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DYNAMICS OF RURAL HOUSEHOLD ACTIVITIES AND POVERTY AT DIVERSIFIED AGRO-ECOSYSTEMS OF TONLE SAP LAKE IN BATTAMBANG PROVINCE, CAMBODIA

Présentée par Kimchhin SOK

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Sous la direction de Betty WAMPFLER et Didier PILLOT

Devant le jury composé de

Philippe MÉRAL, PhD., Directeur de recherche, IRD UMR-GRED	Président du jury, Examinateur
Geneviève NGUYEN, PhD., MC ENSAT Toulouse	Rapporteure
Somyot THUNGWA, PhD., Professor, Prince of Songkla University	Rapporteur
Penporn JANEKARNKIJ, PhD., Assoc. Prof., Kasetsart University	Examinateur
Didier PILLOT, PhD., Ingénieur de recherches, Montpellier SupAgro	Co-encadrant, Examinateur
Betty WAMPFLER, PhD., Professor, Montpellier SupAgro	Directrice de thèse

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Dissertation presented and publicly defended by

Kimchhin SOK

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Dissertation Committee

Philippe MÉRAL, PhD., Directeur de recherche, IRD UMR-GRED	Chairman, Examiner
Geneviève NGUYEN, PhD., MC ENSAT Toulouse	Evaluator
Somyot THUNGWA, PhD., Professor, Prince of Songkla University	Evaluator
Penporn JANEKARNKIJ, PhD., Assoc. Prof., Kasetsart University	Examiner
Didier PILLOT, PhD., Ingénieur de recherches, Montpellier SupAgro	Co-supervisor, Examiner
Betty WAMPFLER, PhD., Professor, Montpellier SupAgro	Thesis-supervisor

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ABSTRACT

The overall objective of the PhD researchis to understand the dynamics of rural households activities in the vicinity of the Tonle Sap Lake (TSL) in Battambang province, Cambodia and to identify their interactions with the transformations of the local agro-ecosystem.. The research deeply investigates the history of land use and of the households' activity systems under various drivers of change (policy, flood pulse, demography). The study proposes different scenarios and assesses their consequences on the local households, taking into consideration their strategies to adapt to shocks and stresses.

The findings highlight the close linkages between the rural livelihoods and the ecosystem services of TSL. Hydrological changes, added to climate change, reduce water availability and the land flooded (and silted) annually by the flood. The governmental policy significantly impacts on the transformation of the households economies, especially on land access, crops diversity, and fishing expansion. Population growth and food demand puts more and more pressure on natural resources.

The study identifies six household types based on production factors, livelihood strategies and economic situation. The coping strategies mainly involve cultivation practices on paddy and other crops, fishing, animal husbandry, aquaculture and non-farms non-fishing activities. The better-off household types are those who are able to diversify their production, whereas the worse-off household types are the Landless people, the Rice mono-croppers, and Small fishermen.

The study suggests that policy implication can however contribute to maximising the long-term economic situation of the three poor household types by regulating the extension of the cultivation over the inundated forest, securing the access and land tenure of the most disadvantaged stakeholders and creating oppportunities of access to capital and inputs to all three types, providing adapted credit and loan systems to the poor households, providing adapted agricultural extension to Landless and Rice mono-croppers, supporting floating gardens extension to the Small Fishermen; improving social healthcare services and good local governance at all local levels.

Keywords: *Transformation of Agrarian Systems, Diversification of Activity System, Agriculture, Fishery, Rural Household, Ecosystem Services, Tonle Sap Lake, Strategy, Poverty, Resilience, Battambang, Cambodia.*

RESUMÉ

L'objectif général de cette recherche est de comprendre les dynamiques économiques des ménages ruraux en bordure du Lac Tonle Sap dans la province de Battambang au Cambodge, et de relier celles-ci aux transformations de l'agroecosystème local. La recherche s'intéresse à l'histoire de la mise en valeur des terres et du Lac sous l'influence des évolutions démographiques, des politiques publiques et des changements environnementaux, en particulier dans le régime de crue du Grand Lac.

Les résultats soulignent la relation entre les systemes de production des ménages et les services assurés par l'écosystème. Les changements hydrologiques et climatiques réduisent l'accès à l'eau agricole et restreignent les espaces inondés et fertilisés par la crue annuelle. Les politiques publiques contribuent à la transformation des économies familiales, en particulier au travers de l'accès au foncier, aux ressources génétiques cultivées et aux droits de pêche.

La recherche identifie six types de systèmes de production, sur la base des moyens de production, des stratégies mises en place par les familles et des résultats économiques qu'elles obtiennent. Les stratégies d'adaptation au changement portent sur les systèmes de culture et d'élevage, sur les modes de peche et d'aquaculture, ainsi que sur les acitivtés complémentaires hors peche et hors agriculture. Les mieux placés pour profiter des changements sont ceux qui ont les moyens de diversifier leurs activités, alors que les catégories « sans–terre », « monocultivateurs de paddy » et « petits pêcheurs » sont plutôt pénalisés.

Les politiques publiques peuvent néanmoins contribuer à maximiser la résistance et la résilience de ces trois catégories, en particulier en régulant l'expansion des cultures sur la foret inondée, en y sécurisant l'accès au foncier des moins bien dotés, en subventionnant certains inputs essentiels, en organisant des systèmes de crédit adaptés les ménages pauvres, en organisant des services de conseil adaptés pour les menages sans terre et les monocultivateurs de paddy, en soutenant l'extension des jardins flottants pour les petits pêcheurs et enfin en favorisant la santé publique et la bonne gouvernance locale.

Mots clés: *Transformation des systèmes agraires, Diversification des Systèmes d'activité, Ménages ruraux, Agriculture, Pêche, Services environnementaux, Stratégie, Pauvreté, Resilience, Lac Tonle Sap, Battambang, Cambodia.*

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LIST OF ACRONYMS

ADB	Asian Development Bank
AS	Agrarian System
BPODP	Battambang Provicial Depatement of Planning
BPDLMLAC	Battambang Provincial Department of Land Management, Land Administration, and Construction
CARDI	Cambodian Agricultural Research and Development Institute
CBO	Community-Based Organization
CC	Climate Change
CCCA	Cambodian Climate Change Alliance program
CCF	Coalition of Cambodian Fishers
CDRI	Cambodia Development Resources Institute
CFi	Community Fisheries
CI	Conservation International
CPA	Community Protected Area
CSES	Cambodia Socio-Economics Survey
ELC	Economic land concessions
EC	Environment Code
ES	Ecosystem Services
FACT	Fisheries Action Coalition Team
FCA	Fish Conservation Area
FCZ	Fish Conservation Zone
FiA	Fisheries Administration
FAO	Food and Agriculture Organization of United Nations
FS	Farming systems
FSA	Farming system Approach
GDP	Gross Domestic Product
GMS	Greader Mekong Sub-regions
GG	Green Growth
GGGI	Global Green Growth Institute
GO	Gross Output
GRiSP	Global Rice Science Partnership
GVA	Gross Value-Added
HH	Household
HYVs	High Yield Rice varieties
IC	Intermediate Cost
II	Intermediate Input
IRRI	International Rice Research Institute
IR	International Rice
IUCN	International Union for Conservation of Nature
KH	Khmer Rouge
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEA	Millennium Ecosystem Assessment
MFIs	Microfinance Institutions
MoC	Ministry of Commerce
MoE	Ministry of Environment
MoP	Ministry of Planning
MoWRAM	Ministry of Water Resource managenment and Meteology
MRC	Mekong River Commission
NAPA	National Adaptation Programme of Action to climate change
NBC	National Bank of Cambodia

NCGG	National Council of Green Growth of Ministry of Environment
NGGMP	National Green Growth Master Plan
NGOs MFI	Non-Governmental Organization Microfinance Institutions
NR	Natural Resources
NTFPs	Non-Timber Forest Products
PES	Payment for Environmental Services
RGC	Royal Government of Cambodia
SAW	Stratrgy for Agriculture and Water
SLA	Sustainable Livelihood Approach
SPSS	Social Package for Social Sciences
TI	Total Income
TSA	Tonle Sap Authority
TSL	Tonle Sap Lake
TSCP	Tonle Sap Conservation Project
TSLP	Tonle Sap Livelihoods Project
UNDP	United Nations Development Programme
UNEP	United Nation Environment Programme
USD	United States Dollar
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

1 US Dollar = 4,000 Riels Khmer (Average exchange rate from February 2015 to February 2018 quoted from OANDA: http://www.oanda.com/currency/historical-rates)

Chapter I: Justification, Problem statement, and Objective of research

The transformation of agriculture in the developing world, in contexts of global change and increased integration to markets, raises active interest from the academic and scientific community. The capacity of family-based farms –often opposed to capitalist entreprises- to take advantage of the emerging opportunities and to face new constraints, as well as the interactions between the rural endeavours and the environment, is a matter of high concern. The future of the food security, the impact of land use innovations on the consumption of natural resources, the capacity to face risks and to recover from shocks, the employment of rural labour force, and finally the environmental, social and economic sustainability of the agricultural production on the long-term have motivated a certain attention to rural household activities mostly called or known as rural livelihoods. The rural household activities are examined and defined the reasons why and how their characteristics present in the context of past, present, and future transformations.

This PhD thesis reviews, analyses and synthesizes the linkages between rural households' activities and environment of Tonle Sap Lake (TSL) in Cambodia. Using an Agrarian System Diagnosis and Analysis approach[1] as an organizing framework, we examine evidences on multiple pathways linking household activities – the land use, cropping systems, animal husbandry, fishing, off-farm activities, migrations, etc and the environmental variables linked with the regime of the Mekong river and its tributaries: the annual flood pulse generated by the rise of the TSL, its stock of organic and mineral silts for future deposits, and its biological diversity. The households are the level where the changing environmental constraints meet the closest the decision taking for the organisation of production. The linkages are mediated by many context-specific factors, although there is strong assumption that dependence on natural resources raises when households loose human, social capital, and there is qualified evidence that environmental factors strongly influence households' decision-making.

By the end of this dissertation, we hopefully should highlight the diversity of the family stakeholders's strategies in a context of variable ecosystem services and of changing public regulation policies. By doing so, we aim at contributing to building stronger models of change and innovation in lowland rice-based systems of tropical Asia, and to identify and assess the various impacts of changes on the households'poverty. The findings should provide more evidence to policy decision-makers, research scholars, and students who should be able to define types of rural households and to discuss their relevance to the analysis of the transformations in place.

[1]This approach is explained in more details in the theoretical and analytica framework of Chapter 2.

1.1. The contribution of agriculture to development in Tropical Asia

Agriculture is a key component of the South-East Asian economies. Agriculture is a source of food supply and food security, labour employment, savings for capital formation, and purchasing power to generate demand for manufactures. Growth in agriculture supports the subsequent growth of industry (FAO, 2014).

1.1.1. Agriculture contribution to the development of Asian countries economies

Historically, in most of the successful Asian economies such China, Thailand or Malaysia, agriculture has played an important role in launching the high growth of the economy. There are links between agricultural development in these regions and poverty alleviation which indicate the positive interaction between the rapid economic growth and a strategy based on emphasizing the role of the rural livelihoods. World Bank (2017) indicates that agriculture contributes from 36 to 40% of GDP to Cambodia's economy, 28% in Laos, 18% in Vietnam, 12% in Philippines annually. This sector is still the largest employer in developing Asia. In Cambodia, Myanmar, Nepal, and Vietnam, the agriculture share in the total employment remains above 50%, whereas the absolute number of people employed in agriculture is still rising. Where the economy is mostly agriculture-based, for example, in Cambodia, Laos, Myanmar, the family farms remain by far the main structure of production.

1.1.2. Agriculture and Food security

Agriculture also used to be a key element of the food security of the people, but there have been changes in this system too. In the past two decades, population of Asia has nearly doubled, and local agriculture has indeed offered the food production required by this growth. The main crops were/are rice, cereals, fruits and vegetables, combined with husbandry and livestock, fishery and fish culture. Those productions significantly contribute to the Asia people's daily diet and quality of life expectancy, but also supply the domestic consumption, and then to the exports. Countries such as South Korea, Thailand, Vietnam and Malaysia, have produced not only enough for their domestic consumption, but now they export surplus to America, Australia, or to European countries.

Rice is the basic food commodity in Asia, it has been playing a very important role in their nutrition and income of the rural populations. As economies grow, there is a gradual but definite movement out of subsistence food crop production, generally in a single crop system, to a diversified market-oriented production system. Recently, FAO and World Bank study on

farming systems and poverty have suggested that diversification from rice production is important source of food security and economy for small farmers in both South and Southeast Asia (FAO, 2015).

Fishing and aquaculture have also plaid an important role for the livelihoods and the food security among low income families in SEA developing countries, where the employment options are limited. Small-scale commercial and subsistence fishing are often the last resort choice of employment for households when paid labour opportunities cannot be found (Keskinen, 2003).

Both productions take an even more important role when one considers their contribution to the food security: the fish contribution to the total animal protein intake in the region was 17% in 2013, and this share goes up to more than 50% in developing nations like some small-island states, Bangladesh, Cambodia, and Indonesia (FAO, 2015). Globally, the annual fish consumption per capita was 20 kg (FAO, 2015; MAFF, 2016). In the Lower Mekong basin, it was estimated up to 52 kg (Hortle and Lieng, 2008).

1.1.3. Changes in agriculture

While agriculture used to be a key element of the rural livelihoods, this has significantly changed in the past 30 years, and these changes often raise issues for the sustainability of the food systems. In the early 1990s, agricultural labour productivity increased significantly in many contexts. In the mainstream model of development based on agriculture, the productivity normally rises to a level where it generates an agricultural surplus, which, in turn, enables the growth of the non-agricultural sectors by mobilizing labour, savings, and tax revenues from the agricultural sector. This is followed by an integration phase, during which the non-agricultural sectors become increasingly significant. Agricultural development is then progressively linked to the rest of the economy through improved infrastructure and the development of markets, until the economy is deemed industrialized (De Koninck, 2003).

In Asia, practical and technological changes in agriculture since the 1960s have led to significant improvements in yields of traditional crops (Allan et al., 2005; Pillot, 2007), the first of them being paddy.

While the World Bank (2014) and FAO (2017) identify eleven broad farming systems within agriculture of Asian developing countries, the three most important of them are based on rice: tropical lowland rice-based system; the rice-wheat system; and the uplands. All together, they account for about 80% of the agricultural population and some 50% of the total agricultural area in Asia. Indeed, the first engine of the progresses in productivity in agriculture

has been the increase of rice production.

In the case of Cambodia, rice yields grew fast from less than one million tons in 1980 to nine millions tons in current year (MAFF, 2006, 2016). Yield growth was achieved partly through the breeding and adoption of modern varieties, which respond better to inputs (chemical fertilizer, water, and machineries) compared to traditional varieties. Increased investments for water management, in irrigation systems, in individual storage (ponds) or in pumping facilities have also contributed to pull the growth.

However, in Southeast Asia, the productivity of the ***agricultural systems has increased faster then the productivity of rice production from the moment they*** significantly diversified. Since 1970, the composition of agricultural output in developing Asia has partly shifted from traditional food crops, especially rice, to higher-value export commodities, with the expansion of industrial food crops (maize, cassava) and industrial raw products (oil palm, rubber). Such changes in the production pattern have been drawn by an increasing shift of Asian diets from the traditional staple foods towards more livestock and dairy products, vegetables and fruits, and fats and oils. The rice consumption per capita clearly tends to decline with income growth and with urbanization (FAO, 2014).

Another factor contributing to the intensification and diversification of agriculture has been the little scope for expansion of farmland. The access to new agricultural land has narrowed considerably, a constraint which is clearly most serious in developing Asia than worldwide: the agricultural land area expanded at only 0.49%/year since 1980, significantly less than in Latin America (0.61%), or in Africa (0.89%). In the meantime, in developing Asia, the growth of land productivity was 2.24% on average, compared to 1.84% in Latin America, and to 1.51% in Africa (FAO, 2015).

Similarly, the fishery sector has also changed, shifting from traditional captures to more medium and large fishing systems and to aquaculture. The total capture production from inland waters, exclusive of aquaculture, was 11.9 million metric tons in 2014, of which Asia made up the largest share of the world total catch. China accounted for 19.3%, followed by Myanmar (11.6%), Cambodia (4.2%), Indonesia (3.5%), making up almost 38% of the world total inland production. However, fish stocks of both marine and inland have significantly decreased from their historical levels due to over-fishing (Allan *et al.,* 2005). However, the inland fisheries are generally small-scale and subsistence in nature, making it difficult to properly value (FAO, 2015).

1.2. Situation of Cambodia

There are over 15 million people in Cambodia, with around 70% habitants living in rural areas. 30% of them, before 2010, and then around 18% in the recent years, were considered as being under the poverty line, most of them relying on agriculture (NIS 2008; 2015). The land cultivation areas were estimated at 37,000 km^2, withrice grown as the main.

According to Pillot (2007) and Diepart (2015), Cambodia can be divided into four main agro-ecological zones, namely upland including the uplands (plateaus and mountains), the Central plain, lowland/flooded at TSL and along Mekong river, and the Coastal zone. Our study modified a land cover map in 2015 of the Open Dvelopment Cambodia[2] to the illustrate the agro-ecological zones in Cambodia through an Illustration **1** based on our own knowledge and consultation with public and private stakehoders.

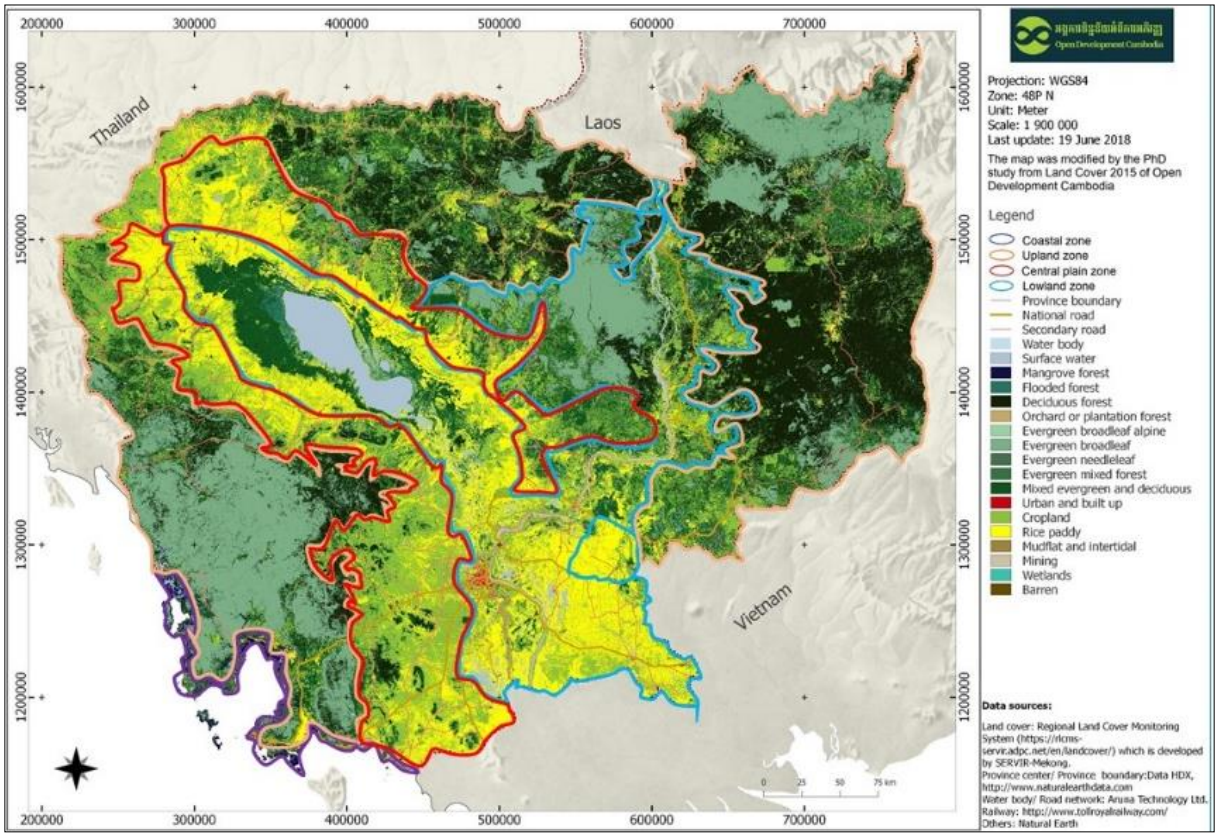


Illustration 1 : Map of Agro-ecological zone of Cambodia

Source: Land Cover 2015 of the Open Development Cambodia and PhD survey 2016-2017

The coastal zone consists of a very small portion of the country located in the Southwest. There are mostly marine and forest-related activities there, whereas the potential for tourism is high.

