sources of AA is presented in the next chapter (Chapter 4).

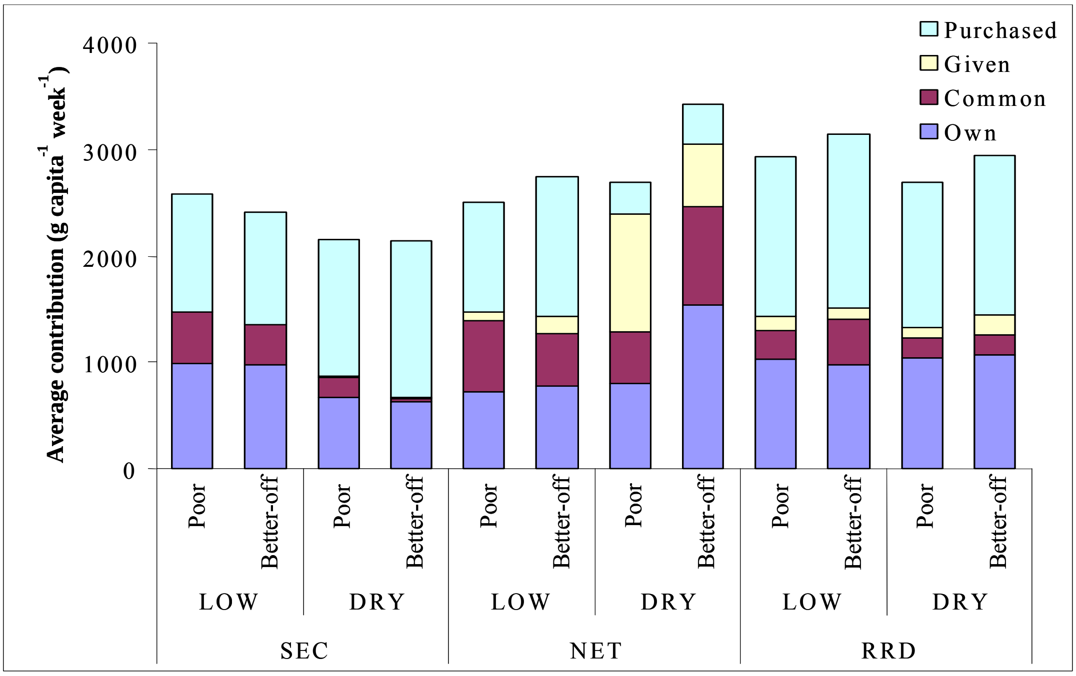
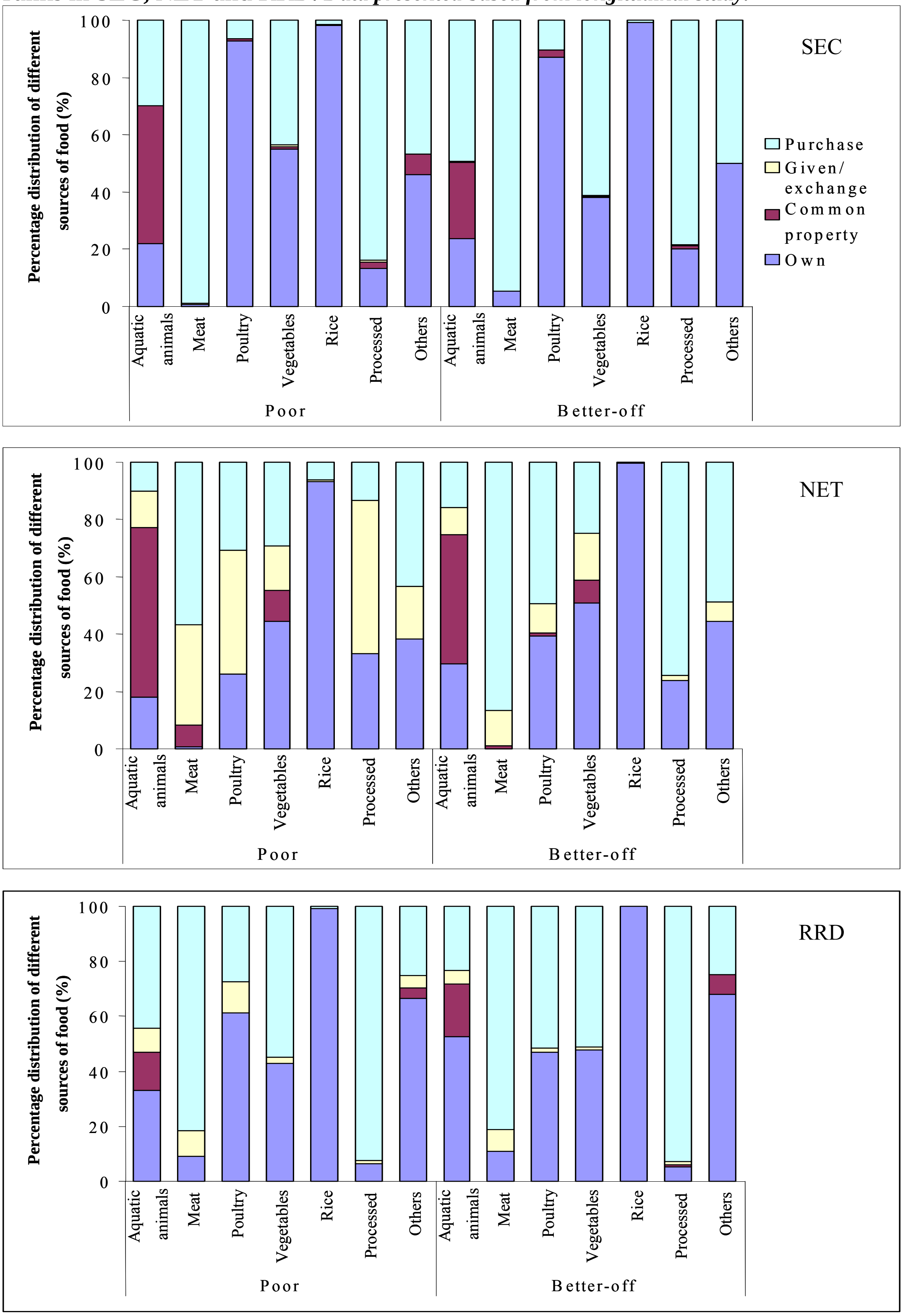


Figure 3.36 Contribution of the different sources of total food being consumed by households in SEC, NET and RRD. ***Data presented based from longitudinal study.***

Figure 3.37 illustrates the contribution of the different sources to the total food intake of households in the three sites. Analysis found that the contribution of the different sources to the total amount of food consumed by different groups of households varied significantly (P <0.001) amongst sites.

In SEC, the contribution of each source was significantly different between AEZ (P <0.001). There was no significant difference in the contribution of each food source by well-being group (P >0.05). Purchased food was most important in both AEZ (1138 g capita^{-1}week^{-1}and 1505 g capita^{-1}week^{-1} in LOW and DRY respectively), whilst food was rarely received as gifts from relatives and friends. Food derived from their own production was the second most important source for households. In NET, the contribution of each food source was significantly affected by household well-being and AEZ (P <0.05). In the LOW area, purchased food was the highest contributor to total food intake by households regardless of well-being (727 g capita^{-1}week^{-1} and 772 g capita^{-1}week^{-1} for poor and better-off respectively). Poor households from the same AEZ consumed more food derived from common property than the better-off (663 g capita^{-1}week^{-1} and 492 g capita^{-1}week^{-1} for poor and better-off respectively). At the DRY sites, the well-being level greatly affected the importance of different sources of food. Poor families relied more on food received as gifts from friends and relatives (1114 g capita^{-1}week^{-1}). On the contrary better-off families consumed more food from their own production (1537 g capita^{-1}week^{-1}). Aside from the own production, food derived from common property was also important among better-off families (922 g capita^{-1}week^{-1}). In RRD, generally, the contribution of purchased food was the main source followed by own produced food (P <0.001) and only a very small amount of food was given by relatives or friends (125 g capita^{-1}week^{-1}). Variation in the source of specific types of food by well-being level and site also occurred (Figure 3.37). In SEC, a large proportion of AA consumed by poor families mostly derived from common property (47%), while better-off families relied more on purchase (49%). The source of vegetables in SEC was also different among well-being groups; poor families mainly consumed own produce while better-off people mostly purchased.

Figure 3.37 Different sources of food consumed by households of different well-being ranks in SEC, NET and RRD. ***Data presented based from longitudinal study.***



In NET, a large proportion of aquatic animals consumed by both poor and better-off families came from common property (OWB). Other food groups had more or less the same origin apart from meat and poultry where differences between well-being groups were observed. Most of the meat consumed by both well-being groups came from purchase (57% and 86% for poor and better-off respectively), however in poor families, a significant amount (35%) was also derived from gifts from relatives. In RRD, sources of the different food group were relatively similar amongst well-being groups apart from aquatic animals and the "other" group. Poor people purchased a high proportion of aquatic animals consumed (44%) and also derived a large amount from their own production (33%). In contrast, better-off families consumed more from their own systems (53%).

Reasons for poor households for consuming particular types of food

As presented from the previous sections, there were several factors influencing the amount and type of food being consumed by households in the different AEZ of the three sites. In this section, the reasons for consumption decisions by poor households are discussed. The main decision-makers in this respect are female members of the household i.e. mother or oldest daughter. Information was mainly taken from poor families from the two AEZ of the three sites.

Figure 3.38 shows the common reasons used by poor household members in deciding the type of food that the family is going to consume. Differences between sites were clearly illustrated. There were at least 9 reasons for deciding what food to eat, however only 4 reasons were considered the most common: familiarity, availability, cost and ease of preparation. Households from SEC decided their food choices based mainly on two factors: familiarity with the food (44% and 42.5% in LOW and DRY respectively) and its availability (50% and 56% in LOW and DRY respectively).

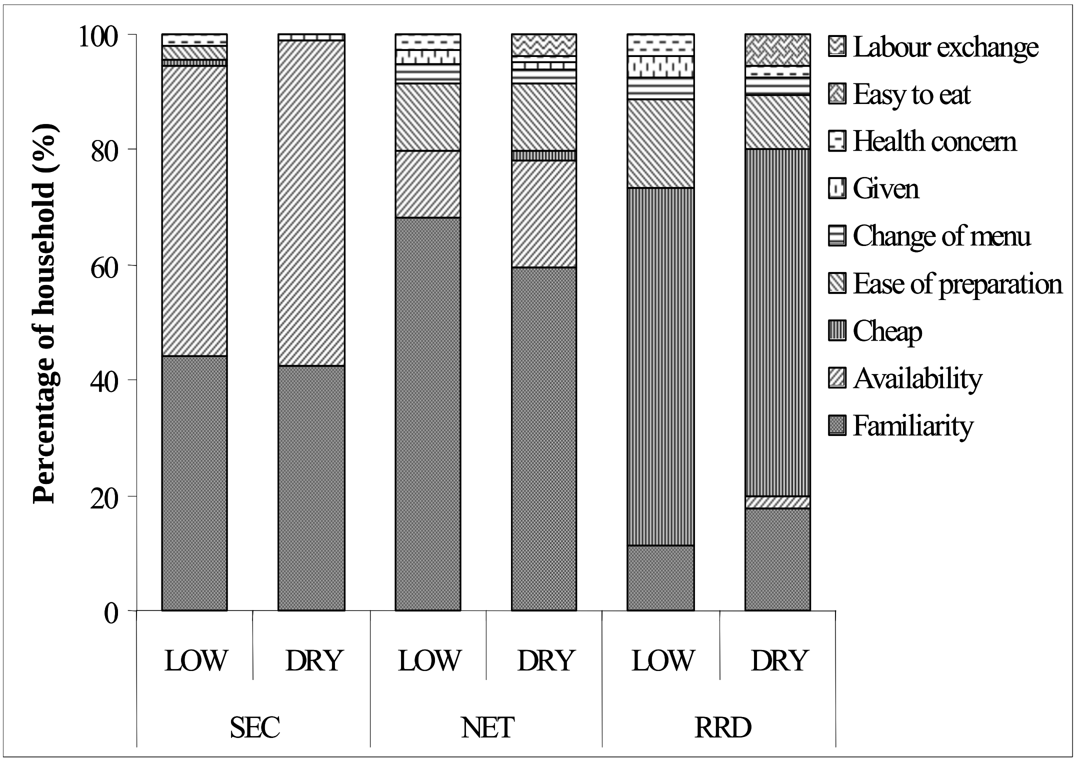


Figure 3.38 Reasons for food selection decision in poor households in SEC, NET and RRD. ***Data presented based from longitudinal study.***

In NET, poor households decided on the food consumed based mainly on their familiarity i.e. households commonly ate the product and it was more available through purchase or access to their own system (68% for LOW and 59% for DRY), additionally households also considered ease of preparation the food (12% for both AEZ) and availability (12% and 18% in LOW and DRY respectively) of such food groups. In RRD, the main reason for food choices was cost i.e. if it is cheap and affordable (62% and 61% in LOW and DRY respectively), while ease of preparation (15% for LOW and 9% for DRY) and familiarity with the food group (11% and 18% for LOW and DRY respectively) were secondary. Preparation of food for exchange labour was considered in NET, particularly in the DRY area. Health is also a minor consideration at all three sites (1.47%, 2% and 3% in SEC, NET and RRD respectively).

The information presented suggests that there is a lack of choice and access to markets in SEC compared to NET and RRD and more limited local sources compared to NET. This also demonstrates that livelihoods in RRD are more market-driven, and less subsistence-based compared to SEC and NET.

3.3.5.8 Discussion on livelihood outcomes

As described earlier, livelihood outcomes are the results of the different strategies an individual pursued by utilising the different resources/ assets available and can access (Allison and Ellis, 2001; DFID, 1999; Ellis, 1999, 2000a,b, Ellis and Freeman, 2005; Scoones, 1998). However, these outcomes were influenced by several factors such as the wellbeing of the households, shocks, risks, level of vulnerability and access to natural resources (Campbell *et al.,* 2005). There are various ways of measuring livelihood outcomes as described in several literatures (Carney *et al.,* 1999; DFID, 1999; Ellis, 2005; Scoones, 1998). Scoones (1998) have identified five key elements of the livelihood outcomes: creation of working days, poverty reduction, wellbeing and capabilities, livelihood adaptation and natural resource base sustainability. In this research all of these five elements were presented and understood, however more attention and discussion were given to the last three elements i.e. wellbeing and capabilities, livelihood adaptation and natural resource base sustainability. The three most tangible outcomes from the three elements were income, expenditure and food consumption. Meanwhile, the natural resource base sustainability will be discussed in the next chapter (Chapter 4).

In the rural areas, earning income was not the main intention for people to work or diversify their livelihoods. In most cases rural households focus on day-to-day survival i.e. they prioritise having something on the table to eat. As a result, the poor tended to work more (Catalla and Catalla, 2002) because of their limited supply of food possible by farming their own land holding. Turongruang and Demaine (2002) also observed that the lower incomes from agricultural production among the poor were offset by off-farm earnings in northeast Thailand. In general, although households spent more time on diversified livelihood activities, households in Cambodia had the lowest average weekly income (11.5 US$ hh $^{-1}$ wk $^{-1}$) because of the nature of these activities which were mainly subsistence in orientation. More than 70% of the weekly income of households in the rural Cambodia came from selling their livestock which was a factor of 10 more than from crop (mainly rice) sales (7%); the contribution of aquaculture in general was only 3%. Catalla and Catalla (2002) reported similar trend of sources of income in rural Cambodia where livestock and non-agricultural activities provide the main source of income. This confirmed the relative importance of livestock as an indicator for the wellbeing. However, the distribution of income found in this research particularly the contribution of agriculture was smaller than that reported by Murshid (1998) (approx. 22%) although the trend was relatively similar. Perhaps the differences on the percentage contribution may be due to the selection process of Murshid (1998) who selected provinces with rice surpluses intentionally. Moreover, Murshid (1998) failed to include the contribution of aquaculture as contributor on the average income of households in Cambodia probably due to less (if none) farmers getting income from aquaculture during that period. Even though the number of activities of households in Cambodia was relatively higher than the other sites, not all of it provided benefits that could be directly converted into cash. Despite the fact that farming was the main livelihood activity (Catalla and Catalla, 2002; Ramamurthy *et al.,* 2001), production was usually geared to subsistence unlike in the two other sites (Thailand and Vietnam) where agricultural production was more easily marketed. Based on an ADB (2004) report, Thailand had the highest agricultural production (22 kg capita $^{-1}$) while Cambodia had the least production (5 kg capita $^{-1}$). Each sites and socio economic groups have different sources of direct income. For instance, in Cambodia although some literature claimed that the area is predominantly agricultural (Catalla and Catalla, 2002; McKenney and Tola, 2002; Ramamurthy *et al.,* 2001), only households in the LOW areas reported income from agriculture and the bulk of income came from sales of livestock and earnings of female members of the household (from weaving, wine making and working in garment factories). In Thailand, household income did not reflect the well-being ranking where households in the LOW area that were ranked poor during the wellbeing ranking earned almost double the better-off earning and three fold that of of households in the DRY area. Unlike other sites, the contribution from agriculture to household incomes in Thailand was the highest (33%) as were wage labour and remittances (26% and 15%, respectively). The contribution from aquaculture was the lowest and low compared to other studies in the same region (AIT/AO, 1998; Demaine *et al.,* 1999; Pant, 2002; Phromthong, 1999). Again, the possible reason for this discrepancy may be due to the sampled areas which may have been concetrations of aquaculture or integrated farming practice.In contrast the sites for this study may have had lower than average conventional aquaculture development for the region because of its relatively productive natural resource base.

In RRD, results of the wellbeing ranking reflected the average income recorded in this research where better-off households earned almost double the earnings of the poorer households. Similar to Cambodia, the contribution of livestock (44%) was very important to the overall income of the household. Moreover, income from aquaculture also contributed significantly (10%) to the total income particularly among better-off households. This result suggested how rearing of aquatic animals in Vietnam was considered as cash crop rather than subsistence like in Cambodia and partially Thailand (Luu *et al.,* 2002; MOFI, 2004). From the living standard report made by the General Statistics Office in Vietnam (GSO, 2000), it was reported that 27% of the household's income was contributed by agriculture, aquaculture and forest production. Unfortunately this figure did not provide much detail on the contribution of each sector. The result of this research however itemised the different sources and generally higher percentages were found compared to existing literature. Again, sampling procedure can be one factor contributing to the discrepancy; on the other hand the intensification of both agriculture and aquaculture in the area may also contribute to the increased percentage contribution to the total income of households in the rural areas of RRD.

The contribution of women to the household income in Thailand (>50%) was significantly higher than in SEC and RRD. In contrast, income was largely contributed by men in Vietnam (53%) and was more linked to well-being as better-off families gained more than the poorer households. Meanwhile in Cambodia, a similar trend was reported by Murshid (1998) on the contribution of women to the total income of household where Cambodian men earned almost double the earnings of women. However, the computation of income contributed by age and gender group was only based on the direct sales or earning made by individual. For instance, whoever in the households sold products produced by the household (vegetables, rice, other crops, livestock) had this recorded as their contribution. This explains why the contribution of men in Vietnam was higher than women as they do the selling of their major product in most cases. Children's contribution to total household income was also recorded and found very limited in this analysis. However, this was due to similar reasons discussed above. The contribution of children may have underestimated for simailr reasons to that given above ie that they had limited roles in disposing of products in which they may have contributed time toproduction or harvest, especially in Cambodia. This is also suggested by the very limited literature on childrens roles within the household economy. Considering the complexities of income and the diversity of individual's livelihoods especially in Thailand and Cambodia, it can be said that well-being was certainly not just about income i.e. money generated by households. There are several factors contributing to the well-being or ill-being such as social, human, and physical factors. Although in some areas, wellbeing indicators were correlated with income (e.g. Vietnam households) which is in line with the observations of Headey and Wooden (2004).

In general, expenditures of better-off households were relatively higher than poorer households except in Thailand where poor households spent almost double than anyone else; this was mainly lionked to their high level of agricultural expenses.

Expenditure by households in rural areas of Asia was mainly related to investment in farming, food purchases and livestock. However, each site had different priorities; for instance in Cambodia and Thailand, food was the major source of expense while in Vietnam, agricultural expenses contributed more than 50% of the household total costs. Expenses for farming may be related to the size of land. In Vietnam where land distribution was relatively equal (Akram-Lodhi, 2001; Kerkvliet, 2006), expenditure was more or less similar. On the contrary, in areas where distribution of land was less equal (SEC, NET), large differences in farming expenditure were observed. In terms of percentage contribution, financial investment in education was only significant in Vietnam (14%). Again, this conformed with the wellbeing indicators identified by the Vietnamese community that education of the head of the household and the capacity to send children to school can be use to determine Vietnamese household's socio-economic level. The percentage distribution of expenses found in Vietnam however, contradicts the report made by General Statistics Office (2000) where an estimate of more than 50% of the expenses was due to food and beverages expenses. The discrepancy on the percentage contribution of food to the total costs may be due to the fact that food consumption (purchases) in Vietnam was relatively seasonal wherein households in rural areas consumed very small amount of food particularly during the peak season of agricultural work. A very interesting result of this research was the contribution of aquaculture to the total household expenditure. The contribution of aquaculture to the total cost in Cambodia was four times higher than Vietnam and Thailand did not report any cost. This finding reflects the type of management being practiced at the different sites. Vietnam is known to use local resources because of the introduction of the VAC system i.e. domestic waste, human and livestock manure and even beer factory wastes (Demaine *et al.,* 2001; Luu *et al.,* 2002). Similarly in Thailand low cost local resources were used in attracting and feeding AA especially in the trap pond, the cost of producing AA was expected to be minimal (AIT/AO, 1998).

In general, net income was high in Vietnam where most of the agricultural activity were considered cash crop (rice, crops, livestocks and aquatic animals). Higher net incomes may be explained by low expenditures on inputs as described above for aquaculture (Demaine *et al.,* 2001; Luu *et al.,* 2002). Poor households had positive net incomes although their absolute earnings were generally lower if not the same as the better-off. The probable reason for this is the low expenditure and also poorer households do not usually invest their financial capital due to high risk and market failure (Ellis, 2000b) unlike the better-off households. Paxson (1993) reported that expenditure in Thailand was not influenced by the amount of income, rather there were seasonal variations in preferences or prices, common to all households. The net income from aquatic management (aquaculture and fishing) was relatively positive in Cambodia and Thailand but less seasonal. This can be explaiedn by the fact that farmers in Cambodia and Thailand usually harvest aquatic animals when food/income is required unlike the households in Vietnam wherein scheduled harvest is commonly practiced around stocking and at the point when aquatic animals reached marketable size; this results in greater seasonality of net income. Differences in net income between agroecological zones was due to the availability of aquatic resources wherein households in the LOW area had more chance of collecting AA unlike in the DRY where aquatic resources were limited (Amilhat, 2006; Little *et al.,* 2004).

One of the most important outcomes of different livelihood strategies is to provide enough food to eat by the households in rural areas. In general, the amounts of food consumed by households of different socio-economic groups were relatively similar except for the better-off households in Thailand who, exceptionally, consumed more rice compared to other groups.The amount of food recorded in this research both conformed with, or in some cases contradicted that of other studies. However, discrepancies can be accounted from the methods of survey, area (location), season (timing) as well as the coverage i.e. all food item, groups. For instance, the average food consumed in the study sites revealed that Vietnamese households had the lowest average food consumed (5364 g capita^{-1} week^{-1}). However, this amount was slightly lower than Quang's estimate (1999) of average consumption of households (average from poor and better-off households) in Hanoi (6309.1 g capita^{-1} week^{-1}). The computation of Quang (1999) in the food survey included all ingredients including sauces and sweets, moreover, this consumption was based from households in the city where food availability is not a problem.

Generally, the largest proportion of Asian diets is rice as reported from several literatures (Catalla and Catalla, 2002; Figuie, 2003; Frei and Becker, 2005; McKenney and Tola, 2002; Mogensen, 2001; Murshid, 1998; Quang, 1999; Turton, 2000) especially in rural areas as confirmed by this study. This reflected the importance of owning or having access to a portion of land (rice fields) as an indicator during the wellbeing ranking as it obviously dictates the amount of the main food available for the households. Aquatic animals, meat, vegetables, processed food and poultry were usually consumed in combination with rice. However, the food group of secondary importance to rice varied at each site. Fish and other aquatic animals was found to be the next important food item in Cambodia as it was relatively available in most of the aquatic resources in the area. According to Gregory and Guttman (2002b), fish and other aquatic animals are the most important source of animal protein in the lower Mekong basin. Mogensen (2001) reported similar findings regarding the importance of fish and other AA from a longitudinal study conducted in Svay Rieng province which was also one of the study sites of this research. In contrast to rice and fish being the clear staple foods of Cambodian people (McKenney and Tola, 2002), in Vietnam, vegetables were clearly the most important food group next to rice. Amount of meat (pork and poultry) was also relatively high. Similar reports by Figuie (2003) and Quang (1999) also confirmed the importance of vegetables within the Vietnamese diet. Hop *et al.* (2003) reported that the program of the government of Vietnam that ratified the National Plan of Action for Nutrition made an important contribution to the improvement of food production and consumption in Vietnam. Through this project the supply of major food item (i.e. meat, poultry, fish and vegetables) increased and therefore consumption increased. The important contributions of each food group were different at each site and explained by several factors: availability, familiarity, economic and nutritional value may have affected the importance of each food group. Aquatic animals contributed more to diets in NET and SEC as reported by Gregory and Guttman (2002b), Praperthchob (1989) and Mogensen (2001) while meat and vegetables were higher in RRD (Figuie, 2003; Hop *et al.*, 2003).

The total amount of food being eaten showed seasonal differences especially in areas where foraging was common i.e. SEC and NET. Amongst the contributor of such seasonality was the availability of animal protein (fish and other aquatic animals). In RRD, where markets were more accessible, less seasonality was observed. Gregory and Guttman (2002b) reported that during the rainy season (June to September) different aquatic systems (e.g. perennial water bodies, trap ponds, rice fields and household ponds, see Chapter 4) become linked encouraging or allowing movement of aquatic animals. Moreover, Tana *et al.* (1994) reported that the severe flooding in lowland areas that usually occured in the region during the months of September to October perhaps contributed to the abundance of aquatic animals in the area. By this pattern, aquatic animals become abundant which can directly affect the amount of consumption of households close to these areas. The seasonality of food being eaten was not only affected by abundance. For instance, in RRD, average food intake decreased during the peak of farming activities i.e. planting (July – August), as most of the households were busy and had less time for preparing food. In SEC and NET, the end of both the dry and the rainy seasons was usually the times when food was most limited. Food stocks from the previous harvest were already consumed during this period. Consumption of processed food was generally high when fresh foods were less available.

The majority of the food being consumed in Cambodia was produced by the households themselves and/or was obtained from common property especially in the LOW area where markets were less accessible. Gregory and Guttman (2002b) and other researchers (Gregory *et al.,* 1996; Prapertchob, 1989; Shams and Hong, 1998) reported similar findings i.e. that rural households in Cambodia and northeast Thailand usually consumed most of their caught by foraging in common waterbodies, forest and wild land (Tana *et al.,* 1994; Turton, 2000) and rarely purchased food (e.g. aquatic animals and meat) for consumption. Tana *et al.* (1994) also indicated that the natural availability of food items such as fish and wild plants, tended to increased the amount of food being consumed. This was also found in this research however the information was presented and discussed in chapter 4 of this thesis. In contrast, a large proportion of the food consumed in RRD was purchased. Farming activities in Vietnam were mainly focused on cash crops as discussed earlier and therefore most of the production went to the market. In NET however, purchased food was only high in LOW areas, whereas in DRY food was mostly own produced.

3.4 Discussion

The sequencel and combination of qualitative (PCA and workshops) and quantitative (cross-sectional and longitudinal survey) research approaches employed resulted in a very comprehensive understanding of the livelihoods of different socio-economic groups from different agroecological zones in the three study areas. Several researchers and development workers (Brannen, 2005; Bolden and Moscarola, 2000; Maxwell, 1998; Sandelowski, 2000; White, 2002) have reported that the combination of different approaches (qualitative and quantitative) tend to give more understanding of the subject as they see/consider the subject from two different perspectives. The evidence presented and analysed in this chapter showed the complexities and how various factors influenced/ shaped the livelihoods of different socio-economic groups in the study areas. The impacts of shocks (civil strife, political problem, economic crisis and even environmental phenomenon) and trends (seasonality, increasing population, and agricultural intensification) continue to influence the livelihood of households in the study areas of SE Asia. Using the different resources and assets that households possessed and have accessed, different livelihood strategies were being undertaken in pursuit to sustainable livelihoods (Allison and Ellis, 2001; Ellis, 1999; Scoones, 1998). However, the community was inevitably heterogeneous: thus some groups were more vulnerable than others as each individual or households have their own assets/ resources that they can utilised. Additionally, the importance of aquatic systems and aquatic animals as part of strategies to sustain or improve livelihoods was illustrated in this chapter. The detailed information regarding aquatic resources is presented in the next chapter (Chapter 4).

Major shocks and trends) have greatly influenced the overall status of livelihoods in rural areas. Cambodia and Vietnam both suffered greatly from war, civil and against foreign nations respectively. In contrast, Thailand did not experience such turmoil. These differences in recent history have impacted at both the macro level in terms of broader development and on the overall assets/resources of individual in the rural community. Natural calamities such as drought and floods had also brought changes and influenced the diverisification of livelihoods. Similarly, increasing population enhanced or eventually caused unsustainable and illegal practices with regard to use of aquatic resource. Intensification of production has occurred but with the trade-off of environmental degradation.

In order to overcome the pressures from shocks and maintain their livelihood (at least), different types of of assets have to be utilised (Carney *et al.,* 1999; DFID, 1999; Scoones, 1998). The characteristics of the household head are clearly critical to the shaping of overall livelihoods of the whole households as in most cases in rural Asia, the household head is mainly the decision maker and economic provider. This was evident in the wellbeing ranking of the community wherein the whole household was classified based on the head's capabilities. Additionally, the household size or the average number of adult units in the household was perceived as an important asset as it reflected the size of the labour force and related income.In contrast a large number of dependants signalled higher expenditure and lower overall well-being. Ownership and/or access to a piece of land was considered a major asset in thr study sites. Rigg (2003) reported that majority of the population in Southeast Asia still live in the rural areas and agriculture related activities still dominate the livelivelihood activity. The sizes and ownership of land however varied depending on the political and economic context. For instance in Vietnam, although decollectivization as been implemented under the Directive 100/CT (Rigg, 2003), land is still owned by the state and equal distribution of land holdings still remains policy. However, on the ground practice has already changed and some farmers now can have long term lease of their land and transfer or even mortgage of land rights is common leading to growing inequities of land holdings. In Cambodia were land laws and property rights are relatively weak, variation in land holdings was greater and the incidence of farmers becoming landless is increasing. Turton (2000) and Catalla and Catalla (2002) suggested that this scenario was caused by the weak property rights as there was massive privatisation of communal property going on as well as land grabbing from the poor by rich and powerful. However, for those who have land in rural areas, agricultural production remains dominant and the area allotted for deeper aquatic systems (e.g. culture ponds, household and trap ponds) minimal. Poor households at the different sites percieved land use differently; in Cambodia, the land or the rice fields were seen to provide rice and aquatic animals for susbistence consumption but in Vietnam, the land is a means to earn income. The source of water is another capital that can be considered important as it can influence the level of agriculture as well as aquatic management. For instance in Vietnam where irrigation systems are well established intensified production both from rice and aquaculture are practiced. Meanwhile in rainfed areas like Cambodia and Northeast Thailand, single cropping, extensive rice farming is the mainstay along with a reliance on natural production of aquatic animals from perennial waterbodies and rice fields. Gregory and Guttman (1996 and 2002b) reported the importance of rice fields as the main source of aquatic animals in rural areas of Cambodia. Other researchers also reported similar findings on the importance of perennial water bodies (AIT/AO, 1992 and 1998; Amilhat, 2006; Garaway, 1999; Islam, 2007; Little *et al.,* 2004; Saengrut, 1998; Setboonsarng, 1993; Shams and Hong, 1998; Tana *et al.,* 1994).

Rural households in Southeast Asia have several physical assets they can access and utilise. Amongst these physical assets, livestock was considered very important. Identified as a key indicator in the wellbeing ranking, monitoring of income flows from livestock confirmed its relative dominance. Large livestock such as cattle and buffalos were used in agricultural activities (e.g. ploughing, transporting inputs and harvests) and also considered as a "walking bank" as the could be easily converted into cash during difficult times or emergencies. However, the issue of land and access to common property for grazing, particularly for poor households and lack of initial capital to purchase them were constraints.

Remittances from household members working in non-farm employment, often after migration to other provinces or large cities were a major contributor especially in households from northeast Thailand. Rigg (2003) reported that remittance is an important source of income in Asia regardless of the type of work the household member is doing. Working away from their family was not a choice but a necessity (Ellis, 2000a) in order to improve not only his/her livelihoods but to help the whole family (Rigg, 2003).

Social networks are beneficial to some households but may be relatively weak among poorer households. Social networks are one of the indicators often used in measuring social capital (DFID, 1999; Falk and Kilpatrick, 2000; Flora, 2004; Krishna, 2004; Krishna and Shrader, 1999; Lochner *et al.,* 1999; Serageldin and Grootaert, 1996). Some indications of the relative importance of social capital and its status were also established. Contrary to the report of Turton (2000) that social capital is very weak in Cambodia, several networking and collective actions initiated mostly by non-government organizations and even some Government departments exisit. For instance in the Department of Fisheries, collective action within community fisheries has been initiated based on establishing no-catch refuges in some provinces (Meusch and Viseth, 2001; Viseth *et al.,* 2002). As an intervention stage of the SRS project, local resource users group (LRUG) wereo initiated with promising early results including the improvement of social networks as well as institutions (Little *et al.,* 2004; SRS and Morales, 2003). Aside from collective actions, another indication of social capital in rural areas was the authority established by village headman, health worker, religious leader or person (e.g. monks) and local tax collector. Their influence in the rural area was very significant particularly in making people work together for the development of the community (e.g. local management of irrigation in Vietnam, improvement of road in Cambodia, management of village fishponds and other perennial waterbodies in Thailand).

Livelihood strategies were influenced by the level of resources each individual household had or could access. This led households into diversified activities which was classified in this research in two ways; based from production or yield (productive and non productive or reproductive) and based on connection with farming (on-, off- and non-farming). As described by many (Baulch, 1996; Rigg, 2003), Southeast Asia is predominantly an agricultural area. The majority of the population in Southeast Asia considered themselves as farmers or connected with farming. However, as presented in this thesis, farming is a diverse activity as it not only involved rice farming. For instance in rural Vietnam, most households were engaged in diversed crop system wherein they grow different types of crop in order to increase and maximise the yield from their land. However, due to the decreasing land available for farming and the increasing population, other households diverted their activities in off or non-farming activities and this included the small enterprise like mat, net, and wine making. There are also others who practiced seasonal or even long term migration in order to sell their labour. Utilizing the aquatic resources either for fishing or aquaculture was also seen as a strategy in the rural areas in order to support their livelihoods. Detailed discussion on this is presented in the next chapter (Chapter 4).

Aside from the available assets that households used to diversify activities, livelihood strategies were also influenced by other factors such as gender, seasonality and migration. The dynamics of intra-household interactions in terms of division of labour, income and expenses and access were also elucidated in this chapter. Both women and men have access to different resources, however the degree of access varied. In general, men are still considered the overall decision maker in the rural households especially in areas where patriarchial culture is still being followed (e.g. Vietnam). However, women have seen playing the major role in terms of production, again in Vietnam, women dominate rice cultivation, irrigation, and application of other inputs. This was also similar in Cambodia but not in Thailand. For children, significant contributions were observed especially in Cambodia.. Cambodian children were mainly involved in land preparation and maintenance of crops but their contribution to aquatic management (fishing) was also important.

Agroecology was an important factor that needs to be considered in deciding a sustainable livelihoods (Edwards *et al.,* 1993; Sivakumar and Valentin 1997), since each type of agroecology has a unique resource (Altieri, 1998). With the available resources in each agrocology, strategies of households or at least the importance of individual activities varied. In terms of the importance of fishing and aquaculture, it was evident that households in the LOW areas relied more on the natural production of water bodies and concentrated on exploiting fisheries rather than conventional aquaculture[4]. However in rainfed areas, storing water on-farm is priortised and farmers dug ponds as a multi purpose resource. Such deeper water bodies not only

[4] This is discussed broadly in chapter 4.

secured water supplies for a variety of purposes but also faciliatated rearing of AA (AIT/AO, 1992 and 1998). Meanwhile in Vietnam fishing is becoming less important, particularly rice field fisheries due to the intensification of rice and also the promotion of aquaculture ponds (Demaine *et al.,* 2001; Luu *et al.,* 2002).

There were three distinct livelihood outcomes from the diversified livelihood activities in rural areas of Southeast Asia, income, expenditure and food consumption. The socio-economic status and perhaps the economic status of the area influenced the capacities for households to diversify activities that led to different outcomes. For instance in agriculture, most of the farmers in Cambodia farmed to support their demand for food. On the contrary, in Vietnam, crop production and even aquaculture were considered cash orientated activities (Luu *et al.,* 2002; MOFI/WB, 2004). In general, livelihood outcomes were affected by seasonality, income and expenses varied depending on season as well as the amount of food being consumed especially by poor households who are mostly dependent on natural production, in other words, hunting and foraging. Prapertchob (1989) reported that most of the aquatic animals being consumed in northeast of Thailand were not purchased. However, Vietnam is different as markets are relatively more important. Moreover, the intensity of agricultural activities in Vietnam results in a greater reliance among households to rely on purchased or own produced sources of aquatic foods.

Based on the livelihood framework (Allison and Ellis, 2001; DFID, 1999; Ellis, 1999, 2000a,b; Ellis and Freeman and 2005; Scoones, 1998), institutions, policies and rules are the mediating cement that influenced households' access and strategies. In this research, the researcher used the involvement of rural households in different organizations including credit providers to illustrate the impact of such organizations on household livelihoods. Generally, involvement of rural households especially poor women was minimal mainly because of the rules implemented by different organizations such as the need for collateral. As a result, households accessing formal credit was highly variable between sites and informal systems based heavily on social capital remained important at the local level.

4 Self-recruiting species (SRS) and aquatic resources in rural areas

4.1 Introduction

As presented and discussed in Chapter 3, aquatic animals contribute significantly to overall rural livelihoods, particularly through contributions to food consumption and income. This chapter, analysed and discussed information on the characteristics of the different aquatic systems, aquatic animals and their exploitation. One of the main parts of this chapter investigates the nature of aquatic resources in rural areas, particularly those managed at household level (FMAS - farmer managed aquatic systems). FMAS are defined for the purposes of this study as any aquatic system where households do 'something' to maintain, sustain and enhance the population of aquatic animals and is certainly not confined to stocking hatchery seed (Little *et al.,* 2004 and Morales *et al.,* 2003).

Self-recruiting species or SRS are defined as any aquatic animals that are present and reproduce in aquatic systems that households/farmers manage and which do not require repeated stocking (Little, 2002a,b). To date, research has mainly focused on the status or potential of aquaculture in rural areas. However, most studies have focused on conventional aquaculture in which hatchery seed is regularly stocked. Attempts to understand existing systems of aquatic management in rural areas were often overlooked, and self-recruiting species have been generally ignored or their eradication promoted. One of the main purposes of this chapter is have a better understanding of the overall contribution of SRS to the livelihoods of the resource poor in rural areas of the study sites.

An analysis of the status of SRS is developed based on primary data gathered using the research process described in Section 2. Initially, the researcher utilised the information generated from the PCA, particularly the resource maps and the scoring/ ranking of importance of aquatic animals. A cross-sectional survey, designed on the outcomes of the PCA, was conducted and eventually generated more detailed baseline information about the different aquatic systems in the area that allowed a better understanding of the types of system and management approaches. This information is mainly presented in sub-sections 4.3.1 and 4.3.2. The use of a longitudinal study in this analysis provided a broader understanding on seasonal variation in terms of management activities, production and utilization of aquatic products.

The chapter's flow of information starts with the introduction (4.1). The next section provides detailed information on the process/ methods used in this research (4.2). Section 4.3 shows all the results from the different research approaches used. This section is further subdivided into nine subsections. Section 4.3.1 present results about the various types of aquatic resources. This is followed by the section describing the different management approaches which include stocking and attitudes towards SRS (section 4.3.2). The next four subsections (4.3.3 – 4.3.6) assess the different types of aquatic animals, their importance, collection and utilization, especially their contribution to total food consumption. It should be noted that the consumption data presented in this section was based on two data collection techniques i.e. AA collection and utilization, and AA general consumption. Sub-section 4.3.7 presents the marketing aspects of AA, i.e.

types/species of AA being sold. Finally, information is analysed, discussed and summarised in the discussion section (4.4) of this chapter.

4.1.1 Research questions

The overall objective of this analysis is to fully understand the different aquatic resources and their contribution to the livelihoods of households of different socio-economic levels in the three study sites. The following research questions were addressed in order to achieve this objective:

1. What are the different aquatic systems and how these systems differ from each other?
2. How are different products from aquatic systems being utilised, and who are the different actors responsible for producing such products?
3. What are the different sources of SRS?

4.1.2 Limitations

The sequential approach that was applied in this study led to the collection of unbalanced data for some of the factors tested in this study, i.e. unequal numbers of households representing different wealth groups, and with different types of aquatic systems. Proportional sampling was used in this research. Logistic and financial constraints limited the number of respondent households to nine per community. Moreover, the timing of some activities by other project tasks particularly the activities of other students implementing their respective researches under the main

SRS project (R7917) (Amilhat, 2006; Beaton, 2002 and Soubry, 2001) in a way affected the decision on the coverage of this research.

4.2 Methodology

Similar to the previous chapter (Chapter 3), this analysis also utilised different research tools and some parts of the study were conducted simultaneously or in combination with the activities presented in previous chapters. Research tools such as PCA, cross-sectional survey, longitudinal study and focus group discussion were used in this analysis. Figure 4.1 illustrates the chronology of the different activities employed. Moreover, the general outputs from each activity were also presented.

The information from the following PCA activities were utilized by the researcher as background/ basis of this chapter: (1) the village mapping exercise where most of the aquatic resources in the village were identified by village key informants; (2) identification and ranking of aquatic animals by different groups within each sites, (3) seasonality of the abundance of aquatic animals and (4) the trend analysis of different events that had happened in the aquatic systems were also used in deciding the next activity of this research.

The cross-sectional survey (background survey) was conducted with the aim of understanding the different types of aquatic systems that different groups of households possessed and/or accessed. A total of 540 respondents participated from the three study sites (180 per country). These respondents were distributed among the six villages in each country (9 respondents/village). As mentioned in Chapter 3, there were two types of respondents in this survey – random and target households.

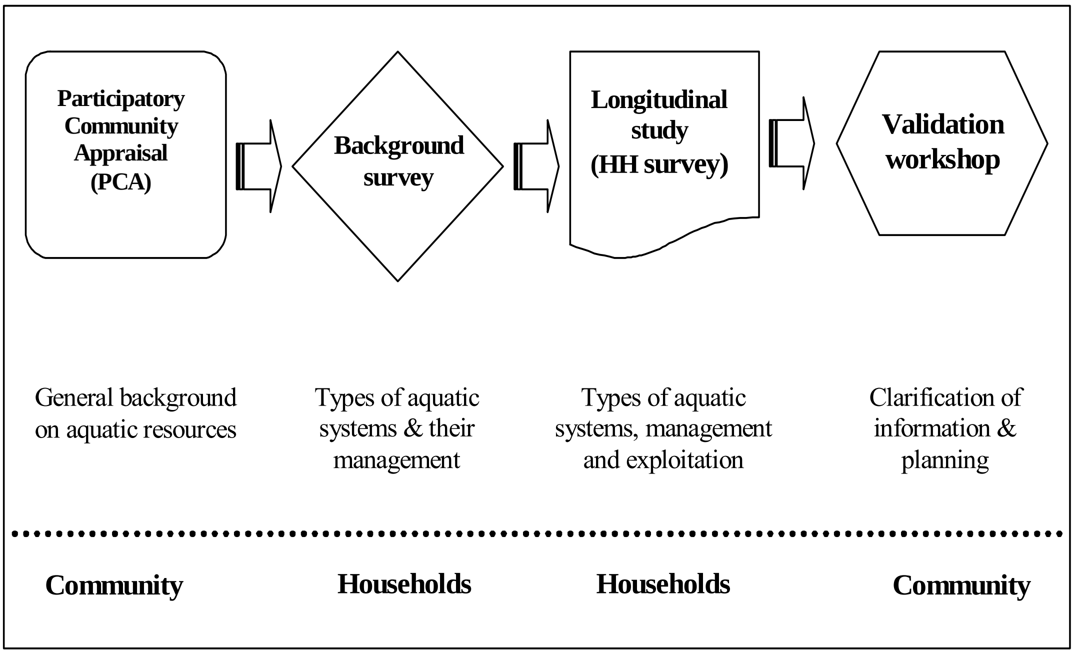


Figure 4.1 Methodological process on understanding the different types of aquatic systems.

Parametric and non-parametric tests were performed using the GLM technique (Grafen and Hails, 2002) in analysing data from this study. Where statistical analysis was not applicable i.e. assumptions were not met, descriptive analyses were used. With the information collected during the background survey, analysis was done to identify the different type of aquatic resources that are present in different agro- ecological zones. Subsequently, results of the background survey (types of aquatic system, management practices, headship, and wealth ranks) were used as criteria in determining respondents for the next phase of the study – the household monitoring of 162 households (54 households/ study site).

The longitudinal survey (household monitoring) was carried out to understand the seasonal variation and patterns on the management, production and utilization of products from FMAS by rural households. Furthermore, the seasonal behaviour of households towards SRS was also better understood during the implementation of the longitudinal study. At the end of the 12 months monitoring at each study site, a summary of the information collected was presented to the villagers who gave their feedback and clarified some contradictory issues. These presentation/feedback activities were carried out as workshops in all of the 18 villages that were involved in the monitoring activity. This was also a chance for local dissemination of the results found in the participatory research to community members that had not been directly involved. Furthermore, the workshop subsequently encouraged the villagers to assess their own aquatic resources and plan to improve their management.

4.3 Results

4.3.1 Types of aquatic resources in rural areas

There were several types of aquatic systems identified in this study (Figure 4.2). Using the village and resource mapping exercise (PRA techniques) during the exploratory stage of the research, information on the availability of water bodies in rural areas and their general contribution to the livelihoods (Little *et al.,* 2004; Morales *et al.,* 2003) were understood. The cross-sectional (background) survey improved understanding of households' access to the various types and characteristics of different aquatic systems. Furthermore, more detailed information and the seasonality and trends of each aquatic system were better understood during the longitudinal study. There were three main groups of aquatic systems identified in this research: (1) FMAS or the farmer-managed aquatic systems; (2) community-based aquatic resources (CAR); and (3) open water bodies (OWB). Water bodies are considered open based on two categories: (i) accessibility to the household; (ii) developed links to different FMAS and other natural water bodies. The first category of OWB refers to the social aspect of accessibility where individuals are allowed to exploit certain water bodies. The second category, on the other hand, refers to the physical connection of a particular water bodies to nearby aquatic systems and movement of aquatic animals are permitted.

4.3.1.1 FMAS

Farmer managed aquatic systems or FMAS is the term used in this research to describe aquatic systems that farmers, or households, manage to increase the biomass and diversity of aquatic animals (Amilhat, 2006; Islam, 2007; Little *et al.,* 2004; Morales *et al.,* 2003). This definition was used to ensure the scope of this research was inclusive of the full variety of aquatic systems present in rural areas and utilised and managed by households. Different types of farmer managed aquatic systems are distinguished principally by size, depth, location and the type of management, especially in relation to the elimination, attraction or neutrality to the presence of non-stocked aquatic species. Initial classification of the different types of FMAS and the distribution of households based from the cross sectional survey is presented in Table 4.1.

In Table 4.1, although households from SEC and NET identified the particular system differently i.e. TP and PnRF, it was decided to put them together as they basically perform the same purpose that is trapping aquatic animals. The only difference that can be found between the two systems was their location where TP in SEC were usually located near perennial water bodies while TP in NET were usually inside the rice fields. A schematic diagram of the different FMAS identified during the cross-sectional survey and its addition during the longitudinal study is presented in Figure 4.2.

Table 4.1 Proportion of households with different types of FMAS. ***Data based from cross-sectional survey.***

Site	AEZ	Well-being group	Total number of HH	FMAS types: RF	Culture pond	HHP	Trap pond/ PnRF
SEC	LOW	Poor	32	87.5			84.8
		Better-off	38	97.4			94.4
	DRY	Poor	16	100			31.3
		Better-off	16	100			31.6
NET	LOW	Poor	20	100	16		48.0
		Better-off	15	100	14.8		63.0
	DRY	Poor	16	94.7	5.2		57.9
		Better-off	18	93.0	23.3		73.3
RRD	LOW	Poor	20	100		22.2	
		Better-off	6	100		53.8	
	DRY	Poor	31	100		35.9	
		Better-off	17	100		64.5	

Note: the rows do not add up to 100% as most of the households have multiple FMAS.
RF means rice field; HHP means household pond; PnRF means pond in the rice fields

Rice fields (RF)

RF is an FMAS type that is mainly used for rice cultivation. However, other crops may be produced concurrently with rice. Rice fields are also used for collecting aquatic animals, and at the same time serve as breeding grounds for some aquatic animals (Little *et al.*, 2004). Amongst the different types of FMAS, RF is usually the shallowest.

Culture ponds (CP)

CP's are conventional excavated ponds, constructed primarily to stock mostly with hatchery produced seed. Culture ponds are most common in NET and RRD. This system is usually constructed near the water source and in most cases adjacent to or inside the rice paddies. One distinctive characteristic of this system is that it is commonly a closed system (i.e. higher dikes and controlled water outlets/inlets).

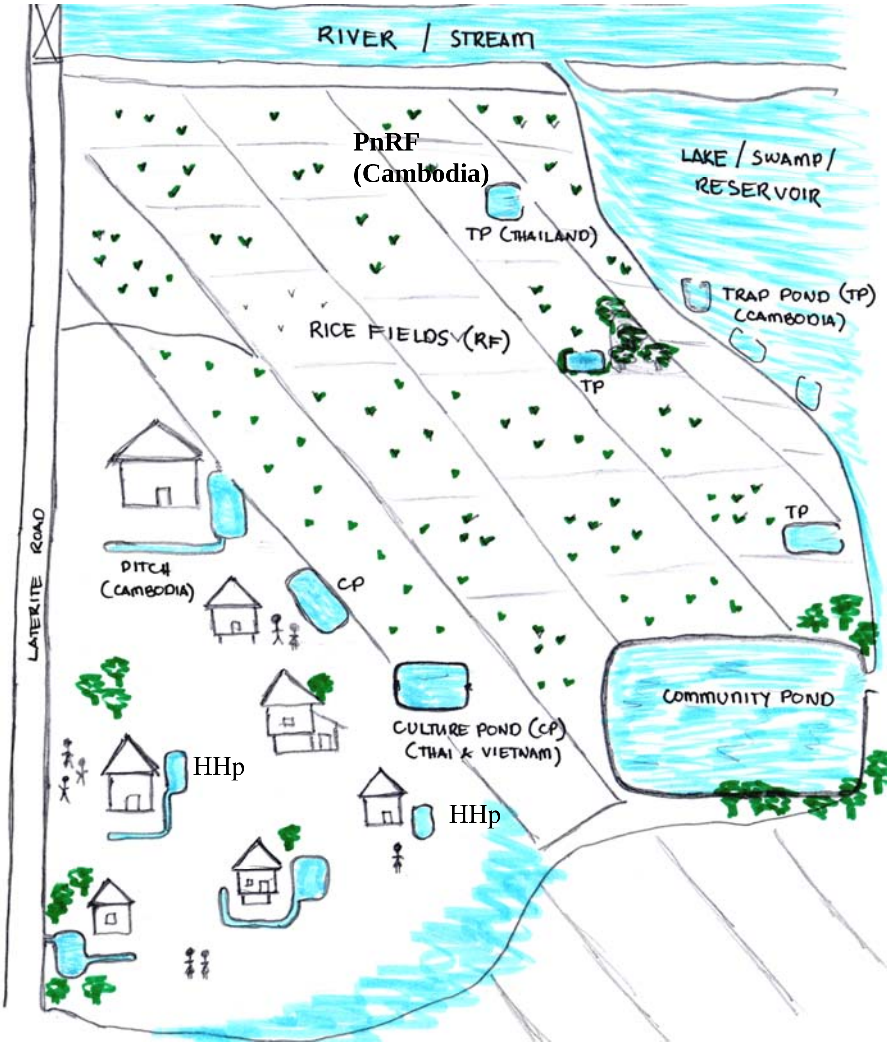


Figure 4.2 Schematic diagram of the different type of FMAS in SEC, NET and RRD

Household pond (HHP)

HHP is another type of FMAS commonly located close to the homestead but usually more multi-purpose compared to CP. In SEC, such ponds were used to store aquatic animals collected from RF and other open water bodies prior to consumption. In some cases where this system is adjacent to rice fields, this system was used for trapping. There are also some households in SEC that stock hatchery-produced seed and use this system for growing stocked AA aside from other uses i.e. household use and keeping other AA. In RRD, this system is very common especially among households practicing the VAC system (Luu *et al.,* 2002) where the pond has a central role as a source of irrigation water and produces a range of aquatic products. HHP were not common in the NET sites.

Trap pond (TP)/ Pond in the RF (PnRF)

This system is a common type in SEC and NET; although local names vary they have the same function – to trap aquatic animals. In NET, TP are commonly located in the lower part of rice fields while in SEC, the same system is usually located close to perennial open-access water bodies such as rivers, lakes, swamps and reservoirs. Aside from trapping AA, such ponds are important refuges for them during the dry season ensuring their survival and reproductive success in the next season. Other uses of this system include provision of water for irrigating agricultural crops during the dry season or as supplementary or emergency supply during the main rain-fed cropping period.

Ditch

This type of FMAS is only present in SEC sites. This system is characterised by its layout, size and its connections to HHP and RF. This system is usually constructed close to the homestead. Like HHP, its primary purpose is to store aquatic animals harvested from open water bodies and from RF. This system is also useful in storing water and maintaining potential brood stock of AA while household ponds are being drained/ prepared. Ditches are excavated to create a boundary around the homestead and to restrain livestock i.e. pigs and chickens.

Community pond

This type of FMAS usually functions similarly to a culture or household pond; however ownership and access may be different. This system may be managed by the community, a group of villagers from the community, or even a single household as is the case of “bid-rent ponds” in RRD. Other members of the community without a share and/or no direct involvement of the system may have some ‘temporary restrictions’ in terms of access to their system i.e. cannot participate in the collection/harvest of main stocked animals (if any). Sometimes the continued collection of other aquatic animals and plants is possible. Examples of this type of resource are the “village fishpond” in both NET and SEC.

Amongst the various types of FMAS, rice fields (RF) were identified as the most common system among households. Aside from RF, other types of FMAS where important at particular sites. In SEC in both AEZ, trap ponds are common especially in the LOW area. Similarly in NET, a large proportion of households have trap ponds. In addition, CP are also common in NET especially among better-off households (Table 4.1). From all the three study sites, it was only in NET that culture ponds (CP) were identified by respondents. In RRD, particularly in the DRY area, a higher percentage of better-off families tended to have household pond (HHP), whereas on the contrary, no households (both well-being groups) in the LOW area possessed such a system.

However, during the collection of baseline information for the longitudinal study a more detailed understanding on the complexities of the various types of FMAS was found. As a result, some of the systems initially identified during the cross-sectional survey were combined (e.g. PnRF and Trap pond) as they functioned similarly in most cases. Furthermore, new types of FMAS were also identified. The distribution of households (i.e. those that participated in the longitudinal study) of different well-being ranks possessing these types of FMAS are presented in Table 4.2.