[2] Open Development Cambodia (ODC) is an 'open data' website, the first of its kind in Southeast Asia (https://opendevelopmentcambodia.net/). The information or data in the public domain is freely available to everyone to use and republish.

The uplands zone (plateau/mountain areas) first include the Plateaus and hilly regions located on the Northeast quarter of Cambodia, starting in the province of Kampong Cham and going up to Vietnam's Central Plateau in the Provinces of Mondulkiri and Ratanakiri. Another set of mountains lies in the South-West in the eastern part of Kampong Speu province, Koh Kong and South of Pursat province. These areas bordering the coastal provinces are still dense in forests and with low population density (Pillot, 2007; NIS, 2012). According to Diepart, (2015) and Yoeu, (2016), the cropping systems on upland areas have shifted from traditional slash and burn cultivation of paddy associated with hunting and collecting from the forest, which mostly was done by indigenous people, to industrial rubber and cashew nut plantations linked to the extension of large-scale land concessions, called Economic Land Concessions (ELC), mostly driven by foreign direct investment.

The central plain in the heart of the country stands in the middle of the Northwest-Southeast corridor from the TSL to the Vietnamese boader in the South. It corresponds to embedded alluvial terrasses, out of the reach of the Mekong rise, which have historically carried the populated Cambodia since the pre-Angkorian times. Still now, the Central Plain carries the highest population density. Thus, the northwest areas bordering Thailand around the TSL zone and southeast areas bordering Vietnam are the main producers of rice (Pillot, 2007; Diepart, 2015). Rainy season (moonsoon) rice is by far the main crop, accounting for 70% of total land area of the country (Ballard, 2006). The agricultural development in central plain have been progressively associated with building irrigation structure. In the places where additional water can be available (vicinity of reservoirs, irrigation schemes, or possibility to pump the underground water), a second crop of "early rice" before the main moonsoon season can be cultivated. The rice yields in this area can reach about 2.6 to 3.5 tones/hectare on average (MAFF, 2006, 2014b). Animal and fruit tree plantation also provide high yield, contributing to local and domestic consumption. However, this agricultural system has been changed with high input and capital, application of technology and equipment, and specialization (Pillot, 2007; J. Diepart, 2015b).

The last zone is the lowlands around the TSL and the Mekong river correspond to all the areas that are directly covered by the annual rise of the Mekong river, between July and October every year (6 to 10 meters at Phom Penh). Within the lowlands, the TSL covers about 5 to 8% of Cambodia's total land area (Sverdrup-Jensen, 2002; MRC, 2003). Connected to the Mekong River by the 120 km long Tonle Sap River, the TSL's surface area annually fluctuates from 2,500 km^2 wide to over 15,000 km^2 wide, driven by seasonal flood pulse from the Mekong River. This flood does not only provide water for the crops, it also carries silts that are deposited

on the land when the water withdraws, thus providing worth condition for rice fields (Pillot, 2007).

Local people depend on the traditional ways of living, still using floating rice and heavy rice farming during the flood, when the depth of water is moderate, combined with intensive receding rice cultivation and small and large-scale fishing, and extracting flooded forest resources, mainly for subsistence purposes. However, the local households are becoming more diversified over time and less dependant from those lowland/flooded systems (i.e. crops, fishery, flooded forestry) depending on the degree of interactions of the adjoining ecosystems (Keskinen, 2003; J. Diepart, 2015b).

So far, people have often shifted from one traditional rice such as floating rice or wet season/heavy rice to double rice and crops systems with high chemical input application, overfishing and overexploiting the natural resource for their subsistence (Pillot, 2007; Yoeu, 2011; Neang, 2015). However, while more kowledge exists about the uplands agricultural systems and those of the Central Plain, the lowland/flooded agricultural systems have been less investigated.

1.3. Agricultural systems in change

1.3.1. Existing models of the agrarian systems of Uplands and Central Plain

The situation of agricultural production all over South-east Asia and more particularly in Cambodia, results from historical changes that, from the neolitic times, have led to the present situation and the current organisation of the agricultural systems.

Following Geertz (1963), Bernstein and Byres (2001), Mazoyer and Roudart (2006) [3], several authors have addressed the issue of analysing how the development of the agrarian societies and their relationship to the environment have shaped the organisation of agriculture, the techniques of production, their economic results and the way the society could be organised to regulate and/or monopolize the production of surplus. In other words, they attempted to describe and interpret how, from the initial development of rice cultivation in Asia, so different agricultural systems could develop over time to reach the current situation. This effort was also justified by the assumption that the understanding of the processes that led to this differentiation of the agricultural systems would enlighten the conditions of the current and future changes. By understanding the past processes, it was assumed that it would be easier to identify the engines of the current changes and, even, to foresee what could be the next changes that may occure.

[3] The French version of the book, *Histoire des agricultures du monde* is from 1997, while the English translation op cit. was published in 2006

One of the pionneers of this family of works regarding South-east Asia has certainly been Clifford Geertz (1963), who studied about agrarian systems change in Indonesia over several hundreds of years. He argued that the understanding of such change depends on an investigation of ecological and sociological points of view. He also characterized two main models of rice-based farming systems in Indonesia: (i) the slash and burn upland rice ("swidden agriculture") and (ii) the lowland rice farming systems ("sawah"), and their geographical localisation ("sawah" being concentrated in Java and Bali along with 70% of Indonesia's population while swidden agriculture was more common in Sumatra, with much less pressure on the land). It then looked at the historical development of these systems, and defined what he called "the process of *agricultural involution*", inherited from the American anthropologist Alexander Goldenweiser (Goldenweiser, 1936). In the *involution* model, the Javanese economy, facing the double challenge of an increasing population and of higher surplus grabbing by the Dutch colonial regime, intensified the existing forms of agriculture rather than it changed the organisation of its systems. This involved putting even more labour into the process of production in paddy field cultivation compared to swidden, increasing per hectare output and the labour intensity in the paddy fields, while maintaining per capita output. Geertz's thesis was that this process was tied up with the development of sugar as a smallholder cash crop complementary with rice production. In the meantime, in Sumatra, the societies living from swidden agriculture did not face the same challenges and did not modify significantly their shifting agriculture systems.

Whereas she did not explicitely mention Geertz's work in Java, Ester Boserup, little after, developed the same kind of ideas. In her work '*The Conditions of Agricultural Growth: The economics of agrarian change under population pressure*' (1965), Boserup challenged Malthus's conclusion that the size of the human population is limited by the amount of food that it can produce. She suggested that the rural societies can increase their levels of production to match the needs of the population. One of the mechanisms is that the challenge of feeding more mouths does motivate people to increase the quantity of labour offered in the same amount of land, which leads in turn to improve their farming methods and to innovate in new systems of production in order to produce more food (Boserup, 2014).

These interpreations of the processes of change challenge both marxist and neoclassical explanations of the economic changes in developing countries.

Geertz's work certainly generated a number of criticisms but combined with Boserup's model, it inspired a number of empirical studies aiming at explaining the mechanisms of change and intensification of locally based forms of agriculture.

One of the major weaknesses of Geertz's work was however that it was based on the comparison of two different kinds of agriculture (*swidden* and *sawa*) that could not actually substitute to each other, since they responded to too different ecological constraints and opportunities: the slopes and the rainfed conditions for the *swidden*, and the lowland flooded (also rainfed) areas for the *sawah*. Although there are forms of transition between the two of them (like the development of terrasses on slopes), both systems cannot be placed on the the same track of change in most of the cases. However, they did indeed represent the two main families of rice-based systems in SE Asia that have been impacted by the pressure of population growth and land demand for the agricultural expansion of double rice production.

More recently, Mazoyer and Roudart (1997) proposed another model based on the concept of agrarian system. According to them, most of rice based agricultural systems could derive from post neolitic slash-and-burn in Asia. The progressive intensification of the zones most easy to intensify, like the uplands of the deltas, led to permanent rice cultivation with progressively more and more control of the water with dykes and canals. According to this vision, the intensification of the rainfed flooded lands would have preceded the drainage and the cultivation of the lowlands inundated by the annual flood. They however note that flood receding rice-based systems could also be developed in the lowlands, and that the deforestation work in those areas required less labour than slashing the thick Dipterocarpacae forests on the terrasses and on the uplands.

Beyond these founding contributions that attempted to build a general model of evolution and transformations of these rice-based systems, a number of locally-based empirical research works have been conducted in Indonesia, Philippines, Thailand, Laos, Vietnam and Cambodia to empirically characterise the modes of transformation and intensification of these both systems (Trébuil and Mahabub, 2004).

About the traditional long fallow shifting cultivation systems practised on the slopes of the mountains and plateaus, the process of transformation is now rather well documented (Castella and Verburg, 2007; Castella *et al.*, 2013; Li *et al.*, 2014; Castellanet and Diepart, 2015). The process of intensification shortens the duration of the long fallow that allows to recover the fertility of the plot between two periods of cultivation. The decrease of the yields are such that, at one moment,, alternative systems that could be developed in the meantime (permanent paddy cultivation in the valleys, orchards of fruit trees, rubber or forest plantations…) become more attractive and get most of the investment and labour efforts by the local farmers. The swidden systems disappear then to be transfomed into a combination of perenial plantations on the higher terrasses and on the slopes, and permanent paddy cultivation

in the valleys.

1.3.2. Existing models of transformation of the lowland agrarian system

The process of intensification of the permanent rice systems of the lowlands is much less documented than one of the shifting cultivation, and Cambodia follows this trend.

What is clear is that, from the moment the Khmer civilisation expanded at the pre-Angkorian times, at the 11th century, all the elements of the modes of exploitation that continued until 2000 were already present. The bas-reliefs of Angkor, as well as the accounts of the Chinese visitors of the time , already describe the two systems identified by Geertz. The uplands of the plateaus still covered with forest were the domain of ethnic groups already shifting. In the meantime, the Khmers installed in the Central Plain and around the TSL, were already cultivating the one rice per year (monssoon) system, ploughed with oxen, exactly the same system with the same tools as the one that was still dominating at the end of 1980 in the same area.

Pillot (2007) argues even more that it is the combination of both the traditional monsoon rice system on the terrasses, together with the exploitation of the floating and receding rice in the lowlands that allowed to build the powerful Angkorian empire. It is clear indeed that the many temples and cities built on the North side of the lake required an important labour force that could not be devoted to rice growing. Similarly, an army able to extend the control of territories from the current Vietnam on the East, to the current Burma on the West could only be effective if important economic surplus could be extracted from the local agriculture of that moment. The Tonle Sap Lake is precisely the place where the same families can cultivate the upland terrasses *together with* moonsoon rice in the low lands between May and November. This could itself be combined withr the floating rice in the area of extension of the TSL, between March and May the receding rice cultivated between December and March.

Contrary to what has been pretended for a long time, the three rice harvests mentioned by the Chinese Ambassador at Angkor Tcheou Ta Kouan were not resulting from a three crops a year system (on the same plots) , but from a the ultimate stage of intensification in the sense of Geertz, with a clever combination of relatively little intensified systems that required labour at different moments of the year. Such a integrated system certainly required lots of labour, but the productivity per capita was high. A strong ideological system was necessary to extract this surplus, which the religion offered, since it gave to the King the status of a God.

From the Angkorian times until the end of the 20th century, the Cambodian lowland

systems seem to have remained unchanged. Khmer Rouge regime, between 1975 and 1979, attempted to develop irrigation and double cropping through massive investments of forced labour to raise dykes and dig canals. These efforts have been poorly successful, especially since they were in most of the time technically badly prepared and since the Khmer rouge did not accept to call on the indigeous knowledge of the local people. After the Khmer rouge, the movements of intensification were encouraged by the growing population and by the changes in the land tenure conditions.

Keskinen (2003) studied the socio-economic situation in the TSLarea. It conducted a new GIS-based socio-economic survey, building a database with existing quantitative information about the rural livelihoods in six provinces around the Tonle Sap zones. His survey found that the main source of livelihood of people in floating villages is rather homogeneous and dependent on a variety of different occupations; majority is related to the exploitation of common property resources and TSL water. He discussed that lake and its floods play significant roles especially for the cultivation of floating and floating/recession rice.

Mak (2005) preferred to focus on the collective resources of the lake that are under pressure due to the increased "development paradigm" in the Mekong region. His paper outlined the key features of the TSL for the local communities, and the issues facing the lake and local communities. The paper also discussed the 'drivers of change' that causes these problems for local communities and their coping strategies. The last part of this paper draws key alternative scenarios and the actions to be taken for the TSL.

Pillot (2007) synthesized several studies conducted by GRET in Cambodia since the early 1990s in the Central Plain. The cropping systems based on rice were described and their economic results were compared. The regression of the floatting rice in the lowlands was noted (400000 hectares at the end of the 60s, 80000 ha in 2001). Rather extensive in labour coumpared to the other systems, floatting rice based systems require an important access to land, which is less and less available when the population grows. When an especially "dry" year occurs (with less flood from the Mekong), farmers of the lowland shift from floatting rice to the cultivation of receding rice (after the flood) in the lowest areas where the complmentary irrigation during the dry season will be less difficult. In some cases, the double cultivation (one early rice before the flood, followed by a receding rice after the flood) can be extended by those who have the less lands.

In Cambodia, the development and the extension of *receding rice* in the lowlands of the Mekong delta is a very obvious phenomena of the period 1990-2010, partly by replacing the floatting rice, partly by the extension of cultivation areas at the cost of the deforestation of

flooded forests. It certainly requires investments in infrastuctures to bring additional water after the recession of the flood, and also in fertilisers and pesticides to take the best advantage of the high potential of these zones just fertilised by the siltation. But the yield can be 5 times the level of the yield of the previous floatting rice that it replaces and this movement is certainly responsible, at the end of the 2000, of the doubling of the paddy production of Cambodia in twenty years time. .

Diepart (2015) studied in 2015 the fragmentation of land tenure systems in Cambodia. His study provides a very broad overview background of the historical evolution of the land rights since the ancient time until now and how the various land reforms attempted to formalize the property rights. The study suggests that the current land tenure regimes are highly fragmented between lowland, central plains and peripheral uplands, which has yielded problematic results. The development and governance of socio-ecological systems trigger considerable economic, social and environmental issues that need to be addressed urgently given the profound nature of the transformations at play in these systems across Cambodia.

Jiao, Pouliot and Walelign (2017) quantitatively examine the dynamics of households strategies on livelihood in the central plain areas. The study makes the dinstinction between five types of household, using criteria such as their intensification strategies, their access to education, the ownership of their physical assets, and their access to infrastructure. These findings also suggest policy implications for improving the range of livelihood choices available to the lower income groups to move out from the poverty trap.

1.3.3. The knowledge gaps for the lowlands

The above studies provided empirical knowledge about the transformation of the livelihoods and ecosystems in Cambodia from the past to present in most of the regions. However, the integration of fishing and agricultural systems in the lowland areas of TSL and Mekong River has not yet been considered, whereas, with the modification of the flood pattern, the region is facing an ecological change that does not exist anywhere else. Indeed, there is no study on the differentiation of the households in the region.

Moreover, the models of change inherited from Geerts and Boserup tend to consider that the agricultural systems are voluntary and coherent responses from the farmers to constraints and opportunities from the environment –ecosystem and markets-. The changes and innovations are generated in response of the growth of population. However, these models do not really consider that this environment is itself changing, and that these changes of course directly impact the response brought by the stakeholders. In return, the response brought in

terms of changing productive systems also has a direct impact on the environment, both on the ecosystem (deforestation, biodiversity, flood) and on the markets.

1.4. A case study in the Battambang province

Our study proposes to develop an empirical study in a province named Battambang located in Northern-west of Cambodia, where is part of the greater natural landscape of the Cardamom region. The topography of this province is made from the West to the East by a series of upland terrassesgoing down to the Tonle Sap lake, with a broad belt of lowland paddy fields in the centre to lowland. A combination of good rainfall, annual flooding and investment in irrigation systems ensures that Battambang soils support a very strong agricultural sector (MAFF, 2014a).

Battambang is the second-largest city in Cambodia, with a population of 1.4 million, located in the country's highest rice-producing area; it also serves as appropriate place for commercial, education, tourism, and other social activities (USAID, 2010; Battambang Provincial Departement of Planning, 2015).

As a result, the province is often taken as Cambodia's rice bowl – it accounts for around 760,000 tonnes (including all rice-based systems: rainy season, early season, receding, dry season, and floating rice) and it is the country's largest commercial rice miller (362,000 tonnes). It also contributes to annual inland fish catches with around 17,000 tones from main rivers and TSL (MAFF, 2016).

However, the province faces remaining challenges for its socio-economic development, such as poverty, natural resources and forest depreciation- including flooded forest degradation and fishery decrease (J. Diepart, 2015a). Since 2005, people have increasingly cleared forested areas to cultivate maize and/or cassava to market to private factories. Most of such products are exported to Thailand. Newly cleared land requires limited amounts of fertilizer at the beginning, whch makes the production quite attractive, but later on more and more fertilizer is needed as the land productivity, watershed, and water resources degrade if no countermeasures are taken.

The agricultural land has increased with 500,000 additional hectares from 2015 to 2018, of which 100,000 ha are for dry season rice cultivation as well as upland rice crop. This trend for commercial cash crop production is likely to encroach significantly on both protected areas and recession flooded forest areas (Ngin *et al.*, 2015). By contrast, the protected areas are increasingly under threat from land encroachment for large-scale agricultural land development (Battambang Provincial Departement of Planning, 2015).

Currently, around 200,000 ha of forest cover only are left, of which 150,000 ha is under the forestry administration's management and 40,000 ha is under the provincial department of the environment. As the result of encroachement, flooding in the province was recorded in 2011 and agricultural production was seriously damaged (about 17000 tons of rice lost in rainy and dry season - MAFF, 2016b). Moreover, there is also more issue and conflict on uneven fish culture, fish yield has decreased by around 40% in the TSL households' catchments after the fishing lots in lower parts of the province were damaged in 2011 by unexpected floods.

These challenges lead to questions about the impacts of these causes on agricultural production losses, livelihood and poverty issue and on the development in the province. To struggle against these changes, Battambang people have responded by adapting their agricultural and fishing practices and by diversifying their cropping, animals, and fishing systems, and also by extending their migrations (Hortle and Lieng, 2008; Clements *et al.*, 2014).

1.4.1. Charateristic of the study area in Battambang

The lowland of Battambang province are covered by Tonle Sap floodplain as the same as other areas around Tonle Sap lake, and the zone distinguished to two main production villages called fishing villages and agricultural villages. The above Illustration 2 illustrates the location of Cambodian country, Mekong River, and study area in Tonle Sap lake of Battambang. The study zone is under two water regimes of Tonle Sap flood pulse; first is a Zone I permanent flooded zone or can be called water zone in, and second is land-water zone a zone II where water reached only in rainy season, then become dry during dry season.

The study targeted zone II considered from national road number 5 as land-water zone, and zone I considered as permanent flooded water where agricultural and fishery activities take place and closed to TSL in the mentioned two districts; Aek Phnom and Sangkae. On the other hand, we used the survey based on agro-ecosystem observation to better understand and define zones, which can explain clearly the agro-ecosystem and how farmers manage the land and fishing production zone to adapt to flood pulse and ecological risks.

Based on flood pulse calendar, vegetation and cropping systems, grassland, shrubs and flooded forest. In the transect map created from our survey in Illustration 2 below illustrates the two images of floodplain varieties of rainy and dry season, showing the high and low peak, and this will be described in detail about the water regimes and flow in the following sections.

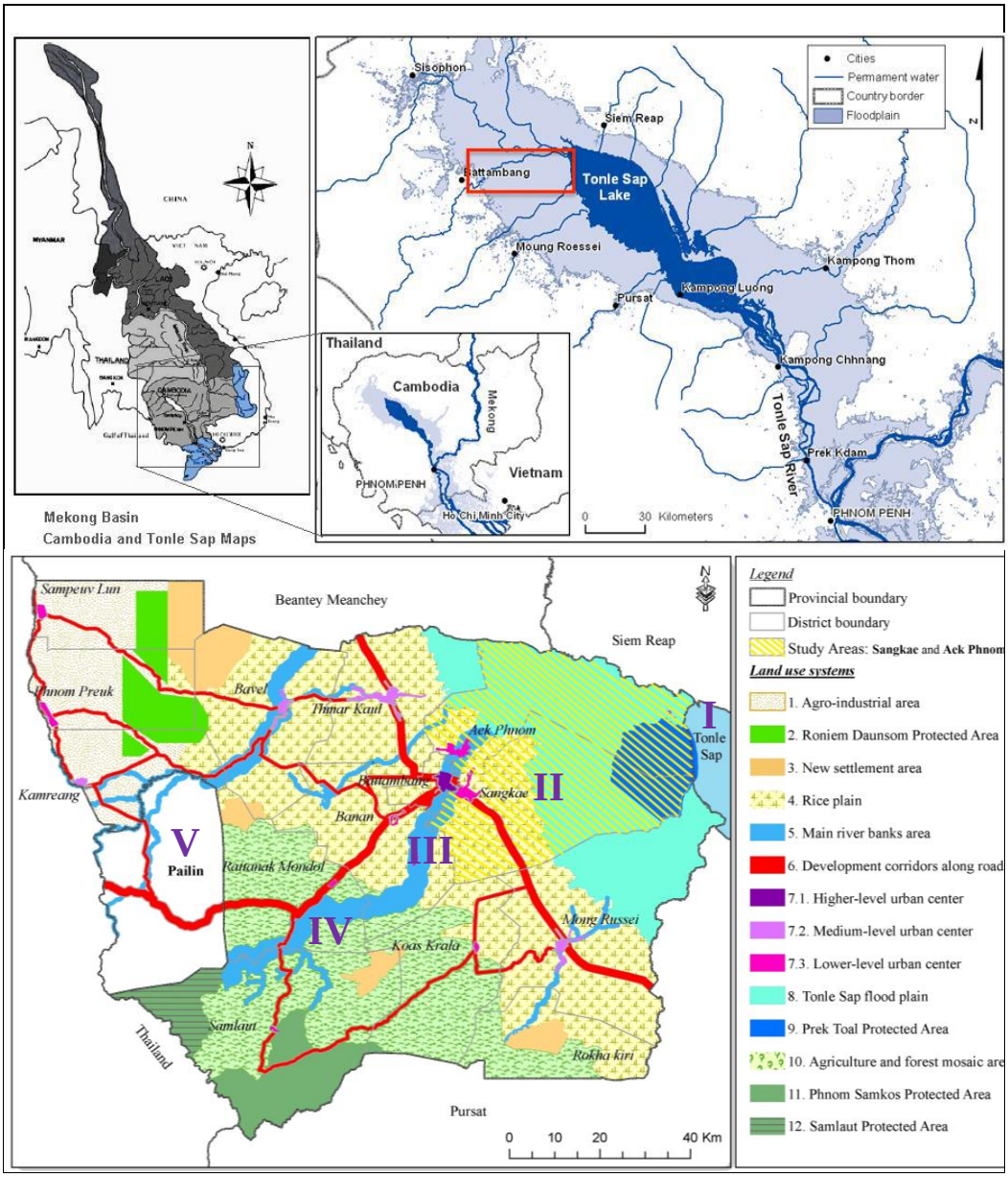


Illustration 2: Mekong River, Tonle Sap Lake, and Administrative boundary map of Battambang province, and study area

Source: Administrative boundary map from Battambang Provincial department of land management, land administration, and construction (BPDLMLAC) in 2015-2016.

1.5. Research Questions

The North West of the Tonle Sap Lake represents therefore a situation where the main lowland agroecosystems are represented, whereas the rice and fish based systems have known important transformations in the past thirty years. The social and economic importance of the basin, still so dependant of its rural endeavours, and the interconnection between the organisation of the production, the quality of the ecosystem services and the impact on poverty situation, justifies that more research is undertaken there, combining theoretical and empirical objectives. In this perspective, we do identify three questions - or set of questions- on which the specific situation of this case study can bring a particular contribution.

1 The local agricultural and fishery systems of production have been significantly transformed in the past 30 years and this change is currently continuing. Since the existing models of change in the lowlands are not sufficient to give a clear understanding of it, what have been the main drivers of change, and more particularly, what have been the role and fonctions of the population growth/demography, the environmental conditions with the flood pulse, and of the institutions and policies in place?

2 Given the diversity of stakeholders living from the local resource extraction, and given that the on going transformations of the environmental conditions, what are the strategies of the main categories of stakeholders,and how much are they depending of the ecosystem services offered by the Tonle Sap Lake? What is the impact of transformation changes on the services offered by the ecosystem, on the rural livelihoods and on the country's economy?

3 And finally, based on the trends identified in the past and leading to the current impacts, what can be the transformation of the rural livelihoods and natural resources that we can foresee for the future?

1.6. Research Objectives

To respond to the need of clear explanation about those changes and transformations, this research is conducted, therefore, to *examine the scope of the history of transformation, the diversification of rice-based farming systems and of rural household activities and to understand the impact of these on poverty in the lowland areas surrounding the Tonle sap lake of Cambodia. It aims at identifying the context of the demography, flood pulse changes, and policy and institutional pressure/constraints to the transformation of rice and fishery systems. The finding will be an empirical case study that to enriches or enlightens the missing models of rural livelihood activities of the household around TSL of Cambodia as well as lowland regions in Southeast Asia through deeply understanding the household systems of activities with the combination of agricultural and non-agricultural activities, clear explanation the characteristic and determents of household types, and the economic impacts of the changes of flooding pattern on individual households and on Cambodia's gross production.*

Despite diversified livelihood strategies, many local households remain entrenched in poverty and this is particularly the case for those living in the villages most affected by seasonal water level changes. In the World Food Program's poverty and vulnerability map, communes located near the Tonle Sap show rather high rates of poverty (above 50% of poor), especially

in the North of the Lake (World Bank, 2009). Various reports also point out that poverty and vulnerability take multiple dimensions in this particular landscape that go beyond the low-income criteria . They are, to some extent linked to low welfare indicators (education, health, hygiene, and nutrition) as well as to the limited access to financial capital and productive resources (flooded forests, fisheries, land). The latter point is of particular interest for our research as it reflects another aspect of the link between livelihood and ecosystem.

Considering that links between the Tonle Sap wetland agro-ecosystems, the livelihoods and the poverty are complex and dynamic, the overall research objective is to advance understanding of the dynamics of rural household activities and of poverty at diversified agro-ecosystems of the Tonle Sap area, so that it can better contribute to better understanding of the transformations of the lowland livelihood systems. The specific objectives of the research can also be defined as follows:

i. Identify the drivers of change on the rural household activities and natural resources in the study area;
ii. Analyze the strategies of households in Tonle Sap to adapt their livelihoods such as cropping, livestock rearing, fishery, and non-agriculture activities, and assess their impact in terms of system productivity and in term of institutions in the study area;
iii. Analyze the spatial economic impact of flood pulse changes in different years on local household livelihood.

1.7. Scope of the study

This research uses a qualitative and quantitive approach adapted from Agrarain System Analysis and Diagnosis to capture indepth images of a small sample of the population in two districts situated in lowlands of Battambang province in Cambodia. Surveys were conducted on the same site from 2014 to 2017 with the same stakeholders (official ministry and departments staffs, development agencies, groups of farmers and fishermen households, and other relevant participants) in different processes of interviews. The sampling resulted from both purposive sampling and stasticial sampling calculation. Hence, the structure of household questionnaire interviews combined quantitative and qualitative aspects of the study.

Truly, the nature of the research and the field observations in permanent interaction with the analysis of the data requires to study requires that the survey guidelines remain flexible to cope the households'strategies, key issues, and enable to cross checking between respondents'answers.

1.8. Research hypothesis

In general, the hypothesis is that the local livelihoods in these regions are characterized by a diversity of economic activities, which are highly dependent on the ecosystem of the TSL. To be able to stress the impacts (Question 1), the strategies (Question 2) and the possibility of sustainable development (Question 3), we need to better understand the diversity of livelihoods, and the relationships between the households and the ecosystems.

The flow of ES used by local farmers, fishermen or forestry resource repliers, contributes to capital accumulation of rural households living in the TSL area, or even increases resilience when economic accidents occur.

The assumption is that the relationships between ecosystem and livelihoods differ for each household depending on its individual (historical) background, on the impacts of policies and institutions, on household economic activity, and on ecosystem services (provisioning through the availability of natural resources, mainly water, fish and land, and regulating services through the effect of the flood pulse).

The research also leans on the following specific hypothesis:

- *Hypothesis 1:* The Tonle Sap area is cultivated and fished with systems that highly rely on ES provided by the annual flood. But this access to ES is uneven among the population.

Explanation: Geographically, Tonle Sap water regime covers two main floodplain zones;

- Zone I is permanently under the water, even when this latter is at its lowest elevation (end f March); the population lives in floating villages, while economic activities are mosty based on fishing.
- while Zone II (or Water-land zone) corresponds to areas covered annually by the rise of the water which occures between May and November. The livelihoods of people is based mainly on a combination of rice-based cropping systems and fisheries systems. In general, households in and around TSL primarily engage in small-scale fishing, with supplemental income from agriculture mainly rice, raising livestock, aquaculture, non-farm and off-farm work, and remittances (Keskinen, 2003).

- *Hypothesis 2:* Movements of economic changes and development in other sectors of the economy lead to a general intensification of agriculture which goes together with a highly increased use of inputs (use of financial capital) which in turn has an uneven effect on the local poverty.

Land concentration tends to generate large scale farming forms of production side by side with the extension of landless farmers . Rice and fish are back bones of the Tonle Sap's floodplain. The development of large-scale irrigation projects in the upper basin and the emergence of private irrigation structures in the flood plain influence the availability of resources to different user groups (Keskinen *et al.*, 2007). The rapid agricultural development is not only associated with the built irrigation structures, the access to the floodplain has also been improved through the construction of rural roads. The competition with higher productivity systems forces local farmers in the Tonle sap area to increase productivity on their side with an increased use of inputs, which in turn impacts directly and indirectly the low income farmers who have less capacities to face these expenses.

- *Hypothesis 3:* The local livelihoods in the Tonle Sap region are characterized by a diversity of economic activities, which are highly dependent on the ecosystem. The flow of ES used by local farmers, fishermen or forestry resource repliers, contributes to capital accumulation of rural households living in the TSL area, or even increases resilience when economic accidents occur. Those with less means of production are more dependent on the ES that those who have intensified, i.e. leading to an uneven fragility against risks. Risks are higher for those who are economically fragile (Badjeck *et al.*, 2010).

The multiplication of dams upstream on the Mekong River and on its tributaries, notably the large hydropower projects in Mekong countries, are threatening the ecosystem and the livelihoods of the Tonle Sap's flood plain as it causes the rise of dry-season water level and the decrease of the water level at the flood peak (Keskinen *et al.*, 2007). The increase in dry-season water level leads to the destruction of flooded forests surrounding the lake; therefore causing significant loss of livelihoods and negative impact on cropping productivity but also the aquatic production in the lake. The effects likely put additional pressure on the remaining resources and thus potentially cause resource competition and fuel related conflicts in the area.

1.9. Structure of dissertation

This thesis compiles six chapters. The initial chapter leads with problem statement the explanation of the questions raised, their justification, and the hypothesis of research. In this chapter, we review the on-going transformation of agriculture in Southeast Asia as well as the specific situation of Cambodia in this regards. We also present the existing models of change in the different different environments that exist in Cambodia, from the mountainous to the

flooded plain area, and we identify the questions that remain raised to understand the rural household activities in lowland area of this country.

In the following chapter, we come up with a review of the theoretical and analytical frameworks that are mobilised to respond to the research questions. The methodology of research and the survey tools that were used–is then presented .

The third chapter details the main comprehensible drivers of evolution/change; institutions and policies that impact on the economic and social dynamics in the TSL plain. The flood pulse changes, the land, rice and fishery policies and, last, the demography in lowland areas are reviewed, with a detailed historical perspective

Fourth chapter aims at analyzing the transformations of the agrarian system, including the cropping systems; animal rearing systems, fishing systems, and other non-agricultural activities, from since the pre-conflict of the Khmer Rouge regime until now. The issue of land use changes in the study area and the history of innovations appearing in agriculture , are addressed. They result in a number of activity systems, from cropping to non farm activities, going through animal husbandry and fishing that are described and whose economic results are analysed. At the end of that chapter, we identify the main types of households that have different economic strategies vs their accumulation and, as a consequence, their dependence vis-à-vis the environmental servces brought by the annual flood. This chapter also details the charaterisation and strategies developed by the economic stakholders throughout their various types in relation with the diversity of family projects, and the strengths and constraints against the changes in the environment. In particular, we assess the main economic performance of the diverse types of households, in agriculture, fishing and non-farm and off-farm incomes. We also measure the economic capacity of the households to meet the subsistence and different levels of poverty of each household type in order to explain their own situation and to highlight their strategy..

Fifth chapter mainly analyzes the economic and spatial impact of the flood pulse changes; we compare the households' income of the various types of systems between "bad years", like in 2013-2014 and "good years" in 2016-2017 vis-à-vis the flood and the services effectively brought by the TSL ecosystem. We also attempt to calculate an indicative impact of such circumstances on the economy of the whole country.

Lastly, the last chapter summarises the main innovative results of the whole thesis. It tentatively extracts lessons learned for the definition of recommendations for policies and for the organisation of appropriate support to a sustainable development of the livelihood of local people and to the conservation of the natural resources on which the future of these livelihoods based.

Chapter II: Theoretical and Analytical Framework, and Methodology of Research

2.1. Theoretical Framework

The overall theoretical and analytical framework that we use for responding to our research questions borrows tools and concepts that, in the field of ***Agricultural and Environmental Economics, have been developped under at least three different, but somehow complementary, frameworks:*** . the **Agrarian System Framework (AS) (**here also called so-called Agrarian System Analysis and Diagnosis [ASAD]**)**, the **Sustainable Livelihood Framework (SL),** and **the Ecosystem Services Framework (ES).**

2.1.1. Agrarian System Framework (AS)

The **Agrarian System Framework (AS)** is used as an holistic approach to understand agricultural transformations in a village, regional and national levels. This approach considers all the fundamental factors that influence farmers' decisions and practices, with the ambition to enlighten the mechanisms of agricultural transformations. Moreover, it takes into account both ecological and socio-economic dimensions of these changes.

The concept of *Agrarian system*, derived from a set of agricultural activity elements, has firstly appeared and became a set of inconceivable elements to scientific researchers in 1940s. This so-called AS, mostly used by goeographers was then more likely a spatial expression at the level of the landscape, until the ideas of production and techniques association implemented by a society were added to its fundamentals. Thirty years after, the study of cultivated landscape as a system does no longer consider the landscape as the product of its ecological characteristics, but also tht it results from its social and economic foundations. From that moment, the concept and method, namely "Agrarian system" was officially documented by the French agronomists during 1970-1980s. From then on, agrarian system designates the interaction between bio-ecological and socio-cultural systems. Moreover, the historical dimension, the social formation made up of different categories of farmers and social division of labour among farmers were hence underlying in the concept of agrarian system (Cochet, 2015).

The identification of groups of farmers who may have similar behaviours in the society and in the environment has always been a matter of strong interest for this school of thoughts. From year to year, methodological tools have been developped and extended with more and more statistical tools; for instance, the Multivariate Statistic analysis (actor analysis through Principal Component Analysis [PCA]; and Cluster analysis) has enabled the researchers to produce farm typologies or household type based explicit combination of factors. The

exhaustive farm typologies refer to grouping the farms which share similarities in their resources allocation (land, level of mechanization, labour force), the socio-economic contexts, the combination of cropping systems (rice, cash crops, forest, fruit trees), or/and the animal raising system (livestock, husbandry, fishery, and fish culture) . In this sense, it builds on the analysis of the ensemble of "crops types, techniques, crops sequences and associations, history of the plot" as a whole under specific climatic condition.

A good understanding of the "agro-ecosystem" of the study zone is unquestionably important since it is a main factor that helps farmers either in making decisions or defining strategies in the choice of cropping systems in order to adapt to all conditions related not only to agro-ecosystem but also the others socio-economic-political factors. The farm typology or production systems modeling is, therefore, a complex analysis of external factors and internal factors. The external factors can refer to the agro-ecosystem transformation, the technical change, or the socio-economic-political change, while in contrast land, labour force and capital available are considered as internal factors. All these conditions are assumed to significantly influence the decisions of farmers when choosing the different cropping systems in order to survive in a specific ecosystem or in order to increase their productivity.

Most authors [Cochet and Devienne (2006); Cochet, Devienne and Dufumier (2007); Barral *et al.,* (2012); Cochet (2012 and 2015)] use the AS as a systematic approach to study agricultural activities in one region from the plot to the village/regional/national level, in a way that accounts for both ecological and socio-economic dimensions. In addition, they consider that the AS methodology can be used to study the farming systems or activities systems as one of key elements, and also to determine of how individual farmers organize their own farm; and a way of their own, managing the combination of crops with/and animal systems by using their inputs such as labour; capital, and land surface in the most efficient manner.

In context of the lowland agricultural systems of the TSL in Cambodia, the agrarian system can be identified as based on different cropping systems using cereals, lowland rice, industrial crops and vegetables. Traditionally, small subsistence landholders integrate livestock with their crop production. With the continuing population growth, intensify crops and livestock systems continue to play vital role in maintaining rural livelihoods Keskinen, (2003); Mak, (2005); Matsui *et al.*, (2005).