Table 4.2 Percentage of households that managed different FMAS in SEC, NET and RRD by segregated by well-being groups. ***Data was based from the longitudinal study.***

System Types	Study sites SEC		NET		RRD	
	Poor (n=29)	Better-off (n=14)	Poor (n=12)	Better-off (n=17)	Poor (n=25)	Better-off (n=17)
Rice Field	100.0	100.0	100.0	100.0	100.0	100.0
Culture Pond	0.0	0.0	8.3	41.9	0.0	0.0
Household pond	72.4	78.6	0.0	0.0	52.0	88.2
Trap pond	17.2	7.1	91.7	88.2	0.0	0.0
Ditch	55.2	64.3	0.0	0.0	0.0	0.0

Note: Each column does not add up to 100 percent as households have multiple FMAS.

Rice fields were the most common type of FMAS that every household accessed at the three study sites. Culture ponds (CP) were managed by both well-being groups in NET and RRD, although the better-off households were more likely to have such a system. Household ponds, rather than culture ponds occured in SEC among better-off and poorer households. The majority of households in NET had trap ponds (TP) and a few households from SEC as well. Households in RRD only have two types of FMAS i.e. RF and CP. Ditches are very common type of FMAS of households from both well-being groups in SEC. This system generally performs the same function as the household pond and they are usually linked to one another. Ditches were not observed in NET and RRD.

Mean area of FMAS (m^2)

Table 4.3 shows the average area of the different types of FMAS at the three sites identified in cross-sectional and longitudinal study. Rice fields are significantly larger than other FMAS and there are significant impacts of site on their average area (P <0.001). Rice fields in NET are larger than in RRD by between 10 – 20 fold. Rice fields in SEC are intermediate. Differences in RF area are only influenced by well-being in SEC and NET (P <0.05). Better-off households in RRD have larger ponds compared to other groups elsewhere (P <0.05). There was no significant difference found in terms of the mean area of TP by well-being groups or site in SEC and NET. Better-off families tend to have larger ditches as compared to poor families in SEC.

Table 4.3 Average* size (m^2) of different FMAS in SEC, NET and RRD. (± Standard deviation). ***Data presented based from the cross-sectional and longitudinal survey.***

System Types	Study sites: SEC Poor (n=29)	SEC Better-off (n=14)	NET Poor (n=12)	NET Better-off (n=17)	RRD Poor (n=25)	RRD Better-off (n=17)
Rice Field	14253.8 ±13699.4	29567.7 ±20623.7	45066.7 ±51136.7	34541.2 ±16829.1	2433.7 ±1245.6	3237.1 ±1273.9
Culture Pond	0.0	0.0	800*	588.3 ±513.6		
Household pond	77.4 ±103.1	338.9 ±279.4	0.0	0.0	608.2 ±522.8	1422.0 ±2076.6
Trap pond	71.6 ±48.7	40.0 ±0	195.5 ±297.7	192.9 ±205.9	0.0	0.0
Ditch	60.8 ±38.7	106.2 ±95.6	0.0	0.0	0.0	0.0
Average Total area (m^2)	14463.6 ±13706.19	30052.8 ±20689.48	46062.2 ±51310.56	35322.4 ±16976.17	3041.9 ±1283.70	4659.1 ±1787.84
Average area of deeper FMAS (m^2)	101.9 ±98.43	336.9 ±285.16	245.8 ±336.46	412.4 ±486.68	316.2 ±482.51	1313.5 ±1989.72

Note: The average was taken from the number of households who manage FMAS only and not from the total number of households from each wealth group.
* No SD for culture pond in poor HH of NET due to only one HH with culture pond found and interviewed among the poorer group.

Different FMAS types can be categorised by depth (average water level) in two ways; (1) shallow which is mainly the RF and (2) deeper which includes CP, HHP, TP and ditch. Table 4.3 shows the mean area of deeper FMAS which also shows variation between well-being groups within study sites ($P < 0.05$).

In general, households in RRD had a larger area of perennial FMAS compared to NET and SEC ($P < 0.05$). However, the overall average mean total area of FMAS was significantly (highly) different between sites ($P < 0.001$) with NET having the largest area ($36055.5 \pm 29099.6m^2$) followed by SEC ($18382.4 \pm 16401.5m^2$) and households in RRD having the smallest FMAS area ($3534.2 \pm 1874.6m^2$).

Relationship of total area and depth of FMAS

The relationship of the total size of the FMAS and the area of deeper FMAS was found to be site specific. In RRD, households with larger total FMAS area had also larger area of deeper ponds (($r^2 = 0.45$, Figure 4.3) ($P < 0.05$). However, in both areas of SEC and NET, the relationship did not show a strong correlation to the mean area of the deeper FMAS ($r^2 = 0.10$ both SEC and NET).

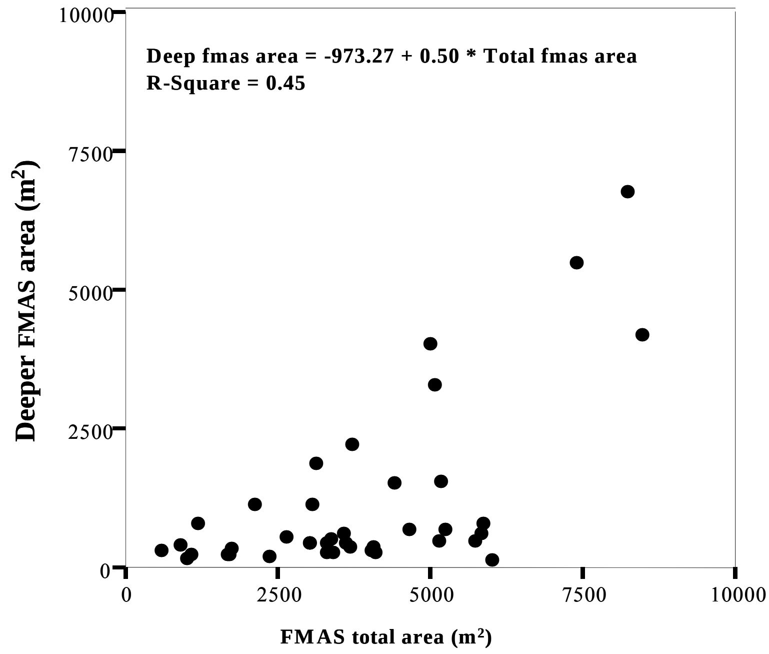


Figure 4.3 Relationship between the mean area of deep FMAS to total FMAS area in RRD. ***Data presented based from the cross-sectional survey.***

Mean number of FMAS per household

The average number of FMAS types that households from the three study sites possessed was significantly different ($P < 0.05$) (Table 4.4). On average, households from the LOW areas of SEC had three types of FMAS (RF, HHP and ditch) which was significantly more ($P < 0.05$) than elsewhere.

Table 4.4 Average number of FMAS types those households of different well-being groups from different AEZ in the three sites possessed. ***Data presented based from the cross-sectional survey.***

AEZ	Study sites: SEC Poor (n=29)	SEC Better-off (n=14)	NET Poor (n=12)	NET Better-off (n=17)	RRD Poor (n=25)	RRD Better-off (n=17)
LOW	2.9 ± 0.7	2.9 ± 0.6	2.2 ± 0.4	2.2 ± 0.6	1.6 ± 0.5	1.8 ± 0.4
DRY	1.6 ± 0.5	1.8 ± 0.5	1.9 ± 0.4	2.4 ± 0.5	1.5 ± 0.5	2.1 ± 0.4

Other groups from all the study sites had a mode of two types of FMAS, rice fields and either a household pond or trap pond particularly in NET sites. The number of each type of FMAS, particularly RF, varied as well between sites. RRD had more RF compared to elsewhere.

4.3.1.2 Community-based aquatic resources (CAR)

A community-based aquatic system refers to any system whereby the access and management is controlled or carried out respectively by a group of households from the community. The size of this system is typically large, however, some village ponds are managed by villagers as a group as conventional aquaculture ponds. Most community based aquatic systems are multi-purpose and water is used for agriculture and domestic use.

4.3.1.3 Open water bodies (OWB)

Open water bodies are usually described as aquatic systems that are open-access allowing exploitation by everyone and may or may not be linked to other household managed aquatic systems nearby i.e. rice fields and TP. Lakes, rivers and streams are examples of open access water resources. As the term implies, households from the village and nearby village can access this type of aquatic system to collect AA or to use the water for agriculture and domestic use. This system is also used for raising poultry (ducks) and livestock (buffalos and cows), for collecting food or domestic purposes. Unlike CARs, OWB are mostly unmanaged.

4.3.1.4 Discussion on the importance of FMAS

Farmer managed aquatic systems (FMAS) embrace a broader range of systems than conventional land-based aquaculture systems based on ‘closed’, excavated earthen ponds. Farmers in the study sites possess mainly rice fields and deeper FMAS which varied amongst the study sites. The various types of aquatic systems may be different in terms of local name and physical appearance but relatively similar in terms of functions and management (Amilhat *et al.,* 2005; Little *et al.,* 2004). For example, ditches, household, and culture pond are used to hold AA until they reach a suitable size for eating or marketing (AIT/AO, 1992). However, physical appearances and the location of these systems are often different. Ditches and household ponds are commonly part of the homestead area and usually small in area (< 80 m^2) whereas culture ponds are typically located in several areas in the community (mostly in rice fields and close to water source). The main difference between the three systems would probably be defined by their openness to the broader environment. The ditches and household ponds are commonly semi-open systems where links with other water bodies exist (Little *et al.,* 2004). This type of system is typical for rural Cambodia especially in the LOW areas (Amilhat, 2006; Little *et al.,* 2004). On the contrary, culture ponds, mainly located in Vietnam (Luu *et al.,* 2002) and by better-off households in northeast Thailand (AIT/AO, 1992) are usually closed systems and dikes are designed and built to prevent stocked AA from escaping but also to prevent wild AA from entering the system. The systems which the majority of poorer households in SEC and NET have are pond in the rice fields (Cambodia), trap ponds (Thailand) and ponds near/adjacent to perennial lakes (Cambodia). All of these systems are located either near to a water source or in low-lying areas. AIT/AO (1992) described trap ponds as anything from depressions deepened by the farmers to deeper excavated structures.They are contiguous at some point of the year with the surrounding land, often lowland and flooded areas. Demaine *et al.* (1999) described the aquaculture systems in the NET which are mainly CP and RF which often contain trap ponds. Another important characteristic of this system is that they function as a refuge for future broodstock from the wild but also as a trap for AA, especially when the water from the rice fields recedes as discussed by AIT/AO (1992) and Little *et al.* (2004) as there are links between these systems (Bambaradeniya and Amarasinghe, 2003). Such systems are less common in RRD (Little *et al.,* 2004) mainly because the perennial water availability means that farmers do not need to store water on-farm for the next planting season. Local regulations also limit the changes in land use from ricefields to ponds (Kerkvliet, 2006).

Rice fields are obviously the most common and important aquatic systems in rural areas of Asia (Fernando, 1993). This system functions as the main source of rice for consumption and a significant contribution to household income particularly in Vietnam. Moreover, rice fields also played important roles in aquatic animal production. Several researchers have already reported the importance of rice fields in fish culture (Fernando, 1993; Halwart, 1994; Halwart *et al.,* 1996; Little *et al.,* 1996) but also rice field fisheries (AIT/AO, 1998; Gregory, 1997; Gregory and Guttman, 2002b; Gregory *et al.,* 1996; Guttman, 1999; Meusch, 1996; Rothius *et al.,* 1998; Shams and Hong, 1998). Meanwhile, rain-fed rice fields in particular can also be considered as complex aquatic ecosystems. The complexity of these systems is high, especially during the rainy season, and they have a range of roles in supporting broader aquatic biodiversity (Bambaradeniya and Amarasinghe, 2003;

Halwart *et al.,* 1996; Fernando, 1993). Rainfed rice fields serve as breeding grounds for many SRS species after the onset of the rainy season. Lawler (2001) suggested that rice fields in most cases act as temporary wetlands and played a significant role in sustaining diversity of invertebrates and vertebrates. They also become common fishing grounds for the local community during the rainy season, especially when the water starts to increase in depth as reported by several researchers (Amilhat, 2006; Gregory and Guttman, 2002b; Little *et al.,* 2004).

In general, the average size and type of ownership of rice fields in the three areas varied; households in the Red River Delta in Vietnam had the smallest average area. The research found that almost every farmer in the study sites have at least 2500m^2 rice paddies regardless of well-being groups or agroecological zone. However great variations exist between sites that needs to be considered. For instance in Cambodia, the average area of land ranges from 1.5 to almost 3 ha which is relatively similar to that reported by Gregory *et al.* (1996). However, there were still poor farmers in SEC that do not have their own rice fields or have lost their land due to unpaid loans. Poorer members of the community usually have smaller areas of rice field, however this is not the case in northeast Thailand where the better-off households have less agricultural land than poorer households. This maybe explained by the result of livelihood diversification in Thailand where most of the younger members of the community tend to focus on non-farming activities and migrate to other places including abroad (Demaine *et al.,* 1999; Pant, 2002). With this trend, land is being sold or rented to other farmers to generate financial capital to support such diversification.

Another important FMAS understood in this research was trap ponds. Some may argue that this is not a production system but rather a device used in fishing. However, the findings of this research showed that trap ponds incurred management costs and that households attempted to increase the productivity of them. AIT/AO (1992 and 1998) and Pholwieng (2001) made similar findings in northeast Thailand where farmers are using indigenous practices in order to attract and maintain aquatic animals and in most cases, these aquatic animals are self-recruiting. Furthermore, Pholwieng (2001) reported that there is an increasing trend of farmers in northeast Thailand excavating trap ponds to varying sizes depending on the experience of farmer. In Cambodia, trap ponds were one of the systems being utilised in a project by the Aquaculture division in the Department of Fisheries, community based fish refuge (Meusch and Viseth, 2001; Viseth *et al.,* 2002). The existence of such systems in both Cambodia and Thailand reflected its importance.

4.3.2 Management practices

In chapter 3 aquatic system management was assessed as part of overall activity regimes of households by gender and age. In this section, a more detailed assessment is given and the seasonality of specific management activities related to aquatic systems is disaggregated by household well-being and location.

4.3.2.1 Types of FMAS management

Several activities (14 in total) were identified in this research through which households managed their FMAS in order to improve the system and increase production. However, in general only a few of these activities were being practiced by any one household; farmers rejected other types of management because they considered them inappropriate for their situation or lacked the required resources. Descriptions of the management activities are also provided in this section.

Figure 4.4 shows the most common management activities and the distribution of households practicing such activities. Clearly, there were differences between the proportion of households doing different types of management activities by site and AEZ ($P < 0.05$). Among the various management activities, harvesting was the most common especially in NET (>40%). In SEC and RRD more than 30% of households harvested SRS during the study period. The importance of other management activities carried out by households varied among sites.

In SEC feeding (18%) and deepening (15%) were the most common activities. Better-off households normally fed while the poorer households mainly deepened their system and created brush parks. Deepening the system was particularly important in SEC. However, in NET, feeding (17%), stocking (13%) and making brush parks (12%) were practiced to enhance the aquatic system production. Feeding was most common among better-off households especially in the DRY area as well as stocking. However, creating brush parks was similarly important to all groups in the site.

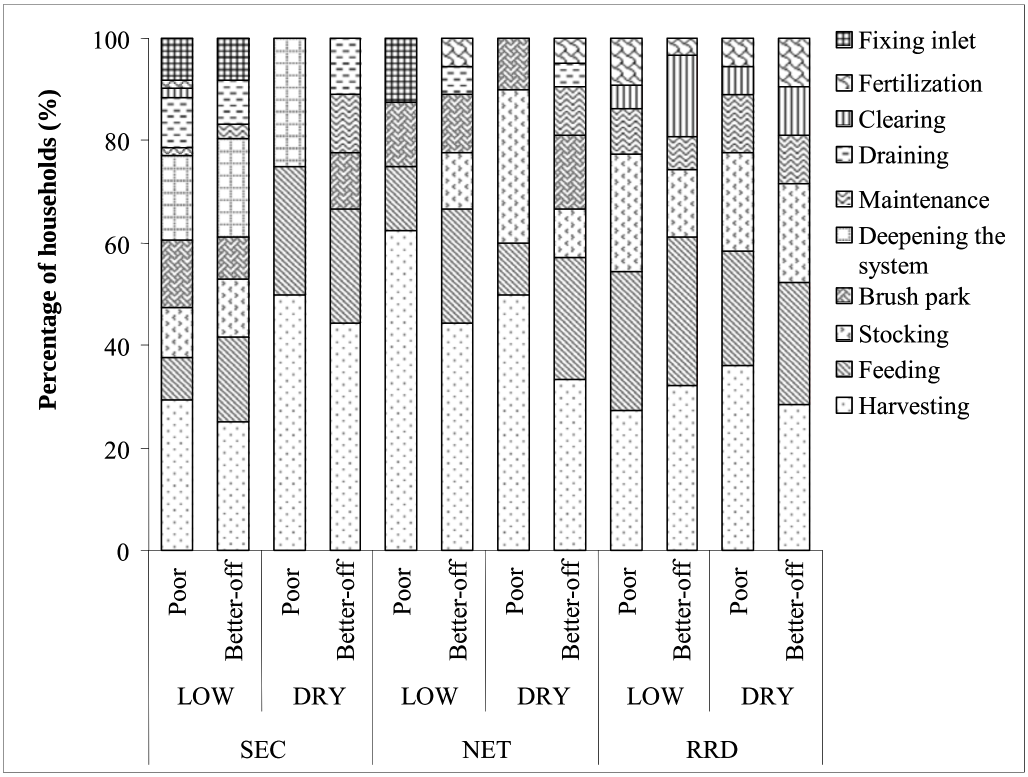


Figure 4.4 Different management activities carried out in FMAS of households by well-being level and AEZs in the three sites in SE Asia ***Data presented based from the longitudinal study.***

In RRD, feeding (25%), stocking hatchery seed (18%) and clearing the system (9%) were the most common management activities in order to increase AA production. Clearing the system is most common among better off, however, feeding and stocking were equally important to all wellbeing groups in the AEZ of RRD. Among the different management activities, harvesting and feeding were generally the most frequent among households at all the three sites (Table 4.5). Households in RRD fed AA in the system regularly (3-5times/week). Both households from SEC and RRD (LOW area) harvested AA from their system more frequently than NET. Poor households from the DRY NET harvested AA less frequently. Certain types of activities were site-specific (Figure 4.4). Pond clearing was only done in RRD and by the poor group from the LOW SEC, between 1 to 4 times in a year. Similarly, only households in RRD fertilized their systems; however, the frequency was low except for poor households in the LOW area. Trapping was important in SEC and therefore fixing water inlets was carried out only in this area. Deepening the system occurred up to every two months in SEC but not at other sites.

Table 4.5 Average frequency of different management activities during the duration of the longitudinal study in the three study sites.

Management	**SEC**				**NET**				**RRD**			
	LOW		DRY		LOW		DRY		LOW		DRY	
	P	BO	P	BO	P	BO	P	BO	P	BO	P	BO
Pond clearing	1								3	4	3	1
Fixing in/outlet	1.6	2			1							
Brush park	3	2.3		1	2	2	2	3				
Stocking	1	3				1	1	3	2	2	1	2
Feeding	**30**	**41**	**2**	**5**	**44**	**23**	**1**	**41**	**58**	**64**	**54**	**42**
Fertilization	1					6		3	16	7	4	5
Maintenance	1	14		3				5	3	7	4	2
Harvesting	**26**	**22**	**11**	**21**	**12**	**11**	**3**	**14**	**28**	**30**	**8**	**18**
Draining	2	1		1		1		2				
Deepening the system	6	6	7									

Note: The frequency was calculated from the households who reported particular activities.
P refers to poor households; BO refers to better-off

The following section briefly discussed the different management activities presented in Figure 4.4.

Pond clearing and preparation

This activity usually occurred after the entire AA were harvested and before re-stocking. This is most common for CP but also household pond and trap ponds particularly when households needed to deepen their system. Activities include scraping the bottom of the system to remove mud, liming to reduce the acidity and as pest disease prevention (commonly done in RRD) and removal of weeds.

Fixing inlet and outlet

This management activity involves the installation of an inlet from the main supply (irrigation canal, run-off from rainfed RF or OWS) to the FMAS. Local materials such as bamboo were typically used but in some areas (RRD) polyethylene pipes were being utilised. In SEC, water was accessed from off-farm sources (lakes, streams and canal) by digging a small canal to link the two systems. Bamboo stakes/screens were usually installed to stop the escape of AA once they had entered CP and HHp. In terms of RF and TP, water inlets were usually created by breaking bunds to allow the flow of water from OWB or even from adjacent rice fields.

Water management

This activity included refilling the FMAS with new water and making sure that the water was good enough for the AA to survive (e.g. enough dissolved oxygen). Disturbing the water surface through manual paddling is a common practice. In irrigated areas like RRD, FMAS are refilled with water by opening the inlets from nearby tertiary irrigation canals. However in slightly elevated areas, manual irrigation is carried out by households with the use of improvised scoops to transfer water from canals to the FMAS. In rainfed areas of SEC and NET, water re-use after harvest is a common practice whereby pumped out water is kept in a nearby system during harvest before being drained back afterwards.

Brush parks

Constructing a brush park is a common strategy to attract aquatic animals to enter and stay in a FMAS. They may also provide shelter and a suitable environment for aquatic animals to graze for food and even to breed. This activity is commonly practiced in SEC and NET, particularly at the beginning of the rainy season. Tree branches, leaves, animal skins, mud from river and lakes, and animal bones are commonly used to create brush parks and attractants. This activity is mostly carried out in trap ponds and household ponds, as well as in some CARs.

Trapping

The purpose of this activity is to concentrate AA within FMAS, thus increasing their productivity and enhancing catch per unit effort. Aquatic animals are encouraged to enter into deeper FMAS to further grow and also for immediate consumption by household. Trapping usually occurs in household and trap ponds. Most of the common practices are based on allowing “easy entry” of AA and then preventing their escape. Attractants of various types and bamboo traps/screens fulfil these roles respectively.

Stocking

Stocking hatchery produced seed is very common activity in conventional aquaculture, however, in this research, stocking also included releasing of juveniles and brood stock collected from CARs, OWBs and other FMAS. Farmers from SEC and NET usually collect aquatic animals during the rainy season from CARs and OWBs and if juveniles were caught, especially those of high value (*Clarias* spp. and *Channa* spp.), they were usually released into their individual FMAS to fatten. In SEC and NET, recruits from their system were temporarily stocked into nearby waterbodies (including FMAS) while their FMAS are being drained and prepared for re-stocking of undersized individuals after harvest of larger AA. Most households in RRD with deeper FMAS stocked hatchery produced seed after first eliminating “unwanted” species, mainly SRS, from their system.

Feeding

This activity includes providing food to the AA present in FMAS and also collection of resources that can be used as feeds. In all three sites, household and garden waste was used as on-farm feeds for AA. Cutting grass, collecting termites, removal and use of pig manure and brewery wastes were common activities associated with supplementary feeding or the substitute of commercial fish feeds. Some of these local ingredients were mixed with rice bran. Commercial fish feeds were commonly used in RRD and households that stocked seed in SEC and NET.

Fertilization

Organic fertilizers were most common inputs although inorganic fertilizers were also being used. Most people used manure from their poultry and livestock to fertilise their FMAS. Fertilization was more frequent among better-off families with culture ponds in NET and household ponds in RRD.

Controlled fishing

This was applicable only in community managed systems (e.g. CARs). Households that were involved in managing community water bodies set regulations on when and what to collect from the system. Such management was most commonly employed in areas where individuals or groups of villagers had invested in stocking

AA. Regulations set by group members pertained to both members and non-members in the community. This was only reported in SEC but such activity did exist and was applied in village ponds in NET and in bid-rent ponds in RRD. In RRD, bid-rent ponds were usually large water bodies (>1 ha) being leased and managed by individuals or even groups from the local authority.

Improving dikes

The majority of the dikes in the study areas were low, small and intentionally cut to encourage aquatic animals to enter from adjacent water bodies to household FMAS. Dike improvements included activities like weeding, rebuilding to elevate the height of the dike and covering unnecessary holes. In NET and SEC, dikes were commonly planted with 'spiky' vegetables or protected with bamboo branches to prevent livestock and people entering into the system.

Making fishing gears

This activity includes the fabrication, repair or maintenance of fishing gear for harvesting and trapping aquatic animals. In SEC, fishing gear that households usually make themselves includes bamboo traps, cast nets and gill nets. In NET and RRD, most fishing gears are purchased.

Collection and harvesting

This was the most common activity at all sites. This included harvest from deeper FMAS and also from shallow FMAS i.e. RF. A variety of gear and techniques such as lift net, small gill net, traps or even bare hands were used. Intermediate harvest of small qualities of AA for immediate consumption occurred, as did complete harvest when households collected a large amount of AA from the system for selling and family consumption. Harvested AA were usually sold after a complete harvest.

Draining/ drying

This activity was not usually carried out by households in areas where water was limited i.e. rainfed areas. In such circumstances, most households only drained their ponds after several years successive use to improve the system through deepening. Households that stocked hatchery produced seed tended to drain FMAS more regularly. Draining was either done by allowing water to run out by gravity or if this was impractical (i.e. design, situation) by removal of water manually using a pump. Manual and gravity draining were common practice in SEC where households manually scooped out the water from the system after releasing most of the water through gravity. In NET and RRD, pumping using diesel pump sets was common.

Deepening the system

The main intention of this activity was to increase the volume of water that could be stored in the system. Some farmers in SEC believed that aquatic animals were attracted to deeper water. The removal of mud also improved the quality of water for the next season. Deepening of the system was most common in SEC and NET while more regular removal of mud was common among farmers in RRD. This reflected the irrigated nature of the area and the lack of advantage of deeper systems.

4.3.2.2 Seasonality of managing FMAS

The timing of different management activities of FMAS depended on the time of the year or phase of the production cycle. Figure 4.5 to Figure 4.7 illustrate the seasonality of the different management activities being carried out by households from different AEZ in SEC, NET and RRD respectively. The figures demonstrate that the type of FMAS management varied by site and AEZ.

In SEC, management activities were more diverse in the LOW area and the number of individuals carrying out these activities was larger than in DRY areas. Activities such as making brush parks, feeding, deepening the systems and making fishing gear were common in the LOW area throughout the year. In contrast, these activities were only carried out by a few individuals in the DRY area of SEC (Figure 4.5). Collection of aquatic animals occurred over the whole year in LOW areas while households from DRY did not collect AA during the months of August and September. In NET, no major differences were found in the type of management activities being employed by households from different AEZ (Figure 4.6). Households from both sub-sites reported feeding, making brush parks and trapping throughout the year. However, stocking was only carried out in DRY areas with low risk of flood. Collection of aquatic animals continued over the whole period in both areas.

	Management activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DRY	Deepening the system					1	1						
	Draining/ Drying						1						
	Collection/ harvesting	13	21	15	12	26	23	9			9	12	11
	Making fishing gears										1	1	
	Maintaining dike												
	Control fishing			1		1							
	Fertilizing												
	Feeding	1									1	2	
	Stocking												
	Brush park/Trap	1											
	Water management												
	Fixing Inlet/outlet												
	Pond preparation and clearing					1							
LOW	Deepening the system	1	3	5	5	11					1	3	
	Draining/ Drying		6	1	8								
	Collection/ harvesting	73	86	83	80	30	52	55	40	69	82	77	87
	Making fishing gears	1	1		1			4	5	6	1		1
	Maintaining dike									3	3		
	Control fishing												
	Fertilizing							1					
	Feeding	9	9	4	1			13	12	19	15	15	11
	Stocking		2					12	2				
	Brush park/Trap	2				6	5	8	2	1			2
	Water management										2		
	Fixing Inlet/outlet				1			1			3	4	1
	Pond preparation and clearing							3		2	1		

Figure 4.5 **Diagram showing the seasonality of the different activities in managing FMAS from different AEZ of SEC. Numbers represent the number of individuals undertook the activity.** ***Data presented based from the longitudinal study.***

	Management activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DRY	Deepening the system												
	Draining/ Drying												2
	Collection/ harvesting	20	13	29	36	21	24	15	24	31	36	32	30
	Making fishing gears												
	Maintaining dike												
	Control fishing												
	Fertilizing					1						1	
	Feeding	5	3	3	1	3	2	4	6	4	7	9	10
	Stocking					1	3	1	4			3	1
	Brush park/Trap		1	1	1	3		2	1		1		
	Water management												
	Fixing Inlet/outlet												
	Pond preparation and clearing												
LOW	Deepening the system												
	Draining/ Drying			1									
	Collection/ harvesting	17	10	28	20	16	26	20	20	19	31	33	23
	Making fishing gears												
	Maintaining dike												
	Control fishing												
	Fertilizing										1	3	2
	Feeding					1	3	6	5	4	3	8	5
	Stocking						1					4	
	Brush park/Trap			1	1	1	3	1				1	
	Water management												
	Fixing Inlet/outlet									1			1
	Pond preparation and clearing					1						4	

Figure 4.6 **Diagram showing the seasonality of the different activities in managing FMAS from different AEZ of NET. Numbers represent the number of individuals undertook the activity.** ***Data presented based from the longitudinal study.***

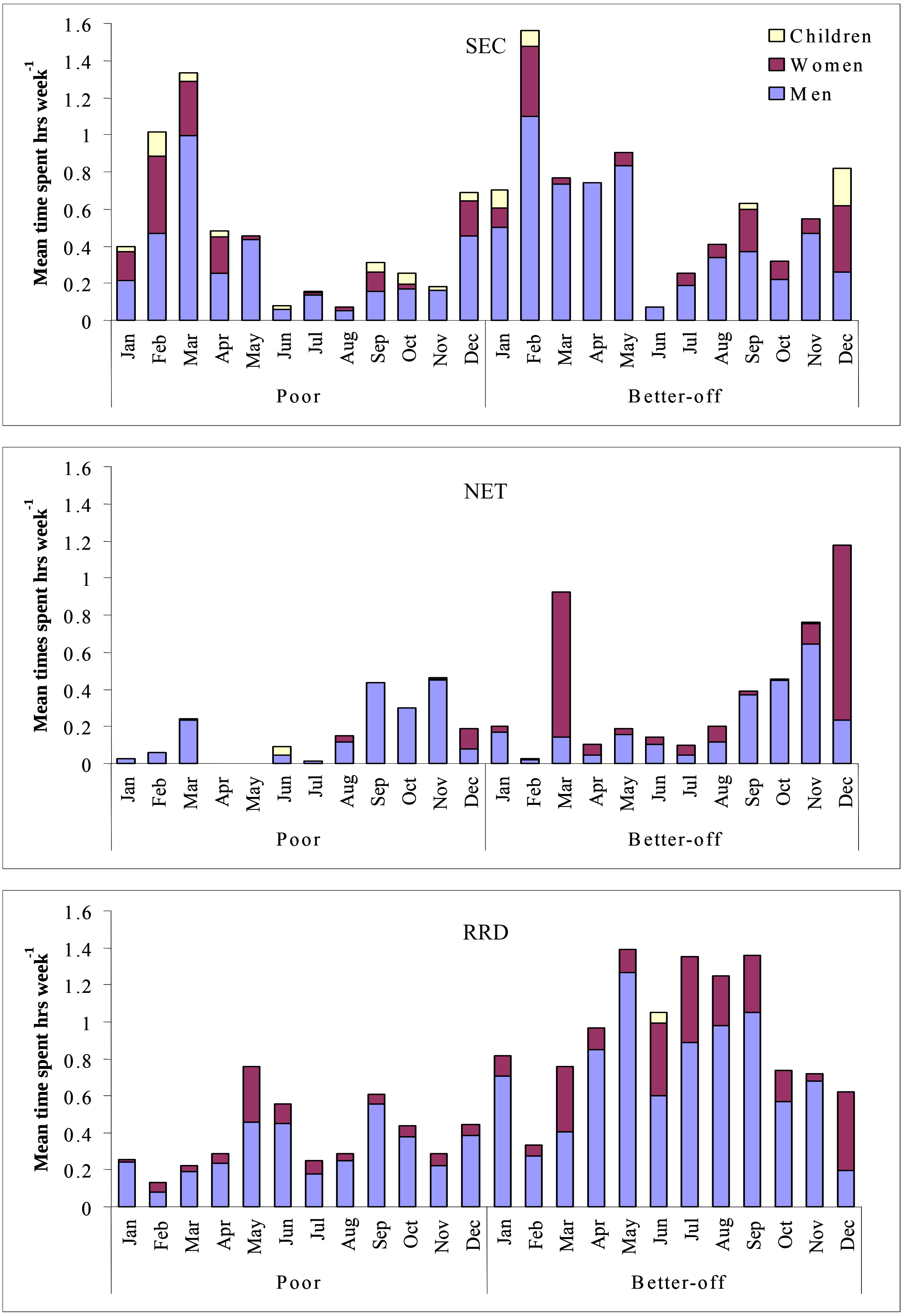
	Management activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DRY	Deepening the system												
	Draining/ Drying												
	Collection/ harvesting	3	6	9	9	19	8	9	14	16	10	15	10
	Making fishing gears												
	Maintaining dike							1					
	Control fishing												
	Fertilizing	1					2		1		2	2	1
	Feeding	11	6	12	7	13	14	16	16	18	17	15	15
	Stocking			2	5	3	6	4	1			1	
	Brush park/Trap												
	Water management				1	4	1	1					
	Fixing Inlet/outlet					1		1					
	Pond preparation and clearing		1		2	5							1
LOW	Deepening the system												
	Draining/ Drying			1									
	Collection/ harvesting	6	10	11	11	26	20	24	16	17	18	14	13
	Making fishing gears												
	Maintaining dike				1								
	Control fishing					1							
	Fertilizing					5	3	1		3	3		2
	Feeding	22	16	13	19	24	27	21	21	30	29	25	16
	Stocking	1		3	4	5	3	5		1			
	Brush park/Trap												
	Water management		1		1	3		1			1	1	
	Fixing Inlet/outlet					1							
	Pond preparation and clearing	1			1	2	2	1	2			2	4

Figure 4.7 **Diagram showing the seasonality of the different activities in managing FMAS from different AEZ of RRD. Numbers represent the number of individuals undertook the activity.** ***Data presented based from the longitudinal study.***

Major management activities carried out by households from different AEZ in RRD were similar (Figure 4.7). Brush park fabrication, deepening the system and making fishing gear were not observed however at either site. This is mainly because such activities mainly aim to attract wild AA which is not practiced in either of the AEZs of RRD. Maintaining dikes, controlling fishing and draining were also very infrequent. Pond preparation and clearing were mostly done in the LOW area. Feeding and collection/harvesting continued throughout the whole year. The number of households feeding AA started to increase in May until January of the following year. February is the coldest month when feeding was reduced as AA tended to eat less. On the contrary harvesting started to increase during this period, particularly in relation to the "Tet festival". Stocking of AA occurred in the middle of the year (summer) however, in the LOW area some households stocked their system in January.

The seasonality of the average time spent in managing FMAS and the contribution of different gender-age groups in AEZ at all sites was analysed and is presented in Figure 4.8. Overall, the contribution of children was only significant in SEC. In Cambodia, the contribution of children of both well-being groups in managing FMAS varied seasonally ($P < 0.05$), peaking in the months of February and December. These labour peaks correlated to the main periods when trap and household ponds were drained, renovated and prepared for the next rainy season.

Figure 4.8 Seasonality of time spent (hr week $^{-1}$) in managing FMAS by gender and age group. ***Data presented based from the longitudinal study.***



As presented, FMAS management is obviously dominated by men; however the contribution of females cannot be neglected. In both SEC and RRD, women contributed some of their time in most months of the year. Women in NET, particularly the better-off, contributed mainly in two months (March and December), whereas women from poor families made more limited contributions. The overall time spent in managing FMAS is highest in RRD ($P < 0.05$), and least in NET. The seasonal difference in the total time spent by households in managing FMAS was also significant between sites and AEZ ($P < 0.05$).

4.3.2.3 Stocking practices

The average percentage of households with FMAS which practiced or reported a history of stocking is presented in Table 4.6. In general, the percentages of households reported stocking were higher among better-off groups than the poorer groups in all sites. In SEC, the percentage of households practicing stocking is generally low, particularly for poorer households (9% and 0% in LOW and DRY respectively). Between AEZs, a greater proportion of households stocked in the LOW areas of SEC and NET than in the DRY area. However, in RRD, stocking was more common in DRY areas. Both wealth groups from NET and RRD included a relatively high percentage of households that had stocked seed.

Table 4.6 Percentage of households in the study sites reporting the stocking aquatic animals in FMAS. Values in parenthesis represent the n. *Data presented based from the cross-sectional survey.*

AEZ	Sites					
	SEC		NET		RRD	
	Poor	Better-off	Poor	Better-off	Poor	Better-off
LOW	9	31	36	66	22	50
	(33)	(55)	(27)	(28)	(27)	(14)
DRY	0	11	29	52	33	65
	(16)	(20)	(21)	(31)	(39)	(31)

The following section present the different information related to source of seed, channels of acquisition, and species of aquatic animals stocked. This information was generated from the background survey conducted in the different AEZ of each sites. As presented in Figure 4.9, stocked aquatic animals were obtained from: (1) conventional hatcheries; and (2) other non-hatchery sources such as recruits from their own or others' FMAS. The formal hatcheries included private hatcheries, research stations, government-run hatcheries and other non-government organizations like cooperatives that included aquaculture as part of their programmes. Non-hatchery sources of fish seed included community ponds, rice fields and other ponds of friends or relatives of the households. Additionally CARs and OWB can also be included in the non-hatchery source of fish seed.

As presented in Figure 4.9, formal hatcheries were the most important sources of seed in the study sites. However, in SEC, a higher percentage of poorer households (75%) from the LOW area stocked seed coming from their own FMAS which included rice fields, trap ponds and other household ponds. Households in DRY areas of NET also stocked seed derived from their own, friends or other peoples' FMAS. Government-run hatcheries in NET contributed a relatively large proportion of seed for stocking compared to RRD. Government-run hatcheries were common in NET where most provinces had hatcheries operated by the Department of Fisheries (DOF). In RRD, the majority of the households stocked fish seed coming from hatcheries which were typically owned by private individuals.

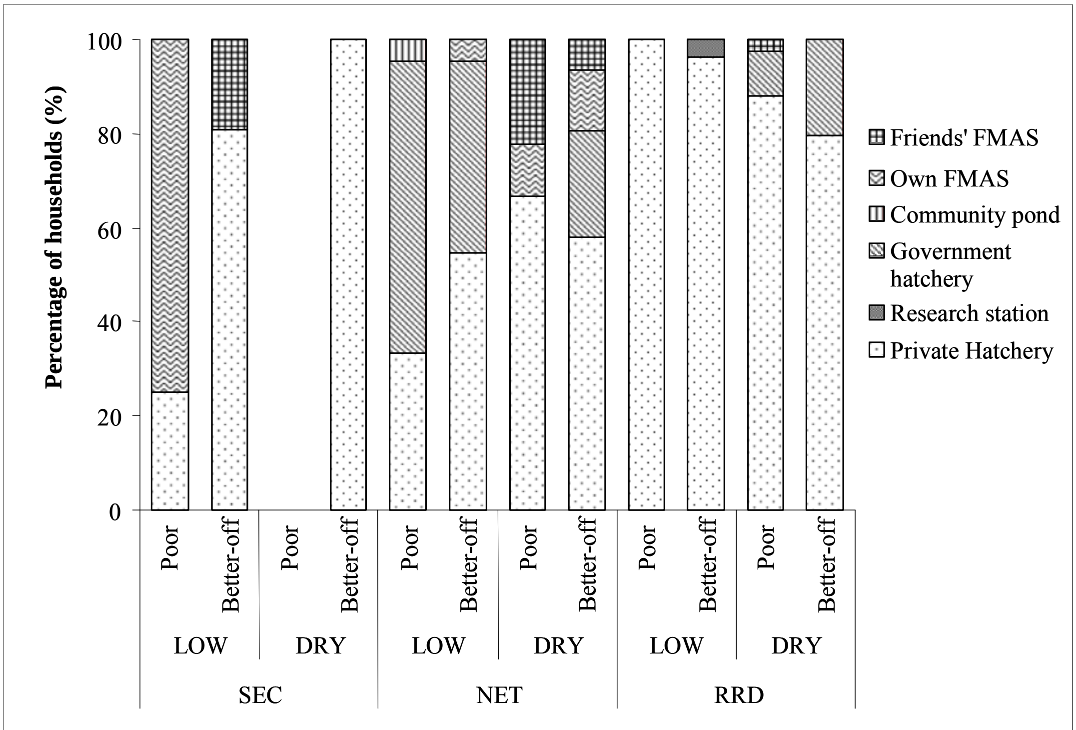


Figure 4.9 Different sources of seed by households of different wealth ranks from different AEZ in SEC, NET and RRD. ***Data presented based from the cross-sectional survey.***

The channels of acquisition of fish seed for stocking varied by site (Figure 4.10). As the majority of the households in the RRD had a history of stocking seed from hatcheries, most seed were purchased. In NET, most households also purchased but acquiring seed as gifts was also common. In SEC, the impacts of relative well-being on stocking strategy are clear; the poor group tended to collect seed themselves from their own and other FMAS, and even from the open water bodies (OWB). Better-off families in SEC mostly purchased hatchery derived seed or received them as gifts.

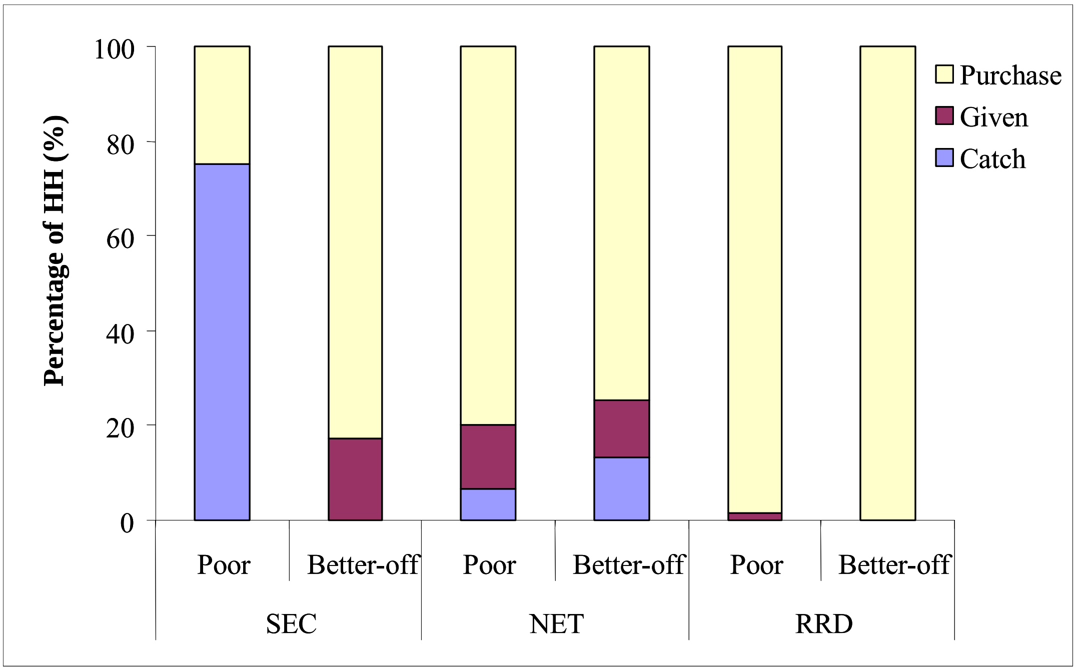


Figure 4.10 Means of acquiring aquatic seed for stocking in FMAS. ***Data presented based from the cross-sectional survey.***

The percentage of households in relation to the composition of aquatic animal species being stocked at the three sites is presented in Figure 4.11. In SEC, there were at least eight species of fish stocked. *Oreochromis niloticus, Pangasius* sp., Common carp and Indian carps were among the hatchery-produced seed being stocked in SEC, whilst *Channa* spp., *Clarias* spp. and *Trichogaster* spp., were amongst the non-hatchery produced seed which poorer households obtained and stocked. In NET, there were at least 10 species of aquatic animals being stocked by households, the majority of which were hatchery produced seed; *Clarias* spp. was the only non-hatchery produced seed stocked by better-off households in both AEZ. Most of the households in RRD stocked hatchery produced seed although the range of species stocked was more limited compared to NET.

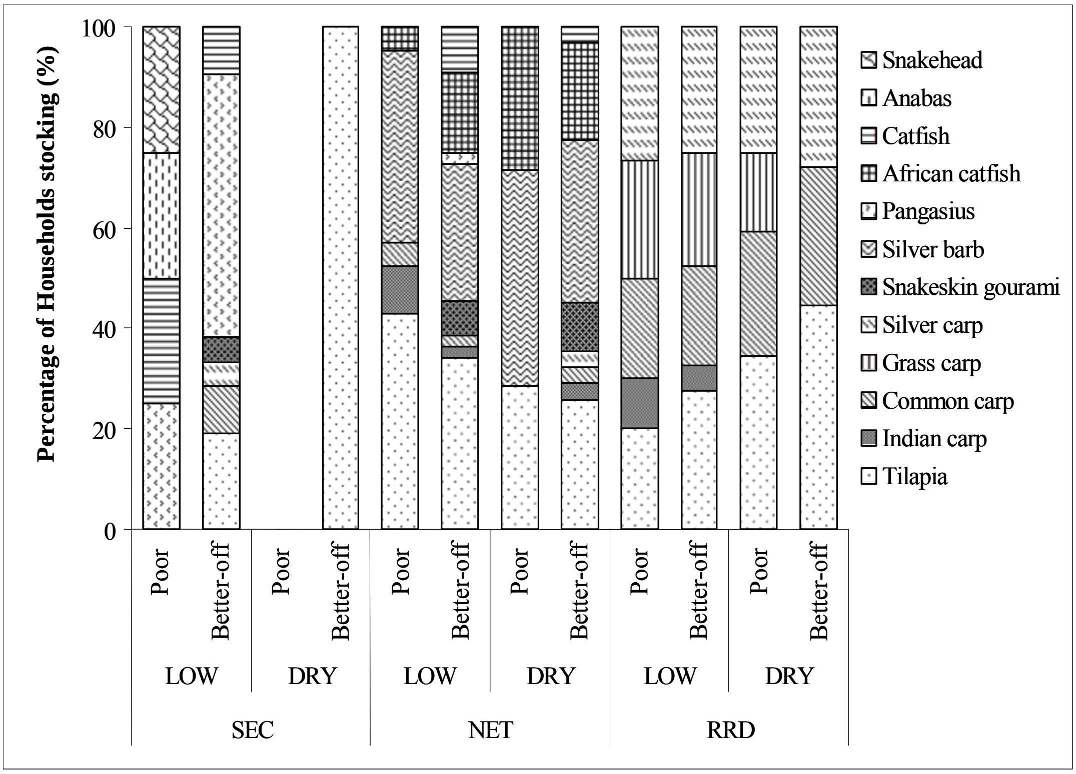


Figure 4.11 Different species of aquatic animals commonly stocked by households of different wealth groups in different AEZ of SEC, NET and RRD. ***Data presented based from the cross-sectional survey.***

4.3.2.4 Attitude towards SRS species

Attitudes of households from different well-being groups towards SRS were assessed as part of the background survey. There were three groups of households identified in this survey. The first group identified was households who allowed or attracted SRS to enter into their FMAS ('positive'). The second group of households were those that prevented and eliminated SRS from their system ('negative'). The third group are households who did not do anything to either attract or prevent SRS ('neutral').

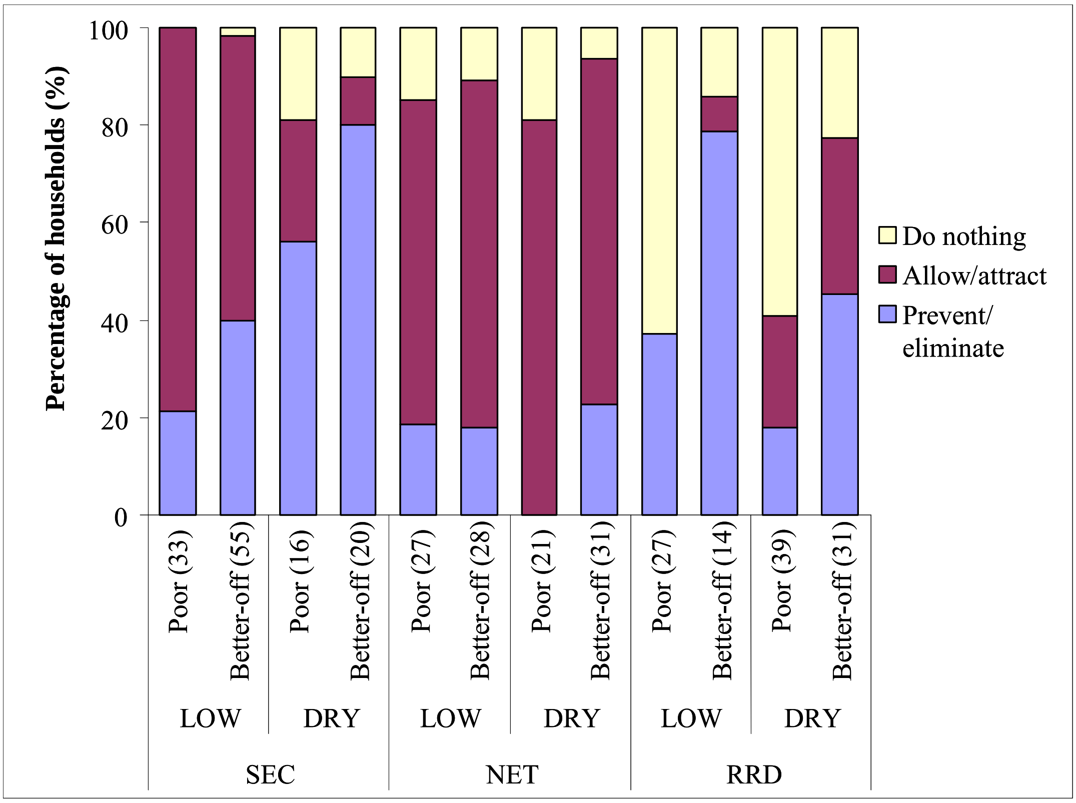


Figure 4.12 Attitude of households towards SRS in different AEZ by wealth group. Number in parenthesis represent (n). ***Data presented based from the cross-sectional survey.***

Figure 4.12 illustrates household attitude aggregated by well-being group and AEZ zone towards SRS. In SEC, households from the LOW area generally allowed/attracted SRS to enter into their system but in contrast, households from DRY areas mostly prevented SRS entering their system (NEG). This probably related to the stocking of hatchery produced seeds, particularly by the better-off households in this area. In NET, households were generally neutral or positive to SRS although a minority (10%) were negative and attempted to eliminate or prevent such species entering their systems. In contrast, mainly better-off households in RRD were either negative or neutral towards SRS.

Management activities to allow and attract SRS into FMAS

Activities being carried out by 'positive' households from different sites to allow and attract SRS to enter into their FMAS are presented in this section. Figure 4.13 illustrates how households from different sites, AEZ and wealth groups differed in activities in favour of such species.

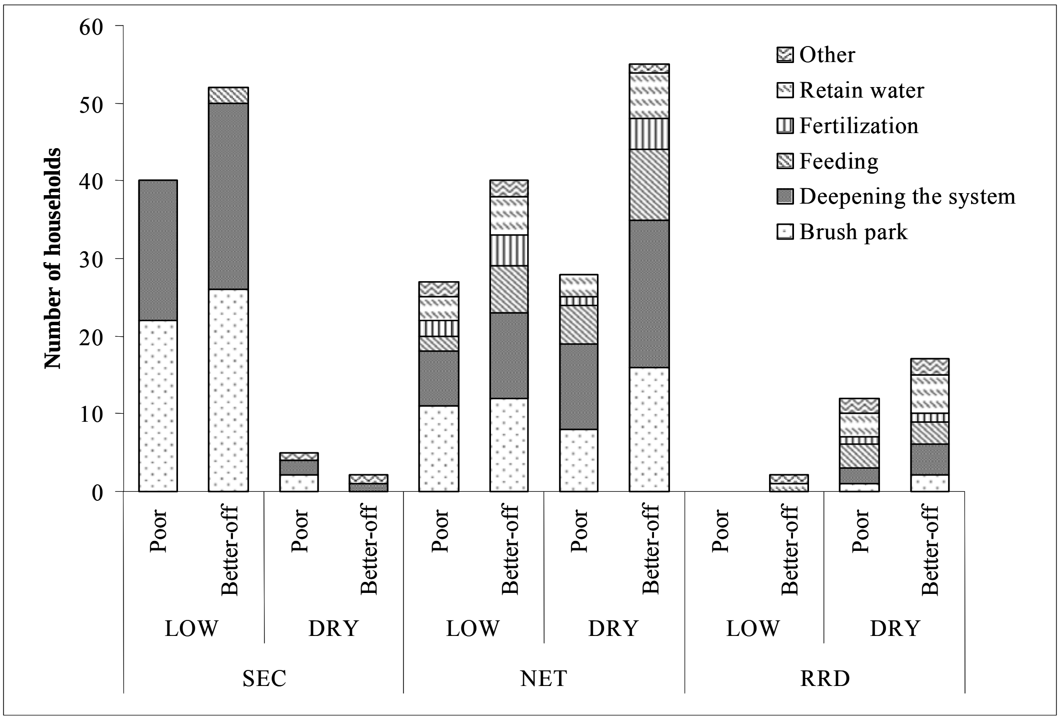


Figure 4.13 Different management activities to allow and attract SRS into the FMAS of households in SEC, NET and RRD. ***Data presented based from the cross-sectional survey.***

Households in SEC that allowed SRS into their FMAS, particularly in the LOW area, typically practiced only two activities, making brush parks and deepening the system. In NET, management activities to attract such species into the FMAS were more varied and included feeding and retaining water for next season use. In RRD, where the number of households that are SRS positive are very small, deepening the system, feeding and retaining water were the most common management activities being practiced.

Management activities to prevent and eliminate SRS from FMAS

Eliminating and preventing SRS entering into the system was being practiced mainly by households who were stocking seed obtained from formal hatcheries. Figure 4.14 shows the different activities being carried out by households to eliminate SRS from their FMAS. There were mainly four activities being carried out to eliminate such species from FMAS: scraping sediments using a basket (only in SEC), liming, drying and fitting screens to water inlets/outlets.

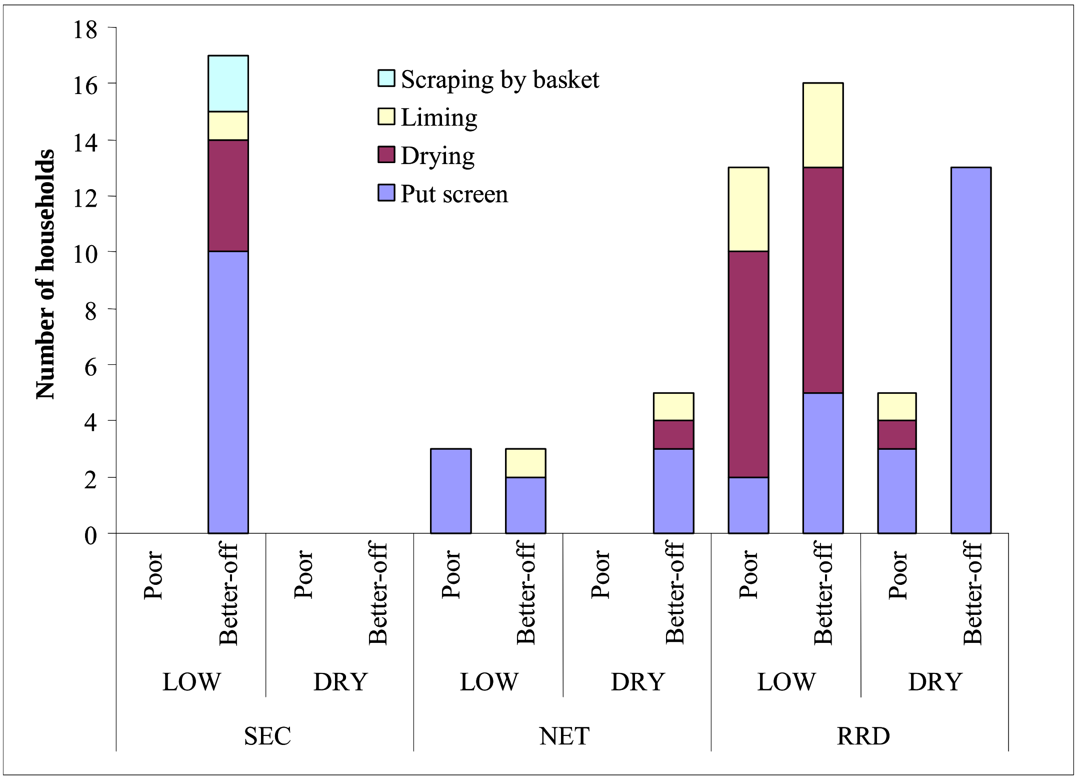


Figure 4.14 Different management activities to prevent entry and eliminate SRS from the FMAS of households of different wealth groups in different AEZ of SEC, NET and RRD. ***Data presented based from the cross-sectional survey.***

In SEC where only better-off households from DRY areas eliminated SRS, placing screens and pond drying were the most common activities. In NET, although very few households eliminated SRS from their FMAS, fitting screens was common to prevent entry of SRS. Aside from using screens and drying the pond bottom, application of agricultural lime was also practiced by households in RRD particularly those households in LOW areas.

4.3.2.5 Discussion on various types of FMAS management

The importance of indigenous knowledge in managing aquatic resources is highlighted in this research. However, the complexities and the level of management in aquatic systems can be related to the intensity of agricultural activities, type of FMAS and the main intention of the AA production i.e. towards subsistence or mainly for cash. In areas where the agriculture is considered intensive but irrigation water is limited, priority of management is always towards the rice fields, particularly in the use of water from irrigation. However, in RRD, fish farming was also primarily orientated towards cash generation as reported by Luu *et al.* (2002) and MOFI/WB (2004) therefore management was relatively different from SEC and NET. In the lowland areas of Cambodia and northeast Thailand, rice fields are seasonal and thus temporary wetlands (Lawler, 2001) but are a major source of AA. Their management usually takes into consideration AA and other FMAS linked to them. Most farmers provide a temporary habitat for AA when they are applying pesticides and fertilizers or even when reducing the water level of the paddies (Fedurok and Leelapatra, 1992; Little *et al.,* 1996). Halwart *et al.* (1996) reported that in concurrent rice fish farming, a refuge is always provided for the fish to avoid mortality during pesticides and fertilizer application and accidental draining.

There were at least 10 activities or groups of activities identified in this research, most of which is being practiced by conventional aquaculturists (stocking, feeding, fertilization, fixing water gates, and harvesting). However, there were other management activities identified which were not commonly practiced by households with culture pond, brush parks making and deepening the system. These two management approaches are popular in SEC and NET particularly those farmers who have trap ponds or household ponds connected to rice fields. AIT/AO (1998) and Pholwieng (2001) reported that making brush parks (adding branches) in trap ponds was the most common management activity in northeast Thailand, however, they also reported that it is now decreasing due to the difficulty of finding branches and the labour costs and inconvenience of moing these materials into distant ricefields. AIT/AO (1992) and Demaine *et al.* (1999) reported that trap ponds are usually 500m to 1500m away from farmers' homestead.

In managing other types of FMAS such as ponds (household, culture and trap) and ditches, two classifications in relation to attitude towards SRS were identified, positive and negative. However, both Amilhat (2006) and Islam (2007) included a group of farmers with neutral attitudes to SRS. The geographic locations and the purpose of farming AA determined the two classifications in this research. In RRD where farming AA was mostly cash orientated (Luu *et al.,* 2002; MOFI/WB, 2004), management was usually negative towards SRS. This may be due to the perceptions of conventional aquaculturists and extension workers that SRS are competitive for food and space or even predatory (Setboonsarng, 1993). However, in most areas of northeast Thailand and Cambodia, FMAS were mostly being managed with a positive attitude to SRS i.e. considering SRS as part of the biomass in the system. Allowing and attracting SRS species to enter into the system was very common in Cambodia and Thailand hence most of the FMAS are semi-closed system to allow the movement of the aquatic animals especially during the onset of the rainy and dry seasons (Islam, 2007; Little *et al*., 2004). Such attitudes toward SRS implied the obvious reliance of households in Thailand and Cambodia on natural production i.e. non-stocked or in other words, self-recruiting species, especially among the poor (Gregory and Guttman, 1996 and 2002b). This also implies, however, pressures on natural stocks. Setboonsarng (1994) characterised an evolution of trap ponds in northeast Thailand to linked-ponds – i.e. stocked ponds linked to ricefields stimulated by a decline in productivity of SRS and. Households in both SEC and NET typically practiced several types of positive management. In contrast, most households in RRD were doing the opposite (i.e. prevention and elimination) and relying on the stocking of hatchery seed. The most common purpose of stocking hatchery seed in RRD was to gain profit and contamination from SRS was believed to negatively affect the expected gains. Complete draining and application of lime were the common practice in eliminating the so called "predators" in the system by farmers in RRD. Demaine *et al.* (1999) suggested several ways of controlling predation which involved draining, poisoning and proper screening. However, Demaine *et al.* (1999) also suggested growing fish seed to a bigger size prior to stocking. A large proportion of households in RRD however, can be considered 'neutral' as they were not doing anything to either eliminate or attract AA into their system. Most of these households belonged to the poorer group for which additional investment in FMAS was very constrained as their main priority was to target all available resources towards their main livelihood activity – rice farming. Most of these individuals also considered un-stocked species to have added importance to the production of the system.

Another interesting finding in this research is the division of labour among gender and age group in managing the aquatic system. In general, aquatic resource management is predominantly a male activity (Pritchard, 1992; Setboonsarng, 2002). However, this research shows evidence how women and children contributed to the management of the system in order to improve yield. The contribution of women and children to aquatic resource management however was limited to the maintenance of the system (feeding, collecting feeds, water management) and during the collection. Stocking, deepening the system, creating brush parks and draining were usually being carried out by adult men. Hatha *et al.* (1995) studied the different responsibilities and roles of Cambodian women as well as children in aquaculture through a survey. Within the production cycle i.e. preparation until post harvest, male labour declined while the involvement of women increased. Women were dependent to some extent on men, particularly for pond construction and repair of embankments (Hatha *et al.,* 1995). This trend is similar to the findings of the current research which only shows important roles for women in production but also some issues regarding access which were limited only on the labour or productive side and not on decision making (Buenavista *et al.,* 1994). Setboonsarng (2002) reported similar contributions of women in fish culture and also highlighted the limitation of women from decision making.

4.3.3 Aquatic animals and their importance

4.3.3.1 Local criteria in determining the importance of AA

The preference scoring activities helped identify the different AA present in the area and their relative importance to the community. This activity was carried out with people of different age, gender and social group. Furthermore, how the importance of AA was valued and the criteria they were using to determine such importance was elucidated in this activity. Figure 4.15 illustrates the local criteria used by gender groups in the three sites in determining the importance of AA. There was no significant difference between gender groups within sites in terms of the criteria used, however there were significant differences found between sites ($P < 0.05$).

A high priority was given to the value of AA for subsistence by households in SEC. In NET, 'good flavour' was the most important criteria. In contrast to these two sites, in RRD, neither of these criteria were mentioned, whereas a range of criteria relating to their monetary value and their harvest were highlighted. Suitability for processing was identified as an important criterion in NET and SEC, particularly the latter where the longitudinal study established that processing was an important strategy to maintain consumption levels of AA over a longer period in this rain-fed environment. Overall the various criteria for valuing SRS employed by different groups in the study sites can be grouped into three categories; (1) availability; (2) economic value; and (3) food and nutritional value.

Figure 4.15 Different local criteria used by gender groups in ranking the importance of aquatic animals in the three sites. ***Data presented based from the PCA exercise.***

4.3.3.2 Diversity of aquatic animals (AA)

The estimated numbers of species that are perceived to be common and available that may or may not be used or exploited in the different sites of this study were established during the PRA. Figure 4.16 shows the variations in terms of the number of species identified by different gender groups from AEZ of the three sites. In general, NET had the highest number of species with at least 117 species identified from the six locations (3 LOW and 3 DRY) ($P < 0.001$) based on local identification. This figure includes different species of barbs, snails, and frogs. A difference in the total number of AA identified by well-being group and AEZ in NET was found to be significant ($P < 0.05$), where poorer households in the DRY area tended to identify fewer species of AA compared to other groups in NET. In SEC, the total number of aquatic animals identified was significantly lower (54 species) than NET, but there was no effect of well-being group or AEZ on the estimated number of species observed, although the number of species in LOW area is slightly higher than in the DRY. Amongst the three sites, RRD had by far the least diverse fauna (23 species). There was no significant difference found in the number of species identified between AEZ, however poor households, particularly the female group from the LOW area, identified significantly ($P < 0.05$) fewer AA (12 species).

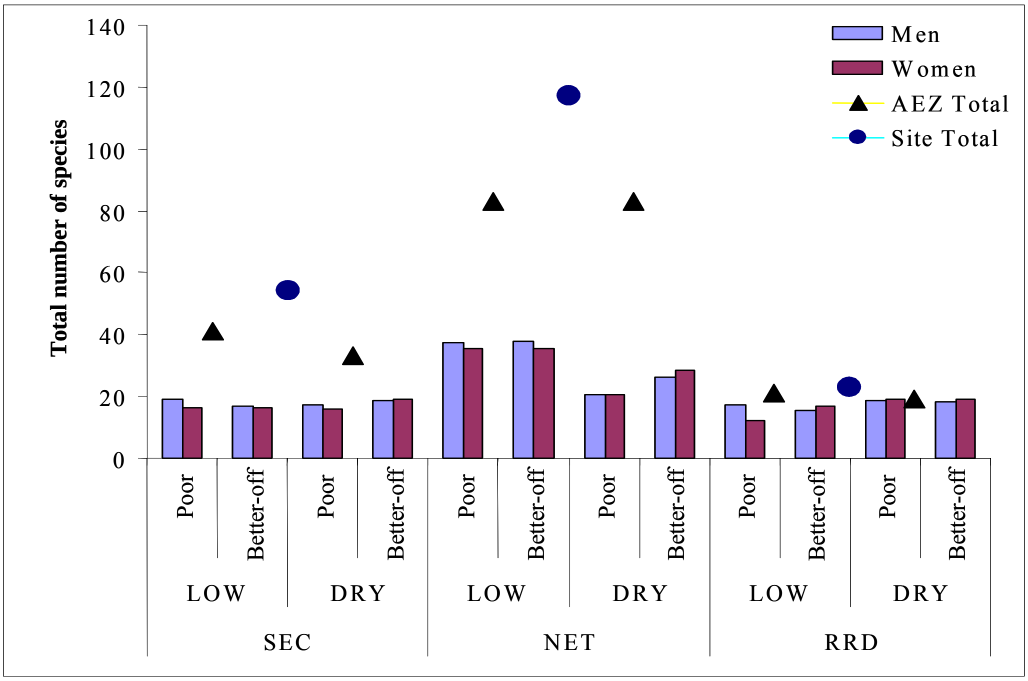
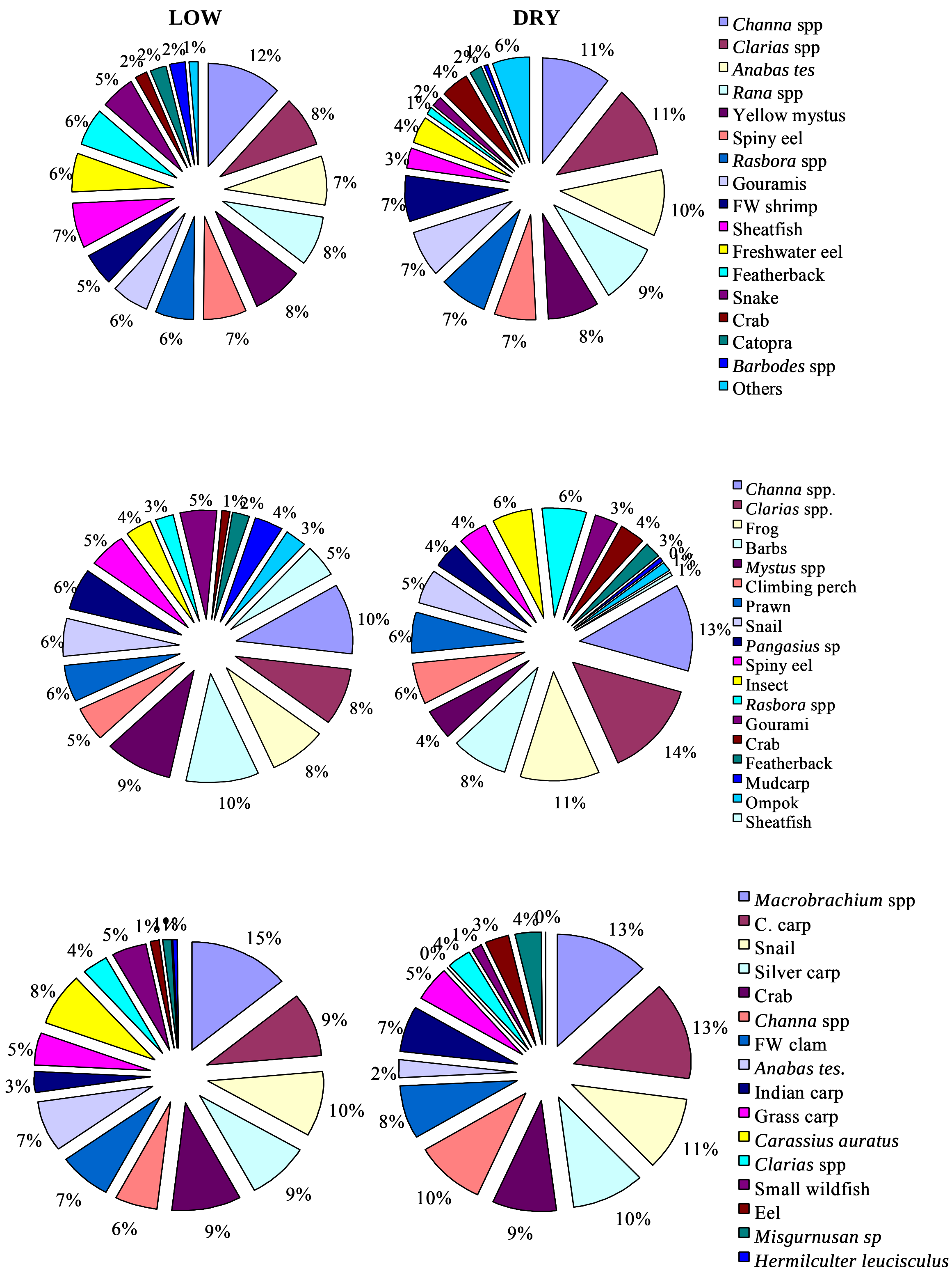


Figure 4.16 Total number of species identified during the PCA exercises by well-being groups and AEZ in the three study sites.

Although there was no significant difference in the number of AA identified between AEZ, there were some differences in terms of the actual species found and their relative importance to the households from different AEZ of the three sites. Figure 4.17 shows the different species identified and their relative importance. In SEC, topping the list of important AA in both AEZ were *Channa* spp, *Clarias* spp., *Anabas testidenus*, *Rana* spp., *Mystus* spp., spiny eel and *Rasbora* spp. These species were initially all considered as wild species by the different groups of respondents during the PCA. Aside from frogs (*Rana* spp.*)*, other non-fish species that were identified as important at this site include freshwater shrimp (*Macrobrachium* spp.) and crabs (*Somanniathelpusa* sp.). In NET, important AA species that were identified included *Channa* spp., *Clarias* spp., *Rana* spp., *Barbodes* spp., *Mystus* spp., *Anabas testidenus, Macrobrachium* spp. and *Sinotaia* spp. In addition, *Rasbora* spp. was also identified as being important in the DRY area of this site. There were also other species that were identified in DRY area but not in LOW like *Wallagu attu*, freshwater clams and African catfish (*Clarias gariepinus*). As in SEC, most of the important AA that were identified by the different groups were 'wild' species. Amongst the hatchery-produced species identified were *O. niloticus*, *Pangasius* sp., and species of Chinese and Indian carps. Important species identified in RRD were relatively similar at the two sub-sites (LOW and DRY). Topping the list were *Macrobrachium* spp., *Cyprinus carpio, Sinotaia* spp., silver carp, common carp, crabs, snakehead, *Anabas testidenus*, and freshwater clams. However, the order of importance of the different species were dissimilar in the two AEZ; common carp and *Macrobrachium* spp. were considered most important in DRY, whereas *Macrobrachium* spp. and *Sinotaia* spp were more important in LOW.

Figure 4.17 Important aquatic animals identified[5] using local criteria by households from different AEZ of SEC, NET and RRD. ***Data presented based from the PRA exercises.***



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[5] Aquatic animals were identified/classified by Soubry (2001) and Amilhat (2006) as part of the ecological part of the SRS project (R7917).

4.3.3.3 Discussion on general importance of aquatic animals

The perceptions of households of the general importance and diversity of AA were understood. The criteria identified were related to availability and economic value as well as food and nutritional value. The dominance of criteria linked to food consumption indicated the overall importance of AA to food consumption as suggested by several literatures (ADB, 2005; Dey *et al.,* 2005; Gregory and Guttman, 1996 and 2002b; Meusch *et al.,* 2003; Middendorp, 1992; Mogensen, 2001; Roos, 2001; Roos *et al.,* 2002). On the otherhand, the criteria related to economic value obviously indicated that growing aquatic animals in the area were considered a cash crop as in the case of farmers in RRD (Luu *et al.,* 2002; MOFI/WB, 2004).

Differences in the level of importance of these criteria were found to be influenced by country (status of aquaculture and dependency to natural production), AEZ and even gender. In both SEC and NET, food and nutritional value of AA were more important (>45% and <60% of the total score in SEC and NET respectively). This findings lead to the conclusion that most farmers in SEC and NET prioritise the food and nutritional need of the households before income. Several researchers reported that most of the aquatic animals being consumed in northeast Thailand and Cambodia were not purchased but mainly caught or own produced (AIT/AO, 1998; Prapertchob, 1989; Shams and Hong, 1998) and In contrast, for RRD households, economic value of the AA is an important characteristic (<60%). Another interesting finding that was presented in this section was the difference of gender in terms of looking at the importance of aquatic animals. In general, women tend to give more importance to AA that are available, easy to cook, versatility in cooking and easy to catch. On the otherhand, men gave more importance on the abundance and economic value. Again this reflects the earlier discussion on the access of men to resources and its social power in decision making particularly in selling their products. On the otherhand, the women's concern on the nutrition and food security of the entire households reflected in their list of criteria. Bruce (1989) suggested that men and women have very different prospects in life, their participation in labour markets, the returns to their labour, daily time used and parenting responsibilities, even though they are in the same cultural setting, class group and family. Women in general, mothers in particular would typically devote resources they can control to meeting the most pressing needs (Bruce, 1989) or immediate needs of the households and in most cases food. Furthermore, Kennedy and Peters (1992) suggested that food security and nutritional status of children has a significance influenced by the the proportion of income in the household controlled by women. This explains why the priority of women group regardless of the wellbeing was linked to food and nutrition. The results of this section suggest that in Cambodia and Thailand (especially among women), meeting the immediate needs of the households for food is more important than increasing the cash flow, whilst RRD is more market oriented.

The Convention on Biological Diversity in 1992 as cited by Coates *et al.* (2003) defined biodiversity as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are apart which includes diversity within species, between species and of ecosystems. In this research however, the diversity dealt with the number and variety of species perceived and observed that were available in the aquatic resources. The perception on local people on the diversity of AA was determined using a participatory approach and presented in this section. Interestingly in areas where aquaculture was assumed to be established and rice intensification is going on and being promoted i.e. Red River Delta Vietnam, AA were less diverse (23 species). In contrast, AA in northeast Thailand where both agriculture and aquaculture were less intensive (AIT/AO, 1998; Demaine *et al.*, 1999), households perceived a more diverse AA, with more than 100 species identified (AFGRP, 2003; Soubry, 2001). The variation in diversity of AA was perceived to also be linked to the intensification of agriculture i.e. rampant use of chemical fertilizers and pesticides (Kyaw, 2001; Lawler, 2001) as well as conservative practices of water management. Coates *et al.* (2003) reported that the threat of biodiversity loss is much greater in the freshwater environment and that the cause is not excessive exploitation like those species in the marine environment rather environmental degradation i.e. habitat loss and pollution. One major causes of degradation of the environment and thereby decreasing AA biodiversity is the intensification of rice farming particularly the excessive use of pesticides (Coates, 2002; Coates *et al.*, 2003). Similarly Cagauan and Arce (1992) suggested that while pesticides offers panacea to pest problems in rice, pesticides also posed threat in AA and even an environmental health hazard. Moreover, Fedurok and Leelapatra (1992) also highlighted that rice field fisheries might be in great jeopardy due to the pollution brought by agriculture related activities and large scale water management that directly affect the movement of AA to the rice fields.

The varying perceptions of gender and wellbeing groups regarding the AA diversity was also an important finding of this research. The poor people who are mainly the fisher who collect/forage AA from rice fields and other aquatic systems (Catalla and Catalla, 2002; Gregory *et al.,* 1996; Murshid, 1998) tended to have more idea on the different species available in the area. This is simply because they were the one directly observing the situation of the aquatic system. On the other hand, the better-off households tended to have smaller number of AA. For instance in RRD, most of the list were composed of cultured AA which is the common fish they better-off households eat or see in the market. Overall, although the perception of the different groups regarding the number of species did not match, the general impression was that the number of species is in the decreasing trend as they have also identified species that became less abundant. This observation was also reported by Meusch *et al.* (2003) from their research in Lao PDR which is bordering with all the three study sites and sharing the main river, Mekong River.

4.3.4 Collection of Aquatic Animals (AA)

The information presented in this section was all generated from the longitudinal study. Through this approach the important contribution of the different groups of AA (SRS, stocked and wild) to the total harvest during the 12 monitoring periods could be understood. Moreover, the effects of seasonality and site of harvest of different species of AA, in relation to the people involved could be interpreted.

4.3.4.1 Mean collection of aquatic animals

Figure 4.18 shows the mean total catch of AA (kg $hh^{-1}week^{-1}$) and the contribution of SRS. There is a large variation in terms of the mean catch of AA between sites, AEZ particularly in SEC and RRD, and among well-being groups ($P < 0.001$). Households in SEC had the lowest total mean catch followed by NET and RRD; total catch of AA by better-off households in RRD exceeded that in SEC and NET by a factor of 6 and 2 respectively.

The importance of AA type was found to be site-specific ($P = 0.05$) with households in NET have the highest mean catch of SRS compared to SEC and RRD. In SEC, SRS species were relatively more important especially in the LOW areas. SRS were the most important part of the total catch in both AEZ within NET. However, in the LOW area of NET, aside from SRS, the contribution of wild species was also important. In contrast stocked species contributed most of the total AA catch in RRD. The contribution of wild AA was important in the LOW area of RRD but that of SRS to the total catch was relatively small in RRD overall.

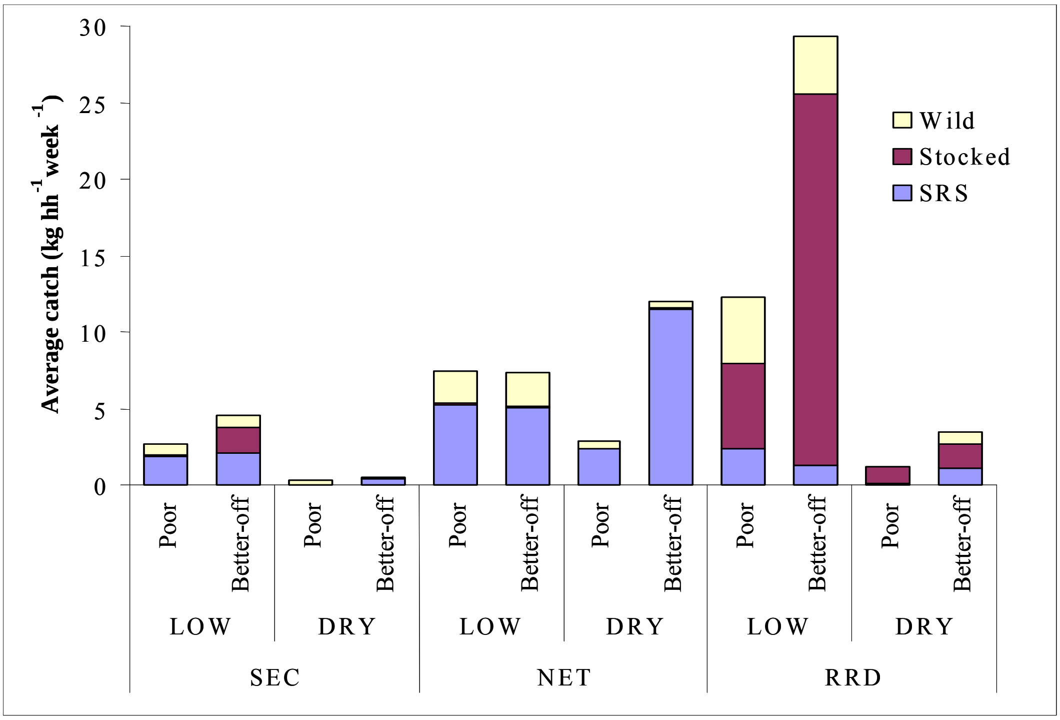


Figure 4.18 Average weekly household catch of AA by well-being group in different AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***

The overall contribution of different age and gender groups was also investigated in this study. Adult males were the major contributors to household collection of AA ($P < 0.001$) regardless of well-being group, or AEZ, in both NET and RRD (Figure 4.19). The contribution of children to harvest of the AA was mostly observed in SEC but not in NET and RRD. However, in SEC, particularly in LOW areas, harvests of AA were more likely to be a combined household activity i.e. involving males, females and children. In NET, although the relative amount is small, the contribution of female members to the overall harvest of aquatic animals was small.

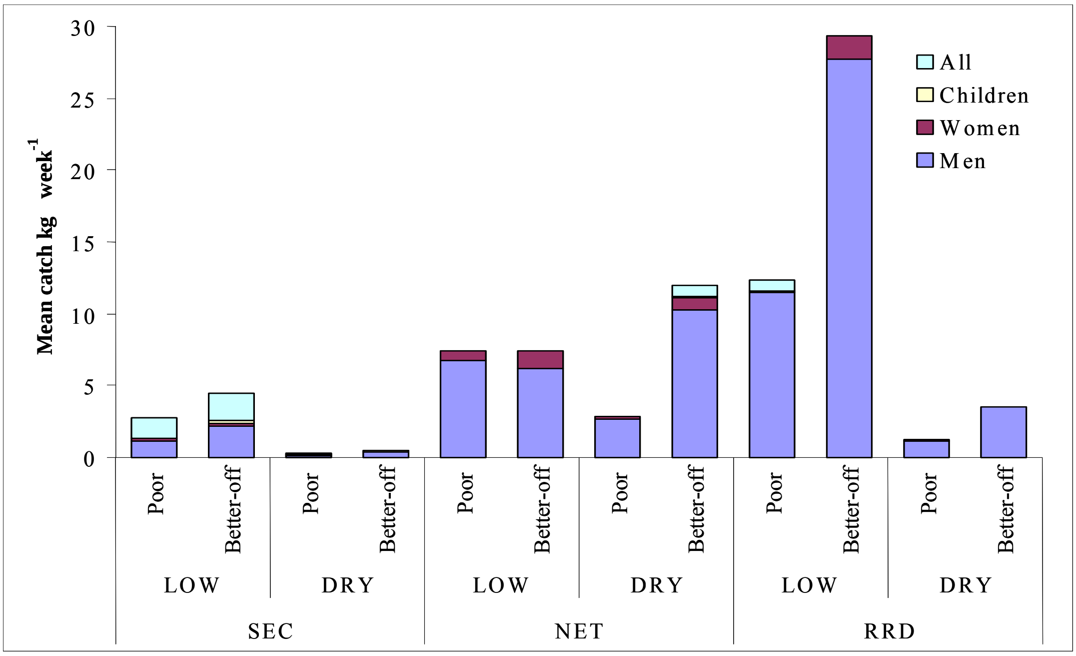


Figure 4.19 Contribution to the household's average catch by gender and age. ***Data presented based from the longitudinal study.***

4.3.4.2 Sources of Aquatic animals

Generally, the location of collection can be classified into two areas: open water bodies (OWB) and farmer managed aquatic systems (FMAS). From the data presented in Figure 4.18, the three main groups of AA that were collected were wild, SRS and stocked. Amongst the three AA groups, wild AA derived from OWB and the two other groups mainly from FMAS. FMAS were more important for AA collection than open water bodies (OWB) in all three study sites ($P < 0.001$). However, OWB were more important to some specific groups at each site. In SEC, poor households in DRY areas mainly relied on OWB such as lakes and reservoirs. In NET and RRD, the importance of OWB was higher in LOW areas compared to DRY ($P < 0.05$). The various types of FMAS contributed differently to the total collection of AA from FMAS (section 4.3.1, Figure 4.20) at different sites ($P < 0.001$). Thus, while RF is a more important source in NET, household ponds were more important in RRD. The importance of each FMAS type within sites was also dependent on AEZ and the household's well-being (P <0.05). For poorer households located in the LOW area in SEC, trap ponds were very important as a source of aquatic animals. In contrast, better-off families in the same AEZ relied more on collection from their household pond. Rice fields were an important source of aquatic animals in NET; however, trap ponds were the main source for better-off families in the LOW area. Generally in NET, better-off families collected more AA from trap ponds than poor families. In RRD, culture ponds were the main source of AA. However, rice fields also played an important role particularly for better-off families in DRY areas. The importance of rice fields and culture ponds were similar for poorer families in the LOW area of RRD.

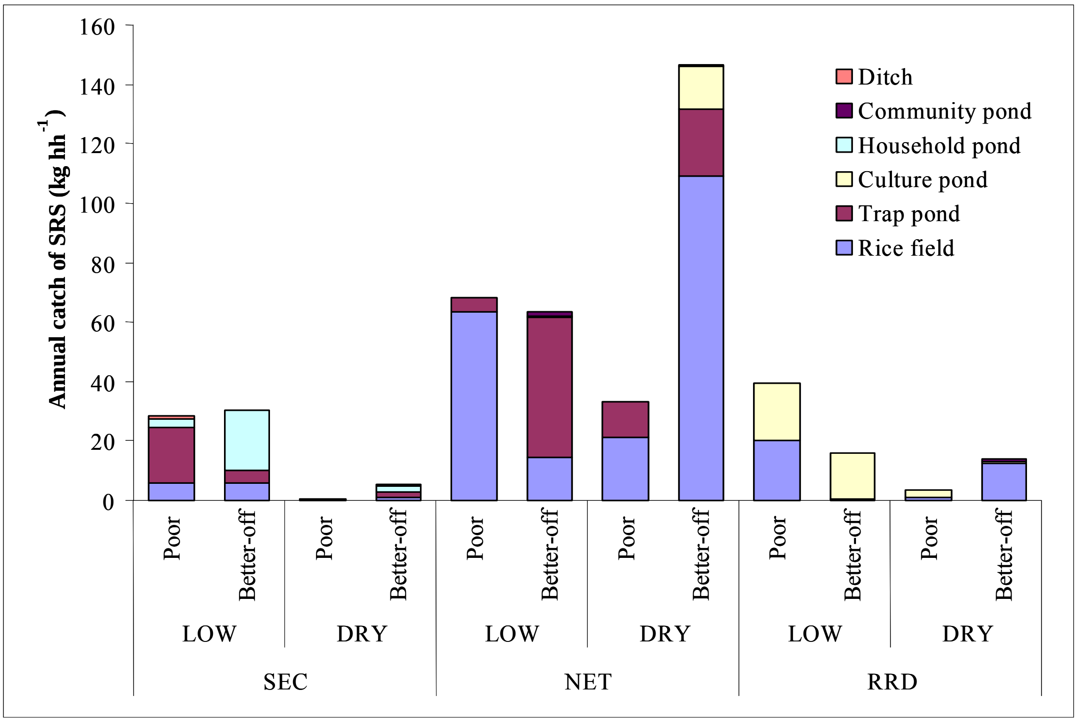


Figure 4.20 Distribution of SRS collected by households with different wealth groups from different FMAS in SEC, NET and RRD. ***Data presented based from the longitudinal study.***[6]

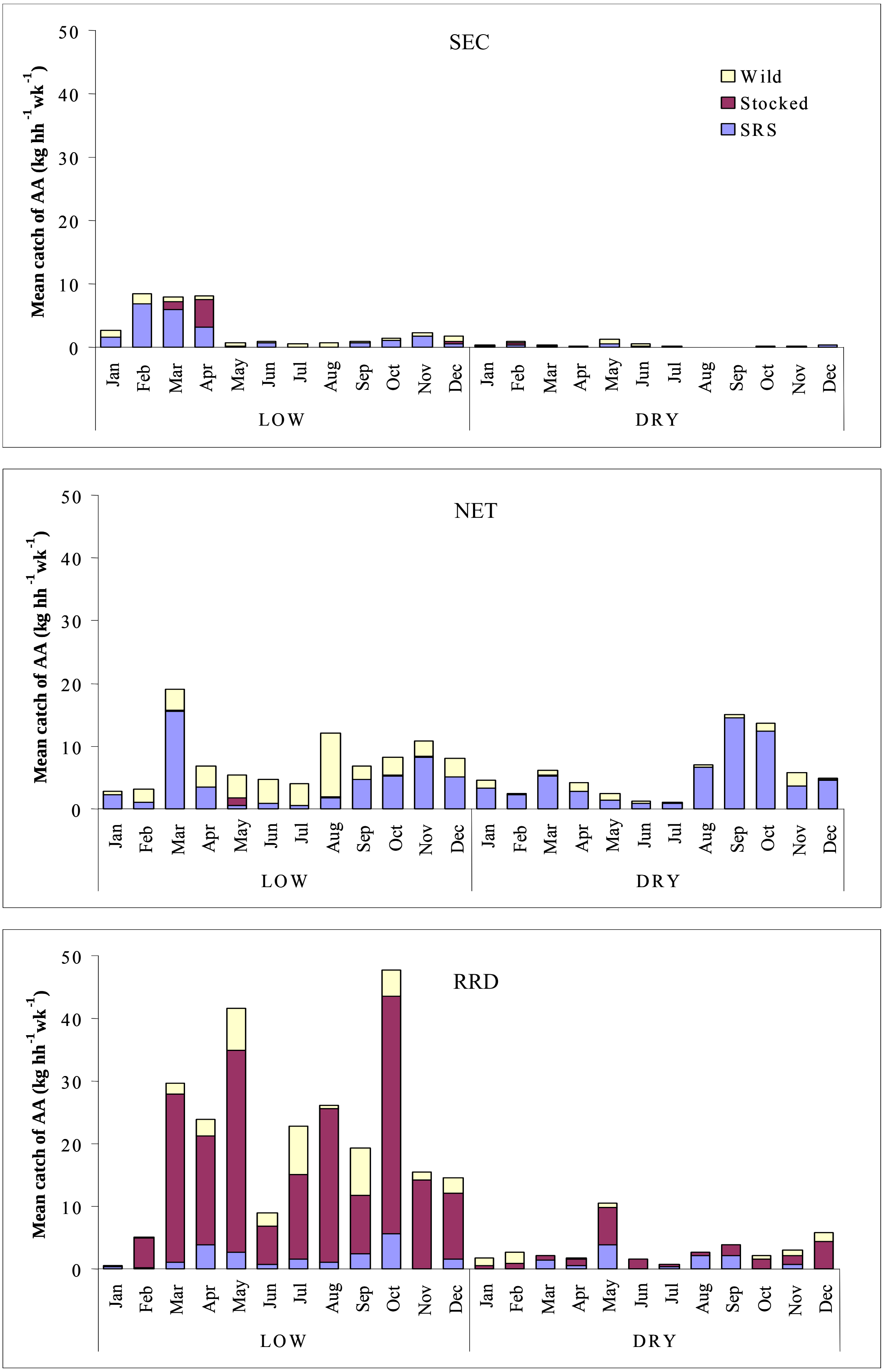
[6] All FMAS types were included in the computation. In the case of no collection in particular FMAS, "0" value was added.

4.3.4.3 Seasonality of AA collection

Generally, the amount of AA collected varied according to season particularly in specific areas within sites (P <0.05), (Figure 4.21). In SEC, mean catch (kg household^{-1}week^{-1}) of aquatic animals was generally low; however, there were three months of intensive collection in February, March and April when most of the trap ponds were drying out and OWB's became shallow, enhancing CPUE. However, this peak was only found in LOW areas whilst the DRY areas did not show the same pattern. Furthermore, there were two months of no collection in this area of SEC. In NET, the harvest peaked in two seasons i.e. rainy season (Aug. to Oct.) and the beginning of the dry season (March). In RRD, the pattern of collection was not the same as in the other two sites. In the LOW areas of RRD, harvests were maintained over a longer period of the year (>6 months). Collection of AA was sustained between March and May, and then again between July and October and the average harvest was significantly higher than the DRY areas (P <0.05). Furthermore, harvests in the DRY areas of RRD only peaked in May. Harvest of aquatic animals continued throughout the year at some level in both NET and RRD.

The seasonal contributions of different groups of AA also varied (Figure 4.21). The contribution of SRS was high at times of peak harvest in SEC. Furthermore, this group of AA was available throughout the year particularly in LOW areas of this site. In NET, the contribution of SRS to total harvest varied between months (<20% - >90%) but was generally high compared to other AA groups. Wild AA dominated catches from May to August in LOW areas however. In RRD, the proportion of stocked AA to total harvest was generally high throughout the year. In contrast SRS and wild AA contributed little at this site.

Figure 4.21 Seasonality of mean catch (kg household^{-1}week^{-1}) of AA from aquatic resources in different AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***



4.3.4.4 Diversity of harvested aquatic animals[7]

The actual number of types of AA collected in the study sites is presented and analysed in this section. Figure 4.22 illustrates how the three sites differed in terms of the total number of species collected during the 12 months longitudinal study. In all three sites, the total number of AA segregated by group (SRS, stocked and wild) were higher than the total number per site mainly because there were certain types of AA that were classified in both groups based on the location of collection. For instance, *Channa* spp. can have two categories; wild, if it was collected from OWB and SRS if farmer collected it from their FMAS. There were also stocked AA that can be identified as SRS (e.g. carps and tilapias in the rice fields).

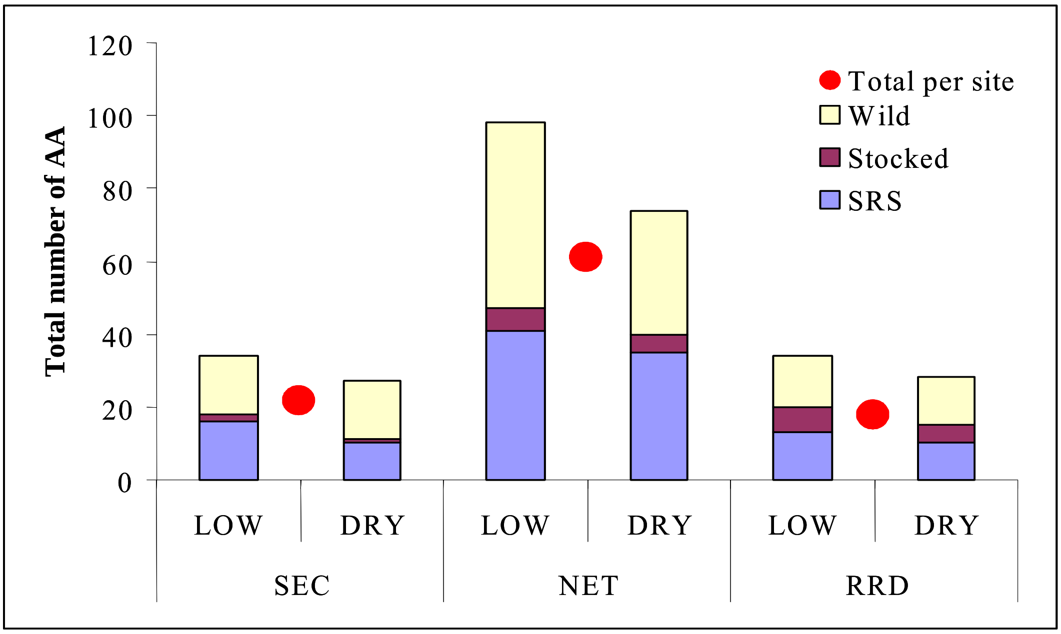


Figure 4.22 Total number of AA caught in different AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study***.

Overall, the diversity of harvested species was significantly different at the three sites (P <0.001). NET had the highest number of AA species (61 species) collected

[7] Identification of species followed the report of Amilhat (2006) who was responsible on the ecological part of the SRS project (R7917).

compared to SEC (22 species) and RRD (18 species). Between AEZ, particularly in SEC and NET, differences in the number of species from each AA group was significant ($P < 0.05$). The total number of stocked species was relatively small compared to the number of wild species and SRS at both sites in SEC and NET. The number of wild types/species was generally higher than the other types of aquatic animals but not significantly different from SRS.

The total number of AA caught at each site varied through the year. As presented in Table 4.7 relatively few species were collected over the whole year or even over a period of 6 months. In the LOW area of SEC, seven species were available throughout the duration of the monitoring and the DRY area of RRD had the least number of species (2) year round. However, the number of species of aquatic animals available for at least 6 months was higher at all sites, especially the low area of NET that had more than double that reported in SEC and RRD (27 species compared to 12 and 10 respectively). In the DRY area, both SEC and RRD had two species available throughout the duration of the monitoring. In NET, however, five species were available throughout the year. All DRY areas of the three sites had four species of AA that were available for at least 6 months of the year.

Table 4.7 Total counts of AA types/species that were available throughout the year.
Data presented based from the longitudinal study.

	Agro ecological zones	
Study sites	**LOW**	**DRY**
SEC	7 (12)	2 (4)
NET	4 (27)	5 (4)
RRD	3 (10)	2 (4)

Note: Data in parenthesis indicate the number of aquatic animals that were available at least half of the year (6 months) excluding those that were available year round.

In the LOW area of SEC, the species that were available for the whole duration of the monitoring were; *Channa* spp*.*, *Clarias* spp*.*, *Mystus* spp*.*, *Rasbora/Esomus, Anabas testidenus,* and a non-fish AA, *Macrobrachium* spp. Both *Anabas testidenus* and *Macrobrachium* spp. were also available in the DRY area of SEC during the whole period of the monitoring.

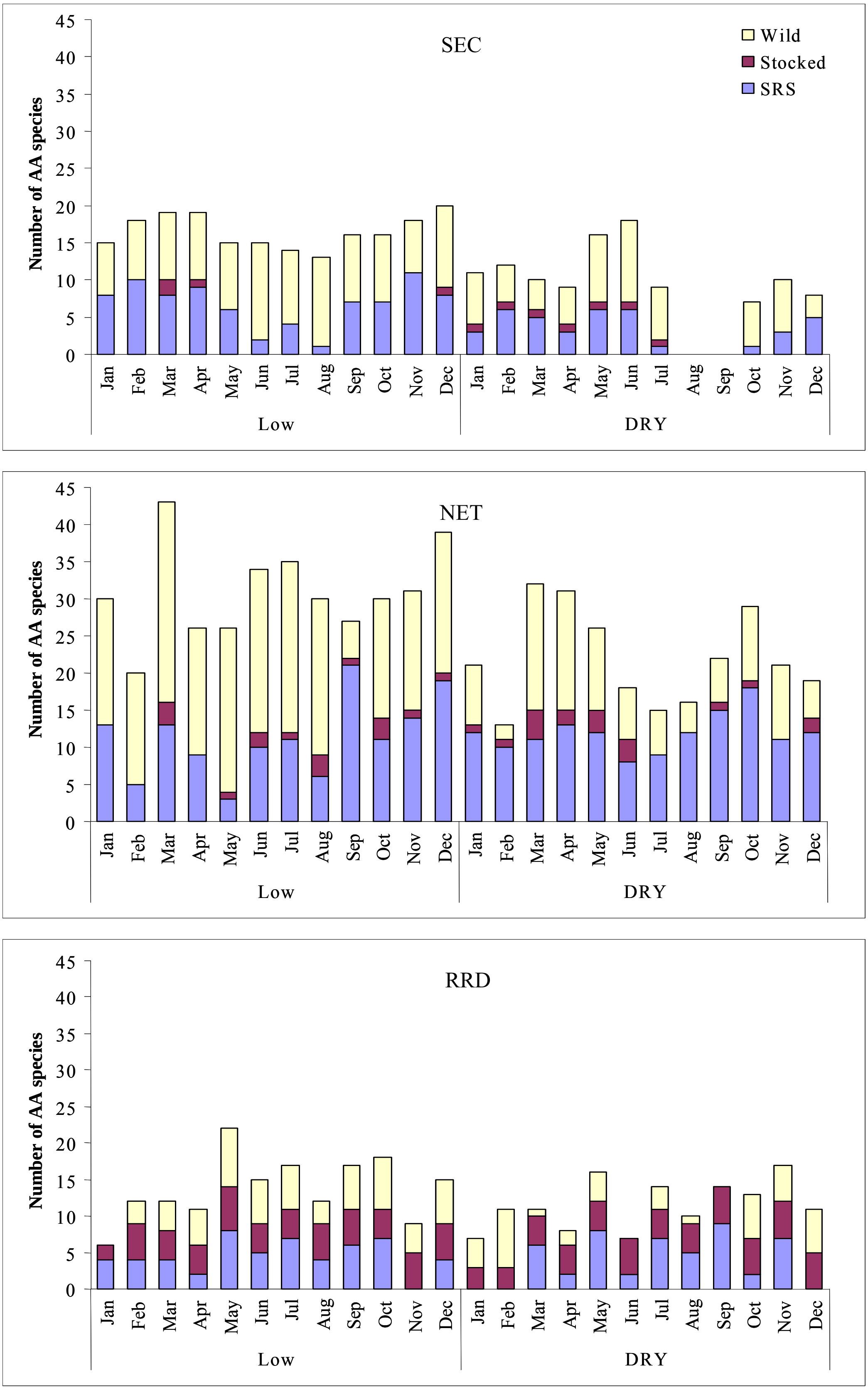
The type/species that were available in LOW and DRY areas of NET have some similarities, such as *Channa* spp. and *Anabas testidenus*. Aside from the two main species, *Osteochilus hasseltii* and *Barbonymus gonionotus* were available in the LOW area*. Clarias* spp., *Puntius* spp*.*, and non-fish species *(Rana* spp*.)*, were also available throughout the year in DRY area of NET.

The species that were available throughout the year in RRD were mainly carps. The composition of these species were as follows: *Cyprinus carpio, Ctenopharyngodon idella, Cirrhina molitorella* and *Carassius auratus. Anabas testudineus* and *Hypophthalmichthys molitrix* were both available for 11 months of the year.

4.3.4.5 Seasonality in diversity of harvested aquatic animals

In general the diversity of AA caught varied significantly through the year at all three sites ($P < 0.05$) (Figure 4.23). In the LOW area of SEC, the number of AA species peaked during the months of February to April and September to December. However, these peaks were not observed in the DRY area of SEC where the species abundance peaked at the onset of the rainy season (May to June). August and September were months where no collection of AA was recorded in the DRY area.

Figure 4.23 Seasonality of the total number of AA species caught throughout the year by AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***



In NET, although the number of AA caught was generally high, there were still months when the number of aquatic animals collected was low, particularly in the month of February (LOW) and July to August (DRY). The periods when collected AA were more diverse were February, June to July, and December in LOW areas of NET. In the DRY area of the same site, March to May and October were the period of the year where more diverse AA was observed.

The diversity of AA harvested in the RRD was generally low compared to the other sites, although there were seasonal increases in both AEZs. In the LOW area, the number of AA species was high between May to July and September to October. In the DRY area, there was no continuous period when AA collection was diverse. Overall, January was the period when the harvest of AA had the least species diversity in both AEZs. Variation in the diversity of SRS caught over time was observed in all sites ($P < 0.05$).

4.3.4.6 Composition of caught SRS from FMAS

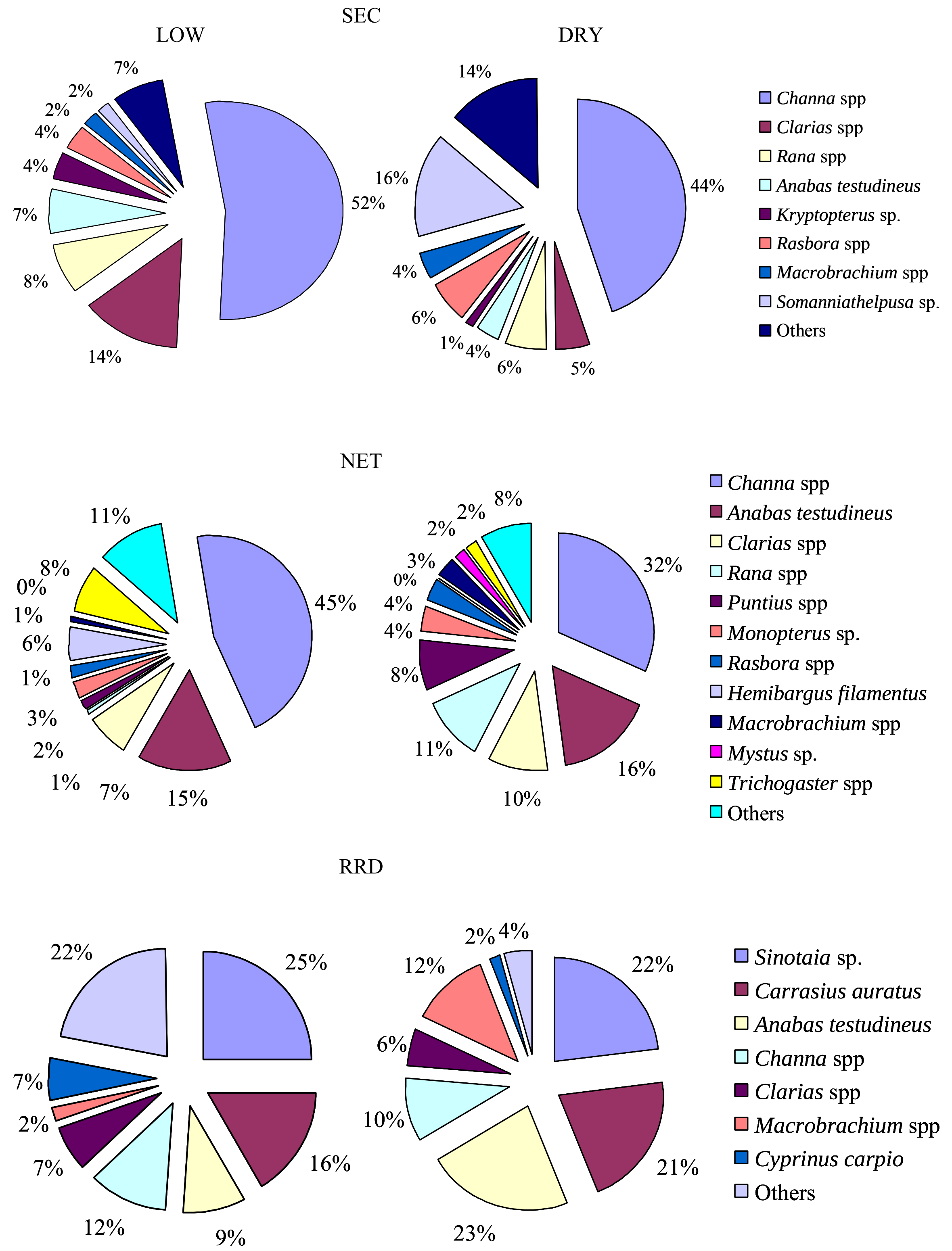
Based on the total weight of the SRS caught during the monitoring period, the composition of SRS was understood (Figure 4.24). The figure illustrates the percentage contribution of the different species of SRS to the total collected SRS from FMAS in all three sites. Species of SRS that were found to be dominating the rain-fed system in SE Asia were: *Channa* spp., *Clarias* spp. *Anabas testudineus, Rana* spp., and the freshwater shrimps. However, the level of importance of these species was observed to be relatively different between sites and AEZ.

There were at least 16 species of SRS identified in LOW areas of SEC and only 11 species in the DRY. Amongst the identified SRS species, *Channa* spp. dominated the catch contributing 52% and 44% of the total weight of SRS caught from LOW and DRY areas respectively. Other species of SRS caught in LOW areas were; *Clarias* spp. (14%), *Rana* spp. (8%) and *Anabas testudineus* (7%). In the DRY area of SEC, *Somanniathelpusa* sp. (16%) was the second larger contributor to the total SRS collection. Both *Rana* spp. and *Rasbora* spp. (6% each) were also considered major parts of the total SRS catch.

Among the three sites, NET has the most diverse SRS caught. Even here however a relatively limited number of species (11 species) contributed most (90%) of the SRS caught during the year. Amongst the main SRS species were: *Channa* spp. (45% from LOW, and 30%, from DRY), *Anabas testudineus* (16% and 15% from LOW and DRY respectively) and *Clarias* spp. (10% and 7%, LOW and DRY respectively). Other species that are important in LOW and DRY area of NET were Gouramis, *Hemibagrus* sp., *Monopterus albus, Rana* spp., *Puntius* spp., *Rasbora* spp., *Macrobrachium* spp., *Hampala dispar,* and *Mystus* spp.

RRD had the fewest SRS species collected during the monitoring with only 14 species and 11 species identified from LOW and DRY area respectively. Eight species contributed to over 80% of the total SRS catch.

Figure 4.24 Composition of SRS caught from FMAS in the different AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***



4.3.4.7 Sizes of aquatic animals

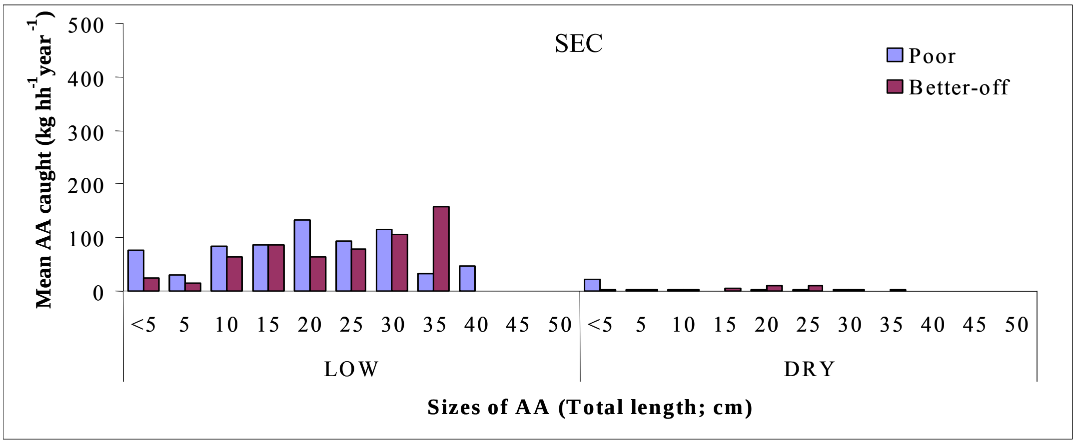
Using the "stick and bowl" technique (Garaway, 1999), the different size of AA collected were determined. This section illustrates what sizes of AA were caught and utilised. Information presented in this section was extracted from the AA collection section of the longitudinal study.