The AS is regarded as a conceptual tool that can be used for understanding the dynamics of farming activity on a regional or/and at national scales. Methods based on AS review attentively all social, economic and political aspects, which lead to a better understanding of the agricultural evolution of the region. Anyway, according to (Barral *et al.*, 2012; Cochet,

2012b), the concept was redefined by Mazoyer and Roudart (2006) as followed *''a way of exploiting an agro-ecosystem that is historically defined and sustainable, adapted to the bioclimatic conditions* ***of*** *a given area, and responding to the social needs and conditions of the moment''*. This new definition is presently adopted in the frame of this study in order to identify the farming or agricultural production systems which small households combine with other various family income activities including non-farm and off-farm. Moreover, at landscape scale, agrarian system framework enables researchers to determine the accessible resources to support the livelihood's activities as well (Cochet, 2012a, 2015).

In addition, Mazoyer and Roudart (2006) also defined the agrarian system is "*the theoretical expression of a historically constituted and geographically localized type of agriculture, composed of a characteristic cultivated ecosystem and a specific social production system.''* The latter makes the long-term exploitation of the fertility of the corresponding cultivated ecosystem possible". Generally, the current situation is the product resulting from not only the interaction between the strategies of local stakeholders, but also an imperial process that has to be examined. This is the reason that the theoretical analysis conducted in our study is aiming to investigate and to reveal the truth and reality at both household and regional level.

Having contributed to the set-up and development of AS, it is a structural concept that integrates ecosystems management, social relations, economic and social conditions. Likely, the AS includes the way the ecosystems are utilised and are sustained; the social relations which govern the forms of production and exchanges. In addtion, it can be used to review the major factors that contribute to political, economic, institutional and social factors at different levels. Furthermore, it includes the set or combination of the production activities and systems of activity, the livelihood strategies, the organisation of family labour and the distribution of wage labour used for the means of production. One among others, AS is used importantly for building historical trajectories and historical background of the households from the past until the present.

This said AS also has its limitation; it seems rarely used when non-agricultural activities (the non-farm and off-farm) activities are determinant of the transformation of the society or of the environment. Indeed, this concept is somehow has limitation to use analysing the roles of five assets and other socail factors inpact on the households. Table 1 summarises the strengths and limitations of the AS concept that descriped above.

Table 1: Stenghths and Limitations of Agrarain System Framework (AS)

Strengths	***Limitation***
✓ Allows investigating landscape and revealing the interaction between the households' strategies and natural resources from the local to regional levels. ✓ Allows reviewing all factors lead to the revolution of institution and policy influences, socio-economic networks, and agro-ecological conditions. ✓ Allows analysing clearly the combination of production activities and activity systems (means of production; capital, land, labour...). ✓ Allows feed-back on history of change and and typology of stakeholders. ✓ Allows deep understanding the households' strategies towards transformation of agriculture and environment…	× Rarely used for non-agricultural activities (Non and off-farm) × Unable to use for analysing the role of five assets (human, natural, financial, social and physical) and other social factors impact on households.

2.1.2. Sustainable Livelihood Framework (SL)

The **concept of Sustainable Livelihood Approach (SL)** was originally created around 1980s. It was firstly influenced by the application of 'systems based' thinking in sectors such as agriculture, then it was sought to bring together concepts in ecology along with social and economic aspects of agriculture (Conway 1985).

According to Chambers and Conway (1991), the SL was initially built on three fundamental conceptual principles of capability, equity and sustainability.

Within the general meaning used by Sen (1993) , the term of capability refers to the ability of a person to perform his/her functioning in different situations. He explains futher that the functioning represents various activities or states that a person manages to do or to be in life. The livelihood capability means an ability to cope with stresses or shocks or being capable to find or make use of livelihood opportunities (Chambers and Conway, 1991). The capability means not just being reactive, but proactive and dynamically adaptable. This also focuses on households' strengths or assets that enable them to make decision of livelihood choices or to withstand crisis. While livelihoods of some people are predetermined, for example as successors from their parents, many others are influenced by socio, economic and ecological environments and it depends on their adaptive capabilities whether being able to exploit new opportunities or become vulnerable to the change (Morse and McNamara, 2013; Seng, 2017).

Equity can be measured in terms of distribution of income, assets, capabilities or opportunities. It focuses on people and social justice where people not only gain access to assets or resources but are able to maintain adequate and decent living (Morse and McNamara, 2013).

The development of SL leads to a broader view of sustainability to encompass dimensions of the current situation. The four key pillars of sustainability associate social, economic, institutional and environmental factors (Scoones, 1998).

Environmental sustainability concerns resource productivity and its effects on livelihoods. It associates with the enhancement of one livelihood activity which may impact on other livelihoods. From ecological literature, sustainability refers to "the ability of a system to maintain productivity in spite of major disturbance, such as is caused by intensive stress or a large perturbation". This also links to resilience which is referred to "an ability of ecological or livelihood system to bound back from stress or shocks" (Allison and Ellis, 2001).

The conceptual framework of the SLA enlarges the neoclassical vision of the capital to consider that livelihoods are the results of the mobilisation of five different assets : human, natural, financial, social and physical, By doing so, it recognises the role of non market values, such as the natural, or social capital, and partly the human capital, as keys to explain the strategies and the decision taking of the social actors. It was also suggested initially by Ellis (2000) to improve the understanding of the famine vulnerability. It provides additional insights not just about the patterns of social or economic failure by considering different assets. It explains why war and conflicts are a crucial cause of vulnerability. It also helps to explain how households and the community make decision about their livelihood strategies and rebuild their life after a shock. Furthermore, the asset pentagon provides an appropriate way to picture the multidimensional nature of poverty and vulnerability being faced by communities, such as poor living condition, inadequate services, lack of skills and assets, or high exposure to risks (Townsley and others, 1998).

In the society of developing countries like Cambodia, the concept of SL has been used widely by national and international development agencies to study different topics of livelihood in rural development, poverty, small landholder, fisheries and natural resources management (Ellis, 2000; Allison and Ellis, 2001). The approach provided a popular advantage to study resource management systems, identifying what existing systems are appropriate and why some have failed (Ferrol-Schulte *et al.*, 2013). Although SL has resonance with older ideas, one of its most prominent influences is the rise of what is referred to as 'human development' and promoted especially by the United Nations Development Programme (UNDP). Indeed, SL has been regarded by some as the 'operational vehicle' of human development (Hoon, Singh

and Wanmali, 1997). Human Development was influenced by the work of the Indian economist Amartya Sen and his writing on capability (Sen 1984, 1985) as well as other authors on vulnerability and access to resources (Chambers and Conway, 1991; Ellis, 1999). These are inter-related in the sense that having a more diverse capability can reduce vulnerability of livelihood to shocks in much the same way that biologists argue that greater biodiversity aids ecosystem resilience to shocks and stresses.

Yet, we consider that the SL has also few limitations, especially associated with the level of details of the information/data needed to document the approach, and the related methods of investigation. It is globally implemented by funders/donors and by Development Agencies, associateed with Rapid Rural Appraisal methodologies, which are done rapidly and with light data collection, are based on the assumption that the knowledge and the representations of the local stakeholders is given and can be taken as such, rather than being critically analysed by triangularisation with other sources of information, and given a specific grid of interpretation. Those rapid methods are totally different from the agrarian systems methods which require the researcher (s) to long period of research with farmers to get better understanding of the whole situations in the study area.

Nevertheless, this does not undermine the value of this holistic, multidimensional approach when the intervention focuses on people-centered solutions. Table 2 below shows a summary of the strengths and limitations of the SL.

Table 2: Strengths *and Limitation of the Sustainable Livelihood Framework (SL)*

Srengths	***Limitation***
✓ Allows analysing the role of five assets (human, natural, financial, social and physical) and other social factor impact on households.	× *Implemented mostly by donors, while rarely used by research scholar.*
✓ Improves understanding of the cause of vulnerability and poverty, but also how the household mobilise their resources for livelihood.	× *Conducted often with rapid appraisal methodologies for data collection.*
✓ Allows reviewing all factors led to the revolution of institution and policy influences, socio-economic networks, and ecological conditions.	× *Unable to deterrmine the value of holistic, multidimensional approach of the intervention, while it focuses broadly on people-centered solutions.*
✓ Allows analysing both agricultural and non-agricultural activities (Non and off-farm)	
✓ Allows capturing the multidimensional nature of poverty and vulnerability, and also to understand the link between livelihood and ecosystem services, effectively.	× *Unable to creating historical trajectories of change and typology of households.*

2.1.3. Ecosystem Services Framework (ES)

The study also uses the **concepts of Ecosystem Services (ES)** that allow to understand the linkages between agro-ecosystem and agricultural practices, and then calculating the opportunity cost of conversion to assure ES provisioning and socio-economic strategy of households to again the issues/transformation of changes (MEA, 2005). Likely Wunder (2001, 2007) considers the links between ES and the economic and social situation of the actors are dynamic, which allows us to look at their role on capital accumulation, increasing vulnerability and so on. Beside, we also argue that links between ES and poverty are strong but complex. Indeed, they can either be positive or negative. In addition, income derived from the environment is a major constituent of the livelihoods of the rural poor, and this direct dependence on nature does not appear to be decreasing (Ellis and Biggs, 2001).

On the other hand, the environment can also be a source of vulnerability: for instance, low-income families are especially vulnerable to natural disasters and environment-related risks. Therefore, we consider the use of this ES concept (Holzmann and Jørgensen, 2000; Sunderlin, Angelsen and Wunder, 2003; Wunder, 2005) for better understanding on the perspective of households' strategy of the local people on the economic and environmental changes in the study area.

Following the classification by the Millennium Ecosystem Assessment (2005), we identify in the literature two main types of ES that contribute to local people's livelihoods, namely as Supporting, Provisioning, Regulating, and Cultural Services.

Supporting services are linked to all the non-material and consumptive functions which play an important role to support 3 others services: soil formation, nutrient cycling, photosynthesis etc (Ahmed *et al*., 1998).

Provisioning services are related to all products and resources local people extract from their environment include fish, non-timber forest products, fuel wood etc. Save Cambodia's Wildlife (WCS, 2010) reported that an estimate between 289,000 and 431,000 tonnes of fish was caught annually in TS. And the lake is the fourth most productive captive fishery in the world, providing some 70% of the protein intake for the entire Cambodian population and the floodplain in TSL contributes to 1/3 of GDP of agriculture (Van Zalinge *et al.*, 2000).

Regulating services are the ways in which living organisms can mediate or moderate the ambient environment that affects human performance: flood regulation, climate regulation, water purification etc. World Bank (2006) also reported that the lake provides habitats for more

than a hundred water bird species, 89 of which are abundant and 14 of which are considered to be of international significance, a large variety of fish migrate in large numbers from throughout the lower Mekong system to spawn during high season, returning with the receding waters to the open lake and river system beyond, water regulation and soil fertility for rice production, and transport by inland waterway.

Cultural services are all the non-material, and normally non-consumptive, outputs of ecosystem that affect physical and mental state of people; spiritual, recreational, educational services etc. TS and river played roles in Cambodian cultural ecotourism activities; birds, floating villages, TSL river trip, etc. (Conway and Chor-ching, 2006).

The concept of ES also allows us to frame and categorize the contribution of ecosystems to livelihoods (MEA, 2005), and it can be complementory on the understanding the impact of the changes of/on the livelihood and the environment, which support to the missing components of concept of AS but also the SL.

Holzmann and Jørgensen (2000) argue that there is a need to go beyond classical poverty and resilience measurements, which generally focus on income and other static indicators. They argue that it is necessary to take into account the risks of shocks and stress (natural and social pressures) and so broadening the scope of poverty assessments to include an analysis of vulnerability to poverty: vulnerability is defined as a measure of well-being, reflecting not so much how *worse-off* and *better-off* household currently are, but what its future prospects are. By contrast, the ES has more limitation to cope the study as much as the AS and SL are capable to take into account.

2.1.4. Towards an appropriate and integrative analytical framework

Therefore, in our study, we combine elements of the Agrarian systems framework with elements of of the sustainable livelihood framework, and finally also with elements of the Ecosystems services framework. We consider that none of them, on its own, can totally explain the strategies and the dynamics that we empirically observed on the field. On the contrary, each of them has the capacity to enlighten a relevant component of the situation.

- The AS framework has to equivalent to explain the historical changes that have shaped and made the situation the way it is now.
- The Livelihood appoach has no equivalent to explain the decision taking and the trajectories of the economic units.

- Finally, the Ecosystem Services framework has no equivalent to explain how the natural environment, and more particularly the flood, has played a central rome to stabilise the livelihood of most of the stakeholders, the poorer of them being even more dependant than the others.

The original combination that we try to achieve leads us to an original framework (see illustration 3) that in fine allows to analyses the rural household activities and poverty. In particular, we highlight on the importance of the institutional environment and national policies in the context of demographics, land management, fishing lot mangement, water mangement, to reduce the poverty and vonerbility caused by the changes. We belive that the results of this study will be useful for discussion of the process of a reflection on the recent land and fishery policies to meet sustainable development and coservation for the study area as well as similar lowland areas in Cambodia.

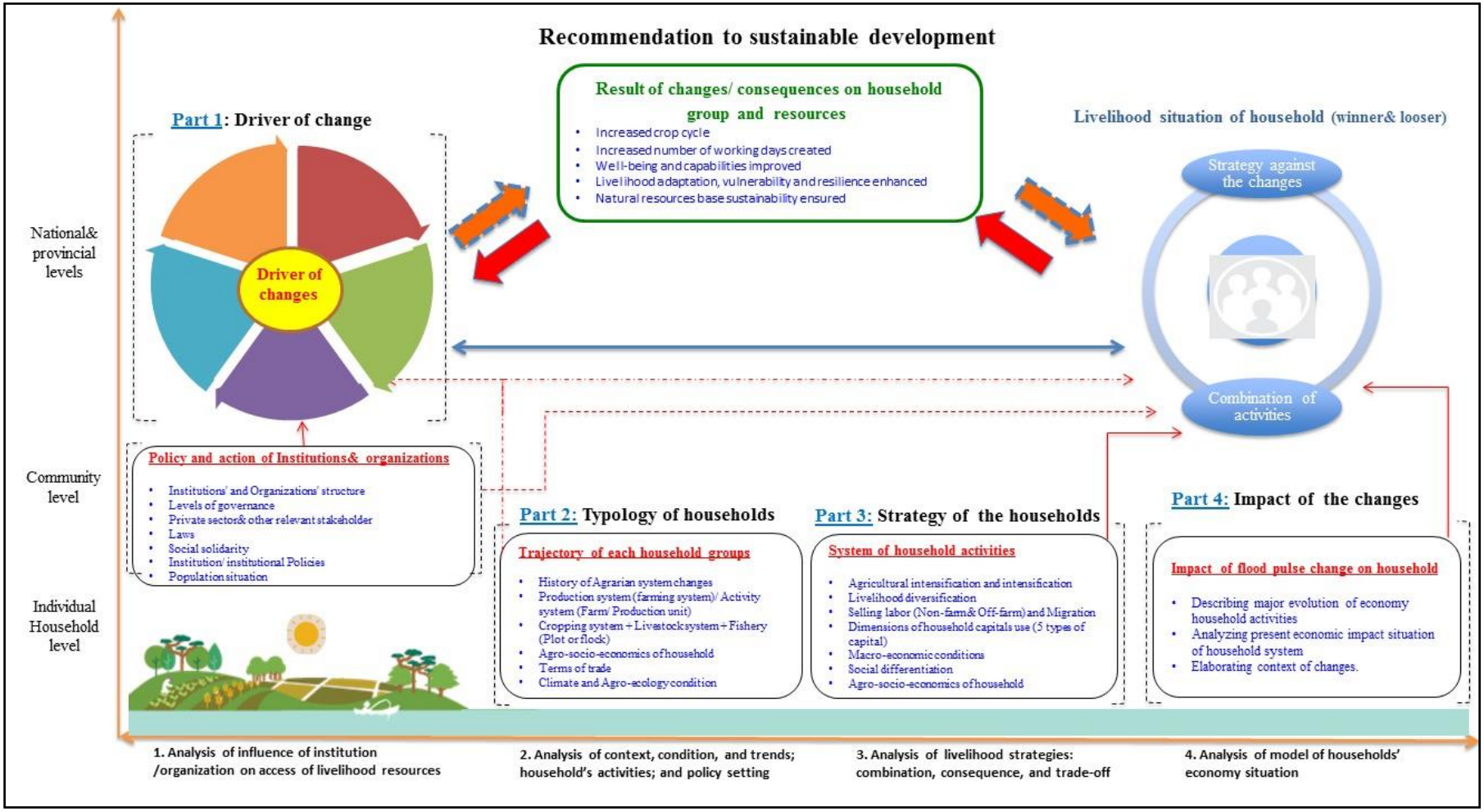


Illustration 3: Global Analytical Framework of the PhD study

Adopted from Agrarian Syste.

2.2. Methodology of Research

2.2.1. Description of Survey design

The research combined direct observations of the stakeholders' practices, like the land use or the resources management, the mapping of the territorial impact of some of them, when it happened to be possible, and the registration of the position and the explanations brought by the stakeholders themselves, through focus group discussions and individual interviews.

The survey was designed to investigate and understand the general situation of farmily farming, including off-farm and non-agricultural activities, to identify different driver(s) of change in the institutional and ecological environment, types of household asset activities, households' strategies to access farm and natural resources, main agro-ecological zones, economic performance of farming systems, migration, key poverty/development related issues at the lowland area of Tonle Sap lake, Battambang province, Cambodia.

2.2.1.1.Site selection

After several visits for feasibility in 2014, before the fieldwork implemention, I decided to target two districts; Aek Phnom and Sangkae in Battambang province as shown in the Illustration 4. Both districts are located in lowland areas, covered by flooded water and flooded forest or zone II of the agroecological zonation mentioned above. Moreover, in the two selected districts, there were similar historical linkages reagarding to the Khmer Rouge rappatriation and intergration in the 90s, settlements, land distribution and land acquisition, migration, political intergration of both rice and fishery policy, and also very similar socio-economic and poverty contexts.

Yet, the two districts offer different forms of agricultural diversification based on the natural resources of/in lowland area; flooded forest, fishery, etc.. The agro-ecogical system of the two districts area mainly similar. They are annually flooded by the annual rise of the mekong level, and partially occupied by crops and flooded forest. In both cases season or floatting rice traditional systems have been diversified to *double rice systems* and *rice and intensified crops systems*. Fishing has also been transformed technicall and from the institutional point of view, with the fishing lotsin both districts. Similarly, people in both districts access to the same infrastructure for irrigation, and to the Sangkae river transportation. Thanks to these, we assume that the farming systems, agro-ecological conditions, and social contexts in the two districts of Aek Phnom and Sangkae, were close enough, while different, to allow relevant and fruitful comparisons for our study.