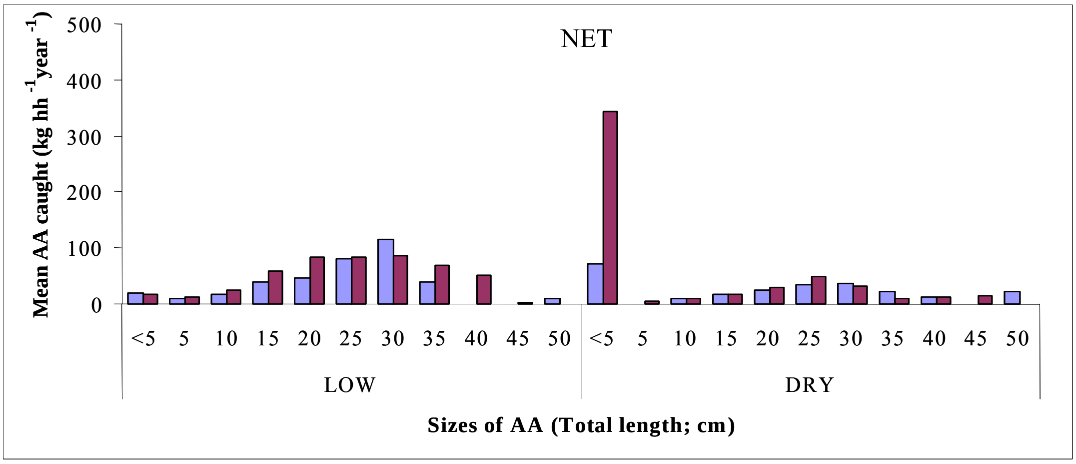
Distribution of sizes of aquatic animals caught

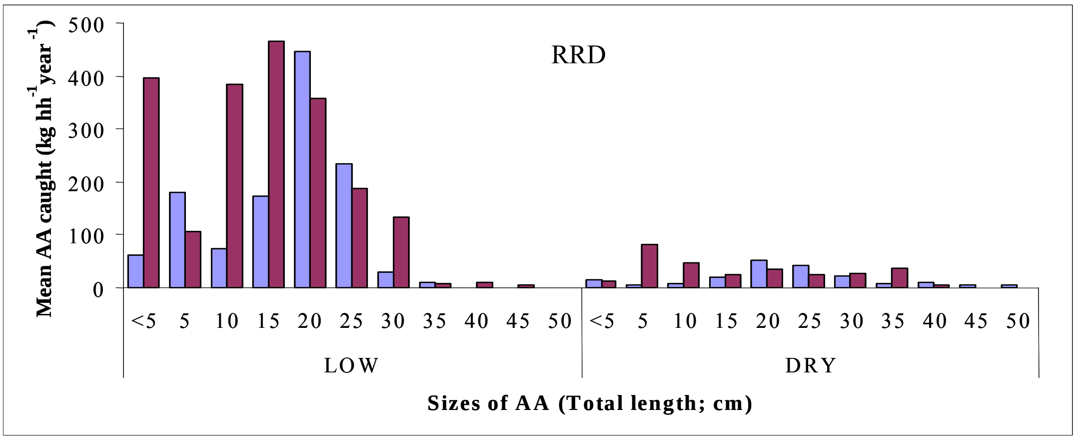
Figure 4.25 illustrates the distribution of AA caught by farmers of different well-being groups in the three sites by size categories. The smallest AA caught were less than 5 cm in total length (TL) which also included non-fish species like freshwater shrimps, crabs, and snails. The largest (TL) recorded was more than 50 cm.

In SEC, poor households frequently caught AA that are not bigger than 10 cm while better-off households in both AEZ caught AA ranging from 5 cm to 15 cm. In NET, the most frequently collected size of AA ranged from less than 5 cm to 25 cm. Slightly bigger AA were more frequently caught (<5cm to 30cm) in RRD (Figure 4.25). Overall the size of AA caught by households in SEC was smallest while households from RRD caught the largest size of AA. Small sized AA collected in SEC were more likely to be fin fish. The mean weight of AA caught by various sizes is presented in Figure 4.25. This was found to be significantly different between AEZ at each site, with larger harvests of each size class in the LOW area than in the DRY ($P < 0.05$). The average total weight of particular size classes was found to be significantly different between sites ($P < 0.001$). RRD had the highest average meanwhile NET had the least. Differences between well-being groups were only observed in households in the LOW area of RRD where the mean harvest of smaller sized AA was greater by poorer than better-off families.

Figure 4.25 Sizes of aquatic animals commonly collected from different FMAS in by AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***



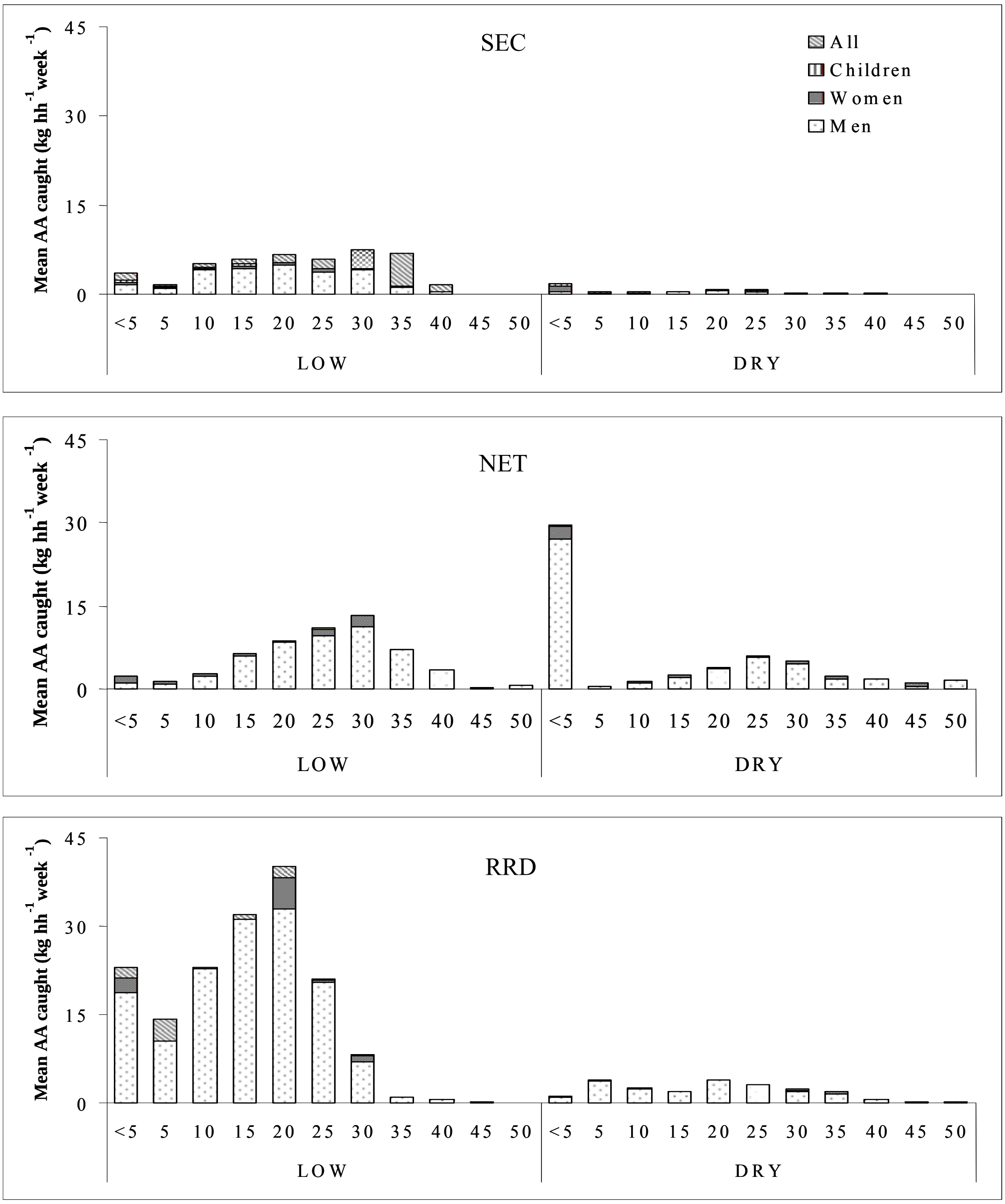




Age and gender variations in collecting different sizes of aquatic animals

The following section presents information regarding the individual size of AA caught by different age and gender groups.

Figure 4.26 Mean weight of AA at different sizes (Total length; cm) caught by different age and gender group of households in FMAS at the three sites. ***Data presented based from the longitudinal study.***

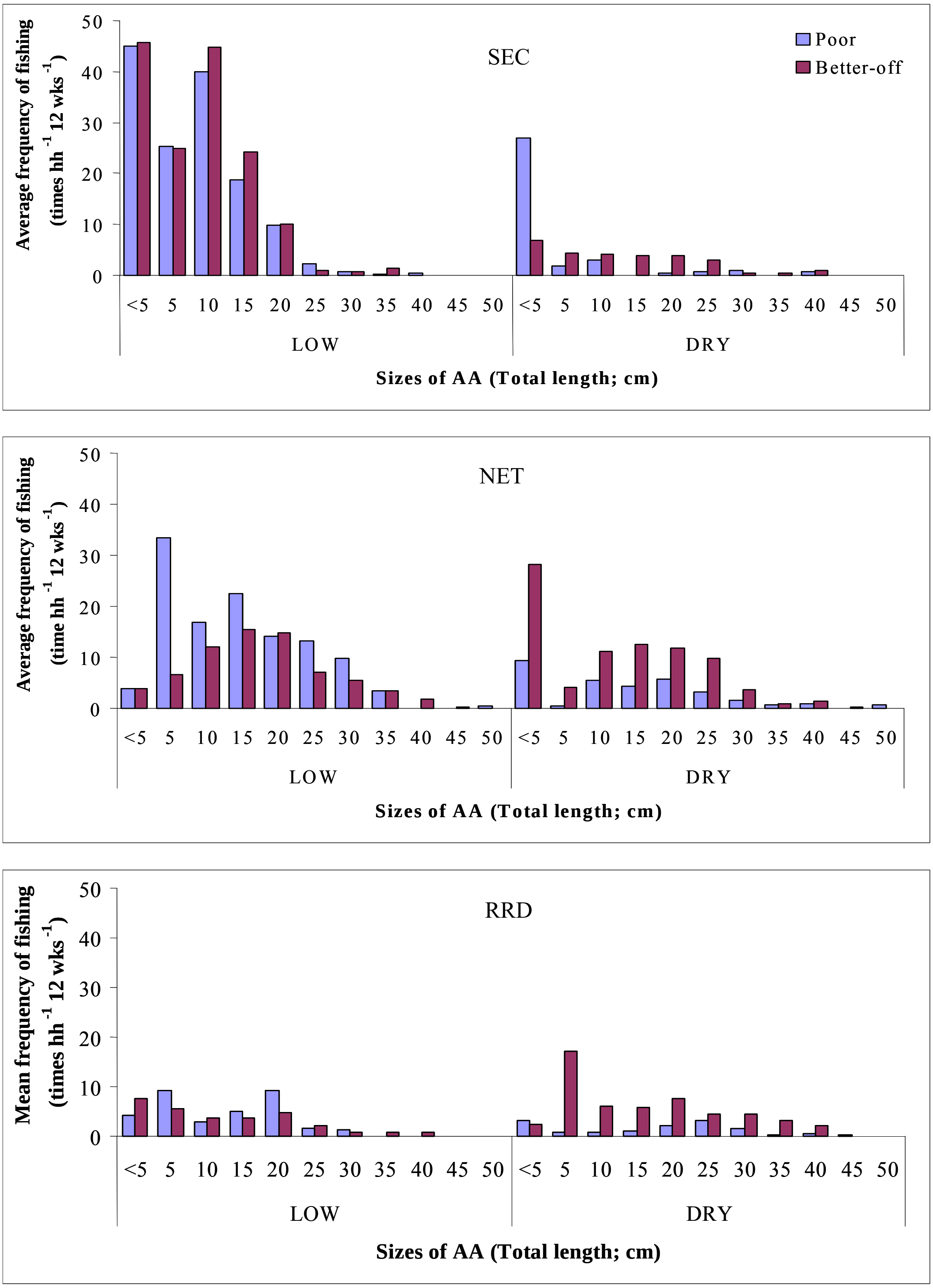


The harvest of AA is a male dominated activity (section 4.3.4), and men collected AA across a range of sizes (<5 cm to >50cm). There was no size class of AA that was specific to any age or gender group in terms of collection. The mean harvest weight of AA by age and gender group was significantly different between sites (P <0.05; Figure 1.27). In the LOW area of SEC, group collection, i.e. both male and female members including children, was most important for the collection of 30 cm – 40 cm sized AA while in contrast men mainly harvested all sizes of AA in DRY areas. However, women in the DRY areas of SEC collected more of the smallest sized AA (<5 cm). In NET, collection of AA of different sizes was mainly in the male domain apart from the harvest of small (≤5 cm) AA in the LOW areas where women played a significant part. In RRD, men dominated the harvest of AA of all sizes.

Mean frequency of collecting different sizes of aquatic animals

The mean frequency of collecting certain sized AA was not affected by wealth group (P >0.05; Figure 4.27). There were significant differences in the size category of AA caught by AEZ at each site. In SEC, the frequency of harvesting small AA was higher in the LOW area than in the DRY, particularly for AA smaller than 5 cm. In NET, the frequency of harvesting AA smaller than 5cm was higher in the DRY zone compared to the LOW (P <0.05). For the other size categories, the frequency was higher in the LOW area. There was no difference in the frequency of harvesting aquatic animals of different size categories in RRD.

Figure 4.27 Mean frequency of collecting different sizes of aquatic animals by household in different wealth groups and AEZ of SEC, NET and RRD. ***Data presented based from the longitudinal study.***



Relationship of mean catch of aquatic animals to number of species, household size (adult equivalent unit)

Figure 4.28 and Figure 4.29 show the results of regression analysis made to assess the relationship of mean annual catch of AA (includes all AA types i.e. SRS, stocked, and wild) with diversity and household size (adult equivalent unit). The mean annual catch of AA was positively related to the number of species exploited (Figure 4.28). The mean harvest of AA tended to increase as the number of species exploited increased ($r^2 = 0.45$, $P < 0.01$).

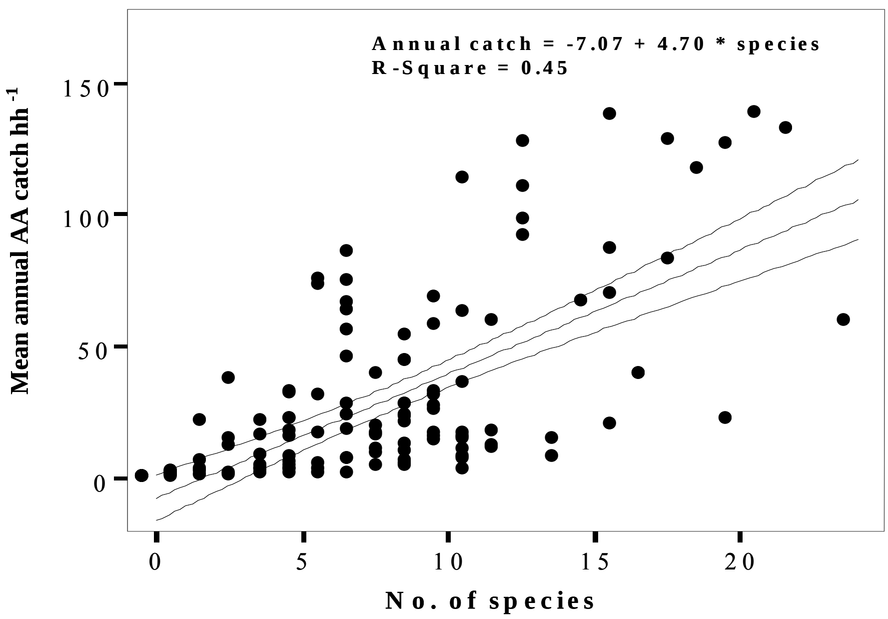


Figure 4.28 Relationship of number of species collected to the amount of AA catch.
Data presented based from the longitudinal study

Although the association between the annual harvest of AA and the average AUE was found to be significant ($P < 0.05$), there was a very weak relationship ($r^2 = 0.20$) found between mean annual harvest of aquatic animals and the number of adults in the households as shown in Figure 4.29. The mean harvest of AA tended to increase as the number of species exploited increased.

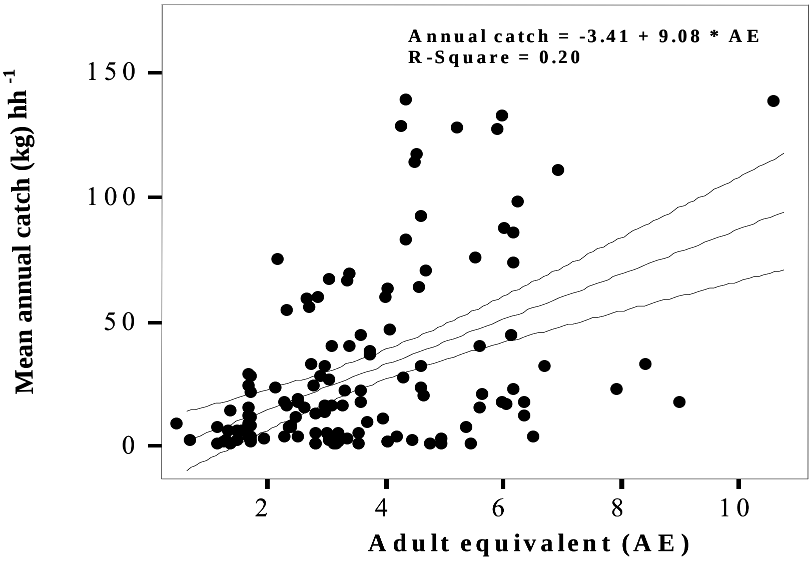


Figure 4.29 Relationship between the total catch of AA to AE (adult equivalent) of households. ***Data presented based from the longitudinal study.***

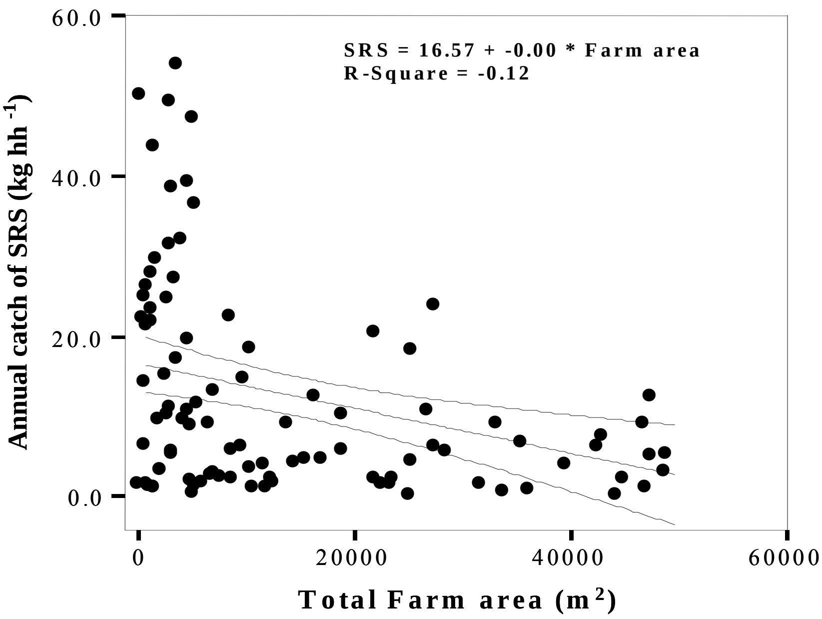


Figure 4.30 Relationships between annual catch of SRS and total farm area (m^2). ***Data presented based from the longitudinal study.***

The annual catch of AA and the total farm area were found to be significantly associated (P <0.05, Figure 4.30). However, there was a very weak correlation between the two variables (r^2 = -0.12), perhaps explained by a reduction in effort collecting AA as the managed area increased. Households with more land were also likely to have more diversified assets requiring management.

4.3.4.8 Fishing effort (FE)

Figure 4.31 illustrates the mean fishing effort by different well-being groups in AEZ of the three sites. Generally, the FE is high in NET (1.01 hr $hh^{-1}wk^{-1}$ ± 2.25 SD) compared with SEC and RRD (0.53 hr $hh^{-1}wk^{-1}$ ± 1.16 SD and 0.41 hr $hh^{-1}wk^{-1}$ ± 1.36 SD in SEC and RRD respectively). The difference in the mean FE between sites was found to be significant (P <0.05). Differences between well-being groups were also found to be significant (P <0.05), where poorer households spent less effort in fishing (0.55 hr $hh^{-1}wk^{-1}$ ± 1.37 SD) compared to better-off households (0.73 hr $hh^{-1}wk^{-1}$ ± 2.00 SD).

In addition to the main effects presented, there was significant interaction between site, well-being group and type of water body (P <0.05) for FE. Better-off households from the DRY area of NET and the LOW area of RRD spent more time harvesting AA in FMAS compared to open water bodies (OWB). On the contrary, poorer households in the DRY area in SEC and the LOW in NET used more time exploiting in OWB.

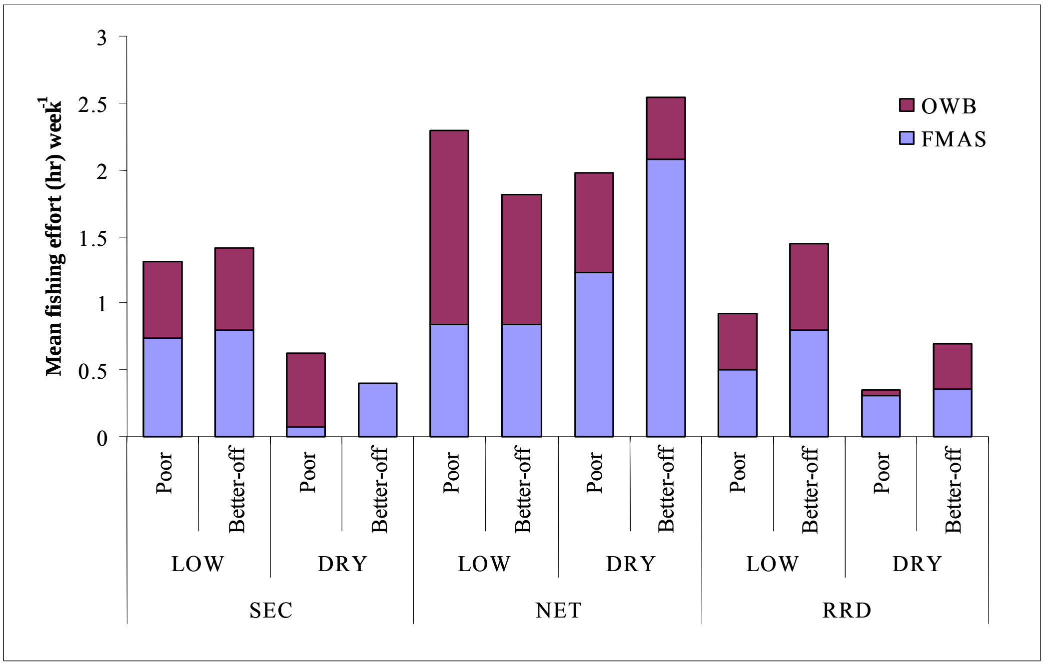
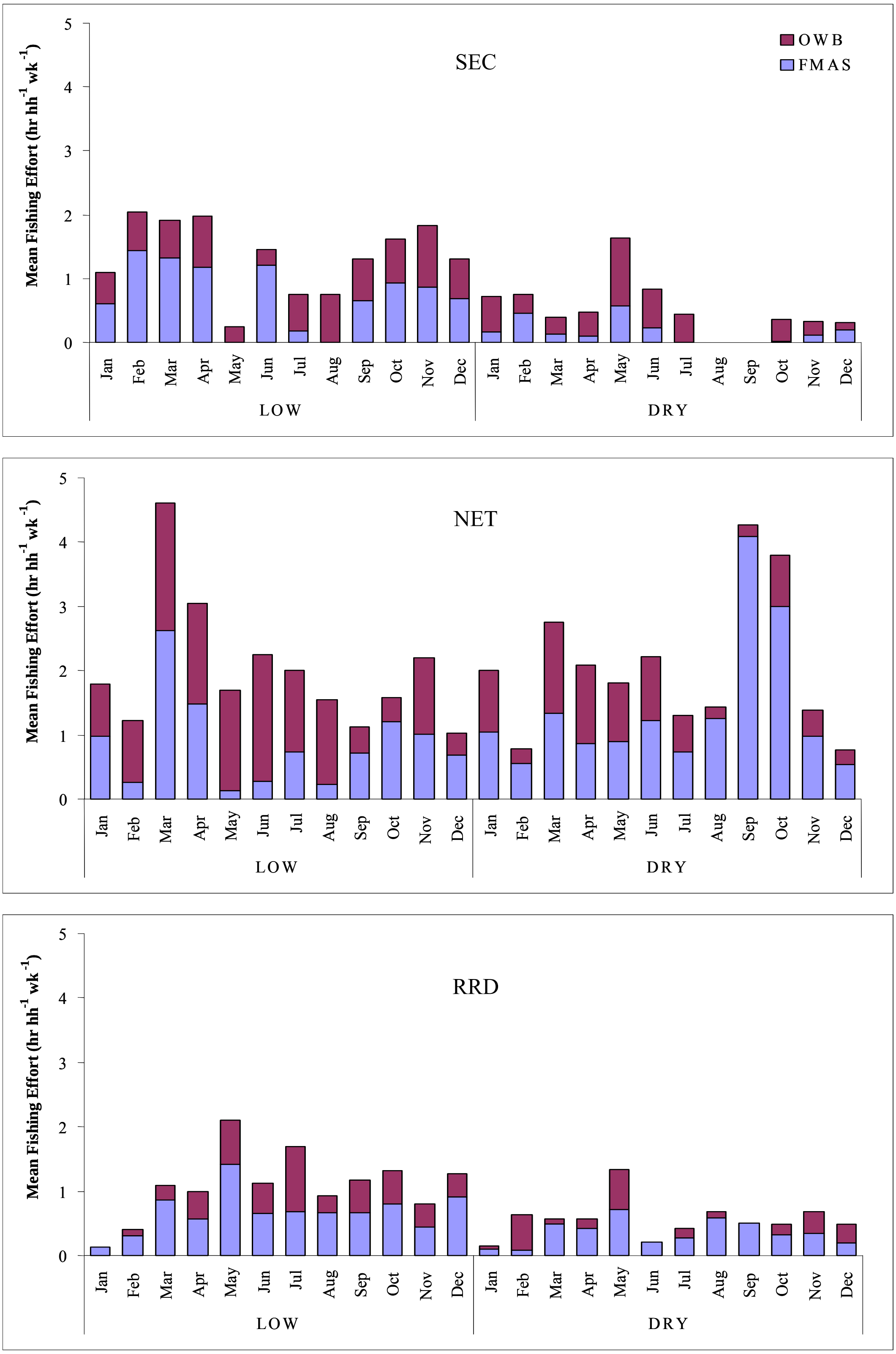


Figure 4.31 Comparison on average household fishing effort (hrs^{-1}wk^{-1}) spent on fishing. ***Data presented based from the longitudinal study.***

Seasonality of fishing effort (FE) (FMAS vs. OWB)

The FE of households from different AEZ in harvesting AA (hr hh^{-1}week^{-1}) showed seasonal variation and interesting differences between site and AEZ (Figure 4.32). Such fishing effort (FE) clearly changes through the seasons ($P < 0.05$). This change of FE is very obvious in SEC; for two months (August and September in DRY) no harvest occurred. In NET, the months of February and December in both LOW and DRY areas were times of lowest effort in both AEZ. January was the month of lowest fishing effort in RRD.

Figure 4.32 Seasonality on fishing effort in different types of aquatic systems (FMAS vs. OWB) in SEC, NET and RRD. ***Data presented based from longitudinal study***



Differences in the time spent exploiting open water bodies and FMAS during the seasons were also significant (P <0.05). However this result was found to be site and AEZ specific only. In SEC, the FE in OWB was highest in the LOW area, during the months of May, July, and August whereas effort in FMAS was more consistent throughout the year. In contrast, FE for OWB was high relative to FMAS in the DRY area throughout the year. In NET, the effort exploiting FMAS was relatively high compared to OWB throughout the year in the LOW areas. In the DRY zone, however; some periods of the year were observed to have higher FE in the FMAS than in OWB (September to January). In RRD, in most of the months, FE was relatively low compared to SEC and especially NET except the month of May and July in the LOW area and only in the month of May in the DRY area. Comparing the effort in exploiting FMAS and OWB in RRD, FE was relatively high in harvesting AA in FMAS in the LOW area except the month of July. In the DRY area of RRD, FE in OWB was only high during the month of February.

Age and gender differences in fishing effort

The contribution of the different household members from different wealth groups and AEZ to the average time spent in collecting AA is presented in Figure 4.33. Male members of the household contributed more time for collecting/harvesting AA except those from poor households in the DRY area of SEC where women contributed significantly more time. The interaction between AEZ, well-being group and gender-age group was found to be significant (P <0.05). This means that household members of the same wealth rank in different AEZ invested different amounts of time for collecting/harvesting aquatic animals.

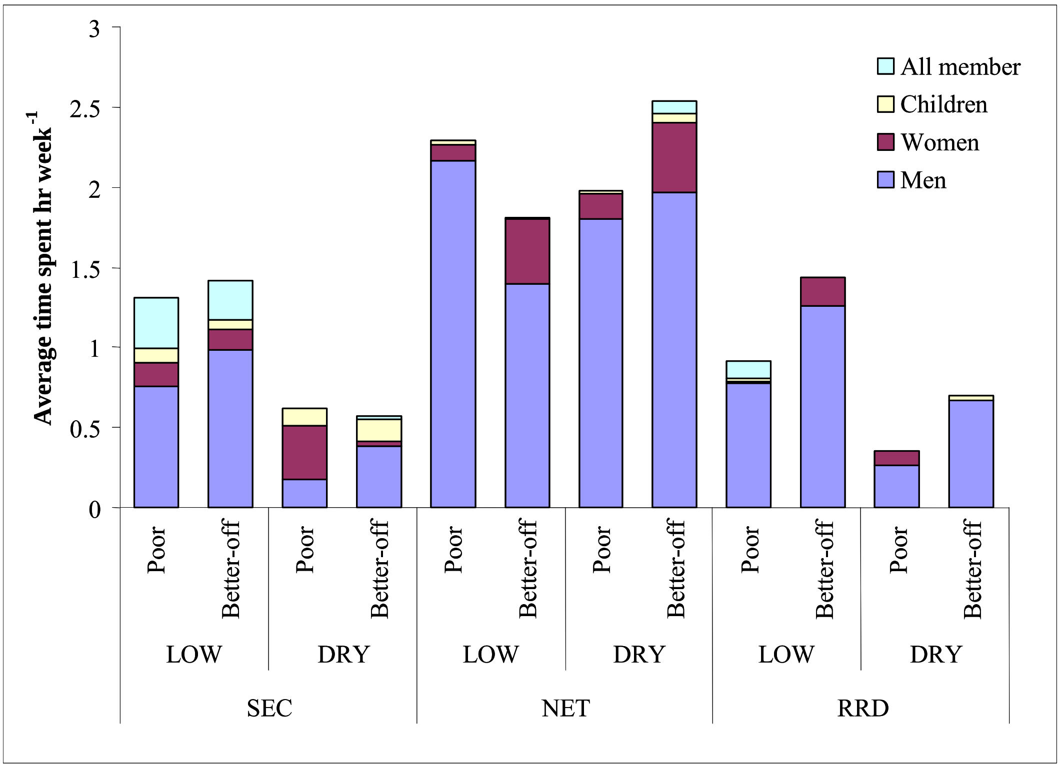
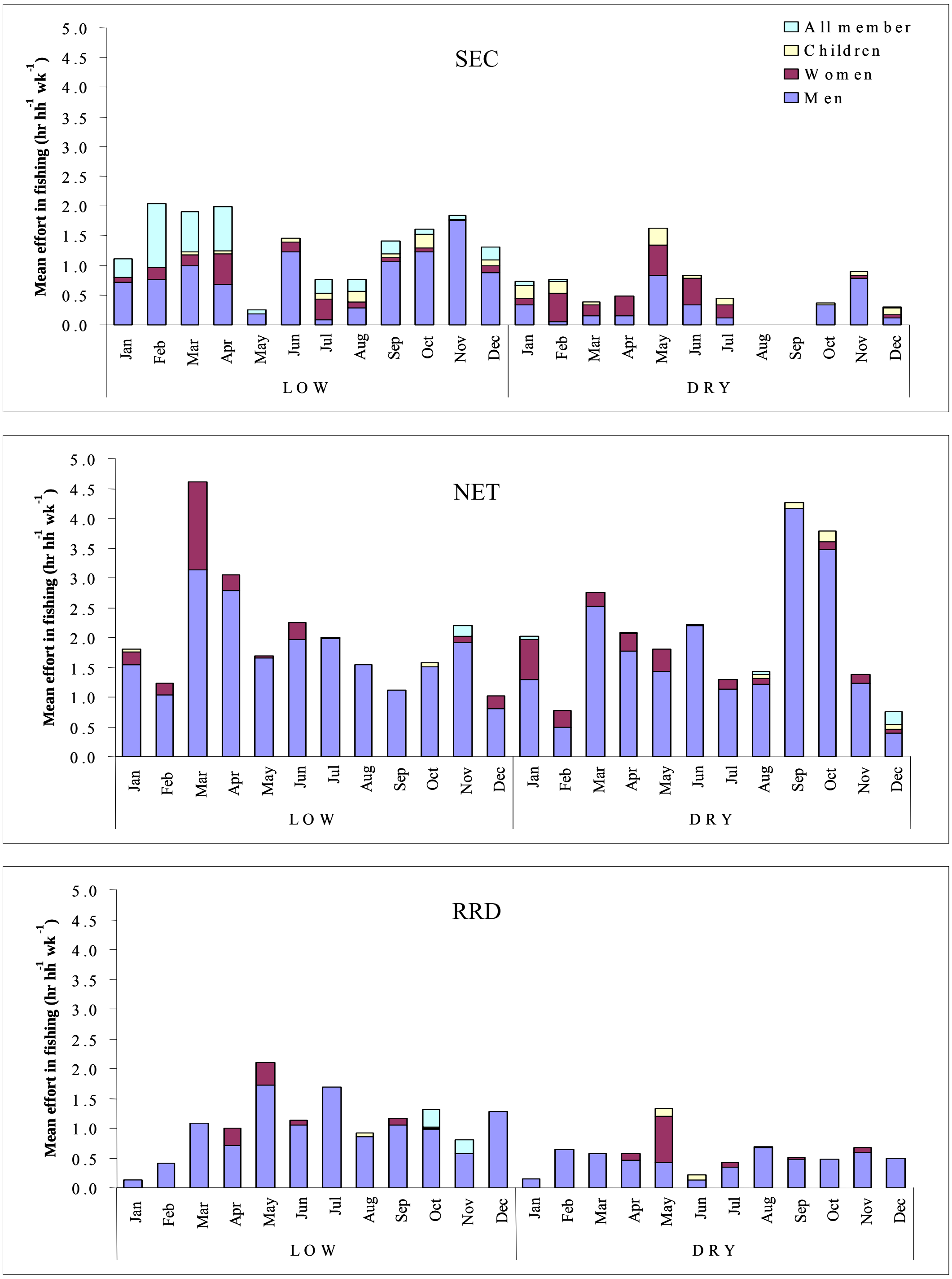


Figure 4.33 Comparison of fishing effort (time spent in hour^{-1}week^{-1}) by household members from different AEZ and wealth groups of SEC, NET and RRD. ***Data presented based from longitudinal study.***

The contribution of different household members varied significantly between sites (P <0.05). In SEC, particularly in the LOW area, group harvest of AA by household members was more important than elsewhere. Children's contribution was important in SEC but not in NET and RRD.

The seasonality of FE by different gender and age group of the households is presented in Figure 4.34. Analysis did not show any significant difference between fishing effort by different age and gender groups of the households; however, seasonal differences by AEZ were significant (P <0.05).

Figure 4.34 Seasonality of household's fishing effort (hr hh^{-1}week^{-1}) for different gender and age groups in two AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***



Although the statistical analysis did not find any significant difference (P>0.05) in the seasonality of fishing effort by gender and age groups, Figure 4.34 shows that the contribution of women and children in collecting AA particularly in SEC where relatively important during the months of April and July in the LOW area and February to April, and June to July in the DRY area. The contribution of children in SEC was relatively high in the months of July to August and November in the LOW area. In contrast, children fished most in the DRY area during the months of January to February and May. Women mainly participated in fishing during the month of May in RRD. During this time, hours spent in agricultural activities were low and women had extra time to participate in fishing activities.

Catch per unit effort (FMAS vs. OWB)

Figure 4.35 illustrates the differences in catch per unit effort (CPUE) of households of different well-being groups and AEZ at the three sites. In general, the CPUE is significantly different among sites ($P < 0.001$). Households in RRD have a CPUE more than 5 fold higher (2.8 kg $hh^{-1}week^{-1} \pm 21.6$ SD) than in the SEC CPUE (0.5 kg $hh^{-1}week^{-1} \pm 2.2$ SD), with NET being intermediate. CPUE was higher in LOW than DRY by almost 100% (2.2 kg $hh^{-1}week^{-1} \pm 16.9$ SD and 1.2 kg $hh^{-1}week^{-1} \pm 5.5$ SD, LOW and DRY respectively; $P < 0.05$) as well as the aquatic system i.e. FMAS than OWB (by a factor of 4) (2.8 kg $hh^{-1}week^{-1} \pm 18.2$ SD , 0.7 kg $hh^{-1}week^{-1} \pm 3.4$ SD, FMAS and OWB respectively, $P < 0.001$). There was no interaction between these factors (AEZ, well-being group and aquatic system; $P > 0.05$).

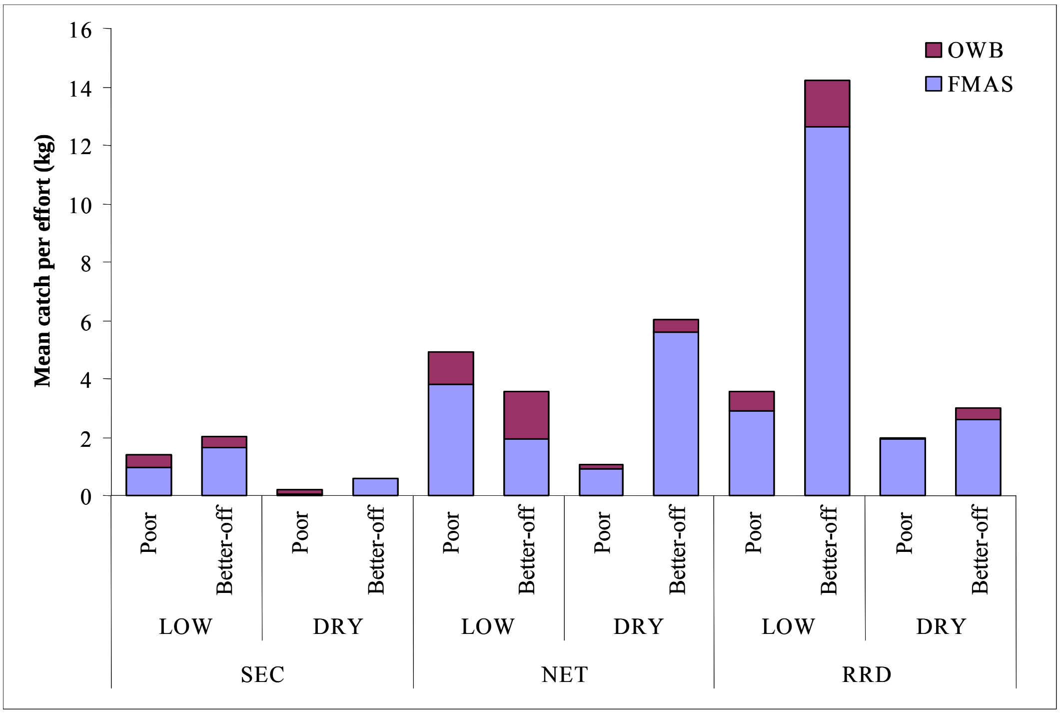
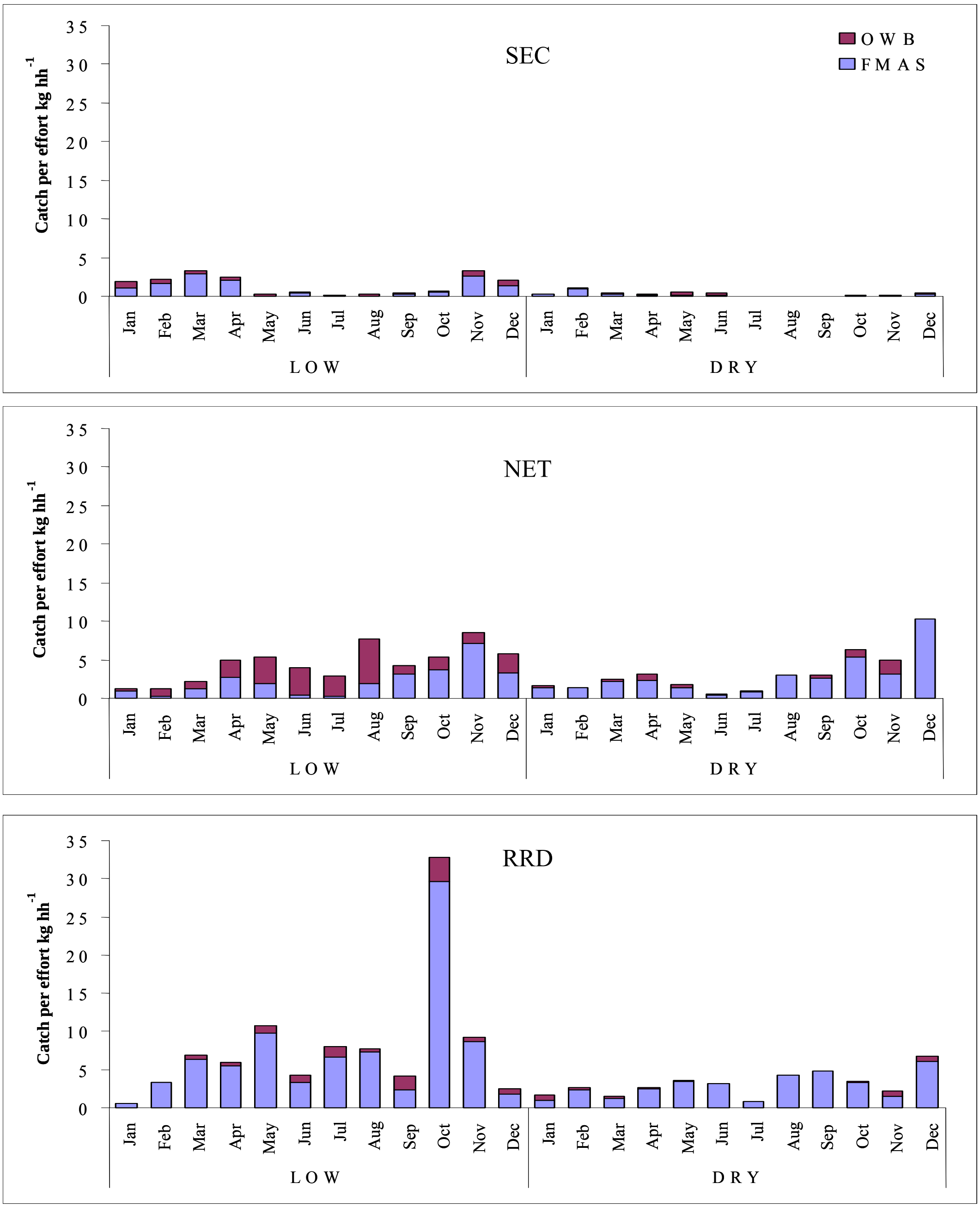


Figure 4.35 Average catch of AA per effort by households by well-being and AEZ in the three sites. ***Data presented based from longitudinal study.***

Seasonality of catch per unit effort (FMAS vs. OWB)

Figure 4.36 shows the seasonal variation of mean CPUE (kg $hh^{-1}week^{-1}$) from different aquatic systems (OWB and FMAS) of two AEZ in the three study sites. The interaction between months, AEZ and type of aquatic systems contributed to the variation of the mean CPUE ($P < 0.05$). In SEC, generally, average CPUE was highest during between November and April particularly in the LOW area. In the DRY/SEC however, catches were very low despite considerable effort.

Figure 4.36 Seasonality on the catch per effort of AA of households collecting from two different aquatic systems in AEZ of SEC NET, and RRD. ***Data presented based from longitudinal study.***



In NET, particularly in the LOW area, there appeared to be strong seasonal complementarities between the catch in OWB and FMAS; in months when the CPUE from OWB was high, the mean CPUE from FMAS was low. However, this trend was not found in the DRY area of NET. In both AEZ, CPUE was particularly low during two periods; January to February, and June to July.

In RRD, it is very obvious that the main source of AA was from their FMAS where CPUE was very high compared to CPUE from OWB throughout the year. The mean CPUE was also different between AEZ but like the LOW area of SEC and NET, RRD LOW area also had the highest mean of CPUE as compared to the DRY. Lean months in LOW were January, June and September whilst January, March, July and November were identified as lean months in DRY.

4.3.4.9 Discussion on the harvest of aquatic animals

Harvest of AA in this study covered all sources and types of freshwater aquatic resources. The average CPUE was highest in RRD (5.68 kg hh^{-1} wk^{-1}) whilst SEC had the least (1.03 kg hh^{-1} wk^{-1}). The average CPUE in NET was intermediate. Variations in average CPUE was mainly explained by the dominant production system at each site. For instance, although similar fishing gears (nets and bamboo traps) were used at the three sites, average CPUE was much higher in Vietnam than the other two sites because most harvest occurred in relatively intensive household ponds. On the other hand, households in Cambodia and Thailand harvested more of their AA from more extensive, shallow FMAS i.e. rice fields and adjacent water bodies (AIT/AO, 1998; Gregory and Guttman, 1996 and 2002b; Gregory *et al.,* 1996; Pholwieng, 2001; Saengrut, 1998; Suvannatrai, 2002) and relatively spent more time collecting AA. The average annual catch of AA showed a big gap between the three sites where mean catches in RRD (602 kg household $^{-1}$ year $^{-1}$) were six times higher than average annual catches in SEC (104 kg household $^{-1}$ year $^{-1}$) and double that in NET (384 kg household $^{-1}$ year $^{-1}$). The recorded annual catch of households in SEC in this study was very low compared to other studies. Gregory and Guttman (2002b) reported 380 kg household $^{-1}$ year $^{-1}$ average rice field catch (including adjacent water bodies) by farmers in the southern part of Cambodia, however, they also noted that the variation between areas rich and poor in perennial water resources were wide (158 - 604 kg household $^{-1}$ year $^{-1}$). It can be argue that the large discrepancy on annual catch was brought by the decreasing trend of the abundance of AA in the rice fields or the increasing number of fisherman thereby reducing average catch as reported during the exploratory stage of the research (AFGRP, 2003; Soubry, 2001). Moreover, the timing of data collection can be a factor in this discrepancy. Gregory and Guttman (2002b) evaluated the catch during the period of August to April which was found in the current research to be the peak season for collecting aquatic animals. The period of May to July was found in this study to be the leanest month in terms of AA production, having these three months included in the study of Gregory and Guttman (2002b) may have lowered their estimate of average catch. It also highlights the danger of extrapolating annual production from highly seasonal data. Shams and Hong (1998) conducted another study in another province of Cambodia and reported that the average AA catch was ~482.4 kg household $^{-1}$ year $^{-1}$ but again, the period of collection was during the time when AA production started to increased. In Thailand, the average catch of AA in this study (384 kg household $^{-1}$ year $^{-1}$) was higher than that previously reported by AIT/AO (1998) which was ~ 192 kg household $^{-1}$ year $^{-1}$. Meanwhile, there was no record (household level) of total average catch (all sources) in RRD except those from the conventional aquaculture which makes it difficult to compare. However, MOFI /WB (2004) in Vietnam reported that there was a declining trend on the inland fisheries catch (river, lake, dam and rice fields) which was mainly related to water shortage. Red River Delta is now devoid of fish (natural production) due to extensive flood control and the closure of flood plain fish breeding and nursery areas.

Categorising the composition of catch is another contribution of this research from the previous research where classification was only limited to stocked (harvest from culture pond and rice-fish culture) and wild (collection from natural waterbodies including rice fields).Three groups of AA were identified in this study that mainly composed AA collection, (1) self-recruiting species, SRS, (2) stocked, and (3) wild. The contribution of the different types of AA however varied with site, AEZ and wellbeing. A large proportion of the catch in SEC and NET was derived from SRS (>50% and <80% respectively). On the contrary, the catch in RRD was mainly stocked species (65%). These variations on the proportion of the different types of AA reflected the importance and dependency of households to natural resources and the impact of aquaculture. For instance, in RRD where aquaculture is well established (Luu *et al.,* 2002; MOFI/WB, 2004), the majority of the catch was based on stocked species. Due to the fact that catches from previous studies were only categorised into two groups, comparison is therefore difficult. In Thailand, Middendorp (1992) reported the contribution of stocked and wild AA to fish production in northeast of Thailand and found that only less that 20% was contributed by stocked species and the rest of the collection came from the wild. If compared with the current study, this percentage is relatively high as the contribution of stocked was only recorded at less than 2% in the total collection of AA by househols in NET. This is at least parlty explained by Middensdorp's data being derived from a stocking trial.

The distribution of commonly collected AA by size ranged from less than 5 cm to > 60 cm. At all sites, a large proportion of the catch (> 80%) was in the size range <5 cm to 30 cm especially among poor households. However, better-off households in NET also consumed a large proportion of smaller sized AA (<40%). The study did not look on the reason behind the sizes of AA caught whether it was the preference of the farmers to catch smaller size of AA or it simply reflected availability and thus the status of AA stocks. The latter is likely especially as trends towards small fish were identified during the exploratory stage of the project. Perhaps an advantage of harvesting small AA was the easiness of allocating it to different household members when being consumed considering the fact that most of the households in the rural areas have large household size as recorded in this study. Moreover, Mogensen (2001) and Roos (2001) reported that small aquatic animals are potentially a better source of essential vitamisn and micronutrients need by human body for development than larger individually sized stocked fish.

Harvest of AA mainly occurred in FMAS (80%), which included rice fields, trap ponds, household ponds, culture pond and ditches, and from OWB (20%) i.e. river, streams, canal and lakes. There are various types of system identified in this chapter and their contribution as source of AA were highlighted. Rice fields dominated the overall source of AA in SEC (37%) and NET (63%) for which most of the harvest was SRS rather than stocked species. Similarly, previous research (AIT/AO, 1998; Shams and Hong, 1998; Tana *et al.,* 1994) identified rice fields as one of the main sources of aquatic animals (>60% - <90%). In contrast, culture ponds dominated the source of AA in RRD (>55%). Trap ponds was also a major source of AA particularly of the SRS consumed by poor households in SEC and both wellbeing groups in NET (>30%).

The amount of AA harvested was greatly affected by seasonality especially in RRD (1.1 – 26.05 kg hh $^{-1}$ week $^{-1}$). Amongst the study sites, SEC had the least seasonal variation of AA collection. The small range of variation can be explained by the variety of sources of AA in SEC as well as NET. Shams and Hong (1998) reported that rainfall was considered the most important factor for the production of wild fish and claimed that the particularly low estimates of production in their study might be explained by the poor (ie dry) wet season during the conduct of their survey. Furthermore, Shams and Hong (1998) identified the month of August as the leanest month of production. However, in the current research, the lean season lasted for almost three months starting from the mid of the dry season (May) until the beginning of the rainy season (September). In Thailand, the months of January, April to July were noted to be the lean season of production and this season was found to be similar to that reported by Suvannatrai (2002) from the research conducted in a similar region of northeast Thailand. Meanwhile, households in RRD only collected AA either from their own household ponds or from the river thus causing a relatively great variation due to specific harvest times (almost every three months).

In general, the harvest of AA was predominantly a male activity, where men regardless of wellbeing, agroecological zones and intensity of aquaculture practices spent more time (> 90% of the total time) harvesting or collecting AA than women and children in the households. However, women's contribution should not be neglected as most of the time, their catch was used directly for subsistence. AIT/AO (1992) reported the male dominance of fishing in northeast Thailand, although women participated in collecting/harvesting AA, their main task was in feeding cultured fish. Fishing activity however is considered a family activity in some households in Cambodia where the time spent by the family together collecting AA was relatively high compared to other sites. Shams and Hong (1998) reported similar trend where men contributed the most time in collecting AA (>60%) however, children's contribution was relatively higher (30%) than the findings of the current report. This low percentage of women contributing to the total catch maybe due to the location of the aquatic systems in the study area as there were few reports suggested that females contributed more when the aquatic resource was located close to the homestead (Navy *et al.,* 1996).

The important SRS species were also highlighted in this chapter based on its contribution to the total production. Amongst the important species were *Channa* spp., *Clarias* spp., *Rasbora* spp., *Rana* spp., *Anabas testidenus*, Indian carps, *Macrobrachium* spp. and *Carassius auratus*. These species were also reported to be important by other workers although the order of importance was different. For instance, Shams and Hong (1998) reported *Channa* spp., *Clarias* spp., *Anabas* and *Rasbora* spp., snail, crabs and shrimp as the most important contributors of the total catch (by weight) in Cambodia. Suvannatrai (2002) identified similar AA species to be important in northeast Thailand as the current study.

4.3.5 Utilization of aquatic animals

The main purpose of this section was to adequately understand the factors affecting the utilization of AA caught from different aquatic systems in the study area based on the longitudinal study. Varying approaches to utilizing harvested AA as well as the differences among socio-economic groups and AEZ are presented in this section. The amounts and percentages of AA being utilized and how these changed through the seasons are also analysed and presented in this section.

There were significant differences in importance of the four approaches to utilizing AA at the three sites ($P < 0.05$). These approaches were (1) consumption fresh by the household, (2) sale, (3) processed i.e. preserving through fermentation and drying (for later consumption), and (4) gifted to relatives or other people (Figure 4.37). All households from all well-being groups in the two AEZ at each study site consumed some of the AA they caught but in varying proportions. In general, NET had the highest mean consumption of AA caught (1.1 kg $hh^{-1}week^{-1} \pm 4.2$ SD). Both SEC and RRD had a much lower average consumption level (0.3 kg $hh^{-1}week^{-1} \pm 1.5$ SD and 0.4 kg $hh^{-1}week^{-1} \pm 1.7$ SD, SEC and RRD respectively).

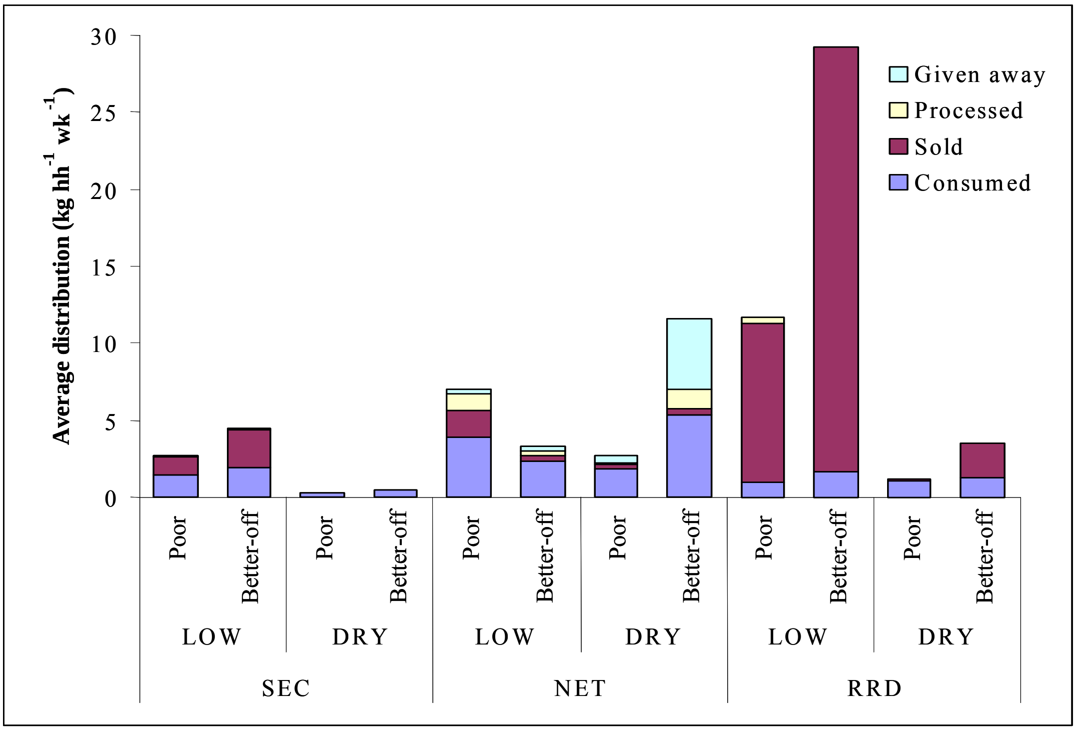


Figure 4.37 Distribution of utilization of aquatic animals collected in SEC, NET and RRD by wealth groups and AEZ. ***Data presented based from longitudinal study.***

Selling harvested AA is relatively more important in RRD (3.6 kg hh^{-1}week^{-1} ± 28.1 SD) and to the group of households in LOW areas of SEC. In NET, processing AA is typical although overall amounts are usually small (0.14 kg hh^{-1} week^{-1} ± 1.6 SD). In contrast, households from SEC and RRD process a very small amount of AA (0.01 kg hh^{-1}week^{-1} ± 0.47 SD).

4.3.5.1 Processing of caught AA

One of the local criteria used to determine the importance of AA in the area was its ability to be processed particularly in NET and SEC as discussed earlier in this chapter (section 4.3.3). During the monitoring activity, collection and utilisation of AA were recorded and the relative importance of processed AA was analysed.

Mean weight of caught AA being processed

Seasonality of the mean weight (kg $hh^{-1}week^{-1}$) of AA caught being processed is presented in Figure 4.38 and there are significant differences through the years ($P < 0.05$). The mean amount of AA processed is significantly different between sites ($P < 0.05$).

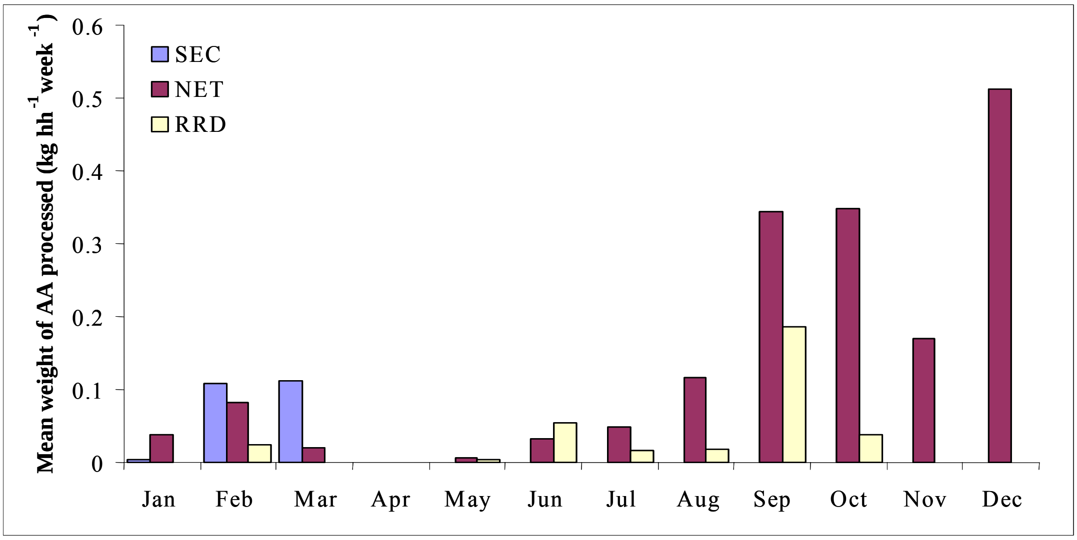


Figure 4.38 Seasonality of mean weight of AA being processed by households in SEC, NET and RRD. ***Data presented based from longitudinal study.***

In this figure, NET has the highest mean amounts of AA being processed (0.14 kg $hh^{-1}week^{-1}$ ± 1.6 SD) and over a longer period of the year (11 months). In SEC, processing of harvested AA only took place for three months (from January to March) and therefore taking into account the months when no processing of AA took place, the mean weight of AA being processed was very small (0.01 kg $hh^{-1}week^{-1}$ ± 0.5 SD). Households from RRD processed a portion of AA caught over at least six months in a year (February and July to October).

Distribution of AA group being processed

The contribution of the three AA groups (SRS, stocked, and wild species) is presented in Figure 4.39. In NET, the contribution of SRS to the total AA processed was considered to be very important with highest mean weight of SRS being processed (0.32 kg hh^{-1} week^{-1} ± 2.61 SD).

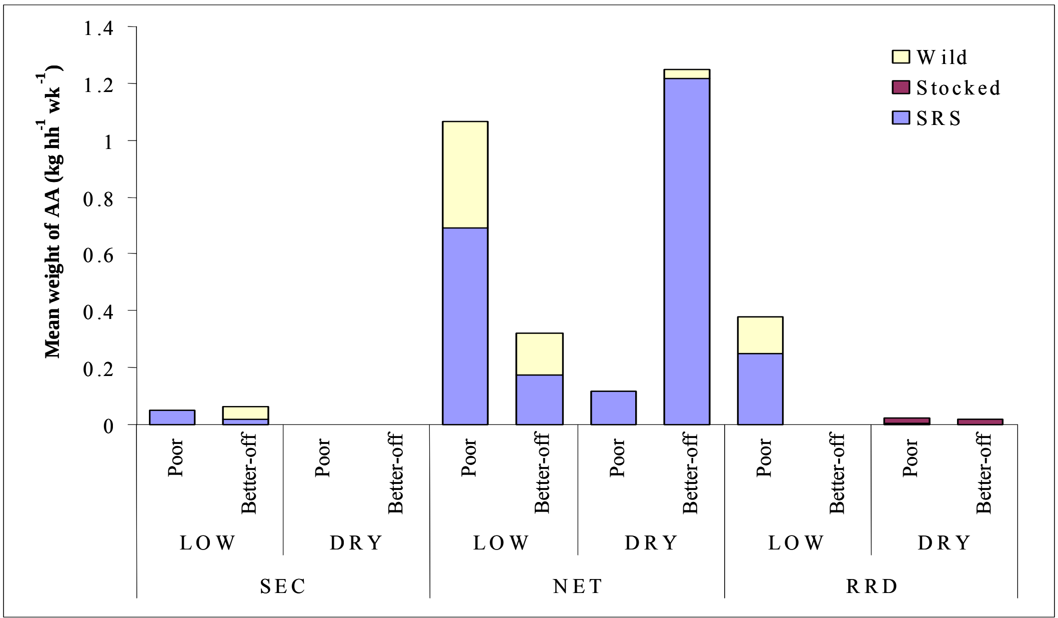


Figure 4.39 Mean contribution of different AA group to the total weight of AA being processed in SEC, NET and RRD. ***Data presented based from longitudinal study.***

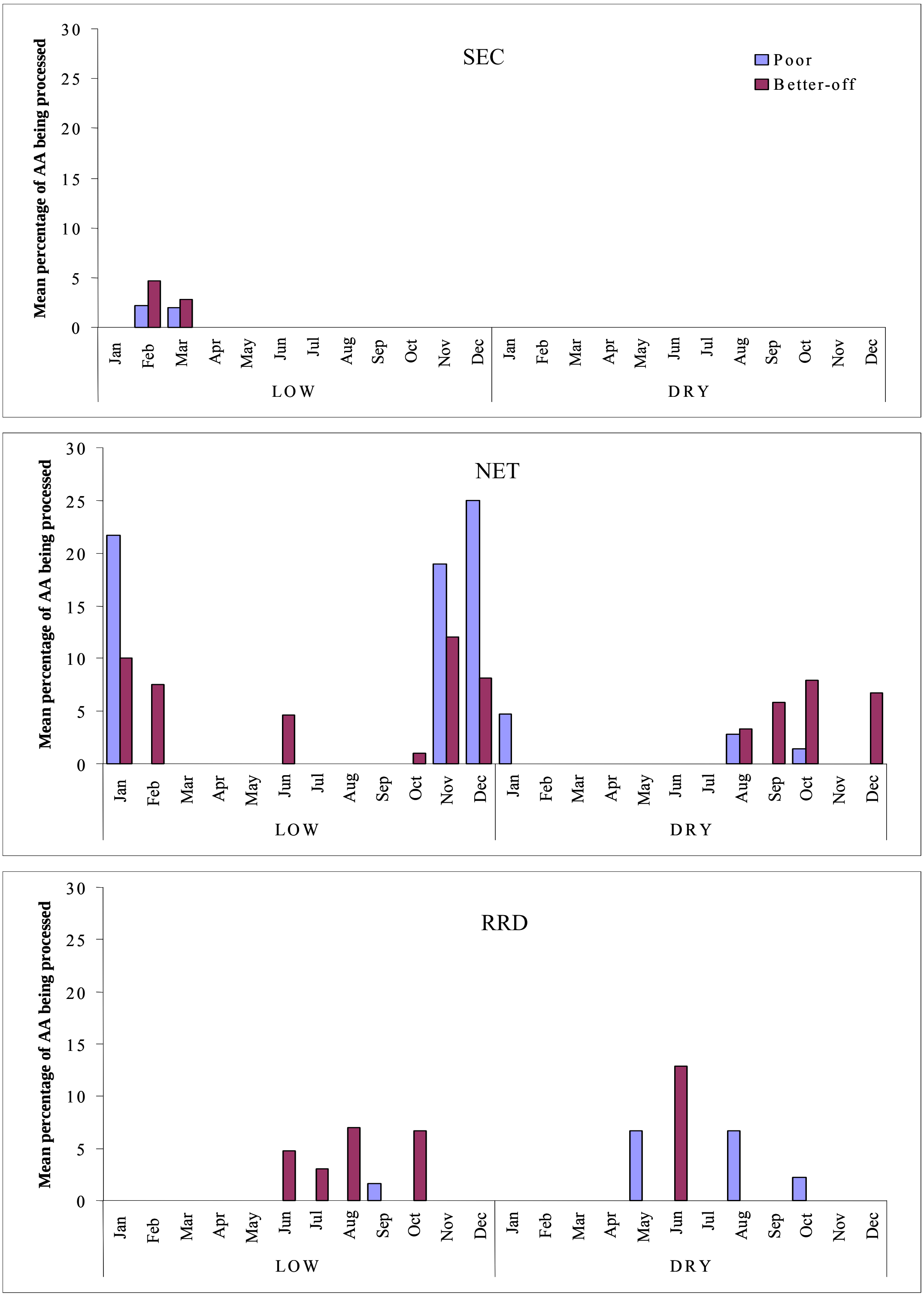
However, in SEC and RRD, the contribution of SRS was only observed in the LOW areas and particularly from the poor group of households. Stocked species were the main contributor in the DRY area of RRD for AA processing (0.01 kg hh^{-1}week^{-1} ± 0.2 SD). This type of utilisation may be a form of 'salvage strategy' i.e. dead/dying fish or smoothing strategy to have more available food for household consumption during the coming days particularly when time is very limited (e.g. peak of agricultural activities).

Seasonality of the percentage of AA caught being processed

Seasonal variation in the percentage of aquatic animals being processed is presented in Figure 4.40. Differences between well-being groups and AEZ during the season were also presented. The percentage of AA caught being processed in SEC is more or less similar between well-being groups (1.4%, 2.4%, poor and better-off respectively) during the months processing occurred. In NET, seasonality in the percentage of AA being processed varied between well-being groups and AEZ.

In general, households in the LOW area, particularly the poorer group, processed a larger proportion of their caught AA compared to other groups. Better-off families in NET usually processed a greater percentage of caught AA during the months of February and June in LOW areas and September and December in the DRY areas. In RRD, better off families in the LOW areas mostly processed aquatic animals during the months of June to August and October. In the DRY areas of RRD, poor households reported processing of caught aquatic animals in the months of May, August and October while better-off families only do it in June.

Figure 4.40 Seasonality of percentage of AA caught being processed by households with different well-being groups in different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***



4.3.5.2 Marketing of caught AA

This section focus only on the information related to the marketing (selling) of aquatic animals caught by households at the three sites. Data presented was based from the AA collection data of the longitudinal study.

Mean weight of caught AA sold

Figure 4.41 shows the average amount (kg $hh^{-1}week^{-1}$) of the different AA groups (SRS, stocked, and wild) caught and sold by the households at the three sites.

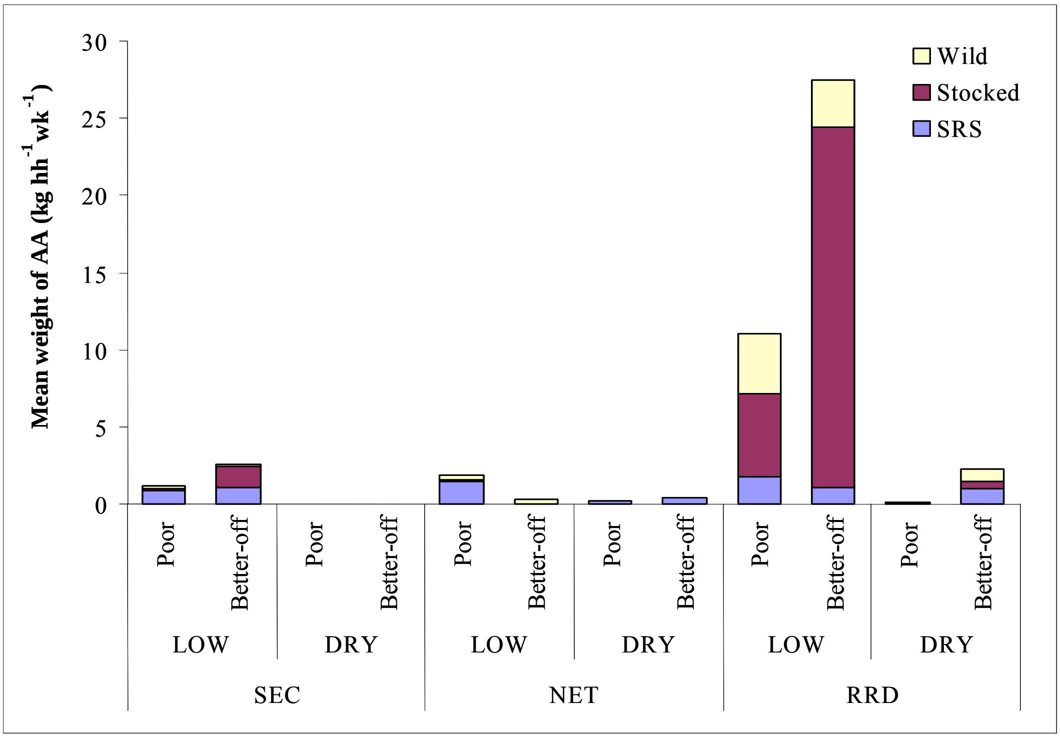


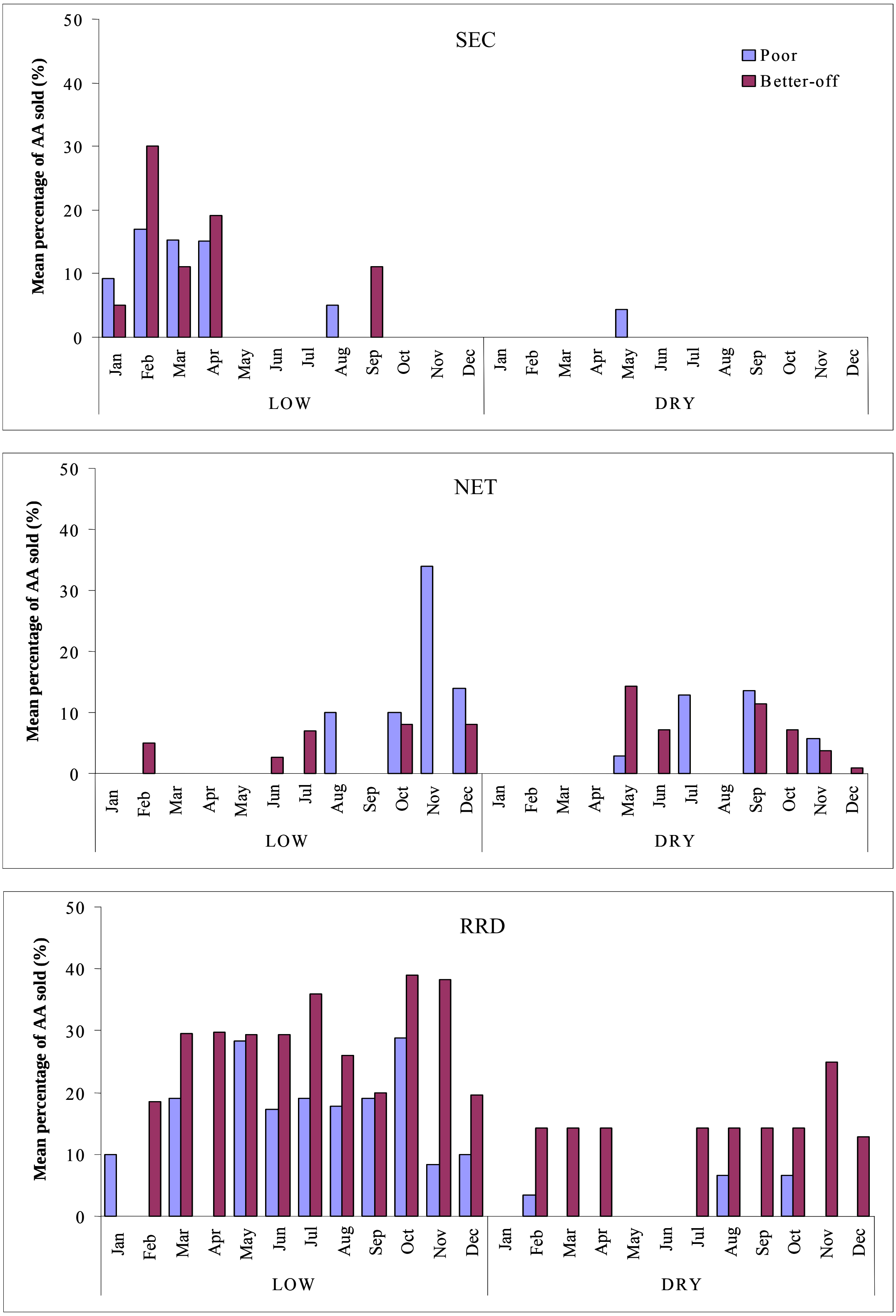
Figure 4.41 Mean contribution of different AA group to mean AA sold (kg hh^{-1} wk^{-1}) in SEC, NET and RRD. ***Data presented based from longitudinal study.***

In general, at sub-sites of RRD, the amount of AA caught being sold was the highest, particularly from the LOW area (6.6 kg $hh^{-1}week^{-1}$ ± 28.2 SD) ($P < 0.001$). In contrast, little fish was sold in either SEC or NET (0.29 kg $hh^{-1}week^{-1}$ ± 4.8 SD and 0.23 kg $hh^{-1}week^{-1} \pm 2.4$ SD, SEC and NET respectively). Differences between AEZ at all three sites were found to be significantly different ($P < 0.05$), households in LOW areas selling more than those in DRY areas. The importance of SRS in terms of the total AA sold is site and wealth specific ($P < 0.001$). The mean weight of SRS sold was relatively high in poorer households from the LOW areas of SEC and NET. In RRD, the main types of AA sold by households were stocked species (8.2 kg $hh^{-1}week^{-1} \pm 46.7$ SD).

Seasonality of percentage of caught AA being sold

The percentage of AA sold from the total AA catch by the households in the three study areas by season is presented in Figure 4.42. The percentage of caught AA being sold was significantly different between sites and sub-sites. Furthermore, seasonality had a great influence on the amount of AA being sold particularly by households from different AEZ. The percentage of AA caught that was sold by households of both well-being ranks was high in the LOW AEZ, however, seasonal variation was significant in particular sites. Sales were only a consistent source of income in the LOW areas of RRD where aquatic animals were caught and sold throughout the whole monitoring period (12 months). Elsewhere, sales were very seasonal (Figure 4.42, RRD). In SEC, February to April were the months when households from the LOW areas sold the largest percentage of their harvest, however, in the DRY areas of the same site, a small percentage of AA caught by poor household was sold (less than 10%).

Figure 4.42 Seasonality of the percentage of collected AA being sold by household in SEC, NET and RRD. ***Data presented based from longitudinal study.***



In NET, caught aquatic animals were sold over the same period (seven months), although the pattern of sales varied through the year. In the LOW areas sales peaked between October and December while sales were greatest in May, July and September in the DRY areas. Mainly poor households sold aquatic animals during the period of October to December in the LOW area while in the DRY area it was mainly in July and September. Better-off households sold more AA in the DRY area of NET. Marketing aquatic animals caught was very common among better-off households in both AEZs of RRD. The lean season for selling aquatic animals caught in the LOW areas of RRD was during the months of January and February (Northern Vietnam winter season). May and June were considered the lean season for selling AA in the DRY area.

Relationship of percentage sold with mean weight of AA caught

The mean collection (kg $hh^{-1}week^{-1}$) of aquatic animals showed a moderately positive relationship with the percentage of AA being sold (Figure 4.43). This relationship explains that any increase in the percentage of caught AA being sold was related to the amount of aquatic animals harvested.

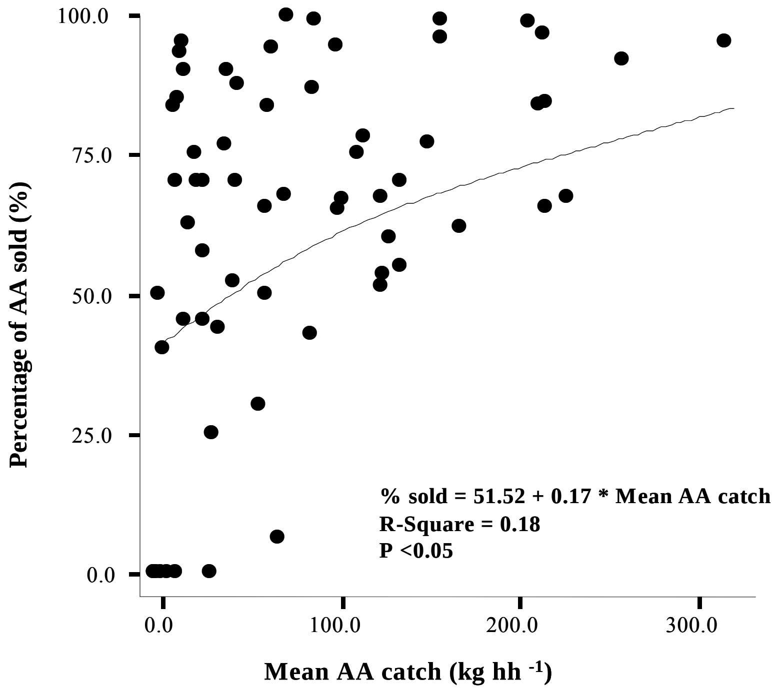


Figure 4.43 Relationship between the amount of catch and the percentage being sold. ***Data presented based from longitudinal study.***

4.3.5.3 Consumption of caught AA

The main focus of this section is to present information about the consumption of AA which were directly caught by households as reported from the AA collection data of the longitudinal study. Comparison of the different types of AA (i.e. wild, stocked and SRS) in terms of their contribution to the total AA consumption is highlighted in this section. However, the general consumption of AA, i.e. including those that came from other sources, was presented in the succeeding section.

Mean weight of caught AA consumed

The mean weight of caught AA that were consumed and the contribution of each AA group are presented in Figure 4.44. In general, the mean weight of consumed AA is significantly different between sites ($P < 0.001$) with households from NET having the highest mean (3.2 kg $hh^{-1}week^{-1}$ ± 7 SD) compared to SEC and RRD (1.2 kg $hh^{-1}week^{-1}$ ± 2.5 SD and 1.3 kg $hh^{-1}week^{-1}$± 2.9 SD in SEC and RRD respectively). Differences between AEZ were also observed and found to be significant in SEC ($P < 0.05$) but not significant in NET and RRD. Households from the LOW areas of SEC consumed more AA that they harvested compared to elsewhere. There was no significant difference found in consumption better-off and poorer households.

The contribution of the different groups of AA was found to be significant between sites, AEZ and well-being groups in general ($P < 0.05$). In SEC, the SRS were very important to households in both well-being groups in the LOW areas, however, wild AA were more important to poor households in DRY areas of SEC. Amongst the three sites, the SRS contribution was highest in NET (2.0 kg $hh^{-1}week^{-1}$ ± 5.8 SD). On the contrary, stocked species were mostly consumed in RRD particularly in the DRY area (1.1 kg $hh^{-1}week^{-1}$ ± 2.9 SD). Wild species of AA contributed a significant proportion of AA consumption in households in the LOW areas of all three sites.

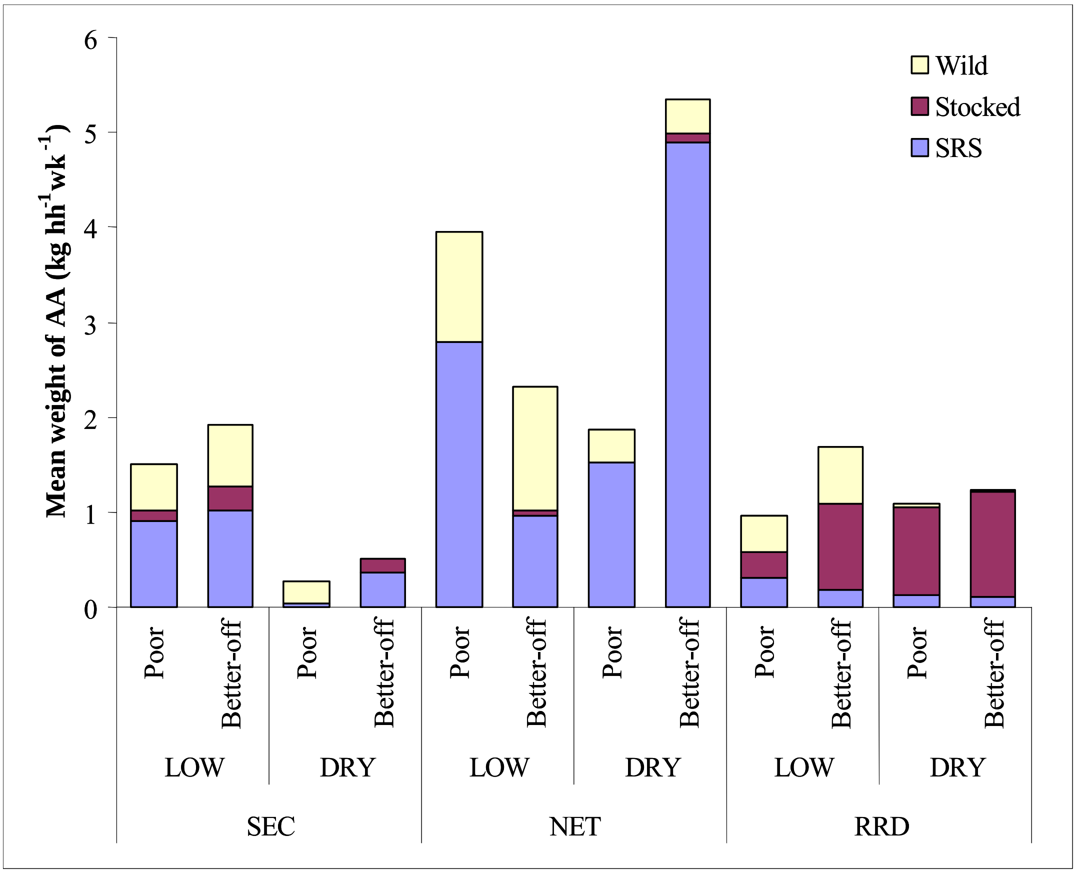
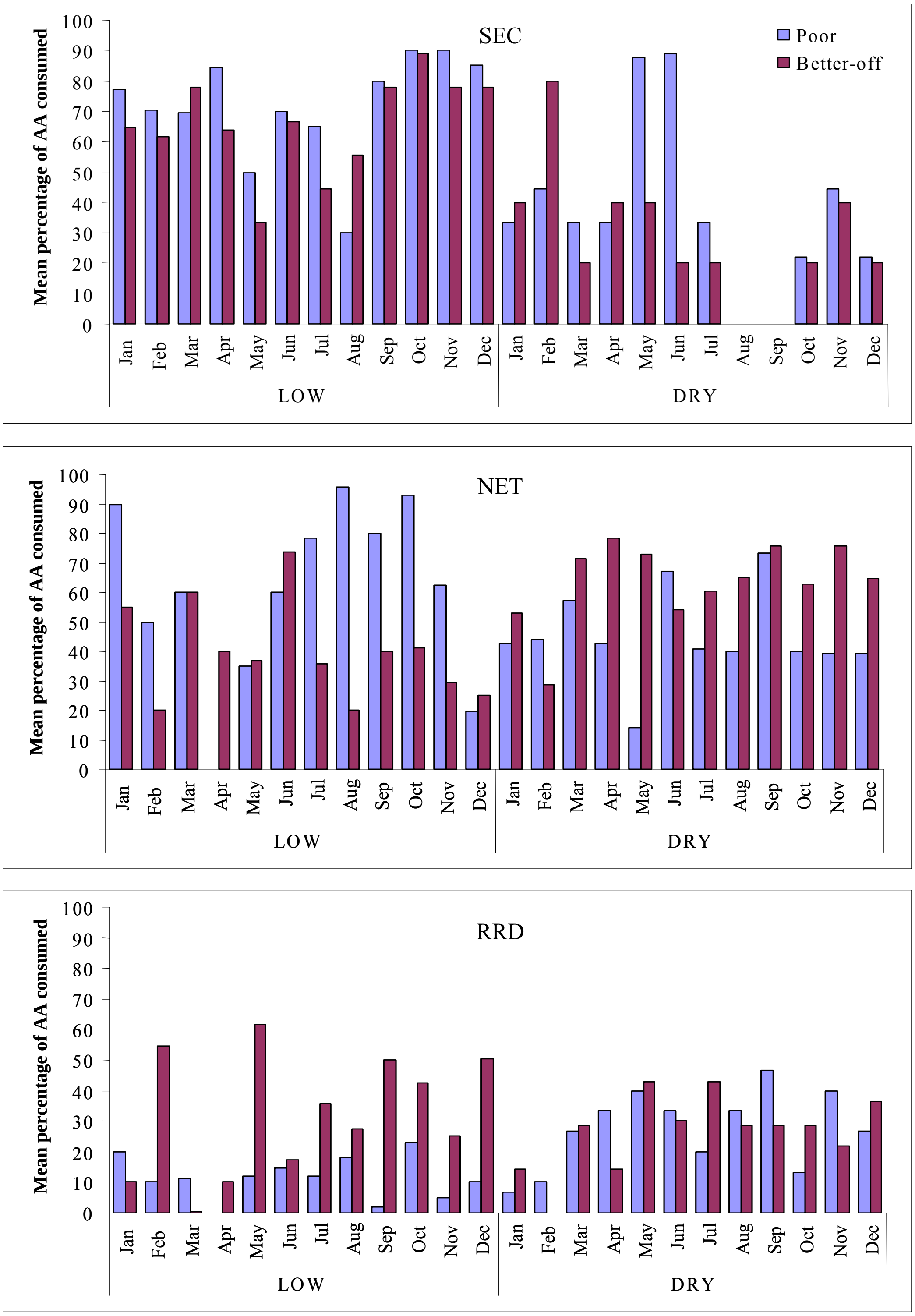


Figure 4.44 Mean contribution of different AA group to the total weight of caught AA being consumed in the three sites. ***Data presented based from longitudinal study.***

Seasonality of the percentage of AA caught being consumed

Figure 4.45 shows the seasonality in the percentage of aquatic animals caught being consumed by households of different well-being groups from AEZ of each sites. Differences between the AEZ at each site are clearly illustrated. Households from the LOW areas of SEC generally consumed a higher percentage of aquatic animals compared to elsewhere. The peaks of consumption of aquatic animals in LOW SEC were observed in January to April and September to December. During this period, households in the sub site (LOW SEC) consumed more than 50% of their catch. In the DRY SEC, there was no clear peak of consumption observed; however, lean consumption months were March, July, October and December.

Figure 4.45 Seasonality of the percentage of caught AA being consumed by households with different well-being groups from AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

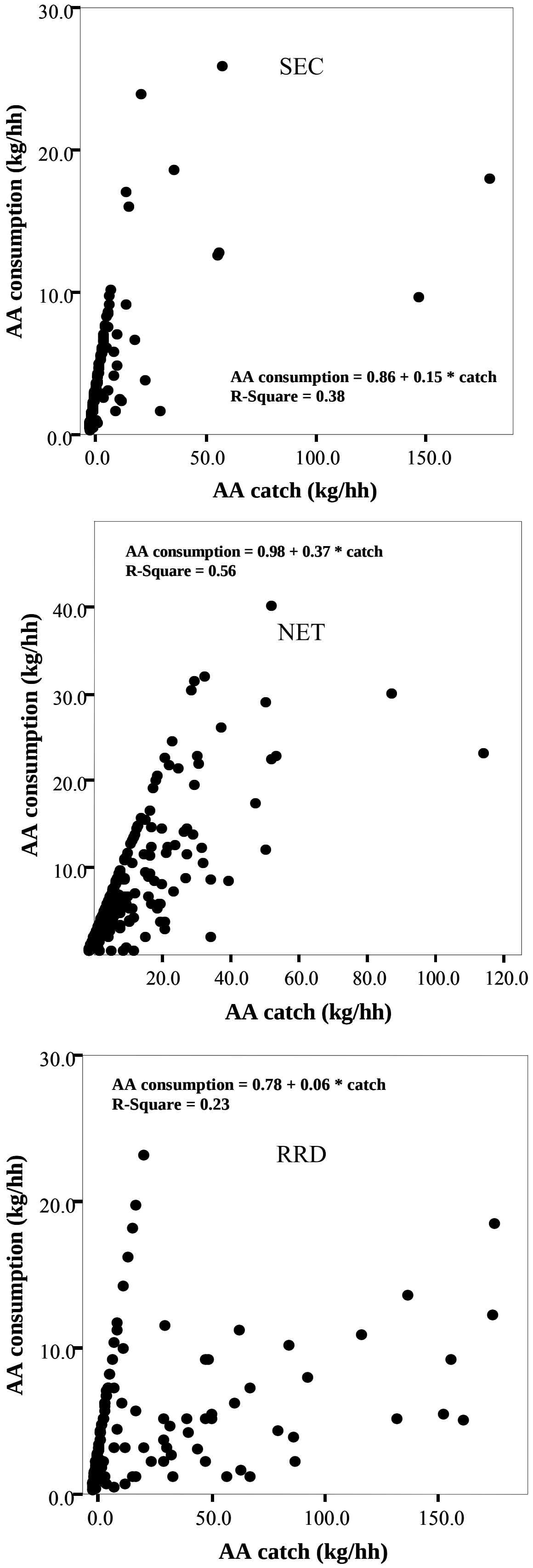


There were two months of the year when households from DRY SEC did not consume aquatic animals at all (August and September) as these were the months when no harvest was reported (Figure 4.45). In NET, households consumed nearly half (49%) of the total catch. There was no clear seasonal variation in terms of the percentage of catch being consumed. Households in RRD consumed the lowest proportion of caught AA (25%). Differences in the percentage consumed were observed between wealth groups in LOW areas where the better-off households consumed a higher percentage of AA caught than poorer households in the same AEZ.

Relationship of mean weight of caught AA consumed to total catch

The relationships between the amount of AA being consumed and the amount of aquatic animals caught are presented separately by sites in Figure 4.46. The relationships were tested separately amongst sites and while the result shows differences between sites, all sites showed positive relationships (SEC, $P < 0.001$; NET, $P < 0.001$; and RRD, $P < 0.05$). Amongst the three sites, NET shows the strongest relationship ($r^2 = 0.56$) indicating that the amount of AA consumed by households was directly affected by the amount of AA collection. Both SEC and RRD showed weaker relationships ($r^2 = 0.38$ and 0.23, SEC and RRD respectively).

Figure 4.46 Relationship between total catch and consumption of AA in SEC, NET and RRD. ***Data presented based from longitudinal study.***



4.3.5.4 Discussion on utilization of aquatic animals

The four forms of AA utilisation (sold, consumed, given, and processed) were presented and analysed in this chapter. Generally, a large proportion of harvested AA was consumed in SEC and NET (74% and 60%, respectively) in contrast to RRD where a large proportion was usually marketed (>60%). This confirms the findings and their interpretation presented earlier regarding the validity of local criteria of AA importance as households in RRD generally valued the economic value of AA. The percentage of production being consumed however varied in Thailand depending on the aquaculture system that the farmer is engaged. Phromthong (1999) reported that farmers practicing polyculture tended to consume more than 60% of the production, however, those that were engaged in cage culture or hybrid catfish production tended to consume less (< 10%). Similarly, Demaine *et al.* (1999) reported a similar trend where farmers engaged in commercial fish culture tended to consume less of their own production. In Cambodia on the otherhand, the range of consuming the production was <30 to >90% of the production (average 54%) as reported by Shams and Hong (1998) which is relatively lower than the finding of the current research. Meanwhile, Gregory *et al.* (1996) also reported a lower percentage of SRS production being consumed by farmers (36%). This was also due to the fact that some households are selling almost 50% of their production particularly if the collection is more than enough for their consumption. Tana (1993) reported that in Cambodia, farmers involved in capture fisheries (including rice field fisheries) utilised their catch depending on the condition of the AA, however, food for the household was still the priority and selling was secondary.

Amongst the three study sites, NET had the highest proportion of collected AA being processed (10%), with very small amounts in SEC and RRD (0.8 and 1.4%, respectively). These figures conflicted with estimates published elsewhere. Phromthong (1999) reported a very low percentage from northeast Thailand (<1%), on the contrary, Gregory *et al.* (1996) reported a much higher percentage of AA being processed (21%). These differences can be related to the type of respondents of the previous researches where in engagement of respodents were selected based on production system (i.e. practicing conventional aquaculture). This result illustrates two important things, the strategy of households in Thailand in smoothing food insecurity and the abundance of AA i.e. amount of collection. Households in Thailand usually ferment their collected AA in order to prolong its availability and at the same time save it from becoming rotten. Processing appears to be more important with the poor groups in the LOW land areas in general except from the better-off households in Thailand. The relative amount of processed AA showed seasonal variation and varied amongst sites. Processing in Cambodia usually took place in February and March when a large proportion of FMAS were being harvested. Meanwhile in Thailand, processing of AA peaked in September until December. In RRD, processing is generally low but peaks occurred in September. Thus the timing of processing especially in SEC can be related to the time of greatest availability of AA in the rice fields, i.e. water recession prior to rice harvest. However, this reason may be less true in the case of NET but more in RRD were the peak of AA processing seems unconnected with seasonal peaks in availability of AA This behaviour in RRD might be explained by processing being prompted by declines in ambient temperatures .

4.3.6 General consumption of aquatic animals (AA)

The previous section analysed the disposal of AA produced within the household but did not frame this within the larger picture of general consumption of AA which includes other sources (i.e. purchased, received). Information for this section was collected using a 7-day recall during the longitudinal survey conducted monthly over 12 months. .

4.3.6.1 Mean consumption of AA

The mean consumption of aquatic animals by household of different well-being groups from different AEZ in SEC, NET and RRD is presented in Figure 4.47.

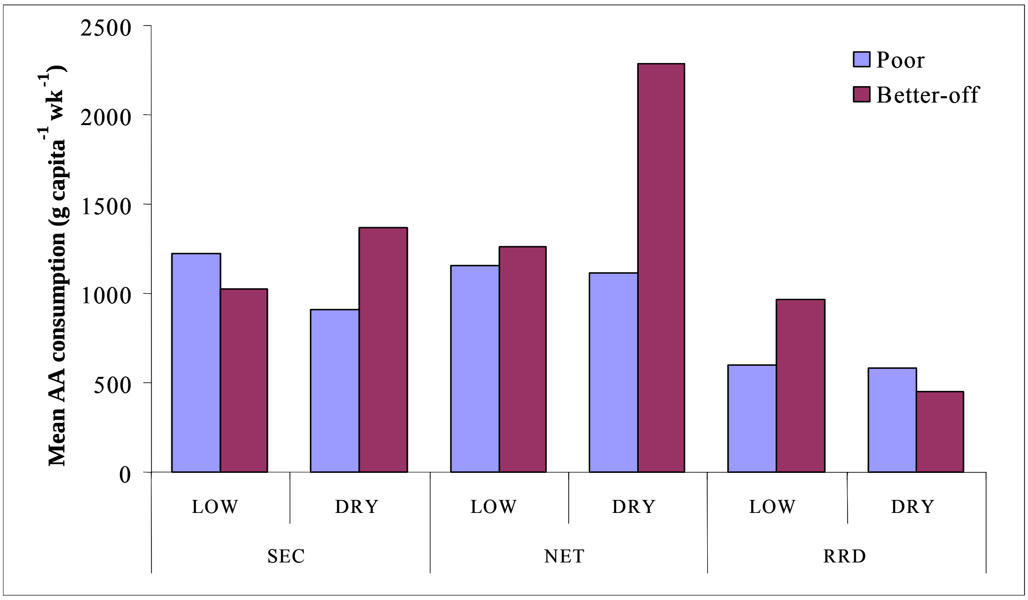


Figure 4.47 Average consumption (g capita $^{-1}$ week $^{-1}$) of aquatic animals by households of different wealth groups from different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

Results shows that mean AA consumption is significantly different (P <0.05) between sites with households in NET consuming the most (1,453 g capita^{-1} wk^{-1} ±

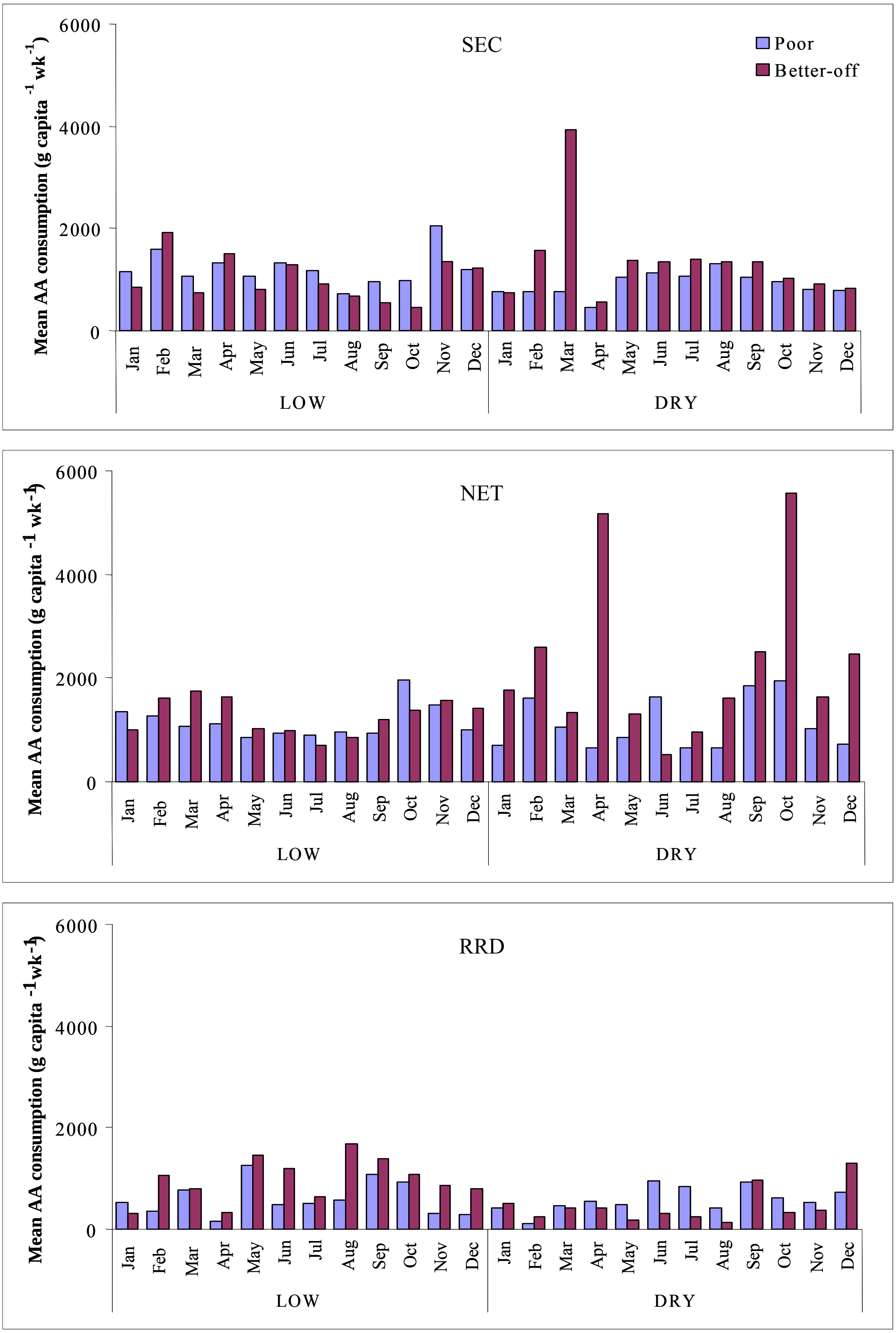
1854 SD). Households in the RRD consumed the least (650 g capita^{-1} wk^{-1} ± 972 SD). Meanwhile consumption of households in SEC was intermediate (1130 g capita^{-1} wk^{-1}). There was no significant difference found between AEZ and between well-being groups (P >0.05). However, the amounts consumed by better-off households in the DRY area of NET is found to be very high (2,285 g capita^{-1} wk^{-1} ± 3902 SD) (P <0.05) compared to elsewhere.

4.3.6.2 Seasonality of AA consumption

The amount of AA consumed by households varied seasonally (Figure 4.48). This variation was related to interaction between AEZ, month and site (P <0.001). Among the three sites, AA consumption in NET is greatly affected by season especially in the DRY area (>800 – 1600 g capita^{-1}wk^{-1} and >800 – 4000 g capita^{-1}wk^{-1} in LOW and DRY respectively). AA consumption in SEC has the least seasonal variation (<700 - >1500 g capita^{-1}wk^{-1} and >500 - <2500 g capita^{-1}wk^{-1} in LOW and DRY respectively).

In SEC, critical months were identified in the LOW area (March, May, and August - October) when households were consuming less AA (<1000 g capita^{-1}wk^{-1}). However in the DRY area of the same site, different periods of the year were identified; January, April, and October to December were most critical (e.g. April >500 g capita^{-1} wk^{-1}). In NET, there were five months (May - September) when AA consumption was low (<1000 g capita^{-1}wk^{-1}) in the LOW area while there were seven months (January, March, May – August, and November) observed in the DRY area.

Figure 4.48 Seasonal variation on AA consumption of households by well-being and AEZ in SEC, NET and RRD. ***Data presented based from longitudinal study.***



In RRD, the AA consumption was generally low and in most months of the year households consumed less than 1000 g capita^{-1} wk^{-1} in both AEZ (9 and 8 months in LOW and DRY respectively). Great seasonal variation was also found in both the LOW (<250 - >1000 g capita^{-1} wk^{-1}) and DRY (<200 - >1000 g capita^{-1} wk^{-1}) areas. The most critical period in RRD when households are consuming less than 500 g capita^{-1} wk^{-1} was during the period of December – January, and the months of April and July in the LOW while January – May, August, October, and November were the critical periods in the DRY area.

4.3.6.3 Source of AA being consumed

The AA being consumed by households in the three study sites were derived mainly from four sources: (1) their own FMAS; (2) open water bodies; (3) purchased; and (4) received as gifts or in exchange for favours given to the household (Figure 4.49). In general, the level of contribution of the different sources of AA was found to be significantly different (P <0.05). Overall the most important source of AA varied between sites (P <0.001); OWB were the most important source in SEC and NET (332.7 g capita^{-1} wk^{-1} ± 749 SD and 578.8 g capita^{-1} wk^{-1} ± 1045 SD in SEC and NET respectively). On the contrary, FMAS is the main source of AA consumed in RRD (211 g capita^{-1} wk^{-1} ± 642 SD) followed by purchased AA. FMAS provided considerable amounts of AA for households in both NET and in SEC. Purchased AA was particularly important in the DRY area of SEC and in households of RRD in general. There was no significant difference found between well-being groups.

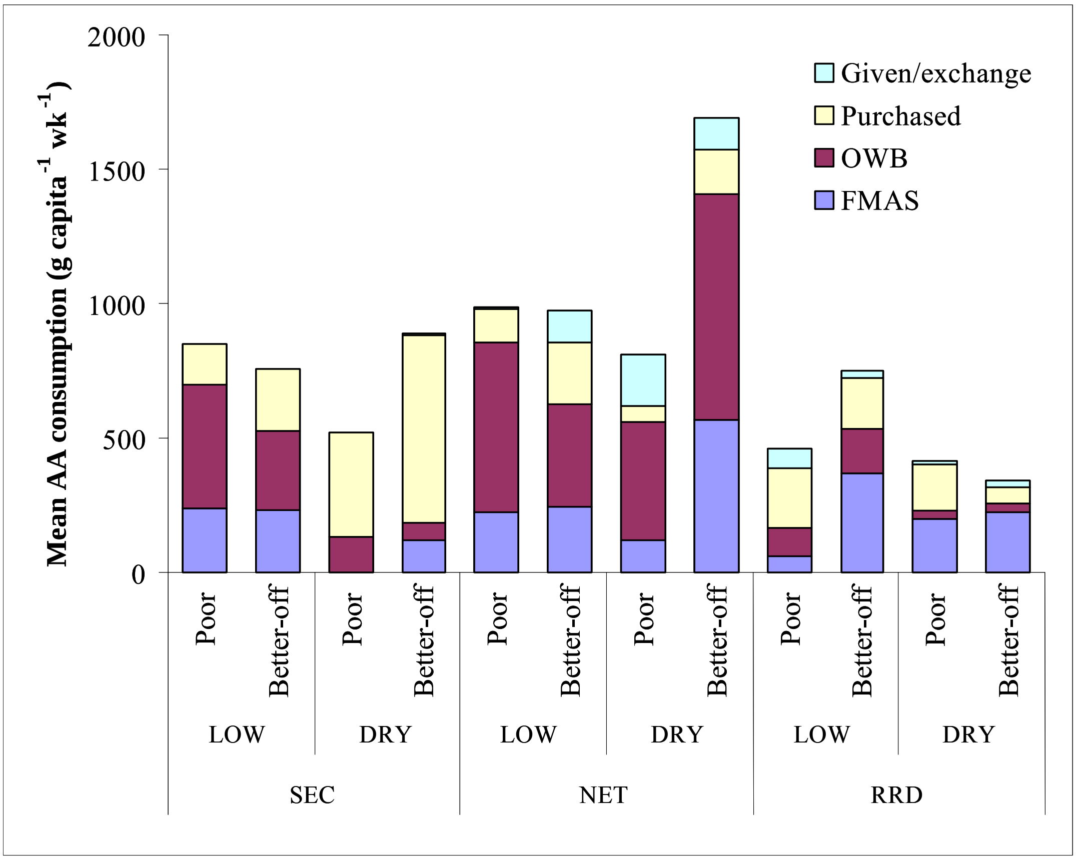


Figure 4.49 Sources of AA consumed by households of different wealth groups in AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

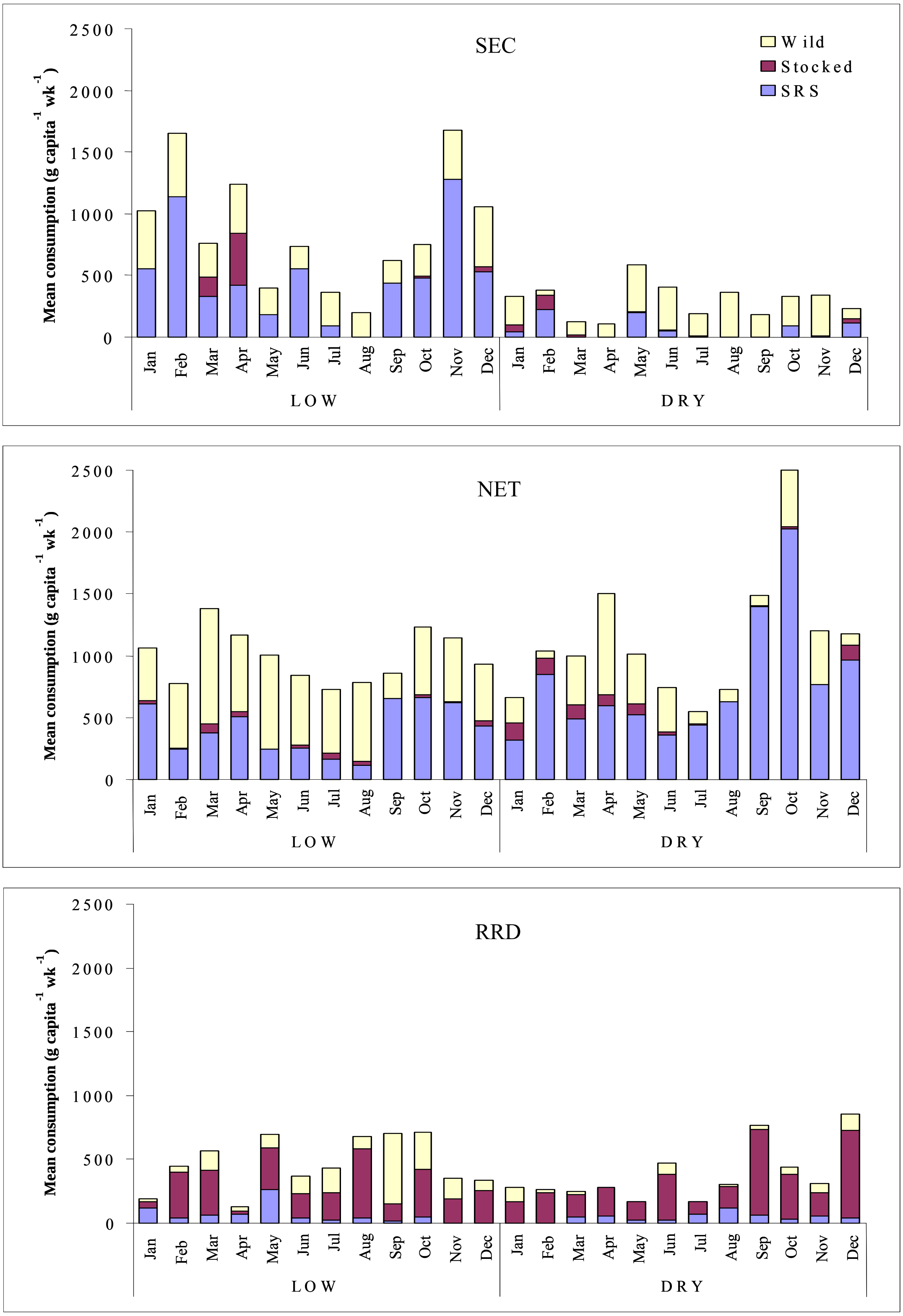
4.3.6.4 Contribution of different AA groups to mean consumption

There were three groups of AA commonly consumed in the three study area: SRS, stocked and wild. Important types of AA based on the mean contribution to total AA were found to varied between sites in general (P <0.001) (Figure 4.52). In SEC, both SRS and wild AA made important contributions to total consumption in both AEZ, however mean consumption of SRS was higher than wild (499 g capita^{-1}wk^{-1} ± 1114 SD and 61 g capita^{-1}wk^{-1} ± 290 SD respectively). The contribution of SRS is significantly high in NET (407.8 g capita^{-1}wk^{-1} ± 769 SD and 780 g capita^{-1}wk^{-1} ± 1477 SD in LOW and DRY respectively) compared to elsewhere. On the contrary, in RRD, the contribution of stocked species (251 g capita^{-1}wk^{-1} ± 926 SD and 288 g capita^{-1}wk^{-1} ± 805 SD in LOW and DRY respectively) dominated the total consumption of AA.

4.3.6.5 Seasonality of consuming SRS, stocked and wild

Seasonal variation on consumption of the different groups of AA was found to be significant amongst the AEZ of the three sites ($P < 0.05$) (Figure 4.52). In the LOW SEC, wild species were consumed at relatively consistent levels throughout the year. However, consumption of SRS and stocked species were more seasonal. SRS consumption was high during February and November (more than 1kg capita^{-1}wk^{-1}) but much lower over the remaining months with one month of no SRS consumption – August. Stocked species were consumed by households during the months of March – April and smaller amounts in October and December. In the DRY SEC, wild AA were consumed throughout the year with little variation. Both SRS and stocked species were consumed seasonally in smaller amounts than observed in the LOW site. In NET, all the three AA groups show seasonal variation, particularly in the DRY area. SRS consumption was high (from more than 0.5 kg capita^{-1}wk^{-1} to 1.2 kg capita^{-1}wk^{-1}) in the months of January and September to November in the LOW area and February, September to December in DRY. Similarly to SEC, the consumption of stocked species in both areas of NET was observed only for a proportion of the year (9 months). In contrast, stocked species were consumed in both areas of RRD throughout the year with consumption peaking in the months of February – March, May, August and October in the LOW area, and June, September and December in the DRY area. SRS was consumed seasonally in RRD; during the months of January and May in the LOW area and August in the DRY area.