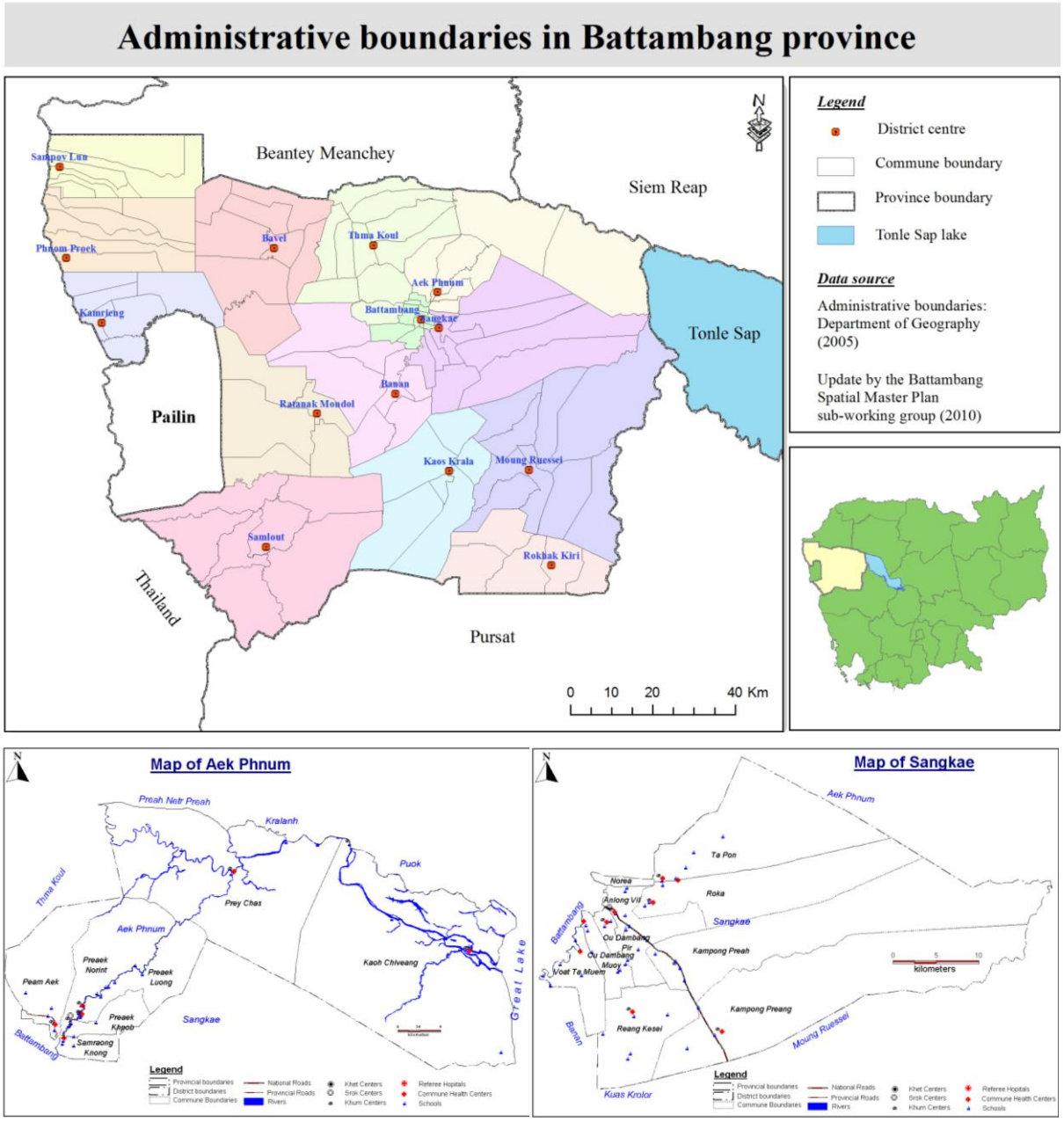


Illustration 4: Administrative Boundary Map of Battambang, and Aek Phnom and Sangkae districts

Source: Battambang Provincial Department of Land Management, Land Administration, and Civil construction in 2016

2.2.1.2. Description of Data collection

The work has been organized in seven following different steps:

1. Landscape reading, land use analysis and fieldield observations: The different natural and social conditions of the area and the way they are used have been described (climate, geology and soils, land cover, animals, topography, and livelihoods' sources). The

analysis of the links between the natural conditions, the human settlement and the use of the lands enabled us to stress out homogenous zones: the *agro-ecological zones* within the territory used by the two villages**.** Field observations and discussion with local farmers (especially with village elders) and the use of maps ended up with a description of the agro-ecological zones in our two targeted districts. This qualitative mapping has been realized from each district to district, commune to communes, and village from our personal observations completed by community mapping in around 7 focus group discussions (FGDs) during the beginning until the end of the fieldwork implementation. *This first step was conducted to contribute to all the three objectives of the study.*

2. Historical Analysis: The objective this secons step was to get precise information about the evolutions and dynamics, which have built up the agrarian area since the beginning of its use. The understanding of these dynamics hopefully enables us to identify the factors which have had an impact on the area, and then, to better understand what could be the future evolutions. This step was conducted through individual historical interviews with key informant like: farmers of different types, government agencies, non-government organization (NGOs), and key informants, and elders from the communities around 20 stakeholders. Discussion with above stakeholders provided legible knowledge and modification to information we collected. This phase contributed to build analytical knowledge for the researcher on the past historical story and cause of the changes in both social and enronmetnal condition, but it also contributed to deeply understand the history of the household from the past to present. It is important to supprt the first and second objective of our study.

3. **Building the sample for the main survey interviews:** The size of the sample of households, built randomly using the position of the residences on the village maps, was calculated by using the simplified formula, Yamane (1967:886).

This formula was used to calculate the sample sizes in table below, using a 95% confidence level and P = 0.5. Interested readers may obtain a more detailed discussion of the purpose of the study and population size in Sampling the Evidence of Extension Program Impact with the formula below:

Formula $n = \frac{N}{1+N(e)^2}$ ➔ $n = \frac{4637}{1+4637(0.05)^2} = between\ \mathbf{340}\ to\ \mathbf{368}\ households$

$n = Number\ of\ sample$ size; $N = Population\ in\ village$; $e = percentage\ of\ error$ ($e = \pm 5\%$)

Finally, the sample gathered was of 346 households. Added to this calculated sample, a number of stakeholders from governmental sectoral ministries and departments in Battambang province, and also from NGOs and communities, were also interviewed;

1. ***10 key informants of government and non-government agencies***, and other private institutions were interviewed individually for qualitative data to deeply investigate the political and institution aspects and sectoral data at national level.
2. ***7 Focus Group Discussions (FGDs)*** of 10 to 15 elder farmers from each village representatives were selected. Our study decided villages to conduct the FGDs based on the zone; for instance,
    - we selected two villages (Prek Norin and Prey Chas villages) at Prek Norin commune in Aek Phnom and two village (Shsory and Roka villages) at Anlong Vil and Roka communes in Sangkae in zone II; and
    - unlikely we aslo selected one village (Prek Toal village) at Koh Chivang commune in Aek Phnom and two villages (Ta Pong and Samdach villages) at Ta Pon commune in Sangkae in zone II and I.
3. ***346 farmers*** were selected for individual questionnaire survey.. We also had some purposive or reasonable sampling literature support like (Denscombe, 2010) suggested that the sample could be ranged from 290 to 350 samples in small-scale survey.

However, as what we mentioned above that the sample selection is the purposive sample choice based on the typology of household to ensure a good representation of the heterogeneity of farmers in the *region* (Barral *et al.*, 2012). ***Therefore, we proposed that the 346 sample selection are based the typology of household from each representative villages and communes of both disctricts in the zone 1 and zone 2 .*** In Table 3 below summarized is the reasonable sample choice based on the typology of households to ensure the heterogeneity of farmers in the region would be ensure confidentially to be done.

Table 3: Summery of Sample Selection for the survey

Study area					N of FGDs
	District	**Zone**	**Commun**	**Sampling of household types and Village**	
Battambang	Aek Phnom	II	Pheam Aek (N = 39)	- Landless people: 4 in Daun Teav; 3 in Korng Thom; 3 in Sour Ey. - Single croppers: 9 in Daun Teav; 5 in Sour Ey. - Diversifiers: 10 in Sour Ey - Large farmers: 5 in Sour Ey	0
		II&I	Prek Norin (N = 76)	- Landless people: 3 in Rohal Soung. - Single croppers: 8 in Prek Torab; 7 in Rohal Soung. - Diversifiers: 23 in Prek Troab; 13 in Rohal Soung; 10 in Tonsong Sork. - Large farmers: 4 in Prek Troab; 8 in Rohal Soung.	1
			Prek Chas (N = 20)	• Small fishermen: 15 in Bak Prea. • Large fishermen: 5 in Bak Prea.	1
		I	Koh Chivang (N = 36)	• Small fishermen: 12 in Anlong Ta Ou; 7 in Prek Toal. • Large fishermen: 8 in Anlong Ta Ou; 9 in Prek Toal.	1
		Sub-total		171	3
	Sangkae	II	Roka (N = 42)	• Landless people: 3 in Roka; • Single croppers: 20 in Roka; • Diversifiers: 10 in Roka; 5 in Oh Mouni Mouy • Large farmers: 4 in Roka.	1
			Anlong Vil (N = 48)	• Landless people: 4 in Khsory • Single croppers: 13 in Khsory; 4 in Samdach. • Diversifiers: 10 in Khsory. • Large farmers: 12 in Khsory. • Small fishermen: 5 in Khsory.	2
		II&I	Ta Pon (N = 85)	• Landless people: 4 in Samdach; 5 in Boeng Teum. • Single croppers: 10 in Ta Pon. • Diversifiers: 18 in Beong Teum; 10 in Samdach. • Large farmers: 9 in Ta Pon; 5 in Samdach; 5 in Svay Sar. • Small fishermen: 16 in Ta Pon. • Large fishermen: 3 in Ta Pon.	1 (Ta Pon)
		Sub-total		175	4
		Total		**346**	**7**

4. Implementation **of individual questionnaire interviews with farmer and fishermen households:**

Following the historical analysis, a large survey of the households of the two villages was prepared. The survey was implemented through interviews with key informants of public and development agencies, and of 346 farmer households in order to:

- to identify types of cropping and farming systems, types of household activities, main changes in cropping and farming systems and agro-ecological conditions,

- economic performance of rice and fish systems, key poverty/ development related issues,
- main ecosystem services (ES) such as quantifying the contribution of ES (provisioning and regulating) to livelihoods in terms of income and capital accumulation,
- collecting detailed characteristics of the target rice and fishery-based systems (Cost and Benefit analysis on rice fishery system-based and crop cultivation),
- measuring different poverty and vulnerability aspects changes over time

In this step, we conducted several fieldworks two to three times in each year from April to August, 2015; the surveys were done by three surveyors (the author and two assistants). Each interview took 2 to 3 hours, which meant that only one to two interviews were possible per day. The surveyors stayed directly at the villagers' residence in the villages during the 4 months. Data cleaning and entry process and the debriefing discussion were done among superiors in each evening.

This step provided an essential contribution to repond to the second objective by investigating the strategy of the households.

5. **Pre-typology: Based on the provisional analysis of the data resulting from the survey, and also from** the qualitative information collected from step 1 to 2, **a** provisional typology was drafted at this point,. This pre-typology was useful to build a second sample of 56 households that were to be interviewed in more depth on the qualitative point of view. The pre-typology was also a key driver for preparing in depth individual questionnaire survey guide that was adapted to each pre-type

   Farmers were therefore selected for a second round of interviews through purposive sampling using the pre-typology. In no way the sample pretended to be representative of any existing diversity of the situations but, on the contrary, it included as completely as possible, all the groups identified, whatever was their representativity.

6. **In-depth interviews with related farmers from the different household types:** The qualitative in-depth interviews were conducted in order to confirm and valid the pre-outcome of typologies/household types. At this stage, there was only the author who lead the interviews, doing only one interview per day from September to mid-December, 2015.

On the other hand, we also collected the GPS data-points of every correspondent during the survey to record their residence location.

7. Second control survey on the large quantitative sample

To complete another stage of the fieldwork, simultaneously from July 2016 to March 2107, we re-conducted interviews with the same 346 households. This responded to five main goals:; (1) comparing the changes of theeconomic situation of the households between the two different years (2) validating and verifying with farmers and stakeholders the results from the first and second phases, (3) producing a GPS village mapping on land use changes, and lastly (4) collecting more data from relevant sectoral ministries and departments about the history of their interventions.

8. Implementation of GPS village mapping on land use changes:

During and after the questionnaire and in-depth interviews, we were able to map the land use changes in two villages. This provided better understanding of the historical land used changes and location of ES, which could literally support to the analysis of historical trajectory. In this stage, the three master students and the author led the GPS data-points collection for developingland use maps. They also mapped the location of the households and their production zones on both agricultural and fishing areas in the two districts. Doing so, initially several discussions among villagers, community members, and authorities, were conducted to build villages and cropping zones limits for each of the different periods of land use in each village. These continually collected the GIS data-point following the results of the discussions with those stakeholders. The study also used Google Earth to delimitate production zones, and this was then aggregated with our GPS data-points and data sources of GIS provided by the Battambang provincial department of land management, land administration, and construction for finally building the final version of the land use maps.

This set of surveys mobilised the author, while some punctal support was brought at specific moments: three master students (one Laotian student at SupAgro and two cambodian students as the Czech University of Life Sciences), were engaged to work on the following topics:

- First master student (Fue YANG), conducted his first-year-master research topic on the "*Identification and Characterization of rice cropping systems in the district*

bordering the Tonle Sap Cambodia, Battambong province". The study aimed at (1) studying the history of agrarian systems in Tonle Sap. (2) identifying the characteristics of farming system in the Tonle Sap. (3) modeling of economic impacts (in the territory) of these transformations. In the work-frame, he also contributed to GPS village mapping on land use changes at Rohal Soung village in Aek Phnom district, where is located in the upstream of the land-water area.

- Another master student (Touch KHIEV) conducted his second-year-research topics on "*The Impact of Microcredit on Rice-based agricultural systems on household livelihood in Battambang province, Cambodia"*. The broad objective of this study is to examine the role of indebt-ness and the the impact of microcredit in north-western Cambodia. The study addresses the following specific objectives: (1) To analyse the situation of debt in the local economics, and the sources of repayment (2) To identify the sources of credit for household famers; (3) To identify the main actors of the management of the credit within the households; (4) To study the impact of microcredit system on the rice based farming system and the local livelihoods;

- And the last student (Raksmey PHOEURK), who was our assistant for doing together the surveys in 2015, had a chance to come back to conduct his own research topics on "*Interactions and Impacts of Ecosystem Services transformation on Local Livelihood - Example of rice-based cropping systems along Tonle Sap lake, northwest of Cambodia: Case study in Sangkae district in Battambang province*". This study aimed at understanding the advantages of rice cropping systems for sustainable intensification and ecosystem services in the study area. To achieve this goal, the study proposed three main specific objectives: (1) Analyze the rice-based cropping systems in the study area; (2) Analyze farmers' experiences and awareness on Ecosystem Services used in rice cropping system, globally and more particularly among female stakeholders; (3) Determined farmers' perception to Ecosystem Services preservation.

2.2.2. Data analysis and Economic calculation

2.2.2.1. Analysis of the data and building the typology

A- Statistical treatment

For the data entry and analysis, we used Microsoft Excel for economic analysis and Statistical Package for Social Sciences (SPSS) for statistical analysis. Both quantitative analysis tools allowed us to confirm the typology of household and the validation of those household types in both qualitative and quantitative treatments. The data receiving from database of the potential cite of stakeholder and collected data of fieldworks was analyzed using both quantitative and qualitative methods. Quantitative analysis in terms of descriptive statistics such as frequency counts, percentages, mean, median, mode, variance, standard deviation, listing, scoring, grouping and inferential statistics such as correlation and regression was used. The SPSS along with Microsoft Excel were used to support the analysis and calculation. The statistical correlation, regression and path analysis depended on the nature of data and hypothesis to be tested. The statistical formulations for livelihood calculation were aggregated in the questionnaire and analysis (See more detail in each following chapters).

B- Method for grouping the households in types

Given the objectives of the typology, which was not to describe the diversity internal to the population, but to group together households that had close *management strategies* to fulfil their livelihood needs and that had similar *decision taking processes* vis-à-vis their livelihood, the traditional multifactorial statitical treatments were not adapted to this ambition. Classifying on *management processes* cannot be limited to grouping individuals by the most powerful combination of structural factors, but to identify qualitatively the most relevant factors shaping the decision taking at the stakeholders level, and applying only then the filtering of the population using these relevant factors. In that case, the statiscical treatment occurs not to make the tyoes, but only *after the types have been done*, to characterise each of them et describe their structure and their outputs. Hence we use **functional typologies approach** to group the households based on variables that describe household dynamics and livelihood strategies (Alvarez *et al.*, 2014). Turning to the independent variables selection for analysing the household strategy, they were listed in the economic calculation and characteristic of farm types

For grouping household in types, the researcher would have to master high knowledge of understanding, gathered from the literature view on the perspectives of dynamics of livelihood and the fields survey analysis (Barral et al., 2012; Cochet, 2012). Various variables of factors are chosen for evaluating the level of social economics and capacity to challenge the issues.

Step 1 - Understanding the context of study area by field observation; this initial step of field observation is the most important to get common clear and well understanding a whole situation of the study area. The first three aspects listed in the methodology in Chapter I including Landscape reading and historical analysis. These provided the researcher to deeply understand the natural conditions of the area and linkages between the agro-ecological zones with the households' settlement and living. Then, it enables researcher to identify the factors, which have had an impact on the area and household as individual and groups (Cochet, Devienne and Dufumier, 2007; Barral *et al.*, 2012; Cochet, 2012b).

Step 2 - Maximizing the quality of data; Staying at the study areas is the important at this stage; the qualified and quantified data were collected carefully and systematically. The researcher could check immediately and easily with correspondences when some mistakes could be found. Meeting with different stakeholders were also conducted for modifying both qualitative and quantitative data, especially the economic calculation of all farming systems, and also the other household activities. For instance, the study conducted several steps of data collection with individual rice farmers and fishermen, and also with the relevant stakeholders to respond to the economic level of productions like number of harvested areas (production area size of rice and crops, vegetables, and fishery), quality of input used in production, market prices of input, family active and required labour force used comparing from plot to regional level, etc.

With this approach the survey questionnaires for in-depth interview of ASAD and household interview have to be well designed for the data collection of from the whole farming system (Alvarez *et al.*, 2014). The variables used have to be well listed in the farm surveys, which could be grouped into specific categories below:

- ***Cropping system category***; cultivation at plot level, fertilizer and chemical inputs, land preparation, weeding, harvest and threshing, transportation, density and fruit quality, Economic resources, nature of farming system etc...,

- ***Household category***; physical context, personal ambition, social, agronomical condition, performance of economic, farm resources availability and management,
- ***Environmental category***; biophysical resources, Socio-economic aspects and equipment, natural condition and resources (Barral *et al.*, 2012; Cochet, 2012a).

Here, in order to ensure a systematic approach, we considered variables related to the main components of the farming system (i.e. household/family, cropping system, livestock system, fishing system, and non-farm and off-farm activities systems) and their interactions with the outside/environment (e.g. environmental context, economic context, socio-cultural context).

In this Table 4, we present an example of a variable set commonly used in the context of aquatic agricultural system farming systems. The key variables for the multivariate analysis were adapted to the purpose of the typology and the study area. Repeatedly, all of these variables are manually calculated to figure out thesir similarity that finally we could identify the six household types (will be presented clearly in next sessions of this Chapter 4).