Figure 4.50 Seasonal importance of different types of aquatic animals to food consumption by households in different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***



4.3.6.6 Contribution of different FMAS types as source of SRS

Consumed SRS came from different types of FMAS, moreover each study site had different types of FMAS as well, as presented in Table 4.8. The contribution of each FMAS types was significantly different between and within sites ($P < 0.05$).

Table 4.8 Source of SRS consumed by households (g capita^{-1} wk^{-1} ± SD) by FMAS type with different well-being groups from different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

Sites	Wealth group	Types of FMAS RF	HHP	TP	CP	Ditch	ComP
SEC							
LOW	Poor	227.4 ±680.8	65.6 ±257.5	95.1 ±728.6	0	56.6 ±	0
	Better-off	131.1 ±389.3	116.7 ±463.3	49.9 ±397.6	0	17.4 ±	0
DRY	Poor	23.1 ±127.4	3.2 ±32.6	0	0	0	6.2 ±0
	Better-off	70.6 ±404.1	21.9 ±90.5	57.7 ±297.2	0	0	15.5 ±47.9
NET							
LOW	Poor	328.7 ±683.4	0	54.6 ±222.5	0	0	15.5 ±118.9
	Better-off	157.8 ±529.1	0	123.8 ±406.6	6.2 ±47.6	0	14.5 ±115.2
DRY	Poor	261.9 ±585.3	0	147.5 ±508.9	0	0	14.1 ±85.3
	Better-off	893.6 ±1896.1	0	334.9 ±1526.3	46.6 ±173.9	0	43.7 ±331.1
RRD							
LOW	Poor	22.9 ±177.9	46.0 ±280.4	0	0	0	1.7 ±18.8
	Better-off	12.9 ±80.9	33.3 ±172.0	0	0	0	0
DRY	Poor	15.2 ±103.0	16.1 ±117.6	0	0	0	0
	Better-off	0	6.6 ±44.8	0	0	0	0

RF = rice field; CP = Culture pond; HHP = household pond; TP = trap pond; ComP = community pond

In general, rice fields (RF) were the main source of SRS particularly in SEC and NET (177 g capita^{-1} wk^{-1} ± 652 SD and 355 g capita^{-1} wk^{-1} ± 936 SD in SEC and NET respectively). Rice fields in RRD made the least contribution to the total SRS compared to elsewhere while household ponds (HHP) were the major source of the much smaller quantity of SRS consumed in RRD (25 g capita^{-1} wk^{-1} ± 172 SD).

4.3.6.7 Size distribution of AA consumed

The common sizes of AA that households from SEC commonly consumed was also analysed in this study. Figure 4.51 illustrates the distribution of sizes of AA consumed in both AEZ of SEC where most are usually small (<5cm - 20cm in LOW and <5cm - 5cm in DRY). Poor households consumed smaller AA.

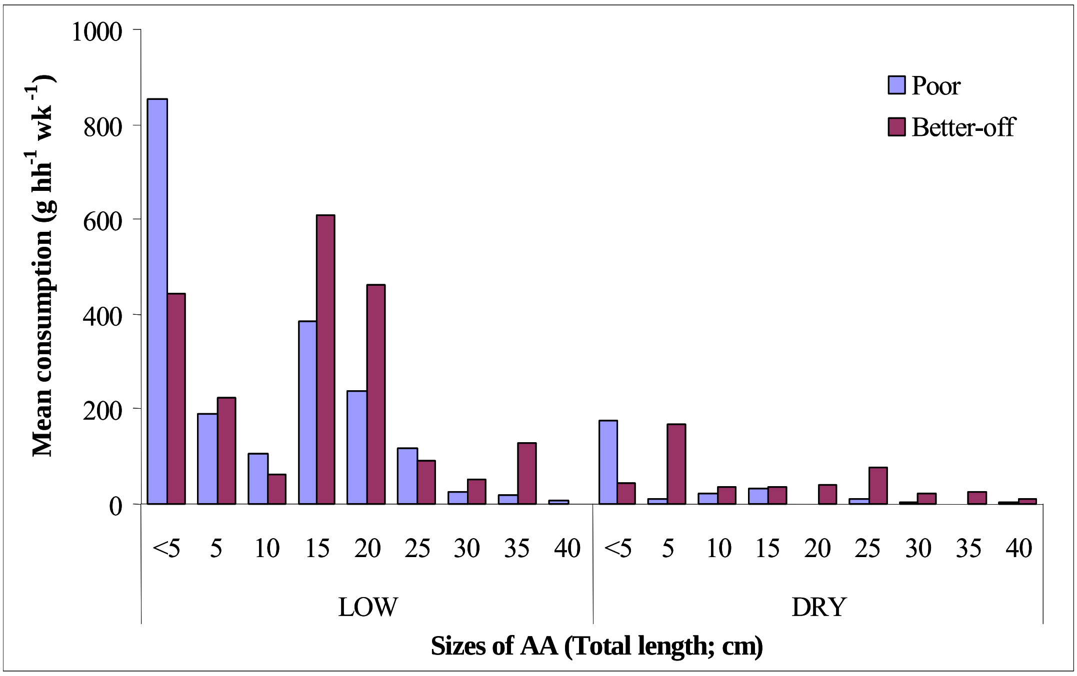


Figure 4.51 Distribution of sizes of AA consumed by different well-being groups in different AEZ of SEC. ***Data presented based from longitudinal study.***

4.3.6.8 Diversity of AA consumption[8]

Mean number of AA consumed

The diversity of AA being consumed at the three sites is presented in Figure 4.52 . The data presented in this section were extracted from the longitudinal study where the species of AA actually consumed by households was recorded. In total, NET has the largest number of species consumed by households (~58 species) while RRD has the least diverse (20 species). The numbers of species were found to be similar between AEZ within sites, however, the number of species within each AA group varied and stocked species were usually the least diverse (2, 5 and 6 species in SEC, NET and RRD respectively). Amongst the three sites, households in NET consumed the greatest diversity of SRS (32 and 25 species from LOW and DRY respectively).

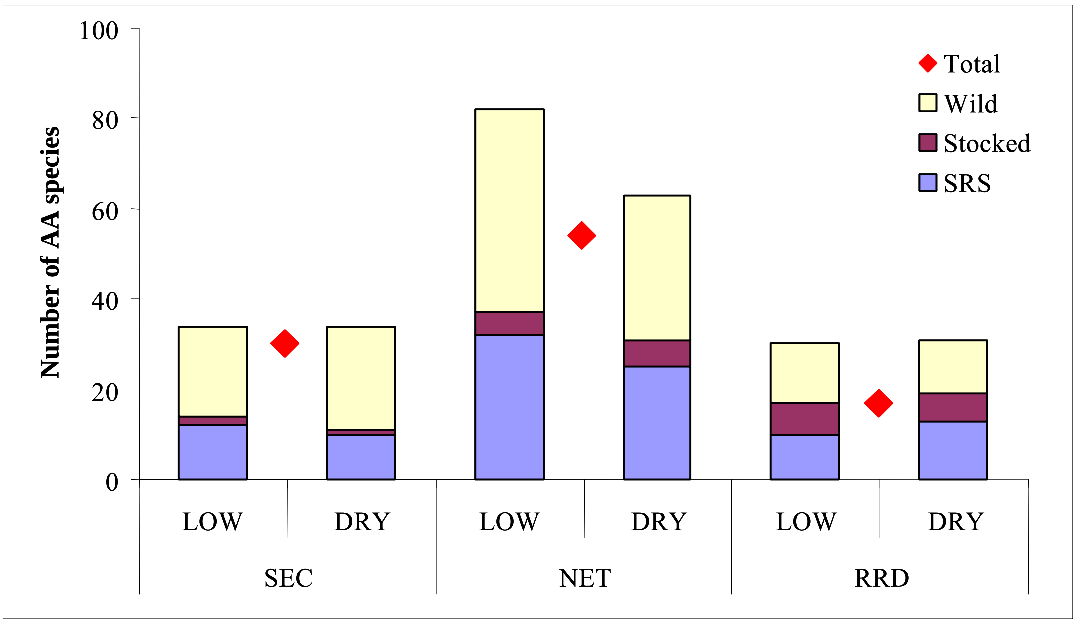


Figure 4.52 Diversity of AA consumed by households from different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

[8] Types/species of aquatic animals were identified based on the report of Amilhat (2006).

Number of AA species available year round

Although the number of aquatic animals consumed was usually high, not all of these species were consumed throughout the year. Most of these species were seasonal and only few were available year-round as presented in Table 4.9.

Table 4.9 Total number of aquatic animals that were consumed over the 12 months monitoring. Number in parenthesis indicates the number of species that were consumed for 6 months at least. ***Data presented based from longitudinal study.***

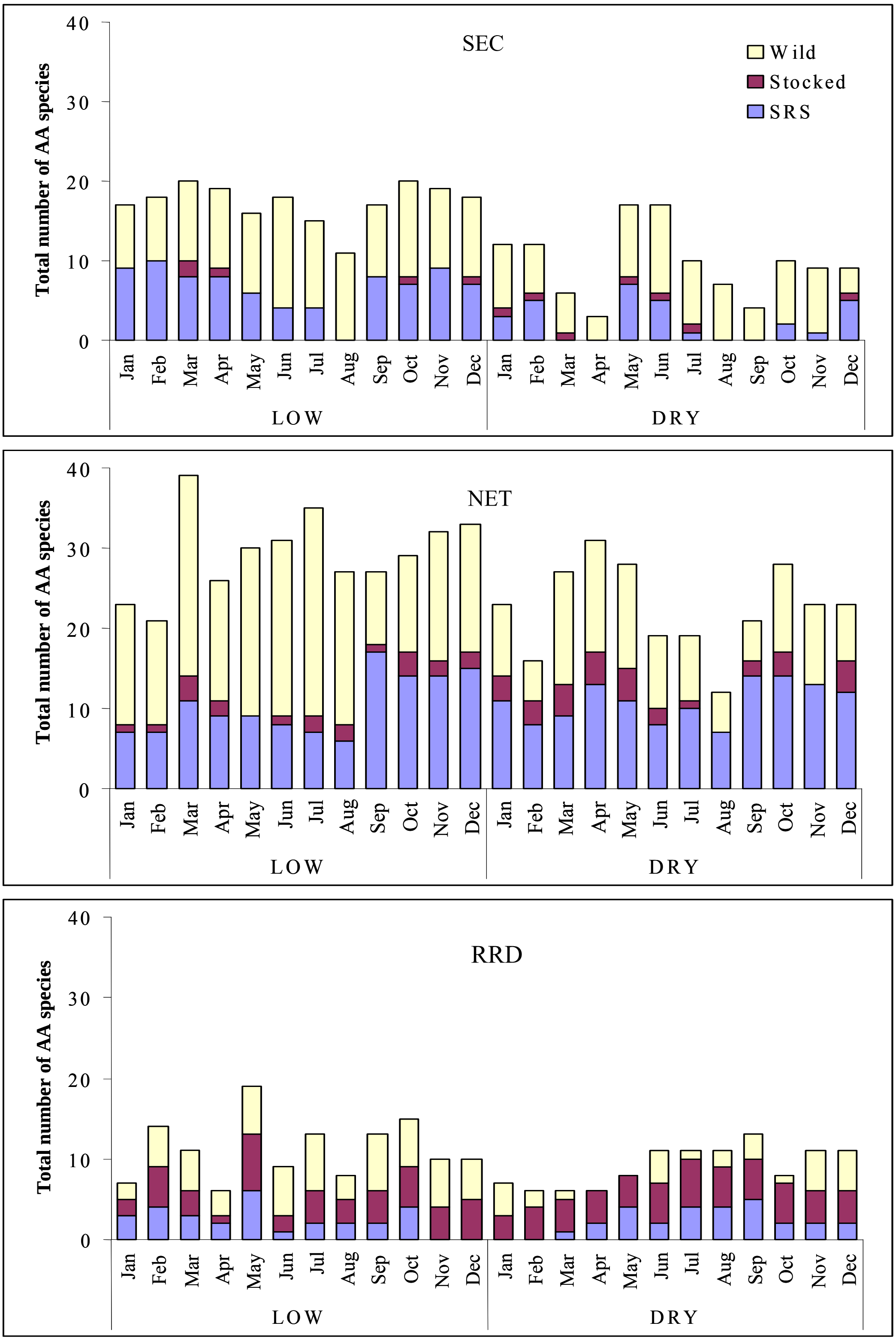
Study sites	Agro ecological zones	
	LOW	**DRY**
SEC	7 (14)	3 (11)
NET	7 (28)	7 (18)
RRD	5 (12)	4 (9)

Seasonality of number of AA consumed

The variation in the number of species being consumed by households from different AEZ within sites was found to be significant (P <0.05, Figure 4.53). The consumed AA were more diverse in NET compared to SEC and RRD. Moreover there was least diversity in RRD in terms of AA consumed. The overall number of AA did not show seasonal variation (P >0.05), however; the availability of some species was strongly seasonal at some sites.

In SEC, seasonal diversity of consumption of SRS species was greatest in February, May, June and December in the DRY area. There were 3 months in the DRY where no SRS were consumed (April, August and September). However in the LOW area of SEC, the number of SRS species started to decline in June until no SRS species were consumed at all in August.

Figure 4.53 Seasonality of the number of AA consumed over the period of 12 month monitoring by households in different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***



In NET, the number of species was relatively stable between January to August in the LOW areas; between September to December the diversity of species of SRS consumed increased. DRY areas of NET showed the same pattern of increased species diversity consumed between September to December. The timing of the high diversity of SRS in LOW NET appeared to complement the low variety of wild species available at this time. In RRD, the number of species, particularly stocked, was relatively the same throughout the monitoring period. The number of SRS species and wild species though showed some seasonal variations. There were at least 2 months when no species of SRS were consumed by households in the LOW (November and December) and the DRY (January and February).

4.3.6.9 Composition of SRS consumed

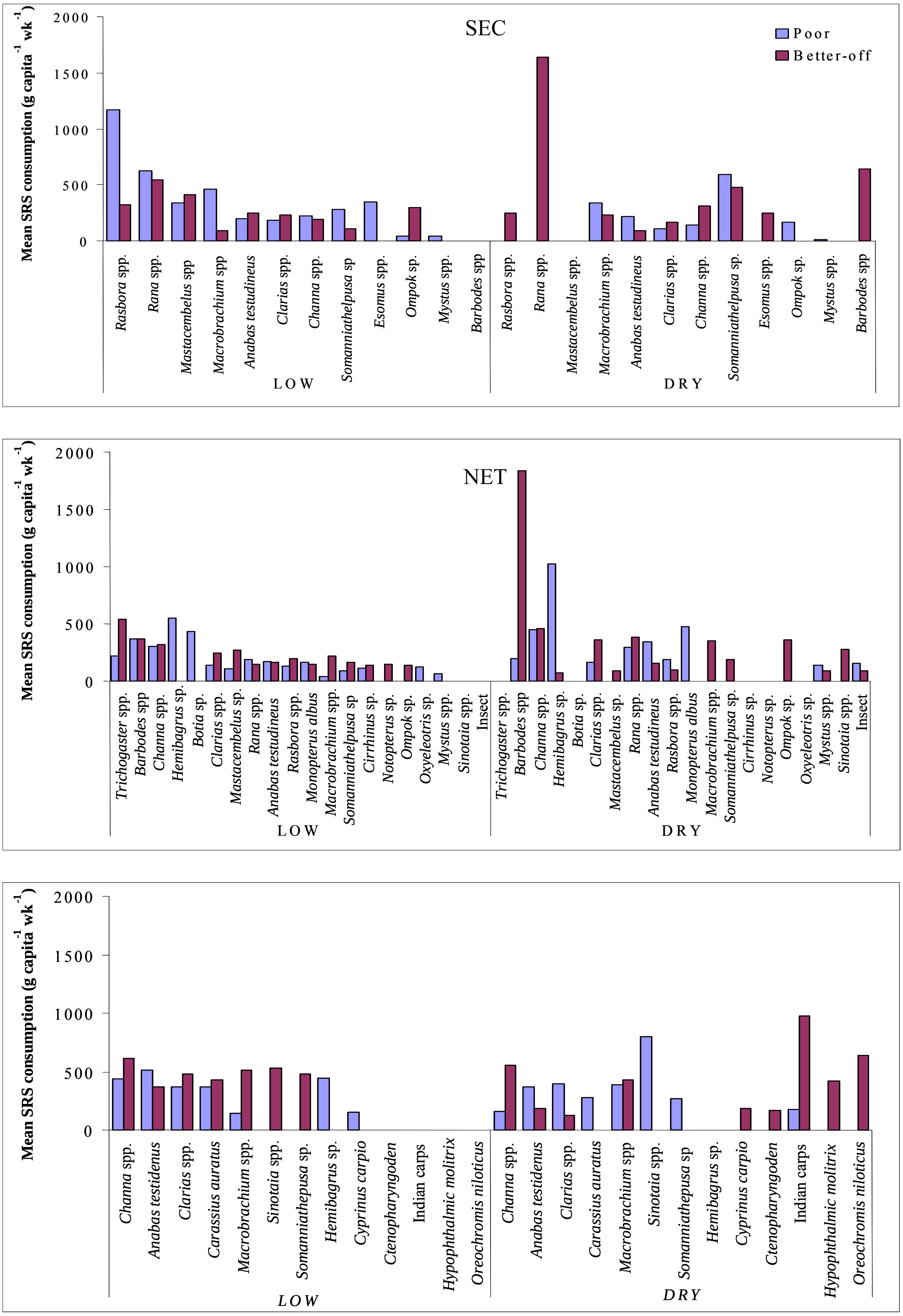
The diversity of SRS (number of species) commonly consumed by household in the three study sites was significantly different as presented in Figure 4.53 and Figure 4.54. Households from different AEZ and well-being groups have different composition of SRS species consumed (P <0.05). The importance of certain species of SRS were found to be site specific, however; species like C*hanna* spp*, Clarias* spp*, Anabas testudineus, Rana* spp.*,* and *Macrobrachium* spp. were found to dominate generally. Species of SRS presented in this section contributed at least 70% of the total SRS consumption.

In SEC, *Rasbora* spp.*, Rana* spp.*, Macrobrachium* spp.*, Anabas testudineus, Channa* spp.*,* and *Clarias* spp., were amongst the most important SRS consumed in both AEZ. Although most of the SRS species were consumed by both well-being groups, the most important species were slightly different. For example, *Rasbora* spp., *Macrobrachium* spp., and *Esomus sp.* were important for the poorer households while *Rana* spp., *Ompok* sp, and *Barbodes* spp. were more important for the better-off in terms of their contribution to the total consumption of SRS.

In NET, *Barbodes* spp., *Channa* spp., *Hemibagrus* sp., *Clarias* spp., *Rana* spp., and *Anabas testudineus,* were also identified as important in both AEZ. The preference of households of different well-being ranks in terms of SRS species were not the same. The better-off consumed more *Barbodes* (particularly in DRY), *Channa* spp., *Clarias* spp., *Ompok* and *Sinotaia* spp. while for poorer households *Hemibagrus, Botia, Mystus* spp., *Anabas testudineus* and *Monopterus* sp. were more important.

Species of SRS in RRD were slightly different from the other two sites as local people included some species identified as stocked at the other sites i.e. carp species. These species are most likely escapees from household or culture ponds that were trapped in the rice fields or other water bodies and that started to reproduce. Important species of SRS were also different by well-being at this site; the better-off consumed more *Channa* spp., *Clarias* spp., Indian and Silver carps, *Oreochromis niloticus* and *Macrobrachium* spp., while the poorer group consumed more *Hemibagrus* sp., *Cyprinus carpio* and *Carassius auratus.*

Figure 4.54 Mean consumption (g capita^{-1} wk^{-1}) of SRS species by households with different well-being group from different AEZ of SEC, NET, and RRD. ***Data presented based from longitudinal study.***



4.3.6.10 Relationships of aquatic animal consumption

The following section illustrates the relationships of the amount of AA consumption to several factors using scattergrams. The variables used in this exploratory analysis were; diversity of AA, area (m^2) of FMAS, mean catch of AA (kg $hh^{-1}wk^{-1}$) and the household's adult equivalent (AE). The mean AA (kg $hh^{-1}wk^{-1}$) consumption and the diversity of AA consumed by households at the three sites was found to have a positive relationship (r^2 = 0.40, P <0.001) (Figure 4.55).

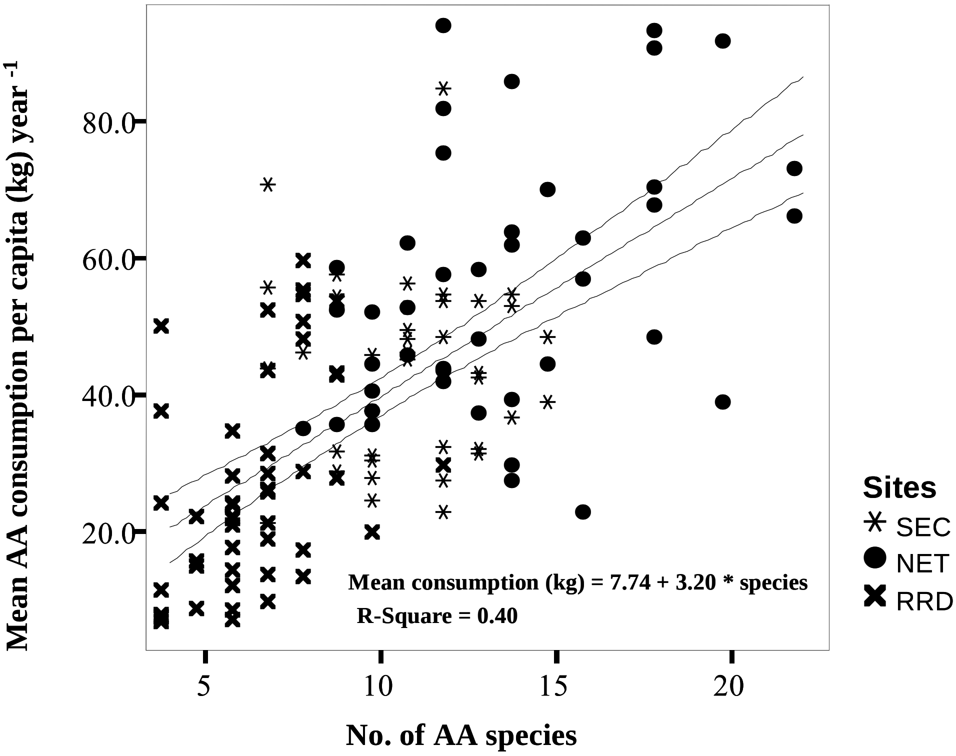


Figure 4.55 Relationship between the diversity of AA species and the average amount of AA consumption. ***Data presented based from longitudinal study.***

The mean consumption of AA in areas where AA are more diverse was high (i.e. NET; 55.2 kg $capita^{-1}$ $year^{-1}$ ± 19 SD and 11 species ± 2.2 SD for mean AA consumption and mean number of species respectively). In contrast, in areas with less diverse AA like in the case of RRD (6 ± 1.7 SD), households consumed lower quantities of aquatic animals (25.8 kg capita^{-1}year ± 15.1 SD).

There was a significant association found between mean consumption of AA and the total area of FMAS (P <0.05), however the relationship was found to be negative and weak (r^2 = 0.18) (Figure 4.56). This relationship indicates that the average consumption of AA tended to decrease with increasing area of FMAS that households managed. However the decreased of AA consumption cannot be accounted for only by the area.

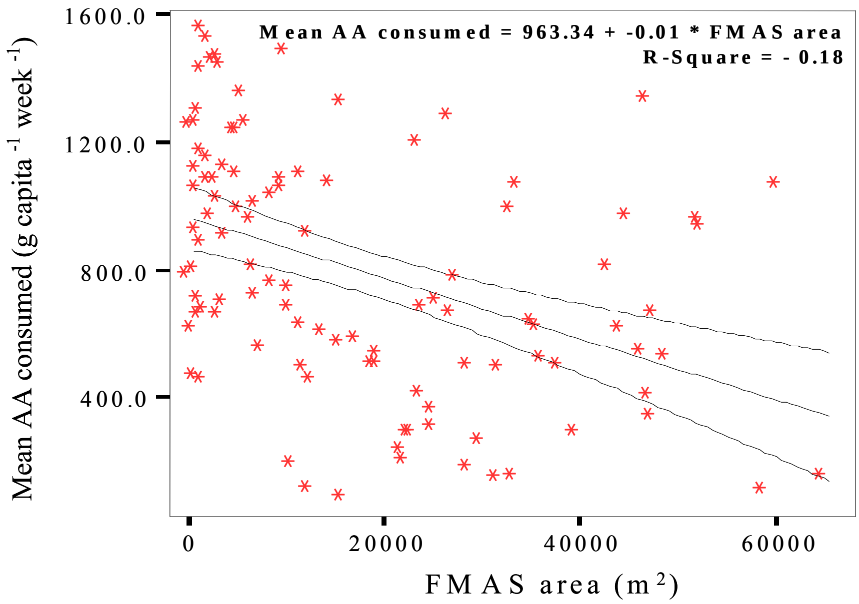


Figure 4.56 Relationship between the total farm area and amount of AA consumed by households in SEC, NET, and RRD. ***Data presented based from longitudinal study.***

The relationship between the average consumption of AA (g capita^{-1} week^{-1}) and mean catch (kg hh^{-1}wk^{-1}) was only found to be significant in households of SEC (P <0.05) but tended to be weak (r^2 = 0.13, Figure 4.57). This association indicated that the amount of AA consumption tended to increase as the average catch increased.

However, such increases in AA consumption cannot be associated solely with the mean catch due to a very low R-squared ($r^2 = 0.13$) which means that there are several factors that could influence such an increase.

There was a significant relationship between the mean consumption of AA and household size in all three sites (SEC, $P < 0.001$; NET, $P < 0.05$; and RRD, $P < 0.05$). However, the relationship was relatively negative and weak ($r^2 = -0.22$, -0.18 and -0.17 for SEC, NET and RRD respectively). This result explains that the increase in household size tended to be associated with a decrease in the amount of aquatic animals consumed.

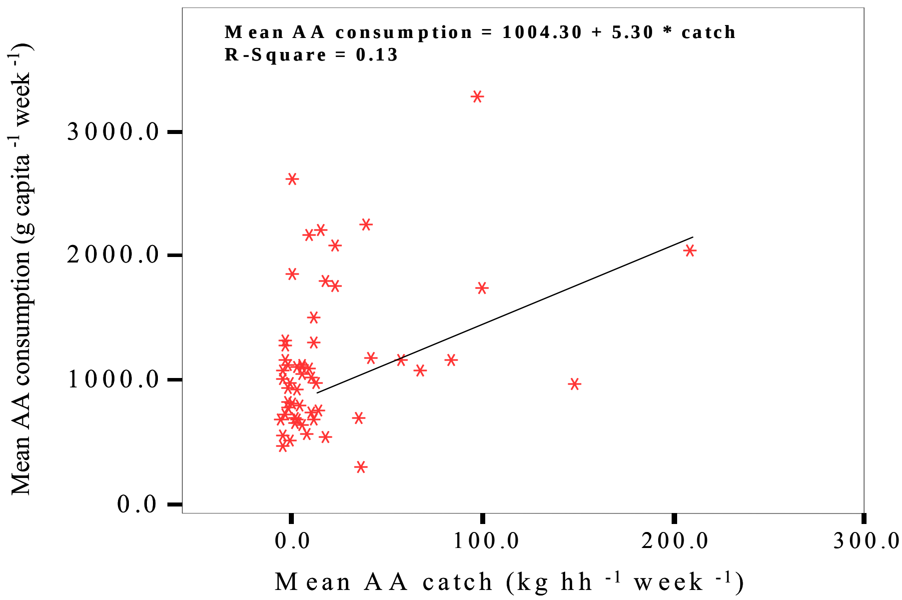


Figure 4.57 Relationship between the mean AA consumption in mean catch by households in SEC. ***Data presented based from longitudinal study.***

4.3.6.11 Discussion on the general consumption of aquatic animals

In general, the average consumption of AA is significantly higher in areas where aquaculture is less practiced i.e. NET and SEC (>1200 g capita^{-1} week^{-1}).

Households in RRD consumed approximately 50% (>600 g capita^{-1} week^{-1}) less than the amounts consumed in NET and SEC. This finding contradicts most published research that suggests that aquaculture is the answer to increasing food availability thereby meeting food security (e.g. Ahmed and Lorica, 2002; Bailey and Skladany, 1991; Dey and Ahmed, 2005; FAO, 2004; Halwart, 2005). The average consumption of poorer households, particularly in the DRY areas, was low in Vietnam (<600 g capita^{-1} week^{-1}). This is only about 10% of the total food consumption reported in Hanoi (6,309.1 capita^{-1} week^{-1}) by Quang (1999). Reports of fish and other aquatic animals consumption in Cambodia varied, however, the findings of this research (57.6 kg capita $^{-1}$ year $^{-1}$) was within the range of 13.2 – 75.6 kg capita $^{-1}$ year $^{-1}$ (Ahmed *et al.,* 1999; Gregory and Guttman, 1996; Gregory *et al.,* 1996; McKenney and Tola, 2002; Mogensen, 2001; Tana *et al.,* 1994). Discrepancies in the amount of AA consumption were due to the timing, duration, location and type of respondents. However in NET, average consumption of AA was relatively high compared to previous reports which ranged from 13.3 – 53 kg capita $^{-1}$ year $^{-1}$ (AIT/AO, 1992; Dey *et al.,* 2005; Middendorp, 1992; Prapertchob, 1989). Again, previous report/research did not collect the information on a year-long basis which probably missed important seasonal variation in consumption. Moreover, northeast Thailand is a very heterogeneous area (Little *et al*., 1996; Pant, 2002) which might have contributed to the discrepancy of the data. However, the issue of the timing could be more important to consider in making this comparison. Meanwhile in RRD, there was limited literature on disaggregated AA consumption of household to date apart from report of Dey *et al.* (2005) - 19 kg capita $^{-1}$ year $^{-1}$ which is very much low compared to the finding of the current research (33.8 kg capita $^{-1}$ year $^{-1}$), however, the previous reports did not include non-fish consumption.

The influence of seasonality on the overall AA consumption was understood in this section. Amongst the three sites, households in NET were greatly affected. The majority of the AA consumed by households in NET comes from FMAS and OWB which the production were greatly affected by season, hence, total AA consumption were also affected. The variation on the amount of consumption of AA in SEC was also affected by the season but the effect varied with AEZ. Consumption in the LOW area was more varied than in the DRY which was mainly because of the dependency of households in the DRY area on the market. Unlike in the LOW area where market is distant, households were mainly depending on the natural production. Mogensen (2001) reported a similar seasonal pattern of consumption of fiah and other AA in Svay Rieng Cambodia where peaks in consumption occurred during the period of September to January and low consumption was from April to July. The period of peak consumption can be associated with the period when AA populations were abundant, this is the period when water is already starting to recede and January to March is the harvest period for most of the trap ponds and other FMAS in the area. In Thailand, similarly, Prapertchob (1989) reported that the amount of AA consumption increased during the rainy season until the beginning of the dry season. Meanwhile in RRD, the lowest amount of AA consumed was recorded during the period of December and January, the coldest period of the yearr.

The relative importance of both SRS and wild to total AA consumption is particularly shown in NET where more than 50% of AA consumption was contributed by wild and SRS. In contrast, the relative importance of stocked species is illustrated by the consumption patterns in RRD where a large proportion of AA consumed (<65%) were contributed by stocked, hatchery-derived species. These findings confirmed the hypothesis of this research that RRD is more dependent on aquaculture production while SEC and NET rely on production from unstocked species from open access and FMAS. The importance of rice field fisheries to rural food security at these study sites (AIT/AO, 1992 and 1998; Bambaradeniya and Amarasinghe, 2003; Gregory and Guttman, 2002b; Gregory *et al.,* 1996; Guttman, 1999; Middendorp, 1992; Shams and Hong, 1998) is confirmed in this study.

This research also indicated that the diversity of AA available in an area influenced the amount of AA consumed. In NET, where stocks of AA are diverse and a higher number of species is available throughout the year, mean consumption was significantly higher than in SEC and RRD. The diversity of aquatic animals in RRD was low (~20 species) with only 4 or 5 available throughout the year and the rest of the species were only present at certain times of the year. The status of diversity and its declining trend in some part of SE Asia can be related to several factors. The intensification of agriculture appears to be a major cause. Several researchers have already highlighted the negative impact of agricultural practices brought by intensification i.e. excessive use of chemical fertilizers and pesticides, flood control and irrigation (Bambaradeniya and Amarasinghe, 2003; Cagauan and Arce, 1992; Fedurok and Leelapatra, 1992; Halwart *et al.,* 1996; MOFI/WB, 2004).

In general more than 50% of the total AA consumed came from the households' own systems and open water bodies, with the remaining proportion being purchased or received as gifts. However, these proportions showed variation between the three countries investigated. In NET for example, the contribution of OWB alone to total AA consumption was more than 50% while in SEC it was only 31%. The importance of FMAS was clearly illustrated in RRD where they contributed more than 40% of the AAs consumed. Another interesting finding is the amount of aquatic animals being given or exchanged with other households in the community. This type of behaviour was particularly common in NET but less so in Vietnam and was hardly seen at all in SEC. This result can be interpreted in several ways, relating to the limited amounts of AA available and collected in SEC, making them highly valued and their use as gifts inappropriate. It might also suggest that using such natural resources as a form of social capital is less developed, reflecting generally lower levels of trust and cooperation between households. Similarly to the findings concerning the collection of AA, it was found that a large proportion of AA being consumed in SEC and NET derived from rice fields (56% and 66% respectively) and the majority was considered SRS. In contrast, 72% of the AA that came from FMAS in RRD were contributed by household ponds. However, aside from rice fields, there were other FMAS that largely contributed to the total AA consumption in both SEC and NET, like TP. This type of pond however was not present in RRD, suggesting SRS management in such systems is inappropriate within irrigated intensive rice production (Fernando, 1993; Fernando and Halwart, 2000; Frei and Becker, 2005). Economic co-production of fish and rice within 'modern' irrigated rice production systems has been described elsewhere in Asia (e.g. Fernando and Halwart, 2000; Frei and Becker, 2005) and specifically for the Red River Delta (Nguyen *et al.,* 1997).

The different SRS species were also highlighted in this section where their contributions to total AA intake were relatively high especially in poor farmers in SEC and NET. Overall, although the contribution of SRS to AA consumption in RRD is low, it was relatively more important to the poor. The variation in the size of AA particularly in SRS that was consumed by different wellbeing groups varied, the smaller size of AA (*Macrobrachium* spp., *Esomus*, *Rasbora* spp, *Mystus* spp., *Anabas testudineus*, small eel) were usually consumed by poor households at all three sites. Previous studies have highlighted the importance of these species to household consumption in rural areas (AIT/A0, 1992; Mogensen, 2001; Prapertchob, 1989; Tana *et al.,* 1994). However, Common carp and Crucian carp were also important to poor households in RRD. Larger sized and high value SRS species (*Channa* spp., *Clarias* spp., *Ompok* sp., Indian carps and Silver carps) were commonly eaten by better-off families. Larger species of SRS usually fetched relatively high prices in the market (Gregory *et al.,* 1996) and in most cases poor farmers tended to sell these species and retain low value AA in the household in order to earn money to buy other necessities of the household.

4.3.7 Marketing of aquatic animals

A set of different research approaches were used to generate information for this section: (1) cross-sectional study; (2) longitudinal study; (3) focus group discussions; and (4) a one-off analysis of markets. An overview of the marketing of AA and the number of households selling a proportion of their catch were generated from the first approach (1). A more detailed understanding of the contribution of different groups of AA to the total sold and seasonal variation was developed from the longitudinal study. Both the focus group discussion and market visits further improved interpretation and understanding of how aquatic animals were marketed.

Markets were generally located away from the specific study areas at all three sites (Figure 4.58). The closest markets that the communities accessed were the commune/sub-district markets. In most cases, small shops were located in the village but these usually did not sell AA, rather supplying only basic needs in the households such as food seasoning, cooking oil, snacks, cigarettes and in some cases preserved food.

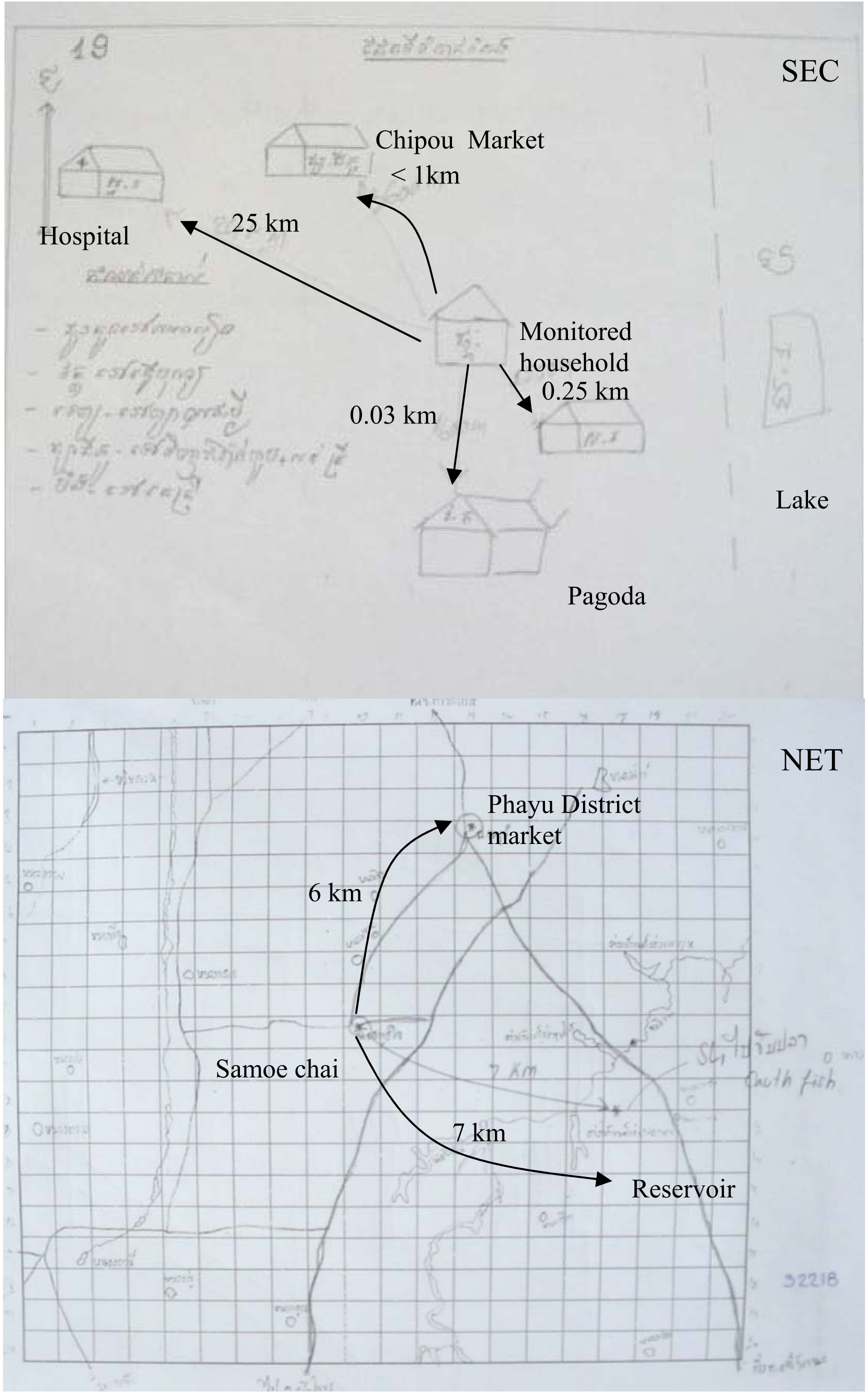


Figure 4.58. Examples of farmers' perceptions regarding their distance to different services including markets. SEC – map from Svay Cheak village (LOW area). NET – map from Samoe-chai village (DRY). *Data presented based from mapping exercise during the longitudinal study. No available data from RRD.*

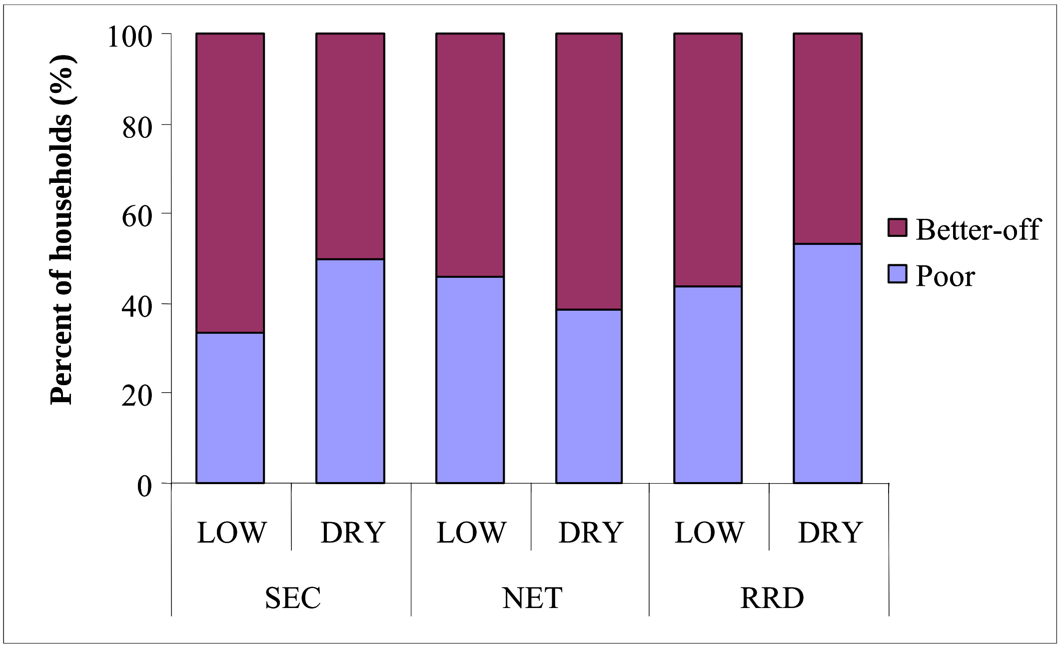


Figure 4.59 Total proportion of households by well-being groups and AEZ of SEC, NET and RRD that reported marketing a proportion of harvested/received aquatic animals. *Data presented based from the cross-sectional survey.*

Figure 4.59 illustrates the percentage of households reported marketing a proportion of their AA caught. As shown in the figure, a large proportion of the individuals reported marketing collected AA were from the better-off households (>50%) especially in the LOW area of SEC (66%). However in the DRY area of RRD, a larger proportion (53%) of individuals reported marketing their AA products came from the poorer group of households.

Amongst the households reporting marketing a proportion of their AA caught, analysis was carried out to determine the location where such AA were sold. Figure 4.60 shows the distribution of households selling their AA caught to different locations. In SEC, households mainly sold AA to commune or sub-district markets (60%), and to a lesser extent within the village or “locally” (40%). In NET, households mainly sold AA within the village (89%). Market intermediaries were relatively unimportant in both NET and SEC. In contrast, households in RRD commonly sold their products through traders (54%). However, selling within the village and nearby markets was also practiced by some households in RRD (23%).

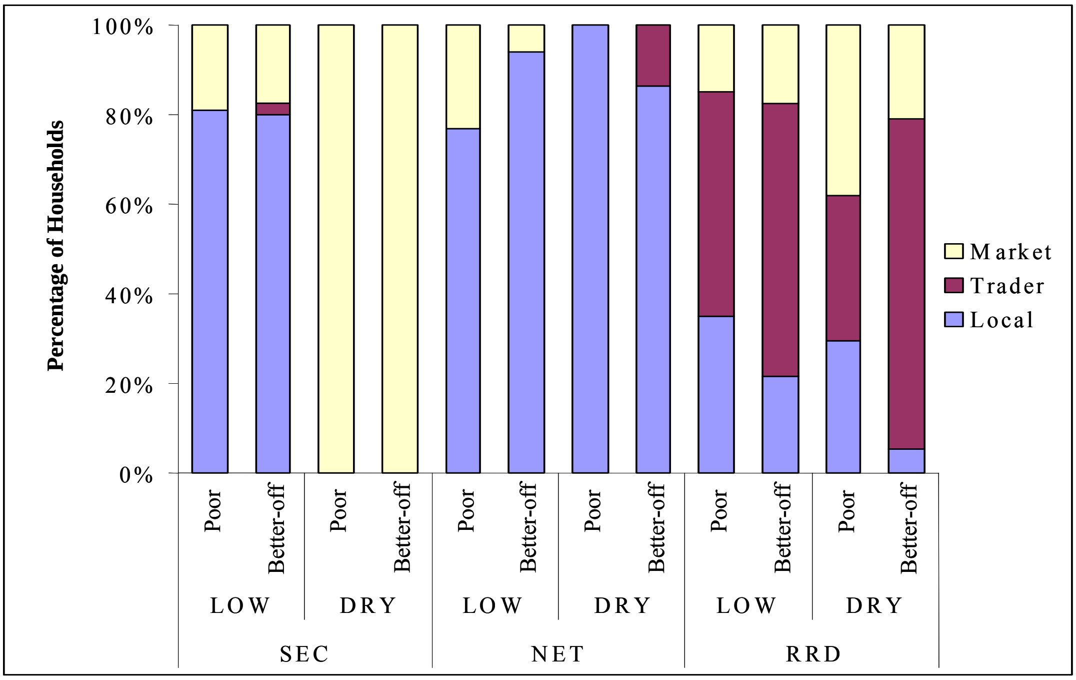


Figure 4.60 Percentage of households from different wealth groups and different AEZ who reported selling aquatic animals to different locations in SEC, NET and RRD.
Data presented based from the cross-sectional survey.

Based on the market visits conducted, the proportion of vendors selling different high nutritional value food groups was identified; fresh fish vendor, processed fish and meat vendors. Table 4.10 summarises the information collected in the market survey. The percentage contribution of the different types of vendors varied amongst sites. In SEC, a higher percentage of vendors sold fresh fish in the markets visited (47 and 50% of total in the LOW and DRY areas respectively). Vendors selling processed AA were the least numerous in the DRY area of SEC (14%).

Table 4.10 Description of different market where households from the different study sites sold and purchased AA as well as other quality food groups. ***Data based from direct market visit.***

Site and AEZ	Name of Market	Type	Number of Vendors: Fresh Fish	Processed fish	Meat
SEC					
LOW	Svay Rieng Market	Provincial	35	39	33
	Prasaut Market	District	17	9	10
	Chipou	District	26	6	10
	Kampong Ro	District	20	4	6
	Chok	District	17	6	5
DRY	Tramkok	District	14	4	10
	Angroka	Commune	11	3	8
NET					
LOW	Mahachanachai	District	9	7	3
	Kumkaunkeaw	District	8	6	6
	Eadsamad	District	9	5	5
DRY	Planoompai	District	26	2	14
	Phayu	District	7	10	13
	Kantararom	District	19	28	19
RRD					
LOW	Guot	Village	5	0	5
	Gie	Village	10	3	15
	New Market	Village	14	2	12
	Khe	Commune	13	2	15
	Bim	Commune	12	5	15
	Bai	Commune	18	5	30
DRY	Da Phuc	District	77	7	150
	Ny	Commune	59	5	100
	Thuy Loi	Commune	15	2	10
	Phu Lo	District	38	10	90
	Nam Coung	District	28	5	65
	Yen Tang	Village	31	6	4

In NET, the percentage of vendors selling fresh fish was the higher than those selling processed fish and meat products. The percentage of the vendors selling processed AA in NET was the highest amongst the three sites (31% and 28% of the total vendors from the LOW and DRY areas respectively). In contrast to both SEC and NET, a higher percentage of vendors were selling meat (50% and 60% from LOW and DRY area respectively) in RRD and a very small percentage were selling processed AA (9% and 5% from LOW and DRY area respectively). The differences in the contribution of different groups of AA to the total value of AA sold were observed to be site and AA group specific (P <0.001) (Table 4.11). The contribution of SRS to the total value sold by households was significantly higher than stocked and wild AA in both SEC and NET. However, in RRD most of the income generated by better-off households was the result of selling stocked AA ($P < 0.05$). The difference between sub-sites (LOW and DRY) in terms of mean value of AA sold was observed to be significant ($P < 0.05$) in NET and RRD where households in LOW areas gained more income from AA than in DRY sites. No seasonal differences were found elsewhere.

Table 4.11 Average value (\$US dollar hh^{-1} wk^{-1}) of AA sold by households from different wealth groups and different AEZ of SEC, NET and RRD. ***Data presented based from longitudinal study.***

Study sites	SRS	AA group Stocked	Wild	Total
SEC				
LOW				
Poor	2.1±15.5	0.1±0.6	0.8±2.7	3±9.1
Better-off	2.3±8.7	1.2±9.2	0.7±2.4	4.2±7.5
DRY				
Poor	0.03±0.2	0	0	0.03±0.2
Better-off	0	0	0	0
NET				
LOW				
Poor	8.5±21.9	0.1±0.6	4.0±11.8	12.6±14.6
Better-off	0	0	4.2±12.5	4.2±31.6
DRY				
Poor	4.3±11.9	0	1.8±9.9	6.1±9.1
Better-off	7.2±42.4	0	0	7.2±29.9
RRD				
LOW				
Poor	2.4±9.8	3.6±19.6	3.7±18.7	9.7±16.6
Better-off	0.5±3.6	16.5±54.0	3.1±12.8	20.1±32.8
DRY				
Poor	0	0.7±1.8	0	0.7±1.1
Better-off	1.1±4.8	1.0±3.2	0.8±4.8	2.9±4.3

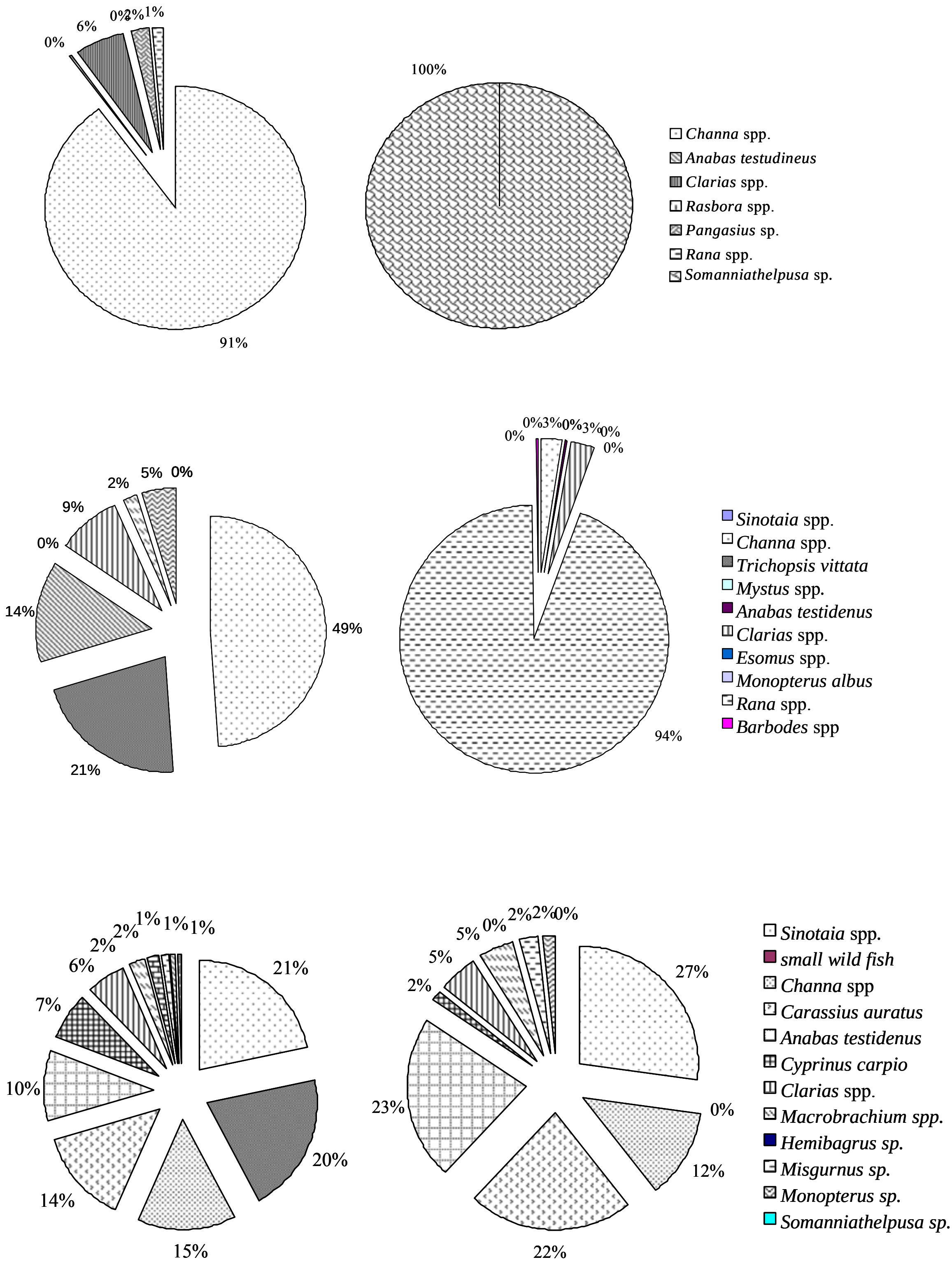
± Standard deviation

4.3.7.1 Composition of SRS being sold

The composition of SRS sold by households in different AEZ in each study site is presented in Figure 4.61. Although there were many SRS species harvested in both areas, only a few were sold. Differences in the important species that were marketed were identified between sites and AEZ. Species of SRS such as *Channa* spp.*, Rana* spp.*,* and *Clarias* spp., dominated the sales in SEC and NET. However in RRD, *Sinotaia* spp.*, Channa* spp.*, Carassius auratus* and *Anabas testudineus* contributed most to total sales of SRS.

In SEC, two main SRS species contributed to total sales: *Channa* spp., (mainly in LOW) and *Somanniathelpusa* sp., mainly from DRY area. However, other species were also sold from different AEZ. In the LOW areas of SEC, six common SRS were sold but more than 90% of income derived from the sale of *Channa* spp. alone (319 kg out of 354 kg). In the DRY area of SEC, only ricefield crabs (*Somanniathelpusa* sp.) were sold by the households monitored. In NET, there were at least six species of SRS sold in each AEZ and mainly dominated by *Channa* spp., *Rana* spp.*, Trichopsis* vittata*,* and *Mystus* spp. However, the species and percentage contribution of each species were different between zones. In the LOW area, *Channa* spp. contributed almost 50% of the total weight (56kg) sold. On the contrary, in the DRY area, *Rana* spp. dominated the sales of SRS, to which it contributed almost 95% of the total weight sold (70kg). Both *Channa* spp. and *Clarias* spp. contributed 3% each of the total SRS sold in DRY areas of NET.

Figure 4.61 Percent contribution of different SRS species sold during the 12 months monitoring. ***Data presented based from longitudinal study.***



In RRD, a larger number of SRS species were sold (12 and 9 species from LOW and DRY respectively) although four species dominated sales: *Sinotaia* spp*.*, *Channa* spp.*, Carassius auratus,* and *Anabas testudineus.* However the number of species might be much larger as farmers reported all small species of non-stocked AA as "small wild fish". Amongst the SRS species sold, snails, small wild fish and *Channa* sp contributed more than 50% of the total sales in the LOW while snails, *Anabas testudineus* and *Carassius auratus* were the dominant species in the DRY, contributing more than 70% of the total weight of SRS sold.

4.3.7.2 Discussion on marketing AA

Markets in general are part of the infrastructure that is lacking or less accessible in most of the villages studied, particularly in SEC. Relative access is higher in Vietnam than in the other sites. ADB (2005) suggested that in Thailand (northeast) marketing of freshwater fish is complex which involves several channels and parties, however, accessing these markets was not considered as constraint for fish farmers including small scale producers. Using the information collected in this study, the earlier report of ADB (2005) is applicable to Thailand and Vietnam, however, markets are still a constraint in rural areas of Cambodia.

Different types of markets were identified in this research, ranging from house to house to provincial and urban markets (e.g. Hanoi city in Vietnam). In both Cambodia and Thailand the markets accessed by the households studied were located only at district and provincial level which were considerably distant. This probably contributed to their importance being relatively low. In contrast, in areas of Vietnam, markets were located close to the study areas and households were more reliant on goods that could be purchased or sold in the market, including AA. The proportions of households selling AA locally were relatively high in SEC and NET. Similarly, Tana *et al.* (1994) reported that in commune and village markets in Svay Rieng province, vendors selling AA were negligible and concluded that fishing farmers were likely to sell their catches from their house or carry them around the village instead of bringing it to the market. However, Gregory *et al.* (1996) found that marketing AA depends on the season. For instance, when farmers collected a large quantity of AA (at the onset of the rainy season or draining of trap ponds), marketing was always carried out through selling from the farm to direct buyers but also through middlemen who will then sell the products to other villages or local market. In Thailand, as reported by AIT/AO (1992) and Demaine *et al.* (1999), similar trends were also found where AA were commonly sold in locally, local markets and by mobile vendors. Selling of AA (live) straight from the system command higher prices and reduces marketing costs of fishfarmers (Setboonsarng and Edwards, 1998). Phromthong (1999) however described a varied system of marketing in the study conducted with farmers whose intention was to grow AA for consumption, excess production were being sold within the village or nearby local markets. However for the farmers who were engaged in larger scale production, then the target mechanism is to sell to traders and provincial markets.

The proportion of market vendors selling fresh AA was generally high in all areas (>40%). Additionally, processed fish was also commonly traded in the market and a significant proportion of vendors were selling this especially in NET (>28%). Tana *et al.* (1994) reported similar trend of proportion regarding the amount of vendors selling fresh AA in Svay rieng markets. Furthermore, Tana *et al.* (1994) also reported that bulk of the fresh AA being sold in the market came from wild caught (including ricefields fisheries) locally. However in RRD, > 50% of the vendors was selling meat. This result explains the different consumption patterns of households especially those that were purchasing a large proportion of the food they consume. For example in DRY areas of SEC, consumption of AA was high although limited aquatic systems which means that most of the households purchased most of the AA they consumed. On the other hand, households in RRD consumed relatively large quantities of meat as it was widely available both in local markets and from their own farms.

As discussed in the earlier section (AA utilization), the proportion of AA produced being sold was relatively little in SEC and NET while it was significant in RRD. Most of these AA being sold in RRD were stocked species, however in SEC and NET, SRS and wild species are mostly sold in the market as they commanded a higher value than the stocked species. Gregory *et al.* (1996) found that large snakehead (*Channa* spp) and *Clarias* spp. always fetched a good market value. Similarly, ADB (2005) reported that snakehead (*Channa* spp) fetches the highest price among other AA species being sold in the market while tilapia, silver barb and Indian carps were relatively cheaper. In this study, there were important differences between the species marketed in different AEZ with non-finfish e.g. *Rana* spp. being particularly important in drier areas of NET and SEC respectively. Bush (2004) identified the relative ignorance of the value of AA other than finfish in fishery studies in SE Asia, especially to the poor, these results support his thesis that non-stocked species may be of greater importance to rural people than conventionally cultured fish. Overall, the marketing of AA varied between wellbeing groups and level of farming and addressing issues related to marketing should be dealt with different approaches.

4.3.8 Comparison of qualitative and quantitative data

This section present the similarities and differences of information collected using PRA and survey data with regards to species of important aquatic animals and the diversity of AA in the study sites.

4.3.8.1 Most important AA

As presented in Table 4.12, most of the important AA species identified during the PRA exercises were also identified as important AA in the two data collection activities carried out during the longitudinal study of both collection and consumption. At least 3 out of the 6 top AA species identified in the quantitative research were included in the list of important species during the qualitative data collection. However, the order of importance slightly varied between the research approaches. In SEC, the important aquatic animals included large and small species of fish and non-fish species such as; *Channa* spp., *Clarias* spp., *Anabas testidenus* and *Rana* spp. in each of the methods used. Similarly, in NET, the same species were identified in all research approaches but with the addition of *Pangasius* spp., *Rasbora* spp., and other barbs. In RRD, however, some species identified as being important during qualitative data gathering were found to be less important when assessed through the monitoring exercise. These included non-stocked species like *Channa* spp., *Sinotaia* spp., and *Somanniathelpusa* sp.

Table 4.12 Top ranked (6) aquatic animals identified using different research methods. Species were arranged by importance.

Sites and sub-sites		Types of data collection		
		PRA (by scoring)	**Collection (by weight)**	**Consumption (by weight)**
SEC	LOW	*Channa spp.*	*Channa spp.*	*Channa spp.*
		Mystus spp.	*Pangasius sp.*	*Clarias spp.*
		Rana spp.	*Clarias spp.*	*Anabas testidenus*
		Clarias spp.	*Anabas testidenus*	*Rasbora spp.*
		Anabas testidenus	*Rana spp.*	*Rana spp.*
		Kryptopterus sp.	*Rasbora spp.*	*Macrobrachium spp.*
	DRY	*Clarias spp.*	*Channa spp.*	*Channa spp.*
		Channa spp.	*Oreochromis niloticus*	*Barbodes spp.*
		Anabas testidenus	*Macrobrachium spp.*	*Rasbora spp.*
		Rana spp.	*Rasbora spp.*	*Clarias spp*
		Mystus spp.	*Somanniathelpusa sp.*	*Carps*
		Rasbora spp.	*Clarias spp.*	*Macrobrachium sp.*
NET	LOW	*Channa spp.*	*Channa spp.*	*Channa spp.*
		Barbodes spp.	*Pangasius spp.*	*Clarias spp.*
		Mystus spp.	*Anabas testidenus*	*Barbodes spp.*
		Clarias spp.	*Clarias spp.*	*Hemibagrus sp.*
		Rana spp.	*Kryptopterus spp.*	*Anabas testidenus*
		Pangasius spp.	*Barbodes spp.*	*Rana spp.*
	DRY	*Clarias spp.*	*Channa spp.*	*Channa spp.*
		Channa spp.	*Anabas testidenus*	*Rana spp.*
		Rana spp.	*Rana spp.*	*Barbodes spp.*
		Barbodes spp.	*Barbodes spp.*	*Clarias spp.*
		Rasbora spp.	*Clarias spp.*	*Sinotaia spp.*
		Anabas testidenus	*Monopterus albus*	*Anabas testidenus*
RRD	LOW	*Macrobrachium spp.*	*Indian carps*	*Indian carps*
		Sinotaia spp.	*Hypophthalmichthys molitrix*	*Hypophthalmichthys molitrix*
		Cyprinus carpio	*Ctenopharyngodon idella*	*Cyprinus carpio*
		Somanniathelpusa spp.	*Cyprinus carpio*	*Carassius auratus*
		Hypophthalmichthys molitrix	*FW clams*	*Anabas testidenus*
		Carassius auratus	*Carassius auratus*	*Clarias spp.*
	DRY	*Cyprinus carpio*	*Indian carps*	*Indian carps*
		Macrobrachium ssp	*Ctenopharyngodon idella*	*Hypophthalmichthys molitrix*
		Sinotaia spp.	*Hypophthalmichthys molitrix*	*Ctenopharyngodon idella*
		Hypophthalmichthys molitrix	*Cyprinus carpio*	*Orechromis niloticus*
		Channa spp.	*Oreochromis niloticus*	*Cyprinus carpio*
		Somanniathelpusa spp.	*Carassius auratus*	*Anabas testidenus*

4.3.8.2 Mean number of AA species

The number of AA species identified during the qualitative research was different from the quantitative research but this was probably because of the way the information was collected during the quantitative approach (Table 4.13). During the PRA exercise, AA that were present or had been observed in each area were identified. On the other hand, during the quantitative research, data were generated from the actual collection and consumption data which means only those species that had a direct link with the households/respondents were recorded. Species that were not consumed nor collected were therefore not included in this list.

Table 4.13 Mean number of AA species identified using different approaches

Sites and sub-sites	Types of data collection		
	PRA	Monitoring	
		Harvest	Total Consumption
SEC			
LOW			
Poor	18	9	11
Better-off	17	9	11
DRY			
Poor	17	6	12
Better-off	19	4	11
NET			
LOW			
Poor	37	16	18
Better-off	37	11	14
DRY			
Poor	20	10	13
Better-off	29	14	13
RRD			
LOW			
Poor	15	5	7
Better-off	16	8	8
DRY			
Poor	19	4	7
Better-off	19	6	7

4.4 Discussion

The information generated through the application of combined qualitative and quantitative approaches that was presented in this chapter helped to understand the complexities of various types of aquatic systems, the management practices and the important contribution of the different products to the livelihoods of households in the rural area. The production from the different systems included wild, stocked and SRS. Furthermore, this chapter analysed different factors (agroecological zone, wellbeing groups, age and gender issues and seasonality) undermining the contribution of the different aquatic products. The following discussion attempts to bring together the different findings in this chapter to achieve the following:

1. Highlight the complexities of the physical characteristics, management and the social aspects of aquatic systems

2. Broadly discuss self-recruiting species (SRS), their management, exploitation and overall importance to livelihoods

The findings of this chapter generally elucidated the importance of rice fields and other linked FMAS as source of various aquatic animals especially SRS. This findings support the various researchers (AIT/AO, 1998; Gregory and Guttman, 2002b; Guttman, 1999; Shams and Hong, 1998) who have highlighted the relative importance of ricefields in providing food in terms of rice and aquatic animals and security of livelihoods in terms of financial and natural capital. Most of the aquatic animals coming from rice fields and nearby waterbodies are considered important source of animal protein and other essential minerals needed by rural households

(AIT/AO, 1998; Gregory and Guttman, 2002b; Middendorp, 1992; Mogensen, 2001; Roos, 2001). Prapertchob (1989) estimated that 57% of animal protein consumed by rural north easterners in Thailand comes from fish which is mainly derived from paddy fields and nearby perennial water bodies. Mogensen (2001) and Roos (2001) both reported the importance of fish and other aquatic animals as a source of vitamin A and other essential nutrients for households in the Lower Mekong Basin (Cambodia) and Bangladesh respectively. In previous studies, no distinctions were made between paddy fields and perennial water bodies whereas the current study sets out the major differences in terms of access, benefits and development potential between the two. Rice field fisheries were traditionally considered an open access resource (Gregory and Guttman, 2002; Shams and Hong, 1998) and this still occurs particularly in LOW areas of SEC and NET, where any household could collect AA provided they did not damage the rice crop or collect directly from the deeper systems attached to or within the paddy. Pressures by increasing population on aquatic resources determine the amount and diversity of aquatic animals collected and consumed in the area. Gregory and Guttman (1996) reported that the production in rice field fishery was declining due to the increased pressures such as overexploitation related to increased numbers of fishermen and the introduction of destructive fishing gear. Soubry (2001) reported similar findings from the result of the PRA activities conducted in NET and RRD. Similarly, Beaton (2002) reported that farmers/households perceived that the causes of decline of AA in the area were brought by similar factors mentioned earlier. Intensification of agriculture, especially the use of pesticides (Beaton, 2002; Soubry, 2001) can also have a negative impact on the AA in the rice fields as reported by several researchers (Ali, 1990; Cagauan and Arce, 1992; Gregory, 1997; Gregory and

Guttman, 1996 and 2002b; Fedoruk and Leelapatra, 1992). These reasons for decline were also reported by Shams and Hong (1998) who predicted that it would result in changing access rules to rice fields. Water management such as development of irrigation has also had a negative impact on fish stocks in the rice fields and adjacent water bodies (MOFI/WB, 2004; Nguyen-Khoa *et al.,* 2005) as natural movements of AA were altered/hindered through the creation of canals and dikes.

The characteristics of trap ponds and their role in the production of SRS and other AA were also broadly described in this chapter. Their uses include the provision of temporary habitat for large species particularly during the dry season, and water storage for agricultural requirements, which were also found by AIT/AO (1992 and 1998) from their baseline survey and assessment conducted in the same region. Trap ponds are popular, particularly in rainfed DRY areas of NET and the LOW areas of SEC. In Thailand this system mainly functions for AA refuge and water storage, however in SEC, such ponds are mainly used to trap and contain AA from nearby large water bodies that are linked, often seasonally, to the system. Several researchers already described and investigated the importance of trap ponds in northeast Thailand. Fedurok and Leelapatra (1992) described trap ponds as the transition from rice-fish capture to culture fisheries which only need simple management and can increase fish production. Setboonsarng (1994), similarly, considered trap ponds as part of the evolution of fish production system in northeast Thailand that eventually led to linked-pond stage and eventually culture ponds. Several researchers have highlighted the importance of trap pond in the livelihoods of northeastern people in Thailand (AIT/AO, 1998; Pholwieng, 2001; Saengrut, 1998).

The rate of development of aquaculture in all areas (SEC, NET and RRD) is rapidly increasing with conventional culture being most common in RRD (Luu *et al.,* 2002; MOFI/WB, 2004). The relative importance of SRS appears to be highly dependent on the availability and maintenance of perennial water bodies that are linked to many types of FMAS. Such linkages and access to perennial water bodies can also influence the importance of other AA. Generally, stocking AA is only common among better-off households who have significant resources. In any community, foraging/collecting non-stocked and wild AA are often associated with poor families. Maintaining perennial aquatic resources and their links to FMAS may be essential to maintain the population of SRS which are more beneficial to resource-poor households as a source of food supply (Cheftel and Lorenzen, 1999).

The heterogeneity of lowland rice field areas in which deeper areas are interspersed within larger areas of rice field may be particularly important where perennial water bodies are limiting. The importance of the links and their management between ponds in neighbouring rice paddies may be important in sustaining SRS productivity (Little *et al.,* 2004). Maintaining or enhancing such linkages might have a great impact on the yield of SRS and other AA (Setboonsarng, 1994) but understanding how this might be achieved is complicated by a capacity for migration among many SRS species. Migration between different locations of seasonally inundated agro-environments occurs in many cases and allows SRS to complete their life cycles (Amilhat, 2006). The combination of open water bodies (e.g. streams, swamps and lakes) and FMAS (e.g. ponds and rice fields) is usually common in SEC and NET. Aside from being open and allowing SRS to move in and out into the system, certain management of different FMAS can also affect the productivity of SRS.

The existence of various types of aquatic systems only reflects a dependency on AA for household consumption as households are using such systems to trap and collect AA. Moreover, the seasonal availability of water may have also influenced the existence of these systems. In Cambodia and in rainfed areas of Thailand, irrigation water is limited and therefore as a coping mechanism, households dig out deeper areas of, usually, low-lying land to keep water for agriculture and domestic use.

4.4.1 Contribution of SRS to total AA collection

A large proportion of collected AA harvested from various aquatic systems in the rural areas came from SRS particularly in areas where conventional aquaculture was undeveloped (Cambodia, 60%) or non-stocked species remained widely available (northeast Thailand, 67%). In contrast, in RRD, SRS only contributed 11% of the average AA collection and most were supplied from stocked species (74%). As discussed earlier, most of the SRS from other sites (Cambodia and Thailand) derived from rain-fed rice paddies. The relative paucity of SRS in RRD-Vietnam where rice intensification is widespread, was likely to be related. Lawler (2001) reported that the role of rice fields as temporary wetlands and habitat for aquatic animals is threatened by increasing agricultural intensification.

A great impact of seasonality was observed in this research. The complementarities amongst different AA groups were also significant particularly between wild and

SRS in Thailand. Overall the critical periods for harvest of AA occurred at the beginning of the year (January) and mid-year (June). The low average weekly collection of AA during these periods maybe accounted for by the delayed rains in the year when the study was undertaken but also the limited time of farmers in rural areas to forage for food as they were busy preparing for rice cultivation. The peak of SRS collection occurred during the beginning of the dry season (February to March) as deeper aquatic systems dry up and AA were confined in restricted areas making for easy collection; and at the end of the rainy season (September to early November) when water from the rice fields starts to recede or is drained in preparation for the harvest.

Catch per unit effort (CPUE) is obviously higher from FMAS than OWB especially in LOW areas. In some areas however, CPUE in FMAS is highly seasonal with a complementary effect with CPUE on OWB especially in Thailand. Overall the CPUE is generally high during the beginning of dry season and the late part of the rainy season. This may be linked to the depth and movement of water from nearby perennial water bodies. During the beginning of the dry season, water recedes to deeper areas of FMAS i.e. trap ponds or households ponds, and in this way, farmers can most efficiently catch AA with less fishing effort. In LOW Thailand, there were months (May to August) where CPUE in OWB was higher than FMAS. During this high rainfall period efficient harvest is possible because flooding stimulates migration of many aquatic species and their capture can be efficient through careful placing of traps within flood channels (Amilhat, 2006).

Different sizes of AA were collected by farmers in this research. It was observed that the contribution of smaller sizes of AA (< 20 cm) contributed more than 50% of the total collection of poor farmers especially in SEC and NET. On the contrary most of the households in Vietnam caught and consumed bigger sizes of fish (>20 cm). Mogensen (2001) and Roos *et al.* (2003) reported that smaller AA consumed in rural areas of south and southeast Asia respectively are good sources of important nutrients needed for growth and development especially if eaten whole. Bones, scales and shells of small AA like Rasboras, freshwater shrimps, etc. are good source of calcium and vitamin D when eaten as whole (Mogensen, 2001; Roos *et al.,* 2003).

The perceived diversity of AA available in the area was significantly higher than the actual number of species being regularly collected, especially in Cambodia and Thailand. In Vietnam, however, the number of species was relatively similar. The discrepancy in the number of species between the perceived and actual catch may be interpreted various ways. It could be indicating a rapid loss in biodiversity-species may remain 'known' but practically be rare or unavailable. This interpretation can be linked to the reports by some researchers regarding the ecological impact of agricultural intensification and human modification of aquatic environment i.e. dams and irrigation creation (Ali, 1990; Cagauan and Arce, 1992; Fernando, 1993; Lawler, 2001; MOFI/WB, 2004). Another interpretation of the discrepancy may be due to some aquatic animals being included in the list because of their characteristics (e.g. good taste) even if rare. In Vietnam, the number of species was similar because most of the species mentioned during the earlier data collection were mostly stocked species and at present, most farmers are still using the same species of fish for culture.

This apparent recent decline in the number of species is even more significant if seasonality of availability is considered. From the longitudinal study, it was found that very few species can be collected year round (7 and 2 from Cambodia, 4 and 5 from Thailand, 3 and 2 in Vietnam, for LOW and DRY area respectively). Most species can only be collected for at most 6 months during the rainy season suggesting that they migrate from deeper water refuges into FMAS at this time. Lawler (2001) suggested that ricefields is a temporary wetland which serves as breeding ground for lots of aquatic animals. This findings conformed to the initial information generated during the exploratory stage of the project where most of the villagers recalled that the abundance of important aquatic animals were already decreasing (AFGRP, 2003; Morales *et al.,* 2003).

Furthermore this research presented the various factors that could potentially affect the average catch such as the available number of species, the size and composition of households, including the total farm area around which rural diversified livelihood strategies are based. The strong and positive relationship between the magnitude of the annual catch and number of species indicates the practical impacts of a high biodiversity on food security. Although the relationship between average catch and number of adults in the household was weak, it may indicated that increasing population in the rural areas has resulted in greater pressure on natural stocks as some researchers have already reported (de Silva, 2001; Gregory and Guttman, 1996; Soubry, 2001).

The most dominant SRS species that contributed to the total AA collection are mainly the large carnivorous and air-breathing species such as *Channa* spp. and *Clarias* spp., additionally, there were also small species and non-fish SRS that contributed to the total AA collection (*Anabas testudineus, Rana* spp., and *Macrobrachium* spp.) which are all important especially with poor farmers in SEC and NET because of its availability, nutritional value as well as economic value (Morales *et al.,* 2003).

4.4.2 Contribution of SRS to total AA consumption

There is no doubt that fish and other AA are important to the total food consumption of households in rural areas of Asia regardless of agro-ecology and relative well-being. Although the numbers of communities and individual households monitored were limited by resources they are probably highly indicative of the situation for a range of rice-based agro-ecologies in SE Asia. These findings support previous work conducted in the same countries. Prapertchob (1989) reported that freshwater aquatic products dominated high quality food items in the diet of rural people of NET compared to chicken and marine products. Little (1995) observed that whereas fish and other AA were everyday food, poultry and other meat tended to be consumed as 'feast food' in this part of Thailand. This contrasts with the research sites in northern Vietnam where pork and tofu are everyday food even in rural areas. In the Mekong Delta Vietnam (Ogle *et al.,* 2001) freshwater fish species such as *Anabas testudineus*, *Trichogaster trichogaster, Channa* spp., and *Kryptopterus kryptopterus* were significant in the diets of Vietnamese women. Rice, fish and leafy vegetables comprised the main food being consumed in rural areas of Cambodia (McKenney and Tola, 2002; Mogensen, 2001; UNICEF, 1994).

Excluding the mountainous areas of Cambodia or those that are close to the sea, most of the provinces produce a substantial amount of freshwater fish, thereby contributing significantly to the country's food security (Ahmed *et al.,* 1999). However the species consumed and contribution to the overall diet varies with agro-ecological zone as well as the portfolio of livelihood activities of the household (Ahmed *et al.,* 1999).

The higher consumption of AA observed at DRY sites in Northeast Thailand (71.8 person^{-1} year^{-1} or 92.83kg^{-1} AEU^{-1}) compared to LOW (58.98kg person^{-1} year^{-1} or 75.35kg AEU^{-1}) contrasts with Prapertchob's (1989) study that found people close to perennial water tended to consume nearly three times as much fish as those in areas with poorer access (36.44 kg person^{-1}yr^{-1}compared to 13.3kg person^{-1}yr^{-1}). The consumption levels in the current study were also much higher than this earlier study, perhaps reflecting heterogeneity of aquatic resources in this area of Thailand. The average consumption of AA observed in the current study in SEC (55.69kg person^{-1} yr^{-1}; (63.35kg AEU^{-1}) in lowland areas and 46.93kg person^{-1} year^{-1} (54.62kg AEU^{-1}) in drier areas was also higher than comparable studies (Gregory and Guttman 2002b; Mogensen, 2001). This finding is high as compared to the most recent report on consumption of AA in southeast Cambodia (Gregory and Guttman, 1996 and 2002b; Mogensen, 2001; Tana *et al.,* 1994). The timing, seasonality and even the techniques in recalling amounts consumed may explain these differences.

The observed diversity of food consumed by households or individuals can lead to different interpretations. It may indicate both an inherent sustainability and also give a measure of nutritional quality. Diversity can also be an important indicator in meeting needs for different nutrients (Savy *et al.,* 2005). The type and numbers of species identified that are being consumed are significantly different among agro-ecological zones and between countries. Similar findings were observed in a participatory community appraisal conducted at the same three study sites (Morales *et al.,* 2003). This previous research reported the number of species identified and consumed in the study areas, however, the source of different types of freshwater AA was not identified. In northeast Thailand, Prapertchob (1989) reported a total of 21 types of fish species identified in the five provinces around which the study was based. An assessment of trap pond harvests of catching teams in Sisaket Province carried out by the AIT-Outreach during 1994 to 1995 (Guttman *et al.,* 1999) reported only 17 species of aquatic animals These figures are significantly lower than the 47 and 30 fish types identified during the current study in Yasothon/Roi-et and Srisaket respectively. Differences in the number of species were expected due to the fact that the region is agro-ecologically heterogeneous (Little *et al.,* 1996; Pant, 2002). Also this study embraced consumption of aquatic animals of all types throughout the year rather than during one season from one specific system. Different agro-ecological zones in the region have different status/availability of perennial water-bodies. The types of agro-ecological zones in NET include irrigated, rainfed drought-prone, rainfed lowland and rolling landscapes (Pant, 2002). Furthermore differences in the development of aquaculture in the area have undoubtedly been influenced by this heterogeneity of the region (Little *et al.,* 1996); aquaculture is relatively undeveloped in the southern part of the Northeast region which also appears to have the most intact and productive aquatic resource base (Little *et al.,* 1996; Pant, 2002). In Yasothon and Roi-et, the increasing trend of excavating the rice fields for building trap ponds, which is the most common FMAS in the area was reported by Pholwieng (2001) and Suvannatrai (2002), which suggests that potentially the productivity of aquatic animals in the area may be an outcome of this increased availability of suitable environments. In Cambodia several studies have reported on species diversity. Gregory and Guttman (1996) reported 19 species of fish and six species of other aquatic animals collected during the period of study from lowland rice fields in Svay Rieng province. In Battambang, another province in west Cambodia, (Gum, 1996 as cited by Shams and Hong, 1998) 38 species were identified. Shams and Hong (1998) reported 35 species of fish collected and utilised from the rice fields of Kompong Thom province. The two figures reported by Shams and Hong (1998) and Gum (1996) were significantly higher than the findings of this research where only 21 and 32 aquatic animal species were identified in the two southern provinces Svay Rieng and Takeo, respectively. However, during the participatory appraisal in the two provinces of Cambodia only 15 and 18 aquatic animals were identified (Morales *et al.,* 2003). In the Red River Delta of Vietnam, 18 (from Phu Xuyen) and 17 (from Soc Son) species of aquatic animals were identified and utilised during the monitoring which were more or less similar to the number of aquatic animals identified during the PRA (14 species in Phu Xuyen and 18 from Soc Son). The number of AA identified during the longitudinal study were relatively similar from the numbers obtain during the PRA. In Vietnam AA were less diverse as identified by both methods, PRA and longitudinal study. In Cambodia and Thailand, higher numbers of AA were identified from the longitudinal study as compared to the number of species from the PRA. There are a number of reasons for these differences: (1) during the longitudinal study, households recalled AA from a previous short period whereas during the PRA, households recalled AA over a longer period; (2) possible contribution of AA from perennial water bodies; and (3) separation of particular species that were commonly grouped together in PRA activities (i.e. *Barbodes*).

4.4.3 Contribution of SRS to nutrition

Fish and other aquatic animals collected from paddy fields and nearby water bodies, are one of the most important sources of animal protein for rural households (AIT/AO, 1998; Gregory and Guttman, 2002b). Prapertchob (1989) reported that 57% of animal protein consumed by rural north easterners in Thailand came from fish, mainly derived from paddy fields and nearby perennial water bodies. Similar results were also found in a recent study conducted in nearby Laos. Meusch *et al*. (2003) found that fish and other aquatic animals were one of the main sources of animal protein in the diet of rural households in Laos. Garaway (1999) reported the average fish consumption in Savannakhet, Laos as 57.5kg $hh^{-1}year^{-1}$ (~14kg per AEU). In Bangladesh, it was reported that one of the rural poor's sources of animal protein were small native species (SNS) of fish (Mazumder and Lorenzen, 1999). In NET and SEC, *Rasbora* spp and *Esomus* were some of SRS that are commonly consumed. One study showed that these species including *Channa striata* were also an important source of polyunsaturated fatty acid (PUFA) in rural, otherwise low-fat diets (Little *et al.,* 2004).

4.4.4 Contribution of SRS to total AA sales

The variable but often important role of the market as a source of aquatic animals for household consumption and a place to convert AA into cash has been identified in this study. The dependency of households in Vietnam on markets for selling and purchasing AA regardless of agro-ecological zones and wellbeing is interesting. The accessibility to market and the mobility of the households in this area may have influenced the level of dependency to purchase AA. In areas where mobility is less and the market is relatively distant from the household, there is less dependency on purchased AA, like in the cases of Thailand and Cambodia, and mainly the better-off families were found to access to market. However, selling of AA occurred informally and locally in the community in addition to markets, especially when the average collection of AA was more than enough for the immediate consumption of the households but not enough to sell in formal markets. At the research sites in SEC and NET most households sold a proportion of their catch locally. In contrast, in the RRD the role of traders and formal markets was much more important.

The contribution of SRS to the total sales of AA was relatively similar to the proportion of SRS to the total AA collected. More than 60% of AA sold by Cambodian farmers were SRS; in Thailand, almost 70% of the AA sold were SRS. In Vietnam, however, SRS contributed relatively less as a proportion of total aquatic animals sold (< 10%).

Moreover, the average value of SRS being sold by farmers in Cambodia and Thailand is more than 100% higher than the value of stocked species, indicating the importance of SRS to the financial assets of the households when such species are sold.

5 Overall discussion

Self-recruiting species as defined in Chapter 3 are aquatic animals that can sustain themselves in a farmer-managed aquatic system (FMAS) and be harvested by households without regular stocking (Amilhat, 2006; Amilhat *et al.,* 2005; Islam, 2007; Little, 2002a, b). This group of species includes large and small indigenous species, AA originating from hatcheries but established as breeding populations or as escapees and non-fish AA such as crabs, freshwater shrimps, snails and frogs. FMAS represents all aquatic systems that households or farmers manage or practice any intervention in so that aquatic resource production is enhanced over natural background levels. They are not limited to water bodies in which hatchery seed is stocked only. SRS has been commonly labelled by conventional aquaculturists as 'unwanted', 'weeds' or 'predators'. Moreover, the common perception is that such species compete with stocked species for food and space and therefore have negative impacts (Setboonsarng, 1993). The main purpose of this research was to set aside such prejudices and investigate this situation more thoroughly. The research investigated the roles that SRS played in livelihoods assuming that well-being level of households and their specific locations (especially with regard to agro-ecology) would have an important influence. Recent studies have tended to focus on either of the extreme ends of the industry's spectrum, i.e. aquaculture or fisheries as observed by several literatures (e.g. Bush, 2004; Edwards *et al.,* 2002; Gregory and Guttman, 2002a; Little *et al.,* 2004). However this research aimed to understand the situation between these two ends of the spectrum based on the premise that there is a continuum in terms of importance between them.

Understanding the livelihoods of households in rural areas is a complex undertaking as there are various factors affecting livelihoods (Adato and Meinzen-Dick, 2002; Allison and Ellis, 2001; DFID, 1999; Ellis 2000a, b). Adopting the sustainable livelihood framework (DFID, 1999; Scoones, 1998) in the attempt to understand the complexities of livelihoods of the rural poor was another challenge. As discussed by Carney *et al.* (1999), various people and organizations have their own understanding and interpretation of the SL framework. Broader understanding of the different aspects of the framework is required before applying it. In the attempt to look at livelihoods in a holistic way, interdisciplinary approaches are needed as various factors affecting the livelihoods but also the concept of livelihood itself is interdisciplinary. Furthermore, the concept of the ways and means in which SRS sustain or improve livelihoods is even more complex. Like the SL framework, the SRS and the aquatic resources are also complex. However, the application of the combination of different research approaches helped to achieve the objectives.

The purpose of this final chapter is to integrate and elucidate the important outcomes of the various studies conducted under this research. There are four main sections of this chapter. Section 5.1 discussed the findings of the research. In this section, the main points from the previous chapters (mainly 3 and 4) were pulled together and the connectivity was discussed. The following section (section 5.2) discussed the contribution to knowledge of the different findings of this research. Discussion of the implications of this research, identification of further research issues relating to SRS, and the final conclusion of the research were presented in sections 5.3 and 5.4 respectively.

5.1 Discussion of research findings

By revisiting the research questions of this study, there should be four main outcomes of this research: (1) broader understanding of the livelihoods in rural areas of Southeast Asia; (2) the complexities and various types of aquatic systems and their importance elucidated; (3) the role and exploitations of aquatic animals particularly SRS understood; and finally, (4) how seasonality affects the various aspects of livelihoods of different groups of people in rural community, as well as the production and importance of aquatic animals particularly self-recruiting species was understood.

The study outputs were achieved through the application of mixed method approaches. The combinations of qualitative and quantitative approaches were employed in different ways i.e. sequential and mixed approaches, as described by Holland and Campbell (2005) to ensure both breadth and depth of understanding of the subject in question as experienced and reflected in the literature (Bolden and Moscarola, 2000; Brannen, 2005; Maxwell, 1998; Sandelowski, 2000; White, 2002). Moreoever, the integration of a structured hypothesis-driven approach with open, participatory elements provided opportunities for triangulation and was critical to build rapport and confidence with the communities involved which is very important (Hagmann *et al.,* 1995). The sequential approach (Marsland *et al.,* 2001) involved the use of the participatory rural appraisal in the exploratory stage of the research which then led to the development of evolved research questions that led to the cross-sectional survey. The mixed approach was implemented during the longitudinal study where both quantitative and qualitative information were collected during the same period (Libarkin and Kurdziel, 2002; Sandelowski, 2000). These different research approaches were applied within the sustainable livelihood

(SL) framework (DFID, 1999; Scoones, 1998). The following subsections attempt to summarise the important outcomes of the research in relation to the research questions stated in the introduction part of this thesis.

5.1.1 Rural livelihoods

The current livelihoods of the people of different wellbeing groups from the different agro-ecological regions of SE Asia were understood using the combination of participatory appraisal and quantitative surveys (cross-sectional and longitudinal). In general, the livelihoods were influenced by various trends, shocks and even policies occurring in the community and affecting different livelihood resources as described by several researchers and development organizations (Carney *et al.,* 1999; DFID, 1999; Ellis, 1999, 2000a, b; Ellis and Freeman, 2005; Scoones, 1998; Suzuki *et al.,* 2006). Meanwhile, diversification of livelihoods was generally the result of the 'shocks' that had happened and directly or indirectly affect the individual households or even the community as a whole (Campbell *et al.,* 2005; Ellis, 1999 and 2000a, b). However, the diversification and strategies were different between sites, agro-ecological zones, wellbeing categories and even among gender groups reflecting varying resources and capabilities (Altieri *et al.,* 2000; Buenavista *et al.,* 1994; Handa, 1994; Suzuki *et al.,* 2006). Several researchers suggested that resources and social dynamics are unique in specific agroecological zones (Altieri, 1989, 1998, 2000 and 2002; Flora, 2004; Sivakumar and Valentin, 1997; Thomas and Kevan, 1993).

Social stratification is a complex issue in rural areas as local people have unique ways of identifying poorer and better-off households in their community. In general, perceptions or indicators used by local people are influenced by the agroecological areas, dominant livelihood activities in the area, gender and the social status of the key informants. An important findings in social stratifications is that the main status of the household head in general (gender, diversified livelihood, human assets i.e. education and health) reflects the overall wellbeing or in a way affects the wellbeing of the entire households. Moreover, majority of the indicators in identifying the wellbeing status is still link or based on assets that can be converted into cash (Headey and Wooden, 2004). In rural areas of SEC, a large proportion of the people were categorised as poor or very poor (> 40%). In NET and RRD, the largest proportion of the community were placed in medium poor to medium rich (81%, and 60%, NET and RRD, respectively) categories. The natural capital (e.g. size, type and location of land), human (e.g. livelihood activities and capacity to diversify) and physical capitals (e.g. house, farming equipments) were the most important criteria used in stratifying households within communities.

As explained earlier, the diversification of the livelihoods depends on the available resources that household possess or have access. It can also be brought by the current challenges that the household faces brought by different shocks and trends (Ellis, 2000a, b). In general rice farming is the main livelihood activity of most of the households in the study areas, however, the degree of intensification of rice production varied with site (SEC, NET and RRD) and agro-ecological zone (LOW and DRY) which confirms the initial assumption of the research as a basis for area selection. Moreover, the economic importance of rice farming in terms of providing cash in the households also varied. The contributions of livestock, non-farming activities (e.g. small enterprises, selling labour, factory workers) as well as remittances from family members also contributed significantly to the total income of the households. Both conventional aquaculture and fishing were part of the portfolio of livelihood activities, however, the level of importance depended on the social and agro-ecological area where the community belongs. Fishing and management of non-conventional aquatic systems were more important to farmers in SEC and NET while conventional aquacultures i.e. stocking hatchery produced seed, was more important with farmers in RRD across wellbeing levels.

Shocks and trends that directly influenced the livelihoods of the people in rural areas of Southeast Asia may have accounted for the natural calamities that were experienced in the region (floods and droughts). Changes brought by political crisis also affected rural communities, especially the poor as they are the most vulnerable due to limited resources and capabilities in withstanding the amount of shocks that they encountered. Furthermore, trends in increasing populations and modernization of agriculture and economic focus in the national level also made and still influencing the livelihoods and its diversification in the study areas. However, regional events particularly the "Asian Crisis, 1997" that badly affected the economy of several countries in Asia (IMF, 1998; Rigg, 2003) were not highlighted at all in focus group discussion with rural people.

The importance of various livelihood assets were identified in this thesis. The human capital included: status of household head, capacity to diverse into different livelihood opportunities, household size and gender. Key aspects of natural capital included the area and location of land, availability of water to support both arable crops and animals. The physical assets included the different equipments and tools for livelihoods, livestock some of which were used in agricultural work but also serving as "live savings" which could be converted into financial capital in times of shocks/risks. Financial capital encompassed income from the diversity of livelihood activities including remittances of family members. Access to credit was variable between sites, reflecting the development of Govenrment and Non Government institutions but informal credit retained importance even in NE Thailand. Access to credit was linked to social capital that included the networks, involvement in collective actions particularly in the management of local resources such as waterbodies and grazing lands. All of these resources play a very vital role in the overall livelihoods; any changes in the resource base that underlie them, through environmental or social causes, can be a serious challenge to the household (McKenney and Tola, 2002). Sustainable livelihoods can be achieved if households able to reduce their vulnerability from the different shocks/risk using the different resources described above.

5.1.2 FMAS in rural areas

There are several types of farmer-managed systems in rural communities. These types of system are not limited to conventional aquaculture systems such as excavated ponds. Based on the different systems illustrated in the aquaculture-fisheries continuum (Guttman, 1996), FMAS in rural areas ranged from intensive systems of aquaculture to the very extensive such as ditches, trap ponds or even small swamps as described by several researchers (Amilhat, 2006; Islam, 2007; Little *et al.,* 2004). Amongst the different FMAS that existed at the study sites, rice fields were the most common and considered important to the livelihoods of rural households but also in maintaining the diversity of aquatic animals. As described by several researchers (Amilhat, 2006; Gregory and Guttman, 2002b; Halwart, 1994; Fernando, 1993; Lawler, 2001) ricefields provide ecosystems to these aquatic animals which allow them to continue their life cycles. The contribution of FMAS particularly ricefields and adjacent water bodies (e.g. trap ponds) in providing food, particularly food of high nutritional value, was highlighted in this research. This finding also conformed with the previous reports regarding the importance of ricefields (Gregory and Guttman, 2002b; Halwart and Gupta, 2004; Shams and Hong, 1998). A range of more extensive types of FMAS were common in SEC and NET while FMAS were dominated by only ricefields and conventional culture ponds in RRD. The type of FMAS and the area they cover appear to equate to the intensity of aquaculture in the area.

There were several types of indigenous knowledge practiced by households in all three sites in managing their aquatic systems. By using IK (indigenous knowledge) of managing various types of FMAS in rural areas, the yield and efficiency of harvest (CPUE) of SRS increased (Amilhat, 2006). The use of local resources like branches of trees, palm trees, water hyacinth, beer factory waste and even livestock and poultry wastes was common and illustrated utilisation of local knowledge for managing aquatic systems. Making the system deeper and use of lots of aquatic plants to increase cover improved productivity of AA in SEC; probably through their value in attracting SRS to enter and remain within the system. Similarly households from NET used livestock and poultry by-products to attract AA to enter into their system. The most common and probably effective practice in RRD is the use of its low-cost inputs (beer factory wastes, human and household wastes) but this related to their intrinsic value as direct nutrients, either as fertilisers supporting natural food production within the system or supplementary feed.

5.1.3 Importance of SRS

The importance of SRS to overall livelihoods in rural areas of southeast Asia is explicitly understood in this thesis. The findings support the recent studies that suggested that SRS including small indigenous species (SIS) played a very important role in the overall livelihoods of most households in the rural areas of south and southeast Asia (Amilhat, 2006; Beaton, 2002; Immink *et al.,* 2003; Islam, 2007; Islam *et al.,* 2003; Little *et al.,* 2004; Livesey, 2000; Wahab, 2003).

The contribution of SRS to overall food consumption was found to be quite heterogeneous between sites although important in all and this finding supported the reports of previous research (Mogensen, 2001; Roos, 2001; Roos *et al.,* 2003; Saengrut, 1998) regarding the contribution of fish and other aquatic animals to the food consumption in rural areas. Aquatic animals in total were significant components of overall diets (10%, 18% and 9% of AA in SEC, NET and RRD respectively) and the contribution of SRS was also significant, particularly in SEC and NET (50%, 61% and 11% of AA in SEC, NET and RRD respectively). It was also demonstrated that SRS contributed to the food security of households that did not have deeper aquatic systems such as trap ponds and household ponds, as one of the major sources of SRS found in this research were rice fields which most farmers accessed. A large proportion of the SRS collected and consumed in rural areas were small-sized (< 30 cm) that are particularly important for providing essential nutrients like calcium if eaten whole (Mogensen, 2001; Roos *et al.,* 2003).

The contribution of SRS in aquaculture as seed for stocking was highlighted in this thesis. SRS can still be considered as a valued component of aquaculture systems even when hatchery seed are widely available like in NET and RRD. The relative importance of such species (SRS) to hatchery derived species reflects the intensity and orientation of aquaculture and wider farming systems (Morales and Little, 2007). The proportion of farmers stocking seed into their system varied and was clearly related to the intensity of aquaculture; whereas only 14% of farmers in SEC reported stocking, more than 80% of households in both NET and RRD had stocked hatchery seed. However, in NET, although a large proportion of households reported stocking, wild aquatic animals and SRS were also important mainly because of their availability and natural production. In Cambodia and Thailand, a large proportion of seed being stocked in household ponds, ditches and trap ponds came from other FMAS such as rice fields and household ponds from other farmers. These seed were usually the recruits of broodstock inhabiting the system. Proper management of these broodstock in farmers' FMAS would mean a more sustainable source of seed in the rural areas as farmers would be less dependent on outside sources of seed which in most cases are the major investment cost (Karim, 2006). Hatchery seed are typically transported over long duration and are frequently of poor quality. Furthermore, the characteristics of SRS fit with the criteria that local farmers valued in important species i.e. highly available, easy to grow, cheap and versatile in preparation and consumption by the household.

The contribution of SRS or even the aquatic animals in general to household income in rural areas is marginal. SRS however did contribute to reducing household expenditures for aquaculture (seed cost) and for food purchase. Ready availability of SRS for food consumption substituted for other types of high value food. Direct impact of SRS on incomes was more significant when households harvested greatly in excess of their subsistence requirements. This scenario usually happened at the beginning of the dry season and onset of the rainy season when water receded to deeper areas of FMAS and aquatic animals were confined and easier to catch. High CPUE characterised such situations. In some households which cultured fish mainly for the market, harvest of SRS could be a valuable bonus to their stocked production as most demanded high value in the market. Such species were also used as payment for the labour extended by neighbours during harvesting or other major activities within the community (e.g. repairing house, excavating land, etc.). The value of SRS was much higher than most stocked and wild species (3 times) except in RRD where stocked species were more valuable. If these species could be sustained and the production increased, a sustainable source of income for the poor farmers in rural areas would be assured.

Additionally, some evidence of the contribution to the improvement of social capital of rural households by SRS was also found. Some of the large carnivorous fish (*Channa* spp., *Pangasius* spp.) were used by rural farmers as gifts to people with high social status in the community to show respect. Sharing of by-catch (mainly SRS) to neighbours after harvest also improved networks.

5.1.4 Factors affecting SRS importance

5.1.4.1 Level of aquaculture and agricultural intensification

The level of aquaculture as well as the intensification of agriculture obviously contributed to the level of importance of SRS in the overall livelihoods of farmers in rural areas of South East Asia as discussed in this thesis. As reviewed in the introduction chapter of this thesis, aquaculture is well established feature of mixed farming VAC systems in the Red River Delta Vietnam (Demaine, 2000; Luu *et al.*, 2002). Pant (2002) have identified several organizations and government programs who have promoted aquaculture as an integrated livelihood activity as part of overall rural development. The overall level of importance of SRS to households was found to be lowest in Vietnam and greatest in Cambodia in terms of food consumption as well as additional income. The different levels of adoption and management of conventional aquaculture may have contributed to the level of importance of SRS in all study sites. In Vietnam, most management activities had negative impacts on SRS (e.g. total draining and complete drying of pond bottom, application of lime, prevention of entry of wild AA through screen installation, etc). In contrast, in areas where aquaculture was not yet established or where dependency on natural production was still important as in Cambodia and Northeast Thailand respectively, SRS were important. In both areas management of aquatic systems was generally positive for SRS (e.g. selective dike breaching and use of AA attractants).

Agricultural intensification has been perceived to influence the importance of SRS and other aquatic animals to households in the rural areas of South East Asia. The findings of this thesis showed that in areas where agriculture is intensified, the importance of aquatic animals, particularly SRS and wild species, is relatively low compared to areas where agriculture remains rain-fed. In Vietnam for example, the contribution of SRS to the total food consumption and household income was very low compared to the contribution of stocked species. In contrast, in both Cambodia and Thailand, the contribution of SRS to the total aquatic animals consumed by households was remarkably high. This finding can be related to the negative impact of agricultural intensification as reported by several researchers (Simpson, 1994; Cagauan and Arce, 1992; Fedoruk and Leelapatra, 1992). The rampant use of pesticides and chemical fertilizers have been reported to negatively affect the populations of AA in the rice fields as well as nearby perennial water bodies which are an important environment for the aquatic animals. Similarly, modifications of the environment, e.g. construction of irrigation systems, also have a negative impact on the populations of AA particularly SRS. Irrigation systems tend to alter or block the migration path of migratory species (Nguyen-Khoa *et al.,* 2005) and many of these species are SRS.

5.1.4.2 Agro-ecological zones

The availability and types of aquatic systems in the area also contributed to the variation in the importance of SRS. Generally, SRS were most important in the areas where various types of aquatic systems such as perennial water bodies and various types of FMAS were available and accessible to households in the rural areas (LOW), whilst in areas where such aquatic resources were limited, the importance was relatively low. In the LOW area, the different aquatic systems had great possibility of linkages in certain parts of the year, especially during the rainy season when flooding usually occurred. During this period, the movement of water from perennial water bodies to shallower aquatic systems (e.g. FMAS) facilitated the movement of AA and their distribution to broader environments. Meanwhile in DRY areas, although flooding also occurred, linkages between different systems were minimal or of lower duration, resulting in more restricted movement of AA from one aquatic system to another. Furthermore, the soil characteristics were also different between sites. In DRY areas, soils tended to be more permeable and less able to hold standing water for long periods. These characteristics may explain some of the variation in importance of SRS between agroecological zones. It is also noticeable that closed FMAS, i.e. culture pond and household ponds, were common in DRY areas especially among better-off households. This can be considered as a strategy or a coping mechanism of households who have the capacity and 'capitals' to invest in such systems which are not fully dependent on natural production in order to lower risk and improve their livelihoods.

5.1.4.3 Well-being stratification

In general, the level of overall wellbeing of households probably also explained some of the observed variation in the level of importance of SRS. Poorer households were usually more dependent on natural production, including aquatic animals and plants, for their livelihoods. In contrast the better-off were more reliant on commercially produced goods, especially those who have easy access to markets as in the case of Vietnam. Most poor households lacked capital to invest in conventional aquaculture as it needs external inputs that cost money, therefore poorer households tends to rely on the natural production as in the case of Cambodia and Thailand where they allow AA to enter into their system in order to increase the production. The greater reliance on harvest of SRS by poorer households relative to stocked species was clear at each site, and perhaps most extreme in Thailand where distribution and dependence on other assets also appeared more equitable. There was a clear tendency for better-off families stocking hatchery produced seed to prevent or eliminate the entry of wild aquatic animals to prevent contamination and minimise loss of stock due to predation.

High proportions of aquatic animals being consumed by poor farmers came from SRS and wild stocks. Better-off families however, especially in Vietnam, had the capacity to obtain stocked aquatic animals which were either available from their systems or purchased from the market.

5.1.4.4 Age-gender

Gender and age of the household member can play a significant role in the importance of SRS to the livelihoods of the household. This thesis showed how different gender groups and age groups varied in terms of activities related to aquatic system management as well as the access to various resources. Decisions on the management of aquatic resources were generally made by men. However, decisions over allocation of the resources that resulted from management were typically in the domain of women, including control of monies and other outcomes. Childrens' contributions to the management of aquatic resources were minimal and only important in Cambodia, a characteristic which perhaps reflected the much lower enrolment in primary education.

5.1.4.5 Seasonality

The changes in season greatly affected overall livelihoods of households or individuals in the rural areas. As the main livelihood activity of households was linked to natural capital, inevitably any changes in the weather i.e. low rainfall or a change in timing of rainfall relatively affected overall food production (both aquatic and agricultural more broadly). As presented in Chapter 3, seasonality influences migration of household labour in the community and the need and opportunity for income diversification of to meet their livelihood needs.

Income, expenses, consumption and AA production are all influenced by seasonality. The season dictates the beginning of the main livelihood activities in rural areas, as most of people are rice cultivators. Most of rural southeast Asia remains predominantly dependent on rainfed agriculture and formal irrigation systems cover relatively small areas (Paxson, 1993). Delayed and limited amounts of rainfall typically delay agricultural production in these areas and make outcomes inconsistent from year to year. Particularly critical periods are the end of both the dry season and rainy season. Paxson (1993) reported that the lean season for agricultural families in developing countries begins prior to the harvest season. Stocked resources (food and cash) at this time tend to be minimal and therefore people need to find alternatives in order to support their needs. Consuming processed food (fermented fish, dried fish, etc.) and other cheap sources are good examples of practical attempts to smooth food insecurity in the rural areas. Decreasing food intake is also another solution, as presented in Chapter 4.

5.1.5 Sustainability of SRS

Sustainability of SRS is threatened by the current situation environmentally, politically and socially. Understanding the dynamics of the linkages of the system in ricefield landscapes could increase awareness of the behaviour and ecology of SRS species (Amilhat, 2006) and eventually lead to proper management and consideration when introducing new technologies in aquaculture, agriculture as well as irrigation and flood management. Local resource user groups (LRUG) have been identified as a potential management approach (Amilhat *et al.,* 2005; Little *et al.,* 2004; SRS and Morales, 2003) based on the concept that management on an individual household basis is unlikely to sustain aquatic stocks. Movement of SRS between natural water bodies and proximal tracts of flooded land suggests that some form of group management is necessary. Local knowledge in managing SRS such as retaining broodstocks, collecting juveniles from the wild for restocking, polyculture with hatchery produced species, building refuge areas and creating linkages from FMAS to natural waterbodies often already exist in communities but need to be scaled up in order to have greater impact on the sustainability of SRS.

5.2 Contribution to Knowledge

The findings of this study are an important contribution to knowledge, particularly to the understanding of the aquaculture-fisheries continuum in different agroecological zones in Southeast Asia.

The livelihoods of poor in the rural areas are diverse and not only limited to farming although the area is generally classified as agricultural land. Availability of different resources and the issue of access to such resources result in diversification of livelihoods. Managing of aquatic systems which are not limited to closed, hatchery seed dependent systems, but rather inclusive of semi-open systems that allow self-recruiting species can play important role in the livelihoods of poor particularly in its contribution to food security as well as to accumulation of financial capital.

The exisiting aquatic systems in the rural community are complex and diverse. This thesis helped to understand these complexities particularly those relating to rice field ecology and the surrounding waterbodies where important sources of animal protein thrive which are not limited only to fishes but also other aquatic animals. The management of such a resource doesn’t necessarily require only modern or traditional aquaculture (Edwards, 2001). The need of considering the resources available and the social factors within the community that can influence the availability and accessibility of such resource are more important.

The result of the different approaches especially the longitudinal study elucidated the contribution of SRS to the overall livelihoods of the poor people as its importance includes providing food, nutrition, additional income, and even source of seed for conventional aquaculture practitioners. Moreover, the management of aquatic systems that enhance the abundance of SRS could also positively affect the social capital in the sommunity as it brings people to work together and therefore improves social dynamics.

Lastly, the importance of seasonality, agroecological zones, and the social factors (gender and wellbeing) needs to be considered in evaluating the impact, designing a research or development program as their influences all aspect of livelihoods.

5.3 Implication of the research

5.3.1 Policy

The results of the research can be used by for developing policies that will not undermine the population and sustainability of aquatic species that are important to the livelihoods of the rural poor. In most cases, policy makers have concentrated on aquatic species that have high commercial value and that directly affect the economy of the nation as a whole. The decisions in making policies regarding aquatic resources are usually based on the knowledge from those who operate predominantly at a macro level. Inadequate knowledge on how local farmers in rural areas operate has often resulted in resource-poor people being undermined and becoming more marginalised (Keeley, 2001).

5.3.2 Research

The result of this research generated some issues that organizations responsible for research into aquaculture technology should consider.

1. Potential trade offs between aquaculture intensification and the loss of traditional production systems should be considered as well as maintaining a balance between promotion of aquaculture and biodiversity protection.

2. Characterisitics of aquatic systems that are important to the SRS life cycles should be better understood in order to develop appropriate management strategies and ensure accessibility for resource-poor households.

3. The biology of SRS species that are important to the poor and interactions with the hatchery-produced species should be an important focus of future research.

5.3.3 Development

Introduction of small-scale aquaculture as an option for livelihood diversification and a direct means to improve food security has been a common strategy among development organizations in developing countries. However, a high proportion of outright failures and poor adoption have resulted (AIT, 1994; Little and Edwards, 1997). This can partly be explained by the fact that even small-scale technology typically requires financial and other capitals which the rural poor lack. Critically analysing the situation, including the availability of different resources in a given area and the importance of natural production may, help development organizations to better target appropriate technologies for their identified beneficiaries. Introduction of SRS management can be one of the approaches that development organizations can implement in pursuit of sustainable livelihoods.

The outcomes of this research can also be used by development organizations to base their work in communities towards understanding the importance of, and requirement for, greater responsibility towards the natural aquatic resource base.

5.4 Conclusion

In conclusion, local people in the sites studied in SE Asia benefit to variable degrees from SRS as part of their overall livelihoods. They are particularly important among resource poor individuals/households in more marginal agro-environments. The contribution of SRS to overall food consumption, as a source of essential nutrients, additional income and social capital are significant across the different sites especially among the resource-poor. The concept of SRS, its management and exploitation needs to be considered in future research and development activities. The perception of SRS being ‘unwanted’ in conventional aquaculture systems has been challenged by this study and found to be untrue for many rural households who incorporate and nurture a range of species in their own aquatic systems. Maintaining or enhancing SRS within more intensive and productive agro-ecosystems remains a major challenge.