Table 4: List of variable used for grouping typology of household

Attr	Category	Variable	Unit
R	Household	Family size	Person
R	Household	Family labor used in household activities	Capita or man-day/year [a]
R	Household	Labor hired	Capita or man-day/year
R	Household	Education of household Head	Level
R	Household	Age of household Head	Age
R	Cropping system	Area owned by the household	Ha
R	Cropping system	Area of paddy	Ha
R	Cropping system	Area of double crop and vegetable Chamkar	Ha
R	Livestock system	Total number of livestock (poultry, cattle, buffalo, ..)	Number
R	Fishery system/Natural Resource	Total weigh of fishery catch	Kilogram
R	Household	Total Gross Value Added (GVA) of farming activities	Local currency (Kh Riel or USD)
R	Household	Non-agricultural activities systems	Classes
O	Household	Production objective/strategies (Withstanding exterior constraints)	Classes
R	Household	Total capital/investment of household activities	Local currency (Kh Riel or USD)
R	Household	Total Annual Income	Local currency (Kh Riel or USD)

Attr.: Attribute; O: Orientations; R: Ressources
a: man-day/year could allow to consider different kinds of labor (e.g. full-time person, children, woman)
b: classes to be defined according to the set of the survey results (e.g. Increase/Maintain/Decrease production, Increase/Improve/Diversify/Change production)

Step 3 - ***Classifying and identifying grouping activities***; this step is essential to identify the cropping system, animal production, fishery, and all non-farm and off-farmers exists in the individual household. The pre-typology and agrarian system diagnosis described in the Chapter 2 were taken in account to identify group household activity systems (based on main three elements of mean of farming such as land surface, capital, and labour) of small households associated with other various households' income activities like: selling labour in off-farm and non-farm including migration. From the in-depth household interviews, the researchers could identify the typologies of activity systems by putting the similar activities to order; the main activity which has high source of income and sufficient in food production being considered as leading activity, the lower was ranked as second until the lowest as last. At this stage, many typologies of activities could be identified. Additionally, the qualitative had also explained about the flow of households' systems of activity from past to present. Obviously, we could narrow down the typologies of activities; by the grouping the main categories are not implicated in order to avoid too many systems of activities.

Step 4 - ***Finding logic and interaction of activity systems***; This step is to find the logic and how the activity systems are interacted with each other; for example, the production shares the plot area and mean of productions. The researchers should identify the specific monoculture cropping and mixing multiple cropping systems, and the same to fishing and non-farm and off-farm activities. This would give an understanding about how the activities could be done by the farmers/households. For example;

- For monoculture such as *floating rice*, or *long-term rice*, or *another crop*, which can be cultivated only one single plot per year, thus the crop could be defined as **one cropping activity**.

- For double or multiple cropping such as *Early season rice and Receding Rice*, or *Early Season Rice and Dry Season Rice*, or *Early Season Rice and Intensified Chamkar crops, mixed crops and vegetables Chamkar crop* or *Double crops and vegetables Chamkar*, which can be cultivated one first cycle crop in wet season and another second cycle crop in dry season, thus the double multiple mixing crops could be also defined as **one cropping activity**.

- For animal, we decided to merge all livestock and cattle raising into one production called animal raising/production since they are all small raising just for additional income, this can be defined as **one animal activity**.

- For fishing, since it is different from cropping system, which is a very complex system; it can be defined based on the fishery species that farmer and fisherman have capacity to catch per one-year season. For instance, for the farmer may be able to catch fishery during their fallow from rice production and so on, so in this case the fishing can be defined as a **Non-specified fishing activity.** Unlike, the fisherman may occupy with only in the fishing for a whole year long, so it can be defined as a **Fishing activity**.

- For non-farm and off-farm, the two systems are also very complex/are also the very complex ones. This study assumes they are additional sources of income for household, we classified them into three main groups of non-farm and off-farm such as; **low, medium, and high non-farm and off-farm activity** based on the different levels of income from each activity.

Step 5 – ***<u>Scoring and ranking activity</u>***; moving to this step, we can start to rank the score for important economic result of the economic efficiencies of each activity such as: Gross Value Added (GVA) per labour; Maximum of working capital/investment (Intermediate Input – II); and GVA per land unit (hectare); and GVA per household. The score can be ranked from less to great and classify as number of star for each ranking according to the different level of reality of the economic result (see Appendix 2: Scoring the economic performance of the activities. Finally, from to total sum of scores gathering from each the economic efficiencies of each system of activity surely explain us which system of activities that can be important and necessary for each typology of household.

After that, we should begin to arrange the important system of activity in order from most to less complied with the abbreviation for each system, for example;

- Monoculture: Floating Rice = FR; Long-term rice = LTR; Early Season Rice = ESR; Water Receding Rice = RR; Dry Season Rice = DSR; Mixed Crops and Vegetable Chamkar or Double crops and vegetables Chamkar = DC; and so on.

- Multiculture: Early Season Rice and Long-term Rice = ESR&LTR; Early Season Rice and Receding Rice = ESR&RR; Early Season Rice and Intensified Chamkar crops = ESR&Inten-Crops; Early Season Rice and Dry Season Rice = ESR&DSR;
- As mentioned previous ordering step, this production can be called Animal production = Ani-Pro, and Aquaculture rearing = Aqua-Rearing.
- Fishing activities can be called to three main categories; Non-Sepcified Fishing = NSF; Small-Scale Fishing = SSF; and Large-Scale Fishing = LSF.
- As already mentioned in previous ordering step; for the non-farm and off-farm are systematically combined to one system of activities = Non&Off-farms.

Using the abbreviation represents the name of system of activity can make us easily recognize the individual and a combination of system of activity. Then, we run to group all activities to a household combination of system of activity. We recommend using the Microsoft Excel for completing this task by using a formula called:

"=CONCATENATE(text1,text2,text3,……,textN)"

Example; = CONCATENATE(FR,LTR,ESR,ESR&RR,Ani-Pro,……, Non&Off-farms)

Then the result of the combination system of activity of a household would be:

"**FR+LTR+ESR+ESR&RR+Ani-Pro+…… +Non&Off-farms**" [4]

We use the auto-short (A to Z) filter in the Mrs. Excel function to arrange the combination of system of activities in the following; this helps us to recognize the similarity of them.

Step 6 - <u>Running regression analysis by crossing the Total Income per household per year (TI/HH/Y) on the Total Income per household member per year (TI/HH member/Y)</u>; At this final stage, we run the statistical regression analysis with objectives to get the confirmation of significant correlated by crossing the annual total income per household and annual total income per family/capita. Finally, we could identify appropriated name given to the groups of household or household types that will be detailed in the result.

[4] (Plus mark [+] can be done with manually added)

2.2.2.2. Economic calculation of outputs

In this study, we quantified the wealth created by on-farm by assessing the Value addred and and the Gross Remuneration of the family labour inorder to perform the economic calculations in the agrarian system analysis. Hence, we also calculate the annual monetary value of the gross output from all total of quantity of sale to markets, household consumption, inkind wage paid, and other gifts for relatives, ct..).

The study assumed that the main reasons behind the farmers's practices would be stand among their economic performance and other social assets. A production function based valuation approach was used to specifiy the feasible outputs such as labour, marchinary, fishing equipement, natural resources, and other economic activities. In the report of Tallis and Polasky (2009) precides that the Production function based valuation approache are based on the contribution of a given system services to the production of commidity that can be traded from farm to existing market.

However, Ferraton and Touzard (2009) argues that the econnomic performance of the croppin system is measured by the land productivity, generally definde as Gross Value Address (GVA) produced per unit of land, or/and labour productivity, definded as GVA produced per unit of labour. This is the application at the plot level/scale.

But at the farm level/scale, Ferraton and Cochet (2002) and Barral *et al.* (2012) states that the output of farming systems can be also assessed by the labour productivity meaning to consider all the GVA from agricultual acvitivities produced at a hosehold level and the farm income or the land productivity at the level of the whole practiced area.

In summary, the study decided to additonally charaterize the Total Annual Income (TI) as the fnal household economic performance as it is important the state the toal household income and it can be indicator to messue the comparision with other differentiation analysis. Therfore, a faomulation for calculaton the combination of farming systems were summaried in the Table 5 provided all economic formulars used in this study from the plot to country's economic level

Table 5: Summary of the economic indicators used for the economic performance of systems of activity analysis

Gross Output (GO_i/ha)

$GO_i/ha = Q_i /ha \times P_i$

Q_i: production (auto consumption + sold production); P_i: average selling price on the local market

Intermediate Cost (IC_i/ha) or Intermediate Inputs (II_i/ha)

IC: monetary value inputs such as seeds, chemical inputs and services used (ploughing, transplanting, weeding, harvest, transport) during one year of production for each activity systems (cropping, Animal husbandry, fishing, and non-farm and off-farm activities) (i) **in one unit of land (ha). Notice: family and labour hire are excluded.**

IC_i /ha= Σ (quantity of inputs used/ha x price) + Σ (services used /ha x price)

Gross Value-Added (GVA_i/ha): It measures the additional wealth created in one year by each cropping system (i) in one unit of land (ha). That can explain the economics reason of its adoption.

GVA_i/ha = GO_i/ha – IC_i/ha

GVA_i/ha allows comparisons wealth created from different cropping system (i=1…9) in one unit of land (ha), which gives economic-technical reason of adoption each cropping system (i).

Total Income = GVA – Labour hire – land rent

2.2.2.3. Minimum Poverty Threshold calculation

The study also compared the total annual income coming from the all household's livelihood activity (including non-farm and off-farms incomes) with a theoretical overall *Minimum Poverty Threshold* (MPT) (Gibson, Fedorenko and Rohde, 2006; Kimsun, Tong, 2011; MOP, 2013, 2014). The MPT correspond to the threshould of income below which the stakeholders would decapitalise if they would maintain the level of livelihood standard. When the families are getting an income, which is below this MPT, they are supposed not to cover their basic needs, unless they recapitalized their assets by selling the land and wealthy assets or increasing the cultivation cycle, hence not reproducing fertility. In contrast, when they get an income higher than the poverty threshold, they have a surplus for possible capitalization.

The minimum poverty threshold was calculated from a minimum consumption threshold of 311.85 USD /person/year[5] at from 1,559 USD to 1,871 USD/household/year depending the size of the family.(generally from 5 to 6 as amean value). Additionally, the sub-group of each household types is examined based on both qualitative and quantitative data for determine the sub-level of living standard within the group. A fomular of Minimum Poverty Threshhold as below:

Cambodian Poverty Line in Rural Area (0.85$ per Capita) x ***One Year*** (365days) x ***Number of Residents in the family***

Chapter III: Identification the drivers of change and impact of the related changes on household activities and on the management of natural resources

3.1. The conditions in the study area: the Tonle Sap in Cambodia

3.1.1 Agro-geographical characteristics of the Tonle Sap Lake (TSL)

Cambodia is a South-East Asian spot of 450 km from North to South, and 550 km from West to East, which covers a total surface of 181,035 km^2. The country neighbors with Thailand at its North-West border, with Laos at the North-East, with Vietnam at the East and South-East and, lastly, with the Gulf of Thailand in the South [6] (Additional description in Chapter I). The topography is such that the country looks like a bowl: the Mekong valley, the Tonle Sap Lake (TSL) and the alluvial terrasses on their sides form the middle of the bowl, surrounded by plateaus and mountains on its borders West, North and East. In the central plain, the bottom of the bowl, the Mekong river is connected with the Tonle Sap lake, which itself collects the rivers from the North West, before releasing this water to the Mekong river during the period the water level is low. At the moment of the melting of the snow during the Himalayan summer, from June to October, the water level increases rapidly in the stream. The sense of the flow of water reverses back from the Mekong to the Tonle Sap Lake, making this latter as an expansion bowl for the flood of the stream. While the Tonle Sap Lake covers only 2,700 km^2 during the dry season, it reaches over 12,000 km^2 in the flood period (as our description in Chapter 1). This mechanism of the annual flood not only brings the water and the fish resources to the local population, but it deeply fertilises the land by the deposit of alluvions, offering to the area a high potential for rice cultivation.

Indeed this potential has been valorised for centuries by rice cultivation. Numerous bas reliefs in temples dated from the 10th century, confirmed by testimonies from Chinese visitors to the Angkor empire 200 years later, show that the area was already highly exploited, with already all the techniques (plough, animal draught power, irrigation techniques, transplanting…) that were still in place 50 years ago on most of the territory.

However, in the recent half century, this country has faced the depression and sadness of civil wars that have slowed down the progress in the development of its economy and the reduction of poverty. The return to peace after 1990 has opened the way to another kind of threat: the rapid forest and natural resources (mainly mine and fishery production) degradation and depletion under the pressure of population, poverty, and migrations (UNDP, 2008; Sothorn *et al.*, 2011; Tong and

[6] Cambodian Country Profile : http://www.cambodia.org/facts/

Sry, 2011; MOP, 2012; J. Diepart, 2015b; Jiao, Smith-Hall and Theilade, 2015; Global Nature Found and Fisheries Action Coalition Team, 2016; Lynch *et al.*, 2016). The same scholars note that in spite of the natural conditions so favourable to the rice production, high rates of poverty persist in the rural areas around the Tonle Sap Lake.

3.1.1.1 Water Sources in Battambang and study area

Based on the Battambang Provincial Department of Land Management, Land Administrationand Construction, Tonle Sap floodplain can be divided into five zones that are subject to strongly different environmental conditions;

(I) Permanently Flooded zone.

(II) Agricultural Land-and-Water zone (low potential),

(III) Agricultural Land zone (high potential),

(IV) Agro-industry and forestry,

(V) Mosaic Agro-industries.

The Sangkae River is one of the key sources of water for the foundation of city development in Battambang. The river originates from the range of the Elephant and Cardamom mountains at an elevation of between 4 to 13 meters, flows from the southwest to north across the Battambang Town and joins the Stung Mongkol Borey River at the Bak Prea and Prek Toal villages about 40 km downstream from Battambang town. The Sangkae River is the combination of two rivers, and it flows through 27 communes of 6 districts in Battambang before draining into the TSL.

Sangkae River is considered as a main water channel connecting water flow from/to Tonle Sap basin and upland of this province. People in Sangkae and Aek Phnom depend on various types of services of this river for this social, cultural, and economic activities (Battambang Department of Water Resources and Monteorology, 2015).

3.1.1.2 Soils characteristic in Battambang

The process of sedimentation in the plain of Battambang has led to two kinds of soil in the province: one on the small hills and upland areas; and the second in the floodplain downstream area.

- The **black soils** (*dey khmao*): There are two kinds of black soils according to the localization.

  One is **black soil "high"** which are positioned outside the depressions and not in hydromorphic conditions. These soils are considered to be the most fertile probably because of their water retention combined with still good drainage capacities.
  The second is the **Black soil "low"** localized in depression and receiving stream and run-off water. The high quantity of clays makes it partially hydromorphic and it can also be reached by the ground water during the second cycle crop: in that later case, only rice is cultivated during the second cycle crop. Moreover, ploughing is difficult and cannot be done by any other animals rather than buffaloes.

- The **brown soils**: much rarer than the black soils, the brown soils are on the high parts of the slopes of the hills and seem to have less clay than the black ones. Even if the drainage is better on these soils, farmers prefer the black ones, probably because they are less drought-sensitive (more clay).

On these lower parts of the area, we can still find black soils without rock, **Sandy-Silt soils** (*dey robay ksach*) and **Sandy soils** (*dey ksach*). Sandy soils seem to be on higher zones than sandy-silt soils: this is why the drainage is better and affords another crop than rice during the first cycle (White *et al.*, 2000; Pillot, 2007; Battambang Department of Water Resources and Monteorology, 2015).

3.1.2 General poverty conditions in Cambodia, Tonle Sap, and in Battambang Province

Poverty issue is a key challenge for the growth of the Cambodian economy. The first credible estimations after the Kmer Rouge period indicate that about 39% of the Cambodians lived under the poverty line before 1993, with an income less than US$ 0.5/day/person. In spite of 10 years of 5 to 8% growth per year, the poverty rate was still of 27% in 2004. Since then, the Cambodian Socio-Economic Survey (CSES) showed that poverty dropped under 23% in 2009, but continued to around 16% until the recent years.

Yet, the poverty incidence is surprisingly high in the provinces which are known to be in fast economic growth, such as Pursat and Kompong Chhnang (neighboring the south west of the Tonle sap), which have respectively 51.8% to 52.4% of the provincial population living below the poverty line, ranking 2nd and 3rd among the Cambodian provinces in this regard.

This national survey also confirmed that the highest rates of poverty were around TSL and central plain areas, accounting for 80% of total poverty of the country. The provinces around the lake, such as Battambang, Kompong Thom and Siem Reap, although they are benefiting from good land, present poverty results hardy higher than the national average (Engvall *et al.*, 2008; MoP, 2015; Network, 2015). The poverty rate occurred in different areas and years are shown in Table 6 below.

Table 6: Poverty rate in Cambodia from 1993 to 2017

Area	**1993-1994 (%)**	**2004-2005 (%)**	**2009-2010 (%)**	**2012-2013 (%)**	**2016-2017 (%)**
Phnom Penh	11.4	4.6	12.8	16.9	14.9
Other Urban	36.6	20.5	19.3	14.4	12.3
Rural area	43.1	33.7	24.6	20	10.5
Cambodia	39.0	27.8	22.89	18.9	16

Source: Cambodian Socio-Economic Survey (CSES) from 1993 to 2017

The Cambodian Socio-Economic Survey also notes that the poverty data are characterised as below:

- Poverty rates are highest in the rural areas and amongst people living in households headed by farmers aged between 30 to 50 years old;
- The size of the households below the poverty line is generally larger, these families having younger and more children, whereas they are likely to be headed by a male or have incomes brought only by males;
- High illiteracy and limited schooling of their family members is another characteristic of these families.

Other conditions of the rural poor, especially in TSL, is indicated as having limited capacities in terms of land and assets, public support, family workers, and dependence mainly on common property resources (Bell *et al.*, 1997; Bonheur et al, 2002; Conway and Chor-ching, 2006). Another study of Keskinen (2003) shows that the poor people living closer to the TSL depended generally on fishing and gathering activities, as well as on the flooded forests and, compared to those living further away, poorer housing conditions, debt, and lack of creditworthiness.

Studies by Keskinen, 2003; Rigg, 2006; CDRI, 2007; Nuorteva, Keskinen and Varis, 2010; MOP, 2014; Network, 2015; Salmivaara *et al.*, 2016; Keskinen *et al.*, 2011; Mak, 2016 characterised the livelihood of the groups of poor households. They argued that fishing was the

main activity for the poor households in the flooded forests and floating villages, but also of some households on the land areas. The main problem of the poor seems to be lack of access to services, poor infrastructure, lack of income opportunities that do not depend on fishing and forestry. The poor reported to be aware of over-exploitation of common resources and indicate a 30% decline in fish catch annually (Hecht *et al.*, 2019).

United Nations (2013) reports that the educational levels and literacy rates are one of the most powerful determinants of poverty and unequal access to education seems to be strongly correlated with the households' income inequality in Cambodia. A number of recent studies Keskinen, 2003; CDRI, 2007; Nuorteva, Keskinen and Varis, 2010; Network, 2015; Salmivaara *et al.*, 2016; Keskinen *et al.*, 2011; Mak, 2016, however, reveal that the current status of education has been poor with very low public investment in education in the rural and urban areas. Keskinen (2003, 2006, 2011) also addresses the issue of poor educational infrastructure, particularly on the areas around the TSL as a priority. In addition, the survey indicates that the literacy rates and levels of education are lowest in the zones closest to the lake and increases remarkably when approaching the national roads and provincial capitals.