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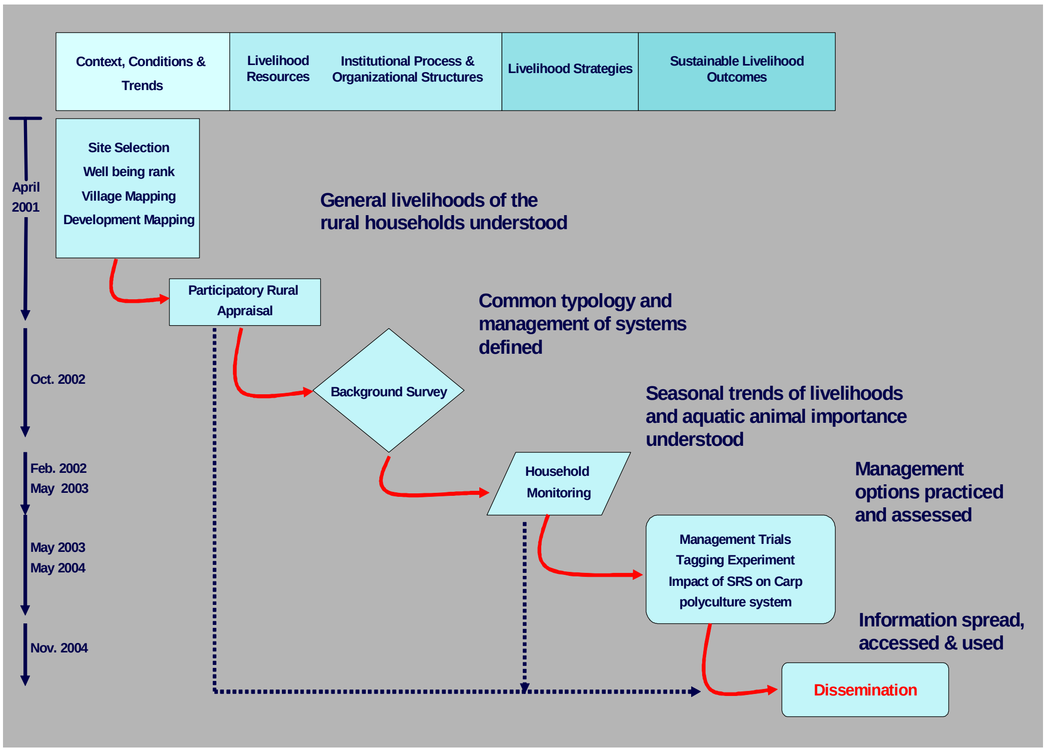
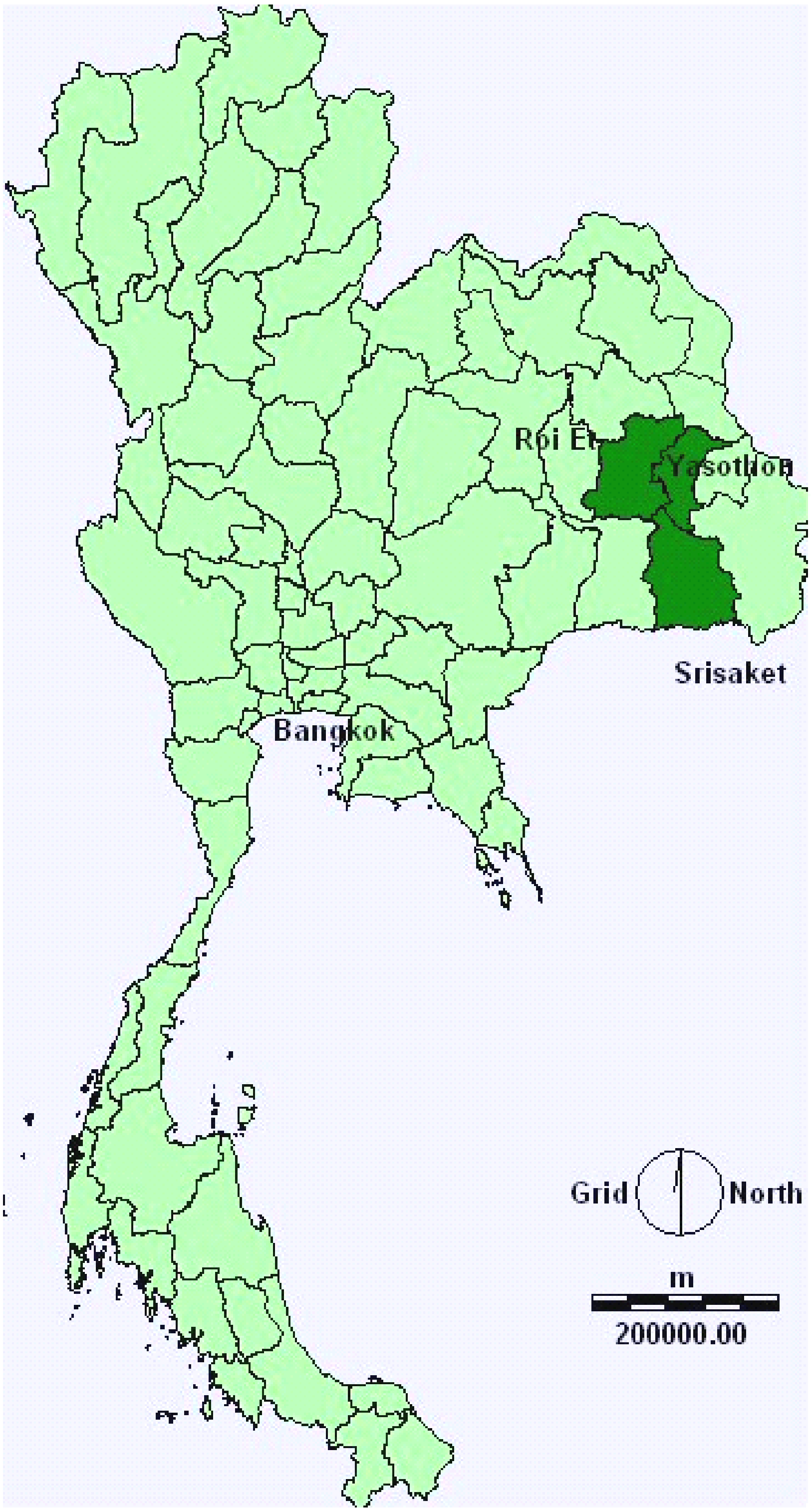
Appendices

Appendix 1. Methodological framework of DFID-AFGRP project “Self-recruiting species in aquaculture – their role in rural livelihoods (R7917)

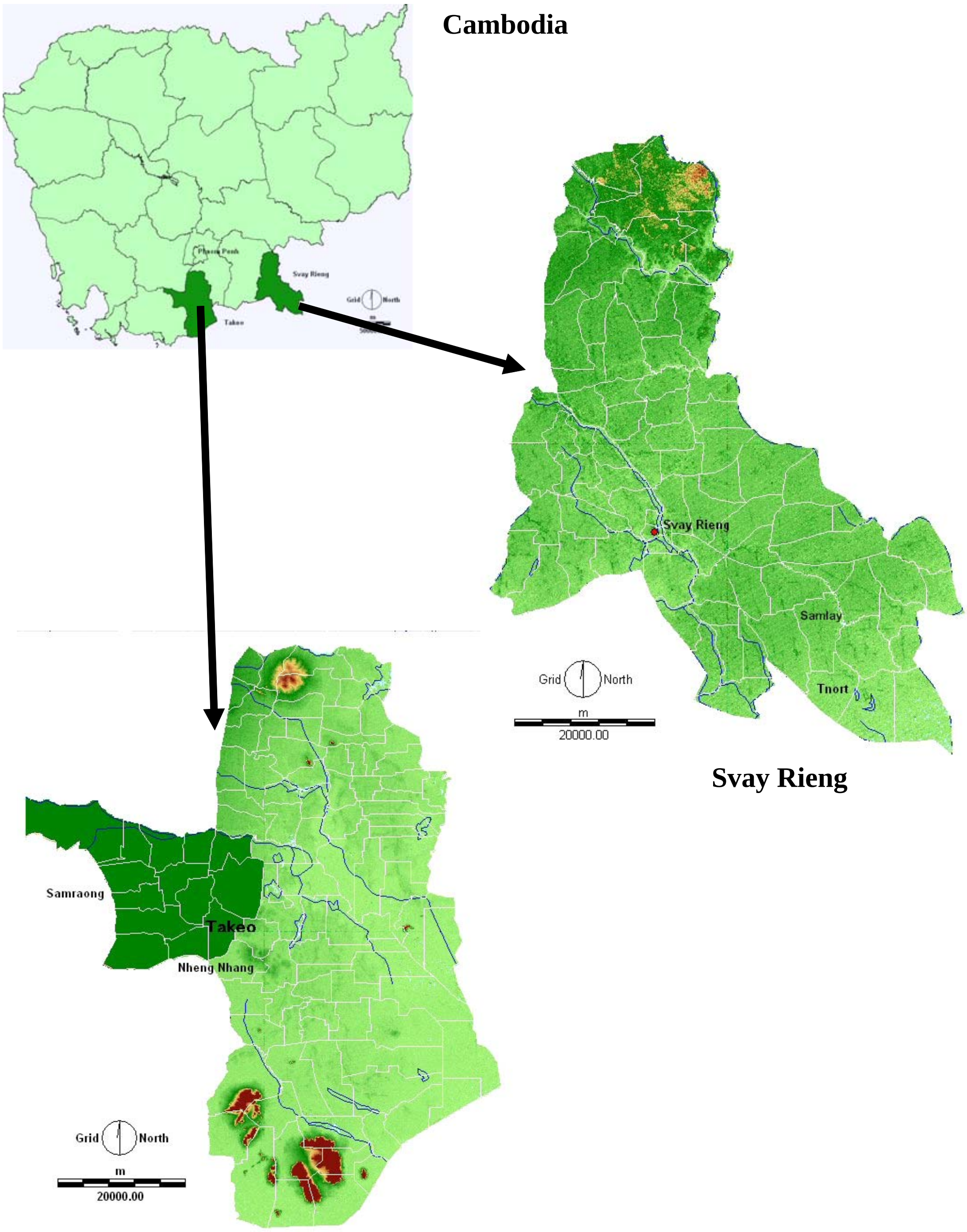


Appendix 2. Map of the location of research in Northeast Thailand

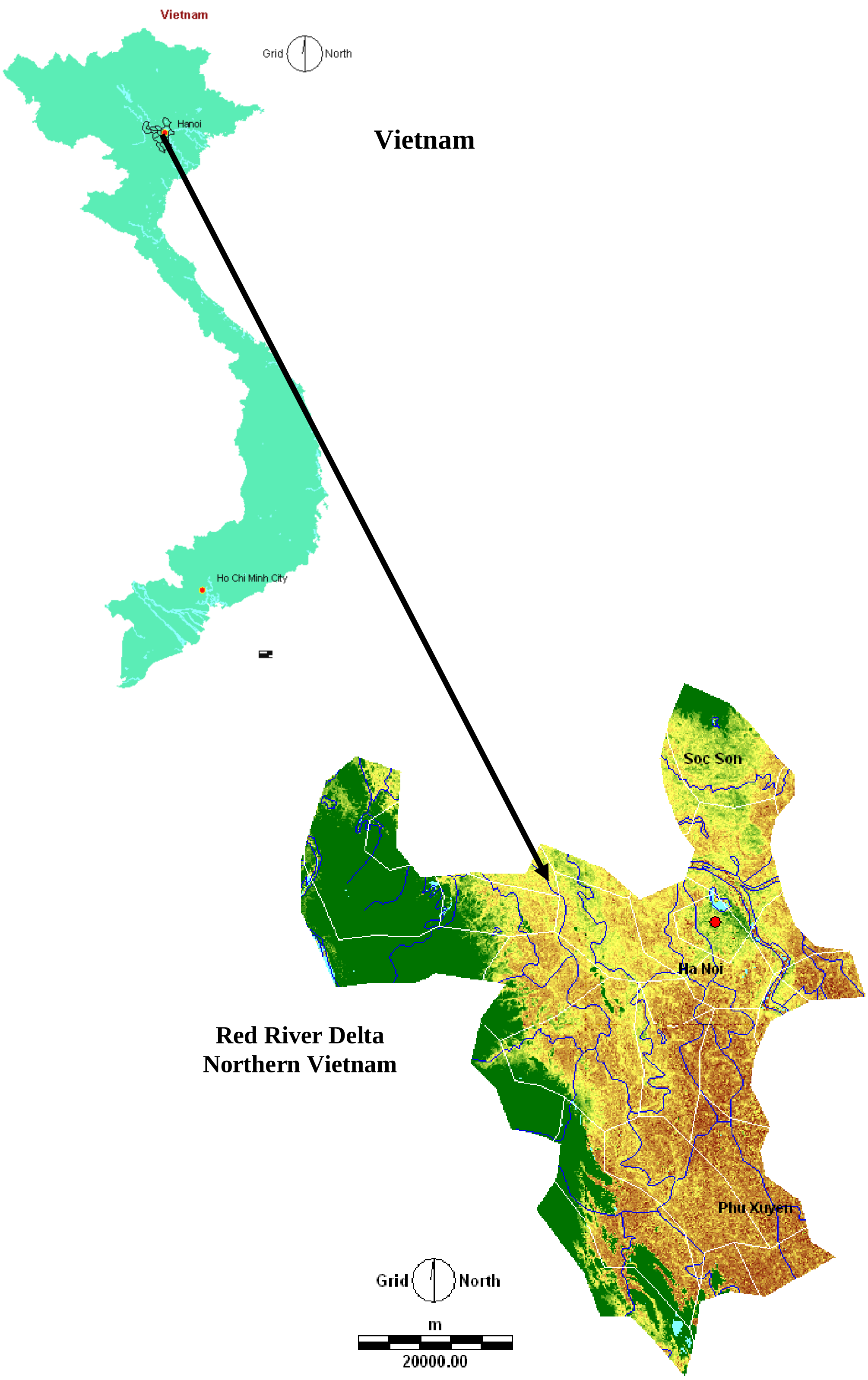


Thailand

Appendix 3. Map of the location of research in Southeast Cambodia



Appendix 4. Map of the location of research in Red River Delta Vietnam



Appendix 5. Local criteria in wealth ranking exercise

Criteria used by key informants to determine the **very poor** households in rural areas

Criteria	Country Cambodia	Thailand	Vietnam
Source of income	Limited source of income Fishing for consumption Selling livestock for food Making basket and mats Wage labour	Mainly rice grower Some work in Bangkok Growing chilli Wage labour	Income mainly from rice Wage labour
Productivity	Production is not enough Use 1 sack of fertilizer/ha	Production not enough	Low yield
Equipment		No tractor	No farming equipment
Land	Use land as collateral 0 – 0.5 ha of land	0 – 0.8 ha of land Sharing land with parents	Use land as collateral
Social status	6 – 8 HH member Living alone	Big households Living alone	Young couple: old people Living alone
Housing	House made of clay and leaves as roofing	Do not have own house; small and made of light materials	No house; some share a small house
Livestock	0 – 2 livestock	0 – 3 livestock	
Food supply	Food enough only from 2 – 6 months		Food enough for 2 – 6 months
Finance	Can only loan from better off villagers No money to buy medicine	Cannot pay loan	Borrow money from better off villagers Cannot pay tax and loan
Transport	Have bicycle	No transport	
Appliances	No appliances		No appliances
Education		Cannot send children to school or primary at most	Children cannot go to school or until primary only
Health			Poor health

Appendix 6. Local criteria in wealth ranking exercise

Criteria used by key informants to determine the poor households in rural areas

Criteria	Cambodia	Thailand	Vietnam
Livelihood	Collecting and selling wood Fishing Making baskets and mats Working in the city Selling livestock Wage labour	Fishing Rice farming as main source of income Off farm works Working in the city Can grow other crops	Children collect AA Children work for family Main income from rice Wage labour Off farm activities
Productivity	Production for family consumption Rice production of 250 – 800 kg/ha Can used 0.5 – 1 bag/ha	Enough rice production Can buy chemicals for farm	Low yield form rice
Equipment		Have hand tractor Some have 2 wheeled tractor	Lacking or borrowing farm equipment
Land	0.12 – 3 ha of land Some are landless Use land as collateral	0.16 – 3.2 ha of land Some are landless Have land rights	Some have no land Use land collateral
Social status	5 – 8 household member Not enough labour	Living alone Young couple; old couple Disabled	Many children Living alone; widow Young couple; old people
Housing	House made from clay and leaves for roofing	Small house, bad condition; light materials	Simple, small, bad condition house
Livestock	0 – 4 livestock	1 – 3 livestock	
Food supply	Foraging for food 3 – 10 months food supply Some limited food	Some buy rice for consumption	Lacking food for 1 to 6 months
Finance	Can get loan from credit organization	Can loan from BACC and other credit org. Remittance form relatives	Borrow money from better off villagers Cannot pay all whole tax Cannot invest; no savings
Transport	Mostly with bicycle	Most have motorbike	
Appliance	Have TV and radio	Some have appliances	Mostly no appliance
Children	Cannot send children to school	Can send children to primary	Can send children to primary
Health		Poor health	Poor health

Appendix 7. Local criteria in wealth ranking exercise

Criteria used by key informants to determine households with medium wealth rank in rural areas

Criteria	Cambodia	Thailand	Vietnam
Livelihood	Several sources of income Can sell some production Mainly income from rice Some have business	Provide credit to other villagers Can sell rice production Working in government Several sources of income Business Migrate for work in the city Wage labour	Main source of income is RF Income from livestock Wage labour Trading
Productivity	0.5 – 3 tons/ year of rice production Can use 1 – 3 bag/ ha of fertilizer	Have 2 wheeled tractor Some borrow equipment Some use livestock	Production enough for consumption Cheap farm equipment or lacking
Equipment	Have generator Fishing equipment	Some have water pump	
Land	0.2 – 3 ha of land Enough land for rice Use land as collateral	0.8 – 8 hectare	
Social status	2 – 7 household member Enough labour	Big households New couple	5 member in the household Enough labour
Housing	House in good condition Iron sheets; tiles; wood Some have small house	House in good condition	Small – large house Some have flat roof
Livestock	2 – 10 livestock Mostly have livestock	10 – 35 livestock Some have less livestock	
Food supply	Enough food for 6 – 10 months		Enough food Mostly lacking food for 1 – 2 months only
Finance	Can loan with better off Have access to formal credit	Can get loan from formal credit (BACC) Can pay loan Supported by children	Can have formal credit Can pay loan Some cannot pay full amount of tax No spare money
Transport	Mostly have bike; some have motorbike also	Mostly have motorbike	
Appliance	Have appliances like TV and radio	Most have appliances	Have appliances
Education	Can send children to high school	Can send children to higher level of school (high school)	Can send children to secondary school
Health			Normal and good health

Appendix 8. Local criteria in wealth ranking exercise

Criteria used by key informants to determine the households with rich wealth rank in rural areas

Criteria	Cambodia	Thailand	Vietnam
Livelihood	Can sell production	Provide credit to others	Children help in increasing income
	Have rice mill	Farming and trading	Good business
	Several sources of income	Government workers, officials	Fruit and ornamental crops
	Operates rice mill	Growing other crops	Employed with the government
	Provide rice credit	Migrate for Bangkok for work	Several sources of income
	Work in Garment factory	Several sources of income	Major income from rice and livestock
Productivity	1 – 1.5 ton of rice /year	Enough rice production and selling	
	Can use 2 – 4 sack of chemical fertilizer		
	High rice production		
Equipment	Have generator	Most have 2 wheeled tractor	Have good farm facilities
	Have water pump	Some have water pump	Rice machine
	Fishing gear		Tractor
Land	0.5 – 5 ha of land	Average 3.6 ha of land	
	Can buy land from other	Maximum of 12 ha of land	
	Can lease land to other		
Social status	4 – 7 household member	Big family	Have more children
		High status in the village	Enough labour
		Supported from other family members	
Housing	House made of wood and tiles roofing, some metal	Big house and good condition	Big houses, flat roof
			Some have 2 floors
Livestock	2 – 8 livestock	2 – 10 livestock	Most have livestock
	Can rent livestock to others	Several livestock	
Food supply	Enough food for 9 months	Enough food to eat	Enough rice to eat
Finance	Can loan for other villagers	Can get formal loan	Can pay loan and tax
		Can pay loans	Some cannot get loans
		Have capacity to invest	Fair income
		Receive remittance	Some have spare money
Transport	Most have motorbike and bicycle	Have motorbikes and some have cars	Most have motorbike
Appliance	Have appliances, TV and radio	Have appliances	Majority have appliances
Education		Can send children to secondary and college level	Children can go to secondary school
			Good condition for children in studying
Health			Good normal health

Appendix 9. Local criteria in wealth ranking exercise

Criteria used by key informants to determine the households with very rich wealth rank in rural areas

Criteria	Cambodia	Thailand	Vietnam
Livelihood	Mainly rice production Operating rich mill Several sources of income Construction worker Provide credit to others	Government officials Provide credit to others Good business Have rice mill Non farm income Sell rice production Working abroad	Off farm income Several sources of income Commune staff Business Retirees
Productivity	24 ton rice production Can use chemical fertilizer 3 – 5 sack/ hectare	High rice production for selling and consumption	
Equipment	Have generator Have water pump	Complete agricultural equipment 2 wheeled tractor	Expensive farm equipment Tractor
Land	0.3 – 7 hectare of land Large land Lease land to others	0.32 – 16 hectare of land Inherit form parents	
Social status		Few household members Village committee	Few children Happy life Look after by the children
Housing	Roof tiles and GI sheet House made of wood and some made of bamboo	Big concrete house Good condition of home	Big house Flat roof with 2 floors
Livestock	2 – 7 livestock	3 – 10 livestock Some don't have livestock	Many livestock
Food supply	Enough food for the year		Enough food and have spare
Finance	Can lend money to others Remittance from relatives abroad	Can invest Can provide loan Can save Receiving remittance form abroad	Get inheritance from parents Have extra income Can pay tax
Transport	Mostly motorbike and bicycle	Mostly have motorbike and cars Some have truck	Most have motorbike and some have car
Appliances	Most have appliances	Complete appliances	Good appliances, telephone
Education		Can send children to university	Can send children to higher education
Health			Normal, good health

Appendix 10. Questionnaire used during the cross-sectional survey (background survey)

Country: _______________
Province/District: _______________
Respondent No. ______

Ranking in the well-being ranking _____

Profile of households head

Name: ___________________________ Sex: _____ (Male) _____ (Female)
Age: _____ Civil Status: ____ Single ____ Married ____ Widow/Widower ___ others
Education: ______ (1) Primary
(2) Secondary
(3) Vocational
(4) Tertiary
(5) Did not go to school

Occupation:
Primary occupation:
Farming: ________________________ Non-Farming: _________________________

Secondary occupation:
Farming: ________________________ Non-Farming _________________________

Profile of household members

Total number of Household: __________
visiting regularly: __________
Sending financial support __________

Occupation and skills of family members

Age	Sex	Educ	Occupation	Health	Other skills	Where	Income
___	___	___	_________	_____	__________	_______	______
___	___	___	_________	_____	__________	_______	______

Do you have relatives sending money or supporting your financial needs? __________

Household assets

Land

Total land owned ____________ Total Farm Area ___________

		Area (m^2)
Total number of Ricefields	_________	__________
Total number of Ponds	_________	__________
Total number of Trap ponds	_________	__________
Share/lease in	_________	__________
Share/lease out	_________	__________
Rent	_________	__________

Livestock
Livestock/poultry_________ Number_________
Livestock/poultry_________ Number_________

House		House material	
Owned	___________	Concrete	__________
Rented	___________	Semi-concrete	__________
Shared	___________	Wood	__________
		Bamboo	__________
		Leaves	__________

House Appliances ____
Farm Equipment ____
Fishing equipment ____

Ricemill _________
Shop _________
Bicycle _________
Motor cycle _________
Other business _________

Access

Do you have access to irrigation? _________Yes __________No

Water source

Lake	__________		
River	__________	Rainfed	__________
stream	__________	Others	__________

Do you use common land to:

_____Collect wood	_____Collect food
_____Fishing	_____Graze livestock
_____Plant crop	_____Others

Can you get credit from the following and in what form :

_________	Bank	___________________________
_________	Government	___________________________
_________	Private lenders	___________________________
_________	Cooperatives	___________________________
_________	Credit union	___________________________
_________	Others	___________________________

Physical characteristics of aquatic systems

	Number	Area	Depth Wet	Depth Dry
Ponds	___________	_____	__________	__________
(in ricefields)	___________	_____	__________	__________
other ponds	___________	_____	__________	__________
Ricefields	___________	_____	__________	__________

Management

Do you ever stock fish? Yes ______ No ______

If yes,

When did you last stock? ___________
When do you plan to stock again? ___________

Where: pond _____ rice paddy_____ other______

Source of seed		Species
Trader	_____	____________________
Government	_____	____________________
Neighbour	_____	____________________
NGO	_____	____________________
Others	_____	____________________

How did you avail for the seed?

Given for free ___________
Purchased ___________
Catch ___________
Other ___________

Do you allow/attract aquatic organisms to enter in your system?

If yes;

What are the activities you do to do this?

___________ Digging ponds or ditches
___________branches/brisk parks
___________retain water
___________feed fish
___________fertilise ponds
___________others

If no, what activities you do to prevent them from entering

___________application of pesticides
___________putting screen
___________other

Frequency of harvesting

___________regularly
___________seasonal
___________occasional
___________others

Do you sell fish? Yes _________ No _________

If yes;

Where do you sell

Place	Species
_________________	_________________
_________________	_________________
_________________	_________________

What proportion (%) do you sell stocked fish and wild fish?

Stocked ___________
Wild ___________

Appendix 11. Questionnaire used during the baseline survey for longitudinal study

Date: ____________
Village name: ____________
Household code: _____________
Reason for selection: _____________

Mapping exercise:
Three types of map are required for each household:
1. Farm Map (done simultaneously with question no. 4) (2 copies)

What should be on the map the farmer, or you draw with him

1. Orientation(North)
2. slope (if there is any)
3. all the systems by codes (ponds, P, fields, F…in local language) and numeration
4. for ponds, write if they are man made or natural
5. depth of the ponds (max)
6. Water supply: canals, river…..(indicate how the water enter the systems)
7. Distances from one system to another
8. Area of the systems, length and width if possible
9. Space at the edge of the sheet used to draw the aquatic system (far from HH land) in relation with farmer systems (Lake (L), reservoir…) .

2.Village map – indicating the location in the village of the farm and house of the household
3. Large-scale map – indicating the location of the village in relation to nearest infrastructures (market, town, health centers, road, etc).

4. Farming system:

Name of system	Area (m^2)	Ownership	Main use	When	Production	Value	Second use	When	Production	Value	Water source

5. Profile of household members

Name	Age	Gender	Civil status	Education	Main occupation	Where used	Frequency	Second occupation	Where used	Frequency

6. Any member of the family involved in any organization? __________

HH Member	Organization	Activity of organization	Position	Benefits

7. Housing

Ownership	Walls	Roof
_____ (1) Owned _____ (2) Rented _____ (3) Shared	_____ (1) Concrete _____ (2) Semi-concrete _____ (3) Mud _____ (4) Tin _____ (5) Wood _____ (6) Bamboo _____ (7) Others	_____ (1) Concrete _____ (2) Tiles _____ (3) Tin _____ (4) Straw _____ (5) Leaves _____ (6) Others

8. Livestock holdings

Animal	Adult		Juvenile		Total number	Total Value
	Male	Female	Male	Female		

9. Equipment (owned)

Household	#	Transport	#	Farming	#	Fishing	#

10. Can you access credit from:

Source	Y/N	Name	What form? (money, goods, services)	Do you use? (Y/N)
Commercial Bank				
Government Bank				
Gov't Organisation				
NGO				
Cooperatives				
Private Lenders				
Others, specify:				

11. Are then rules to <u>when</u> you can take different forms of credit? Y/N? : _(__)_
12. If yes, details:____

13. Do you save money? Y/N? : _(__)_
14. If yes where?____(if a bank, which bank)

Appendix 12. Questionnaire used during the longitudinal study (household monitoring)

DATE: _____________ Village:________________ HHcode:___________

1. Agricultural activities on household land *IN THE LAST SEVEN DAYS*

Household member	Agricultural activities	Where (code)	Frequency	Time spent (Total)

Major other agricultural activities on HH land during the last month:

____

2. Agricultural activities on other people's land *IN THE LAST SEVEN DAYS*

Household member	Agricultural activities	Where	Frequency	Time spent (Total)	Remarks

Major other agricultural activities on other's people land during the last month:

____

3. Aquatic Animal management *IN THE LAST SEVEN DAYS* on all land – (use the 1st set of map 1,2,3)

Household member	Activities	Where	Frequency	Time spent	Remarks

Other AA management activities in the last month:

____

4. Aquatic animals collected *IN THE LAST SEVEN DAYS* (use the same first set of the 3 maps)

Who collected	Species	Size						Location	Gear	Frequency & time spent	How it was utilized				Where and reason for selling
		Big			Small										
		Type of stick	Number	Kg	Type of bowl	Number	Kg				Sell	Eat	Give	Processed	

5. Non-farm activities (both in and outside the village) *IN THE LAST SEVEN DAYS*

Household member	Activities	Where	Frequency	Time spent	Remarks

Other major non farm activities during the last month:

____

6. Food consumption *IN THE LAST SEVEN DAYS*

6.1 Types of food eaten

Types	Frequency	Quantity	Source	Preparation	Who eats	Remarks

Any other special food eaten during the last month?:-

____

6.2 Types of aquatic animals eaten *IN THE LAST SEVEN DAYS*

Species	Frequency	Quantity	Source	Preparation	Who eats	Remarks

Any other special AA eaten during the last month:

____

7. Income *IN THE LAST SEVEN DAYS*

Source	Y/N	Who	Frequency	Amount
Wages				
Income from rice				
Sales from farm production				
Livestock				
Selling aquatic animals				
Selling aquatic plants				
Services (rental of land, equipment)				

Any other important income during the 3 preceding weeks ?:

____

8. Expenditure *IN THE LAST SEVEN DAYS*

Expense	Y/N	Who	Frequency	Amount	Remark
Rice					
Other food					
Farming needs					
Livestock					
Buying aquatic animals:					
1:					
2:					
3:					
Buying aquatic plants					
Services (school, clothes)					

Any other important expenses during the 3 preceding weeks ?: ___________________________

9. Visitors/helpers in the last month Y/N: ____

Relationship	Purpose of visit	Frequency	Time spent

Other questions regarding the last month

10. Has anyone been ill in the last month? Y/N:____ if yes, who?:______

11. Has any livestock been born or died in the last month? Y/N____
if yes what:_______

12. Did any special occasions happen in the last month? (festivals), Y/N?____
If yes, precise:________

Questions regarding the next month

13. Will there be any big aquatic animals harvests in the next month (e.g. from your ponds, cultured ponds?…) Y/N?: _________

14. If yes, please precise where and when: ____

15. Will any special occasions happen in the next month? Y/N? : _______
If yes, precise: ____

16. And will any aquatic animals be required for these special occasions? Y/N? ____
If yes, precise: _______________________________________

Appendix 13. Codes for data analysis during the cross-sectional survey

Variables	Code	Code Value	Variables included
Country	1	Cambodia	SEC
	2	Thailand	NET
	3	Vietnam	RRD
AEZ	1	LOW	Svay Rieng, Yasothon/Roiet Phu xuyen
	2	DRY	Takeo Srisaket Socson
Wellbeing	1	Poor	Poor and very poor
	2	Better-off	Rich and very rich
Gender	1	Male	Adult male
	2	Female	Adult female
	3	Children	Girls and boys
	4	All	All family
Level of education	1	Did not go to school	
	2	Not yet	
	3	Preparatory	
	4	Primary/elementary	
	5	Secondary	
	6	Vocational	
	7	Higher degree	
Health condition	1	Good	
	2	Fair	
	3	Bad	
Type of illness	1	Coughs	
	2	Fever/ flue	
	3	Body pain	
	4	Headache	
	5	High blood pressure	
	6	Internal pain	Abdominal
	7	Others	
	8	Diahreoa	
House wall materials	1	Concrete	
	2	Semi-concrete	
	3	Soil	
	4	Tin	
	5	Wood	
	6	Bamboo	
	7	Leaves	
	8	Others	
House ownership	1	Owned	
	2	Rented	
	3	Shared	

Equipment	1	Farming	
	2	Fishing	
	3	Transport	
	4	Household applicances	
Livelihood activities	1	On – farm	
	2	Off – farm	
	3	Non – farm	
General activities	1	Agricultural	Including activating in other farm
	2	Livestock	
	3	Aquatic management	
	4	Fishing/ collecting AA	
	5	Non-farming income	Small enterprise, wage labour, trading
	6	Household chores	
	7	Social and religion	
	8	Education	
Agricultural activities	1	Land preparation	Ploughing, turning soil, prepare seedbed
	2	Seeding	
	3	Planting	Including transplanting and broadcasting seed
	4	Collection and transporting of fertilizers	
	5	Fertilization	
	6	Weeding	
	7	Watering and Draining	
	8	Crop maintenance	
	9	Pest control	
	10	Harvesting and collection	
	11	Trasport of harvest	Including post harvest activities
Income source	1	Aquatic animals	
	2	Livestock	
	3	Agriculture	
	4	Labour & Services	
	5	Trading/ small business	
	6	Remittances	From children, husband, wife working outside the village (non-farming)
	7	Others	Lottery, land rental, debt interest
Expenditures	1	Food	All food item and ingredients directly purchased
	2	Farming	Fertilizers, pesticides, equipment rent, seeds
	3	Aqua	
	4	Livestocks	
	5	Social & religion	

	6	Schools & Clothing	
	7	Maintenance	
	8	Others	
	9	Medical	
General Aquatic mangement	1	Construction	Including improvement
	2	Stocking	
	3	Feeding and fertiliztion	Using animal manure
	4	Collecting food	
	5	System maintenance	Including clearing of system
	6	Harvesting & Collecting	
SRS attitute	1	Positive	
	2	Negative	
	3	Neutral	
Positive mgt. of SRS	1	Brush parks	
	2	Digging or deepening	
	3	Feeding	
	4	Fertilization	
	5	Others	
	6	Retain water	
Negative mgt of SRS	1	Put screen	
	2	Drying	
	3	Liming	
	4	Others	
Sources of seed	1	Private hatchery	
	2	Research institute	
	3	Governemnt Hatchery	
	4	NGO/Coop	
	5	Community pond	
	6	Ricefields/ wild	
	7	Friends/neighbors	
AA group	1	SRS	AA species harvested in FMAS without stocking
	2	Stocked	All hatchery produced stocked species
	3	Wild	AA harvested from OWB
AA form	1	Fresh	Including iced AA, live, dead
	2	processed	Fermented, salted, dried, smoked
Aquatic Resource	1	FMAS	All aquatic systems where farmer doing something to enhance production and not limited to stocking
	2	Open water bodies	Aquatic systems not managed

Type of FMAS	1	RF	
	2	Culture pond	
	3	Household Pond	
	4	Trap pond	
	5	Ditch	
	6	Community pond	
Food item	1	Aquatic animals	Included all AA groups
	2	Meat	Pork, Beef, goat, dog, etc
	3	Poultry and dairy	Chicken, duck, Eggs, milk
	4	Vegetables	Both leafy and non-leafy
	5	Cereals	Mainly rice
	6	Processed/precooked	
	7	Others	Seasoning
	8	Marine products	Fish and shelled
	9	Insects	
Food source (including AA)	1	FMAS	Produced by HH
	2	Open	From natural/ wild
	3	Markets	All purchased
	4	Given	From neighbors/relatives
	5	Others	Combination
AA collection			
AA Utilization	1	Consume	
	2	Sold	
	3	Process	
	4	Give	
AA selling location	1	Local	In the village, house to house
	2	Trader	Middleman
	3	Market	Proper market (commune, provincial & city)
Months	1	January	
	2	February	
	3	March	
	4	April	
	5	May	
	6	June	
	7	July	
	8	August	
	9	September	
	10	October	
	11	November	
	12	December	

Appendix 14. Protocol and guidelines during the monitoring data validation workshop

Action	Why	Outcome	Who
1. Introduction of the team			
Introduce the outsiders present to the meeting	So everybody will be happy, comfortable	Everybody would be at ease	
2. Introduction about the project	Review about the project to the 9 HH and overview of the project to the new villagers	Everybody will understand what we are doing	
- Research project; non government, AIT, UK Universities	Because otherwise confusion with subsidized development	They know that we are not here to hand out 'free' things	
- 5 countries	Other places have SRS	Farmers feel part of the team	
- Working with households over 2 years to find out people's priorities and their activities in their lives	Grey areas between fisheries and aquaculture, need to understand current and potential role of SRS from farmer managed systems	Understanding of the role of SRS from farmer managed systems in livelihoods	
- 6 villages in Thailand	Differences between the villages	Farmers see that they are part of the bigger picture	
- 54 households in each country	Differences between the households	We want to learn about the differences between households	
3. Objective of the project			
To find a way to maintain or improve AA availability from farmer managed systems for the benefit of all, especially those with less access.	Gap in the knowledge about AA from farmer managed systems	We hope that AA production will be improved and increase the living standard of the poor people and that they will be interested in developing that knowledge	
Action	**Why**	**Outcome**	**Who**

4. Objective of the workshop			
Feedback information	A lot of information has been collected and we would like to give back information to you and see what you think of its value	Increase the ownership of the study by participating households Check value of the process	
What else we can learn together, discuss the interest in an approach to learning more together	We have only describe the situation so far, not improved it	Interest of farmers in future research simulative	
Presentation	Details – nature of information	Notes	
We will present the results by province to give an overview and a chance to compare with another province.			
1. Different farming systems	Most people have a trap pond as well as having rice fields		
	New village: know the distribution of the different systems. Is it similar?		
2. Important AA	More species in Yasothon than in Srisaket (lowland area; more river fish)		
	The more frequent collected species are carnivorous species		
	In your village….		
3. Trend of AA consumption			
4. Sources of AA		Does having a trap pond in the rice fields/lakes enforce ownership over all the fish in the system?	
Action	**Why**	**Outcome**	**Who**
5. Distribution of AA collected			

6. Common gears			
7. Life history			
8. Migration			
9. Disease			
10. Management activities	What are the most common activities being practice?		
Discussion	Q: Any problem with the data/information (does it represent the village?) Q: Is it similar in other places?	Farmers' comments and feedback should be noted down the staffs	
Small group discussion			
More understanding of current management practices	We do not have all of the information We need to know to clarify the reasons	Raising interest in new households in the village More and complete understanding of the mangement	
Main management are relating to feeding and stocking, and other strategies related to attracting	Clarification of the reason behind the different management activities. Common household management, we are talking about the system, AA moving. The resource is interconnected. Interconnected – how we can improve it? Board with RF,TP,CP moving Farmer manged systems but part of the larger system, AA moves through community resource Where fish are coming from all fish are connected. Way for overall improvement of the stock is to work with the whole area.		
Questions for the group:			
RF only: 1. Do you think yield of AA is going down			

or up? 2. Is there any impact of TP or CP? 3. Does yield depend on the position of the rice fields? 4. Why do you have RF only? 5. What can a group do to improve the AA yield? Where?			
RF and TP: 1. Does having TP limit access of others to the larger system? 2. Why did you dig TP? Is TP meeting your expectation? 3. Why did you dig your pond in that location? 4. What can a group do to improve the yield of AA? Where? 5. Why you have TP instead of CP?			
Action	**Why**	**Outcome**	**Who**
Culture pond/Household ponds: 1. Why do you have both or only one system? 2. What made you dig a CP or HP? 3. Impact of wild AA in CP/HP? 4. Effect of CP/HP on the yield of surrounding rice fields?			

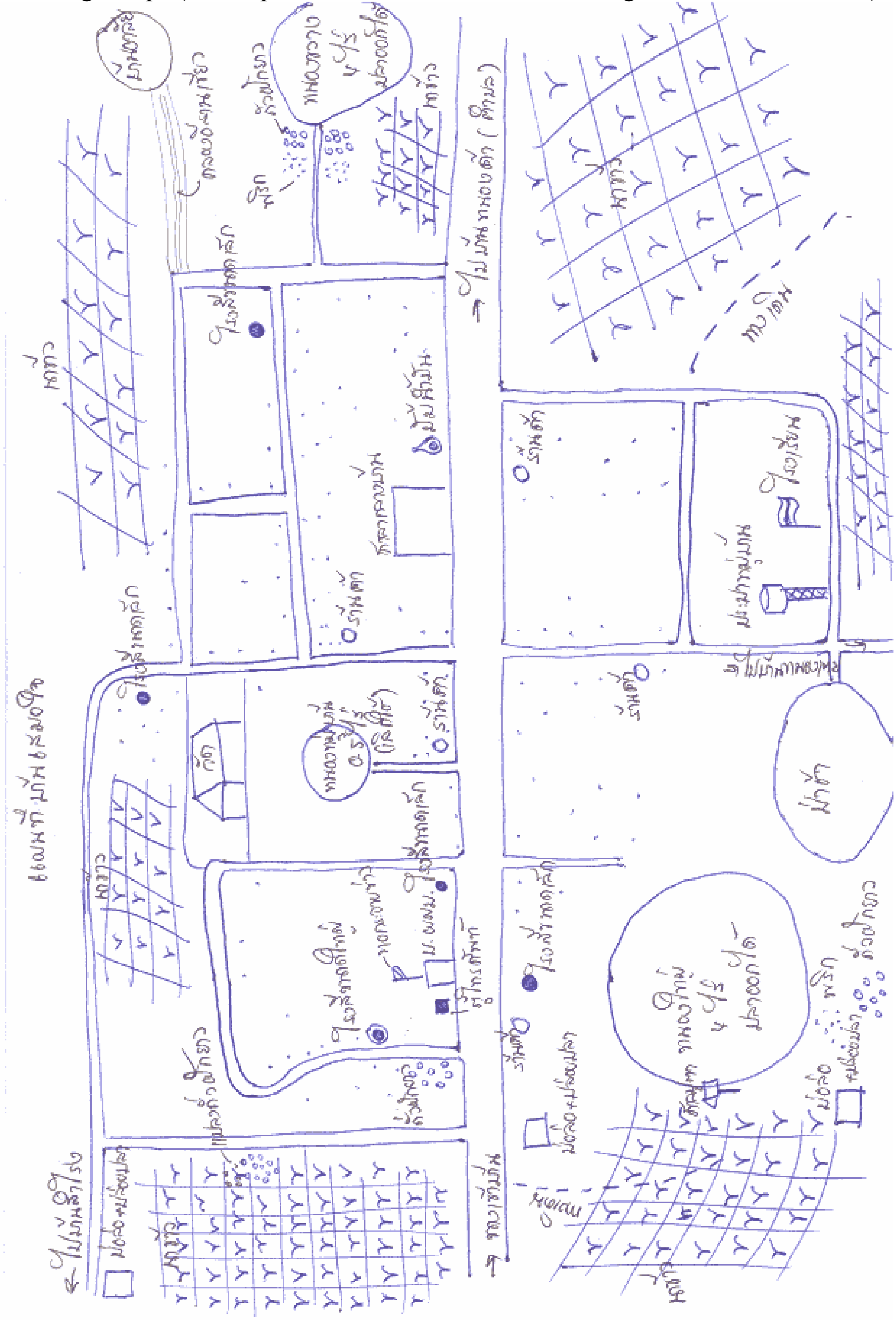
5. What can a group do to improve the yield of AA? Where?			
Committee: Do you think a goup of 10 – 15 households that have land, CP,TP in the same area could work together to improve the sytem? Where do you think is possible? What activities they can do as a group and individual?			
Big group discussion: How can you improve the system			
Back to the village as awhole: With more effective, where things can be feasible; determine the area wherein small group management is possible. What a group can do? In what area? Where and how it is possible?	People in the meeting that have land in the tract should contact farmers around to see if they are interested in joining. If they agree, they should come to a meeting again.	We will try to monitor the effect taking a minimum time from the farmer. Monthly group meetings, we will harvest the system, but need some return from the farmer to cover cost of fry so that we can work with other farmers next year. Areas identified and group selection initiated.	

Appendix 15. Indigenous knowledge in the management of aquatic systems

Site	IK	Purpose
SEC	Deepening system and putting of water hyacinth	To attract aquatic animals from the wild to enter into the system
	Using light	To lure aquatic animals especially frogs at night to move closer to the light and eventually trapped into the deep hole
	Brush parks (leaves and branches of trees	To attract aquatic animals to enter into the system
NET	Use of termites	Use as feed for stocked species
	Putting of river mud into the pond bottom	To attract aquatic animals from adjacent perennial water bodies
	Cow skin and bones	To attract aquatic animals to enter into the system
	Use of water hyacinth for temporary keeping of potential broodstock	To keep potential broodstock in the system while completely draining it. The water hayacinth can keep some water where fish can temporarily stay before the drained water return to the system
RRD	Water scoops	To irrigate the system using big scoop operated by two individual by filling water from the other side of the system and pulling and throwing the scoop to another system to transfer the water

Appendix 16. Examples of outputs during the participatory community appraisal.

1. Village maps (An output from PCA in Samoechai village, Northeast Thailand)



2. Seasonal Calendar (Source: AFGRP, 2003, SRS report from Thailand)

3. Timeline/historical transect (Source: AFGRP, 2003, SRS report in Cambodia)

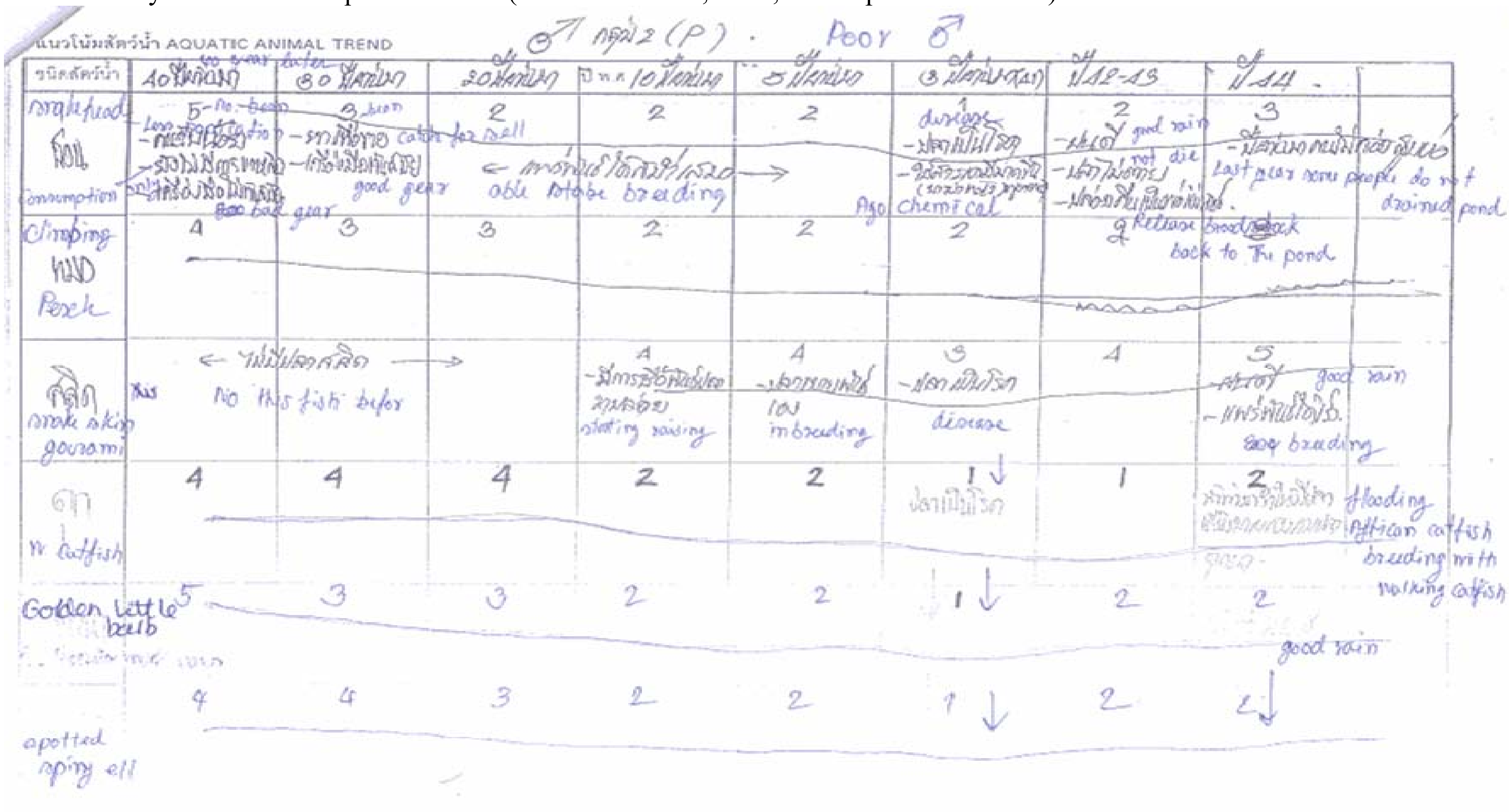
Year	**Events**
1952	French colonial that time also came Isarak and Geakong to the Village and they has been violence leave people in the Village ane they robbery livestock. -Isarak leave from 1952 -At first this Village small on Small oblong trap 4-5 households -This Village named Korktakeo
1958	-American has been bombed and destroyed all the household -People lived very poor
1970	-American still bombed has been killed 100 people also livestock and that time this Village still kept the same name Korktakeo -Have one big lake, a lot water plant and fish
1975	-Revolution from Lonol to Polpot regime, people eat and worked in community that time people checked mutual, and all the wealth and livestock were in community.
1975-79	-Escape people to another Village they afraid. People seascape to VN also this Village mix with Khmer Rouge.
1979	-People came back to home land and that time the Village has been changed from Korktakeo to Trapaingdearkrom Village. All the household has been destroyed also forest and bamboo, trees Abundance of more fishing and go to exchanged on rice in Svay Rieng Province Northern Svay Chrum district. Fishing by using line, pointed spear , Handled pick out Not enough food Government distribute rice by exchange with mouse ties.
1985	-Standard living is moderate people can do the rice field but not enough . -People do small business in VN -Fish is abundance, Fishing can selling.
1993	-Election all the people in the Village go to election. -The majorities occupation are rice production also making mats, cropping, fishing(the main sources of income is fishing)
1993-2001	-Population increased reduce the number of fishing. -In the Lake have more species of fish like Tilapia, Gian snakehead, Big snakehead. -In the present appear difference species of fish because Hun Sen Dam, people used water for livestock, rice production. -More wells, flooded in 2000 destroyed rice and killed some of livestock. -Rice production by using livestock, water pump, chemical, fertilizer, each household use from 3-4bag -Rice yield increase 1-1.5/tone.

4. Activity matrix (Source: AFGRP, 2003, SRS report from Vietnam)

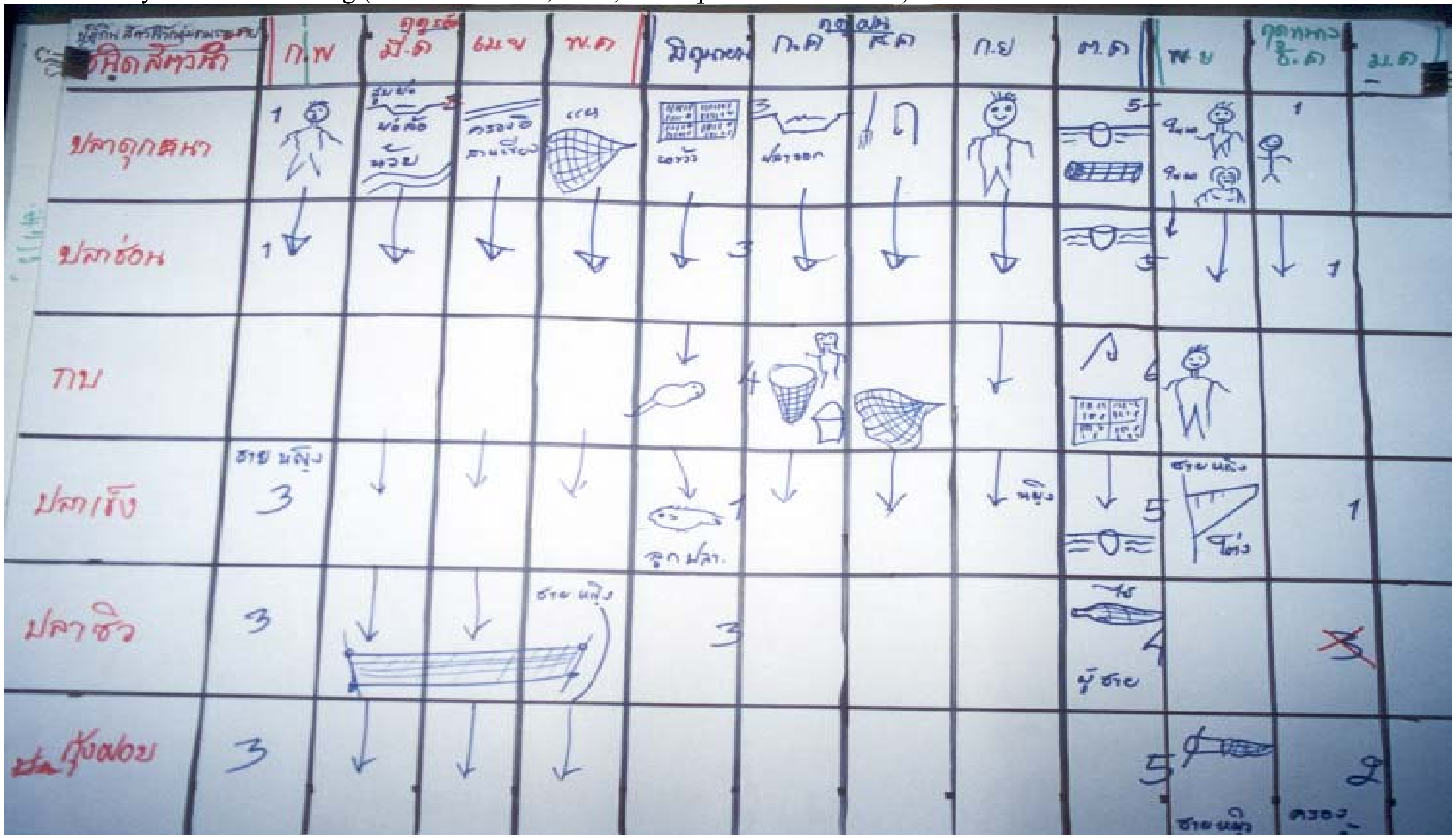
5. Aquatic animals identification (Source: AFGRP, 2003, SRs report from Cambodia – poor men group)

Species	Characteristics							
V1 Poor men	Family consumption	Easy to sell	Tasty	Processing	Drying	Easy to catch	Availability	Prefer to eat
Rasbora	3	0	0	1	0	1	2	1
Small shrimp	3	0	0	1	0	2	1	2
Snakehead	1	4	3	0	3	0	0	2
Climbing perch	2	1	1	3	0	2	1	2
Catfish	3	2	2	1	2	1	1	2
Mystus	2	0	1	0	0	1	1	2
Spiny eel	2	3	1	2	1	0	2	1
Pygmy gourami	1	0	0	1	0	1	1	1
Three-spot gourami	0	0	0	2	0	1	0	1
Whisker Sheatfish	2	1	0	0	0	0	0	1
Yellow mystus	1	2	1	2	1	1	0	2
Frog	1	1	1	0	0	0	0	1
Ricefield Frog	1	0	0	0	0	0	0	1
Freshwater Eel	1	1	0	0	0	0	0	0
Snake	0	1	0	0	0	0	0	0
Freshwater turtle	0	1	0	0	0	0	0	0
Crab/shell/snail?	1	0	0	0	0	1	0	1
Monitor lizard/mouse	0	1	0	0	0	0	0	0

6. Seasonality and trends of aquatic animals (Source: AFGRP, 2003, SRS report in Thailand)



7. Seasonality of AA and fishing (Source: AFGRP, 2003, SRs report from Thailand)



Appendix 17. List of self-recruiting species (SRS) in rural areas of SEC, NET and RRD

Southern Cambodia	Northeast Thailand	Red River Delta Vietnam
Frogs	Snakehead	Climbing perch
Rana sp	*Channa sp.*	*Anabas sp.*
	Frogs	Catfish
Rasbora sp.	*Rana sp*	*Clarias sp*
Snakehead	Climbing perch	Snakehead
Channa sp.	*Anabas sp.*	*Channa sp.*
Climbing perch	Catfish	Freshwater shrimp
Anabas sp.	*Clarias sp.*	*Macrobrachium sp*
Catfish	Barbs	Snail
Clarias sp.	Puntius spp.	*Sinotaia sp.*
Freshwater shrimp	Snail	Gold fish
Macrobrachium sp.	*Sinotaia sp.*	Carassius auratus
Crab	Freshwater shrimp	Crab
Somanniathelpusa sp.	*Macrobrachium sp.*	*Somanniathelpusa sp.*
Gourami	Crab	River catfish
Trichogastersp; Trichopsis	*Somanniathelpusa sp.*	*Hemibagrus sp.*
Flying barb	Freshwater eel	Short eel
Esomus sp	*Anguilla sp.*	*Misgurnus anguillicaudatus*
Spiny eel		
Macrognathus sp.	*Hemibagrus filamentus*	
Sheatfish		
Kryptopterus sp.	*Rasbora sp*	
	Common carp	
Barbodes spp	*Cyprinus carpio*	
Irrediscent mystus	Gourami	
Mystus vittatus	*Trichogastersp; Trichopsis*	
	Spiny eel	
	Macrognathus sp	
	Irrediscent mystus	
	Mystus vittatus	
	Butter catfish	
	Ompok sp.	
	Loach	
	Botia sp.	
	Featherback	
	Notopterus sp.	
	Catopra	
	Pristolepsis sp	
	Siamese mudcarp	
	Cirrhinus siamensis	
	Labiobarbus siamensis	
	Sand goby	
	Oxyeleotris marmorata	