The health risk is also one of the biggest concerns to general Cambodians, especially for the poor (MOE et UNDP, 2011). The peoples' expenditure for health care is seen as very high for the poorer households compared to their income. There are many kinds of diseases, that healthcare is difficult for the poor to afford. Several studies (Keskinen *et al.*, 2013; United Nations, 2013; Mak, 2015) show that people are lacking access to clean and drinkable water that occur to suffer from the illnesses and diseases, namely diarrhoea, dysentery, and typhoid fever. Under such circumstances, the poors have faced the healthcare risk, and they just lose their savings and they consequently might incur in unpayable debts, which finally force them to sell their assets, small land, just for the health treatment. Badly, the survey found that those small households like landless and small fishermen fall into serious debtness year after year.

Lack of non-farm and off-farm employment opportunities could also affect negatively the poor. (Keskinen, 2003; Keskinen *et al.*, 2013; FAO, 2014) underline that the impact of increasing population, added to the privatization of common property resources, puts more and more pressure on employment in rural areas and especially in/around Tonle Sap lake. The studies have also highlighted the same situation about land ownership, leading to serious disputes and conflicts.

Lack of infrastructures including irrigation systems in rural areas might reduce access to

social services, and farm, non-farm, off-farm income opportunities (Mondiale, 2006; Briones and Felipe, 2013; Salmivaara *et al.*, 2016)

3.1.3 Agro-ecological zonation of the Tonle Sap lands in Battambang province

Keskinen (2003) classifies the Tonle Sap floodplain into five different zones based on the water level or elevation ***meter above sea level (m.a.s.l.)*** .

- Zone I is ranged from 0 to 6 ***metres a.s.l.***,
- Zone II ranges from 6 to 8 m.a.s.l.,
- Zone III ranges from 8 to 10 m.a.s.l.,
- Zone IV ranges from 10 meters up to national roads 5 and 6,
- and Zone V which covers all urban areas.

These zones are also roughly grouped into rural (Zones I to IV) and urban areas (Zone V) (Keskinen *et al.*, 2003).

Varis et al. (2006) notes that villages in Zones II to IV are engaged in agriculture, particularly rice cultivation, and that this forms the main occupation of these people there. In Zone V meanwhile, the occupation of the residents is more diversified, since many are engaged in market activities and less in agriculture and fishing. Details of the zone classification in the Keskinen's study is shown in Table 7 below with short descriptions and the charaterisation of each zone as it was described in Chapter I.

Table 7: Characteristics of villages in the Tonle Sap zones

Zone	**Definition (Metres above sea level = *m.a.s.l.*)**	**Basic environmantal and socio-economic characteristics**
Zone I	0 to 6 Metres above sea level	***Permanent water (TSL in the dry season).*** Mostly floating villages. Main occupation is fishing with some involvement in agriculture and trade. Lowest livelihood levels and highest incidence of ethnic minorities, and more Vietnamese.
Zone II	6 to 8 Metres above sea level	***Flood expansion zone, deep flood.*** Main area is for lowland rice cultivation, particularly floating and water receding rice. The livelihood significatnly involvement in rice and small crops production, partly involvement in fishing.
Zone III	8 to 10 Metres above sea level	***Flood expansion zone, irregular flood.*** Main area is for rice cultivation, particularly deep water rice and receding rice. Part-time involvement in fishing is significant.

Zone IV	10 m.a.s.l. Metres above sea levels	***Out of the reach of the flood***. Main area is rice cultivation, plus a growing importance of other industries like commerce and manufacturing. Better access to markets and higher livelihood levels than in lower rural zones.
Zone V	- Occupation more diverse in rice, crops, and fruit plantation - Highest livelihood and educational levels - Most developed infrastructure	

Source: Keskinen *et al.*, 2003 *and the PhD survey 2015-2016*

3.1.4 Ecosystem Services of the Tonle Sap Lake (TSL)

TSL covers some areas of the approximately 250,000 ha with 4,500 millions m^3 of water volume in the dry season and around 1.6 million ha with 82,100 millions m^3 in the wet season (Keskinen *et al.*, 2011; Puy, 2012). According to the RGC's Degree August 2011, the flooded forest (inundated at each annual flood) covers 647,407 km^2 and hosts 151 species of trees under protection; it constitutes home to 107 species of freshwater fishes, including 17 endangered species, 225 species of water birds, 42 species of reptiles, and 46 species of mammals (Puy, 2012). The lake provides other valuable ecosystem services to the 4.3 million of Cambodians living on and around the lake. Households' livelihood activities depend significantly on those natural resources, therefore, there is a very strong relationship between livelihood of the Cambodian people and the ecosystem services provided by the lake (Keskinen, 2003; MOE, 2012).

Table 8 indicates the size of TSL in two different seasons of dry season and wet season and water level. This explains that the size of the TSL is in expanded from 2,300 km^2 dry season to 13,000 km^2 in rainy season with the water level from 1 to 9 meter depth in the lake budy.

Table 8: Size of the Tonle Sap lake in the Rainy and Dry seasons

Season	Lake area (km^2)	Water level (m)
Dry season	2,500-3,000	1.2
Wet season	10,000-16,000	8-11

Sources: Kumma et al. 2008, Nikula 2004, ADB 2005

3.1.4.1 Ecosystem of Tonle Sap for aquatic and fishery systems

Water flow connections from the Mekong river allow fish and other aquatic resources to migrate from one to another place in the lake and in the river but also to the land area for around six months. This contributes to their reproduction (Baran, Starr and Kura, 2007). The water raising

urge fishes to travel to the floodplain and land areas to find feeds (Varis and Keskinen, 2006; Paula, Marko and Olli, 2010).

When the water recedes back by the end of October, fish migrate back to the Mekong River for the same purpose of reproduction and feeding in the low water conditions; they wait there for raising water again at the next flood season (Varis and Keskinen, 2006; Baran, Starr and Kura, 2007). Therefore, the water flows in and out from TSL to the Mekong river are very imporant for the composition of the vegetation and for the fish traffic between the lake and the river (Poulsen et al, 2002; Campbell *et al.*, 2006).

3.1.4.2 Ecosystem of Tonle Sap for wetland and agricultural production

Lamberts (2001) reports that the ecosystem of the Tonle Sap naturally produces alluvial fertilisation for the plantations. He also highlights that floating aquatic plants that are formed on the lake have thick and dense amounts of vegetation. The depth of water level from 1 to over 6 m in the zone I allows the decomposition of this vegetation into alluvial mud, which in turns favours the rice and crop cultivation. That is a reason to explain why receding rice and some rainy season rice cultivated on the flooded area can still give relatively good yields without being fertilised by the alluvial mud from the lake.

The rising and receding water of the lake contributes to characterise different terrestrial ecological zones. According to Keskinen, 2003; O. Varis *et al.*, 2006, most of the lands in the zone I to III are reached by the lake's flood, and thus beneficiate from the alluvial deposits. There are cultivated areas along with mainly receding rice, mung beans, water melons and a wide range of other vegetables that are planted when the floodwater recedes. These systems account to around 23% of the total flooded land area around the lake (ADB, 2006; MAFF, 2006).

According to Javier (1997) and Pillot (2007), before 1990 the main floating rice production area was found around the Tonle Sap Lake. Farmers classify their rice cropping systems based on the rice varieties that are adapted to these water conditions. In the six provinces around Tonle Sap, farmers cultivated the floating rice between 6 and 8 m.a.s.l (zone II), long-term varieties were cultivated between 8 and 10 m.a.s.l, while water receding rice was grown whatever is the depth of the water during the flood, since it is planted when the water recedes back to the lake.

These authors conclude that farmers could actually choose their systems within a wide range of options, using different genetic materials and different lengths of cycle and adaptations to

the depth of the water. However, all these systems resulted in one crop per year in the rainy season, so that an early harvesting could be done after the water recedes by the end of rainy season or the early dry season (Javier, 1996; Keskinen, 2003; Pillot, 2007; Johnstone, 2013). In the PhD study, we could confirm the same situation, the local farmers in the Sangkae and Aek Phnom cultivated their local varieties of floating rice and long-term rice according to the position of each plot in the topographic profile, We shall see later that this situation , common to all the areas around the lake, has now much changed in the recent twenty years.

3.2. Identification of the drivers of change over time in agriculture and fisheries around the Tonle Sap lake

3.2.1. Agriculture and land use the historical background of the institutions and policies

3.2.1.1. From the Angkor era to the Khmer Rouge agrarian revolution: the pre-modern basis of the current agriculture

The present is just the output of the past. There is no understanding of the current situation without looking –and understanding also- why and how the use of natural resources by humans has led to environmental changes and then how these environmental changes have impacted the organisation of agricultural systems. In this regard, to be able to understand the actual situation of natural resources, we highlight the history of the transformations of Cambodian agriculture and fisheries, with a specific concern for the the local circumstances or modalities of transformation in the North –West of the Tole Sap Lake.

- **<u>The Angkorian-Khmer Empire (9th to 15th century)</u>**

Angkorean Empire was known as the Khmer kingdom that culminated in the 12th century, often called Angkor Thom as its capital city, located at the North of the . Emergence of the Empire was certainly due to an active agricultural economic basis. The TSL area provided a central location for an extensive but very productive agriculture, especially rice, fishery, and cattle that supplied the surrounding area for centuries. The combination, at the level of the families, of the three cropping systems based on annual rice (season rice, floatting rice and receding rice), all cultivated at different levels of the topographic profile of the TSL, allowed to generate important agricultural surplus (Pillot, 2007).

When mobilised by an efficient ideological captation system, this surplus could generate

the capacity of building impressive temples and cities, and to support an army capable to run short wars from the current Vietnam on the East to the current Thailand on the West. The collection of prisonners and slaves who could then be installed around the TSL increased in turn the capacity of generating surplus, and hence again the military and architectural power of the empire. On the top of this agricultural basis of this power, strongly rooted in the TSL, commercial and industrial productions, and foreign trade were handled by Khmer minority groups and Chinese people using the Mekong river and Tonle Sap route to facilitate the exchange of commodities between India and China.

Only when the Kingdom fell in instability of civil wars by the early 15th century (Chandler, 1992), this system collapsed.

- **<u>The French Colonial Period (1863/1883-1953)</u>**

At the arrival of the French colonials in 1863, the country was exhausted due to a succession of Siamese wars. Even if Cambodia did not benefit from the same colonization attention as the one for Vietnam, its presence brought peace and stability that the country had never known since the Angkor empire period (Delvert, 1983; Ponchaud, 2007).

The contemporary history of Cambodia's economy hence begins with the colonization in 1863, yet little happened for quite sometimes because France's development focus was on Southern Vietnam, where most tax revenues from Cambodia were sent (Country Profile, 1993). According to Alain Forest's doctoral dissertation "Le Cambodge et la colonisation Française" (1980), Cambodia had begun efforts to modernize and develop under the French guidance (Forest, 1980). Investments in rubber plantations were done on the plateaus in the East, but this did not really impact the local conditions of agriculture around the TSL. He also cited that there were evolutions of property rights and the taxation of rice paddies, tobacco, Jute, cotton, sesame, sugar cane, indigo, and other foodstuffs from the Cambodian farmers at that time.

- **The Sihanouk Period (1953-1970)**

In the post-second world war years, Cambodia's economy remained strictly non-industrial: fishing, agriculture, spices cultivation, and (rubber) plantations (Delvert, 1983). One should however note the extension, around the Tonle Sap Lake, of large farms dedicated to commercial floatting rice cultivation (that is, as we shall see in chapter 4, the most estensive, but the most labour productive form of rice production around the Lake) economy continued to export rice and rubber to France, while the latter sent high value-added goods (i.e., luxury imports) to the upper echelons of Cambodian society (Khieu, 1979).

In 1953 Cambodia was granted independence peacefully. In the following years, the new king Sihanouk made a number of critical choices, which would become the backbone of the economic development for Cambodia during the 1950s and 1960s. The first two-year plan, promulgated in 1956 and renewed in 1958, emphasized the development of infrastructure and agricultural development, especially irrigation for rice production. Locally, the production of floatting rice by commercial farms all around the Tonle Sap continued to expand. In Battambang province, it covered almost the totality of the flood area (the current zone II) at the end of the 1960. According to statistics available on rice exports, Cambodia became self-sufficient in rice from 1956 to 1966 (Dauphin-Meunier, 1961).

- **The Khmer Republic (1970-1974)**

On March 18, 1970, a day that lives in infamy for Norodom Sihanouk, the chief of the army and prime-minister, Marshall Lon Nol, performed a coup d'état. A new constitution abolishing the monarchy was passed and Cambodia became a Republic. The fall of the kingship certainly encouraged the Khmer rouge rebellion, that existed for years as a secondary outcome of the Vietnam conflict that was active at the same moment on the East. One by one, the provinces fell under the control of the Khmer Rouge, including the one of Battambang, which led to the disorganisation of the rice value chains, the fertilisers and the machinery (tractors) arriving no longer in the rural areas.

- **Democratic Kampuchea: Khmer Rouge (KR) genocide (1975-1979)**

Nonetheless, the Lon Nol regime fell five years later, letting the Khmer Rouge regime to experiment radical options of agrarian revolution, from April 1975 until 1979 (Chandler, 1992).

The Khmer Rouge regime imposed a radical agrarian civilization to a whole country. The land ownership was eradicated. All citizens were removed to rural and forest areas to re-launch agricultural production with forced labour and by a collective forced organisation. Rainy season paddy was the high political priority. Considerable human investments were engaged by the Khmer rouge for controlling the water by dikes and dams, and for developping capacities of irrigation. This resulted rather in a massive disorganisation of the local agricultures, and it ended in a dramatic fall of the production, then of the food security of the whole society. Scholars (Chandler, 1992, 2008; Clayton, 1998) report an estimation of around 3 million civil citizen (a quarter of the population at that time) died by food shortage, over work-force and malnutrition at that moment.

In the study area, the villages' elders and many correspondents reported that there were not many population movements to the flooded part of TSL in Battambang. Most of the central plain and upland areas were grown with cash crops such as maize, bean, cotton, jute, etc.

This traumatic experience ended in 1979 after a military intervention by Vietnam which forced the Khmer rouge army and regime to flee to Thailand. The "re-construction" period started then, leading to the current situation.

3.2.1.2. The recovery and the modern transformations of agriculture and fisheries in the area

- **Political,institutional and economic factors**

As shown in Illustration 5 below, the Khmer Rouge era collapsed in 1979, and Vietnamese armies took the control of most of Cambodia.. However, thousands of surviving Khmer Ruge soldiers were forced to live in areas close to the Thai border, notably around the strategic precious stones mines of the Pailin province, between Battambang (both lowland and upland areas of this province) and the Thai border: the zone of the PhD study is within this area.

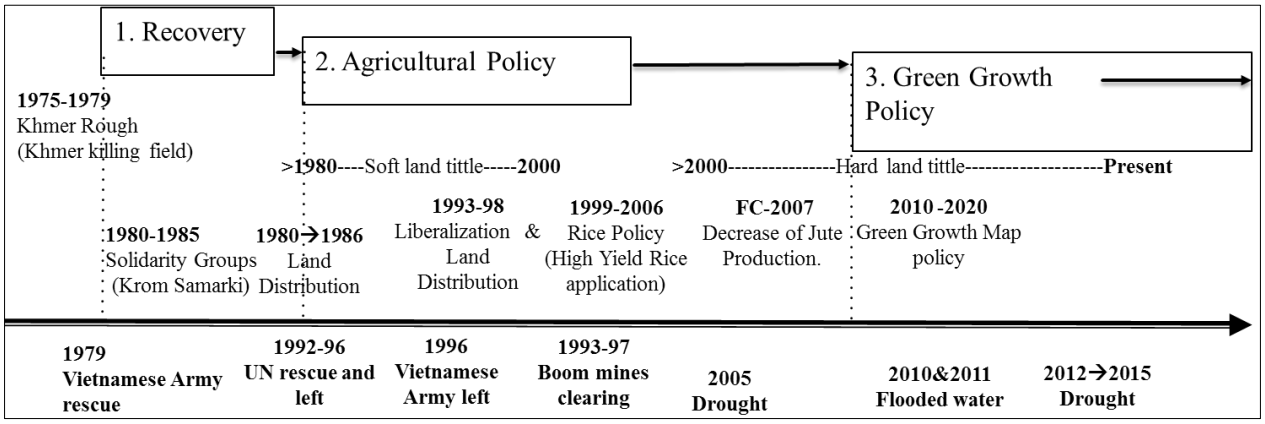


Illustration 5: Period of change in around 40 years (only from Khmer Rouge until present)

After the collapse of Khmer Rouge era in 1979, the remaining Khmer Rouge army continued to fight against the government until the surrender of the last groups in 1998. To finance the war, the Khmer Rouge tried to maintain control over controlled the areas where there were valuable timbers and mines (mostly diamond and gold) that could be exploited and traded lucratively, especially with Thai companies.

Also, due to the lack of labour and insecurity, many farmers tended to leave their large paddy areas to join in crowded village places, where they could find higher security. This reduced the rice production. Fishing in ponds and in natural rivers was also important for the people at that time. There was very small scale of business and trade between neighbouring countries like Vietnam and Thailand.

To reorganise the production in the –relatively- safe areas, from 1980 to 1986, the government created collective production groups called "Krom Samaki" (Solidarity group in English). The objective was to share the rare production means that remained available, especially the catlle and draught power. After a few years, once the crisis was passed, the Krom Samaki started to distribute the land cultivated to individuals, officially on an equal basis while in the reality, the politically powerful actors of that moment certainly managed to get more than others, thus strarting a process of social differentiation based on land and production means. In 1989, , the Vietnamese withdrew from the country, the government officially recognised the land allocation to private stakeholders.

In 1991, the Paris Peace Agreements were signed and, a year later, public elections were organised. Until 1998, full peace and security for the whole country were successfully established, and repatriation of the former Khmer rouge refugees living in the camps on the Thai side of the border was organised. Former Khmer Rouge army chiefs were often reintegrated and appointed in a high position such as chief of village, commune, district, or province, fishing lot controller; soldiers at the ministry of Interior, etc. Uncultivated land, sometimes from natural forest resource areas, was allowed to be distributed to the new settlers, and even more to the KR heads that decided to surrender. After 1992, the government supported the land distribution to with official land ownership of residential land one Rai[7] for each member of one family.

[7] 1 rai = 0,16 ha, or 6.25 rais = 1ha

However, there were still issues for the public administration to provide land ownership documents to farmers. Correspondents in the survey reported the bigger farmers who had big agricultural machinery and network/connection/relationship with Solidarity Group members, thus they got easier opportunity to get larger cultivated land. As part of the deals, the Khmer Rouge veterans had autonomous management of administration in their strongholds and organized authorization to create villages and the boundaries of fishing lot areas. Vast forest lands were allocated to the former Khmer Rouge militaries to sustain their living based on agricultural activities. Being informed about enormous available forest lands, close relatives of thesemilitary also moved in to get land for free. The clearance was generally done by hand and usually started from the front part to demarcate the ownership. Paddy, maize, and bean were among important crops for the local market. The survey found that thousand hectares of flooded forests in Sangkae and Aek Phnom were cleared by then for floating rice cultivation. However, unfortunately, we could not find any sources could provide the specific images of the degradation.

Between 1993 and 1998, again under immigration and repatriation, people started to struggle for the land access against private concessions on natural forest resource area. Beyond the residential area already distributed, the Government extended the land allocation to 3 to 6 Rai (a half or one hectare in average) to any family in the forests and and in the flooded Tonle Sap area (will describe more detail in Chapter 4).

As a result of the increasing demand for rice and cereals for fast growing agro-industries in the region, profitability of rice and maize grew fast, encouraging conversion of forest lands to farm land. Without any legal basis, each one just focused to clear the upland forests and flooded forests as soon as possible. In 2001, the Cambodian government legally formalised the access to land by a new land law. That law granted the possibility of "*Economic Land Concessions*" for the agricultural and special purpose, for a maximum duration of 99 years (United Nations, 2007; J. Diepart, 2015b), which in turn allowed the development of large holdings leading to capitalist plantations However, among the total 943,069 ha of Economic Land Consession (ELC) that were granted to companies in Cambodia, there was only around 8,000 ha that were granted in Battambang province (MAFF, 2006).

However, neither in the literature nor by direct survey, we found that the ELC really impacted on the land use and land cover in the lowland area of Battambang province. On the contrary, the process of land use and land cover change in the province rather appeared clustered into three successive periods:

(1) from civil war to peace or liberalization (from the 1980s to 1993s);

(2) the peak migration and land rush leading to massive cropland expansion from 1993s to around 2010s; and

(3) lastly then a recent shift to food sufficient farming and to diversification of income generating activities including non-agricultural jobs.

During the second and thirdperiod from 1993 to 2010, we observed that the forest cover was decreased dramatically. According to Senevirathne *et al.* (2010), land cover change detection in the Tonle Sap watershed indicates that the forest cover has been decreased from 20,170 km^2 to 11,436 km^2 in the period of 1990 to 2009. And the flooded forest that was cleared for the only agricultural purpose that increased from 14,0762km^2 to 18,858km^2, mostly floating rice production and new settement installation. .

Turn to the forest cover in whole Battambang, it was found there was a decrease in its cover everywhere of this province, through the data base of Battambang provincial department of planning as shown in Figure 1. The total forest went down from 4% of provical land surface in 1973 to 2% in 2014. And the dense forest is lost from 2% on 1972, then to 1.6 in 2000 considered as in first period. The land clearance in a second period was seriously happened during 1989 to 2002 which was a peak migration and rush to get land for rice and cereals and fruit tree plantation based commercial intensive farming. And last period from around 2006 to 2011, the forest was cut for more commercial-diversified farming, and finally to it remains only 0.2% in 2014, and it goes even less in the recent year.

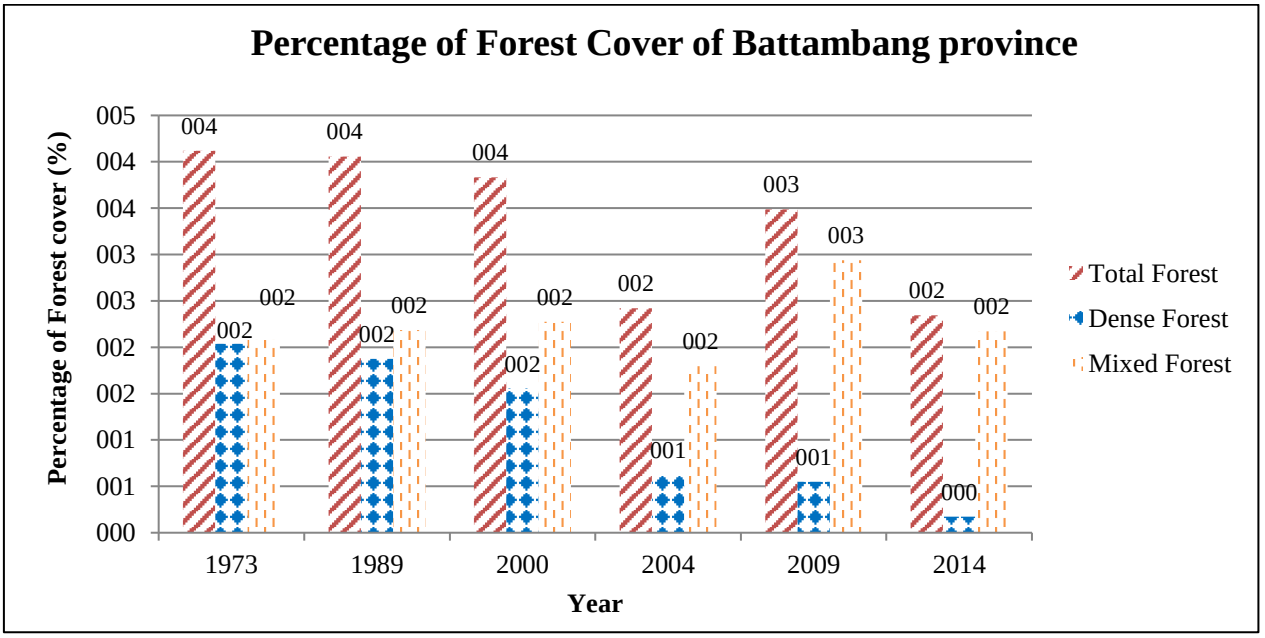


Figure 1: Forest cover of Battambang province

Source: (Battambang Provincial Departement of Planning, 2015)

After the 2006-2007, new changes occurred in the cropping systems. Beyond rice cultuvation, diversification towards industrial crops occurred more often, together with a higher sensitivity to market incitations. For instance, farmers replaced small soybean by maize cultivation where and when good export opportunities have been offered to Thailand. In turn, after 2014, they shifted their maize to cassava production also for export to Thailand. And sesame,groundnut, fruit orchards and rubber also became larger productions (Figure 2).

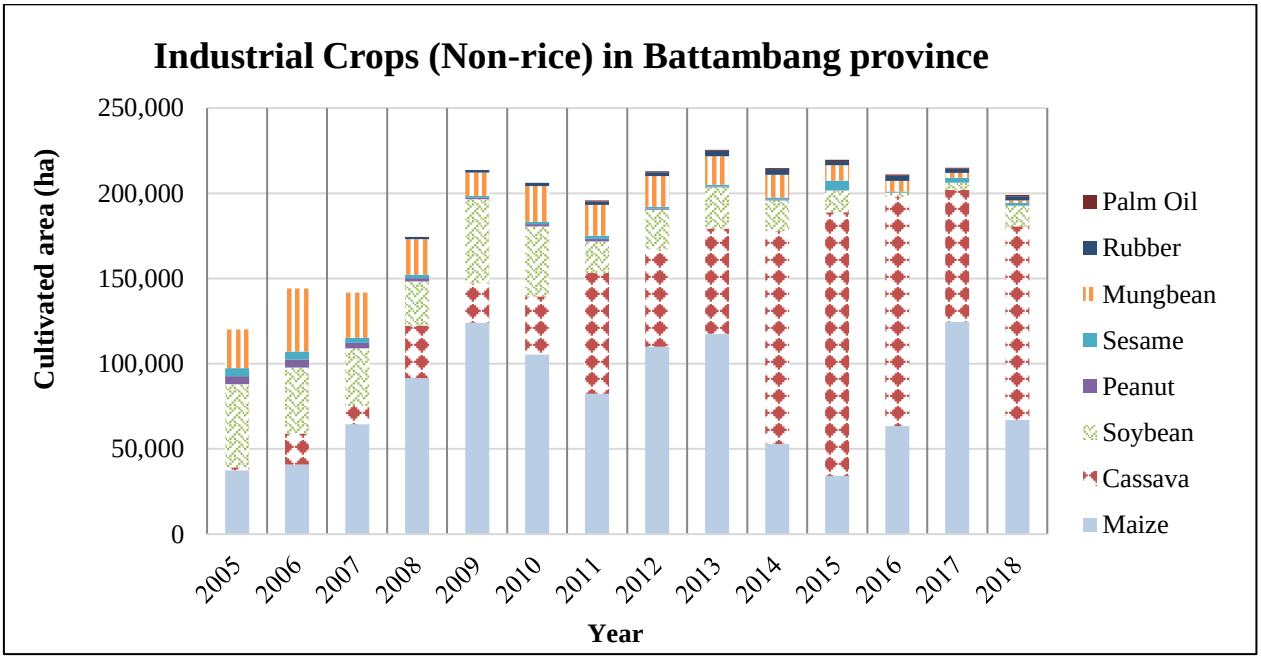


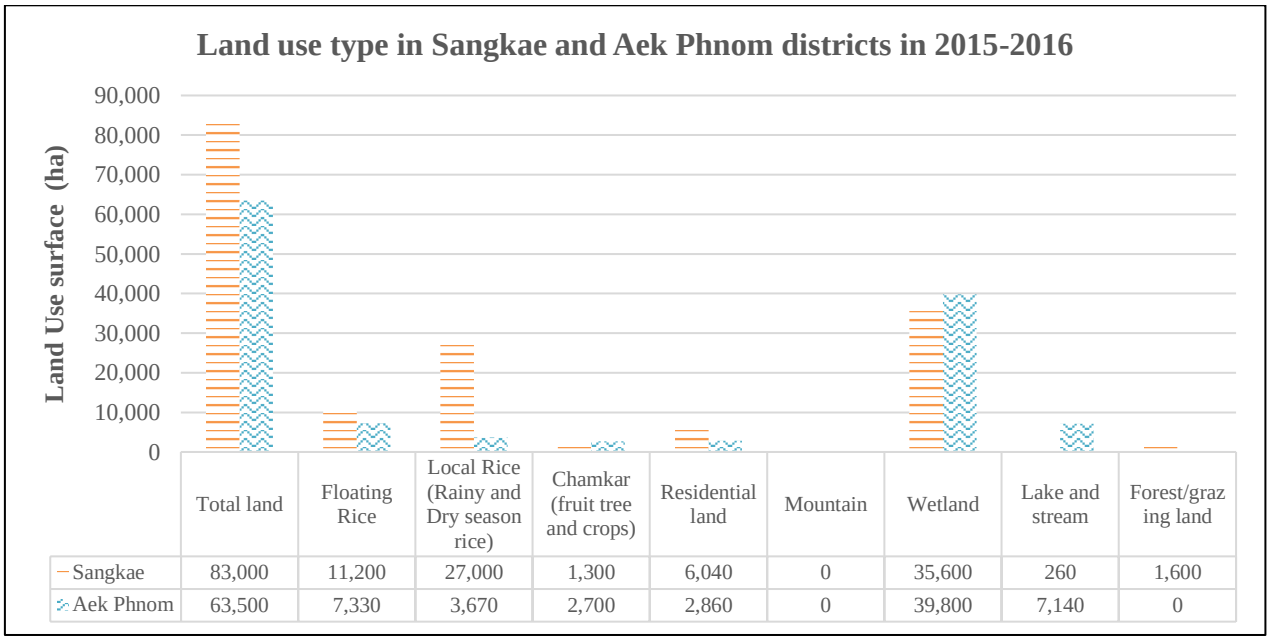
Figure 2: Crops (Industrial crops) cultivated area of Battambang province

Source: Battamabng Provincial Department of Agriculture 2005-2018 of MAFF

However, these changes did not impact that much the lowland areas of the study zone, since all these crops are not adapted to partly flooded ecosystems. The changes that occurred in the study area addressed the rice cropping systems, with the shift from one crop /year (floating rice or some late wet season rice) to double rice per year before (early season rice) and after (receding rice) the flood.

If we look that the land use types in the Figure 3 below, we see that the cultivated lands in floating rice and in rainy and dry season rice represent the largest surface in both districts (11,000 ha in Sangkae and 6, 700 ha in Aek Phnom). The wetland and flooded forest land represent as the second largest area in the two districts (35,000 ha to 39,000 ha respectively).

The land surface of Chamkar (fruit tree and crops) is clearly smaller than the others, given that the non-crops or industrial crops and fruit tree plantations are not that large as they may be in the central plain and in the upland areas of the province. We observe that more and more farmers have been trying to change their single rice crop to double rice production area.



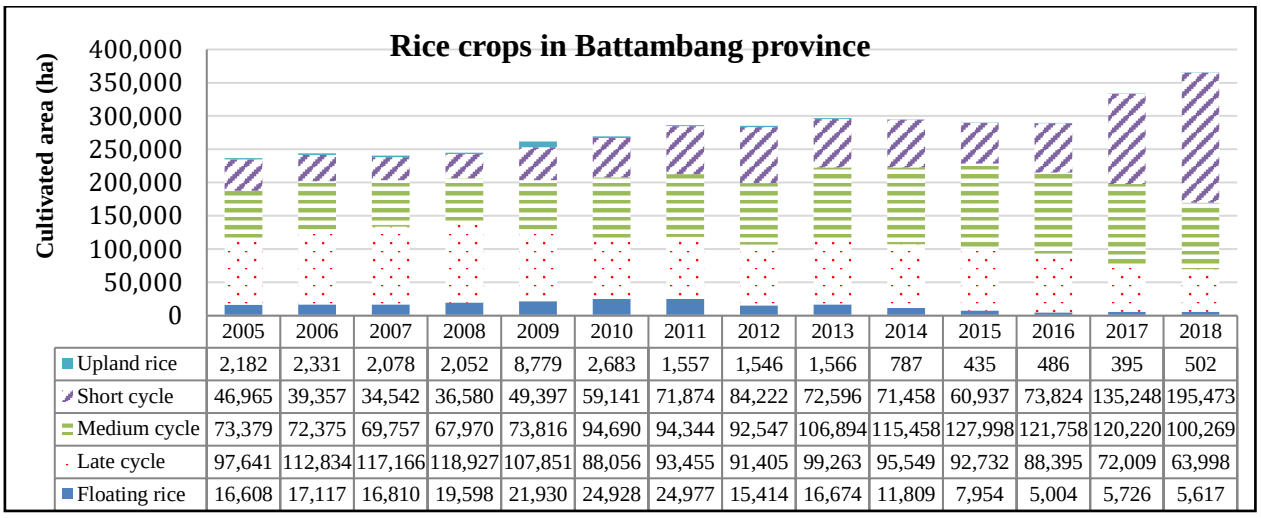
	Total land	Floating Rice	Local Rice (Rainy and Dry season rice)	Chamkar (fruit tree and crops)	Residential land	Mountain	Wetland	Lake and stream	Forest/grazing land
Sangkae	83,000	11,200	27,000	1,300	6,040	0	35,600	260	1,600
Aek Phnom	63,500	7,330	3,670	2,700	2,860	0	39,800	7,140	0

Figure 3: Land Use types in Sangkae and Aek Phnom districts of Battambang Province
Source: Battamabng Provincial Department of Agriculture 2005-2018 of MAFF

The cultivated land of rice in Battambang have been increased by shifting from traditional rice such as; floating and long-term rice to double cycle rice. The data based in Figure 4 below shows that the cultivated paddy land of floating rice has decreased from 16,000 ha in 2005 to only 5,000 ha in 2016.

In the meantime, short and medium term rice and dry season rice strongly increase. For instance, the short-term rice cultivated land was increased from 47,000 ha in 2005 to 74,000 ha in 2016 and 2018; and the medium-term rice cultivated land was increased from 73,000 ha in 2005 to 122,000 ha in 2016 and 2018.

The farmers in the survey reported that they had to diversify their rice crops to meet the market demand and faster earning income. Additionally, waiting for the income from floating rice and wet season rice is too long for them. This could explain the lead of change in land use and land cover change in the areas.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Upland rice	2,182	2,331	2,078	2,052	8,779	2,683	1,557	1,546	1,566	787	435	486	395	502
Short cycle	46,965	39,357	34,542	36,580	49,397	59,141	71,874	84,222	72,596	71,458	60,937	73,824	135,248	195,473
Medium cycle	73,379	72,375	69,757	67,970	73,816	94,690	94,344	92,547	106,894	115,458	127,998	121,758	120,220	100,269
Late cycle	97,641	112,834	117,166	118,927	107,851	88,056	93,455	91,405	99,263	95,549	92,732	88,395	72,009	63,998
Floating rice	16,608	17,117	16,810	19,598	21,930	24,928	24,977	15,414	16,674	11,809	7,954	5,004	5,726	5,617

Figure 4: Paddy cultivated area in Battambang province

Source: Battambang Provincial Department of Agriculture of MAFF from 2005 to 2018

Rice also increased a lot in terms of production and cultivated land in Cambodia. The annual database of the ministry of Agriculture, Forestry, and Fisheries from 2005 to 2018 shows that the rice production has increased by around 15 to 20% annually, from 5,900,000 tonnes in 2005 to over 7,500,000 tonnes in 2009, 8,250,000 tonnes in 2010, and around 9,300,000 tonnes in 2015, and more than 10 millions tonnes to 2017 and 2018. With contribution to increasing national rice production, Battambang is known as always one of the top areas for rice production, with around 600,000 to 760,000 tons annually.

Figure 5 illustrates the annual rice production of Battambang compared with the annual production in Cambodia from 2005 to 2015 (MAFF, 2016).

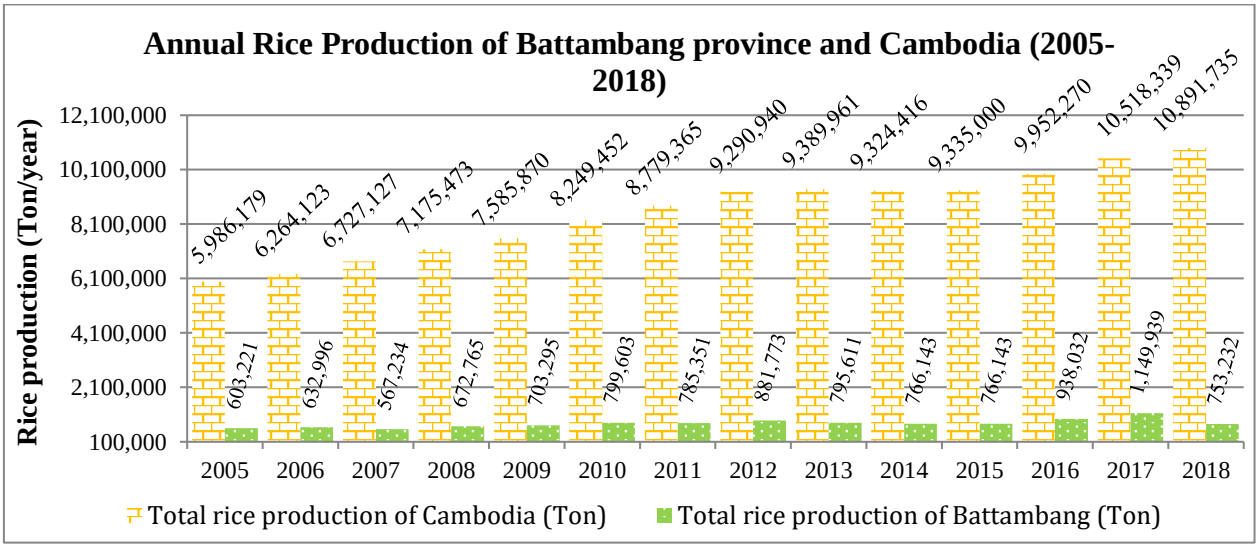


Figure 5: Annual Rice Production of Cambodia and Battambang – average of the 10 previous years

Source: MAFF: 2005-2015

As a result of this increase of production, rice is more and more exported to the neighbouring countriesm, EU counties, and to China. Throught the figures in Table 9 above, we note that the rice production for export has been increased from 20 thousand in 2010 to 53 thousand tonnes in 2015 and continuously increased until 2018-2019.

Table 9: The quantity of rice exported monthly for each year 2011-2015 (tonnes)

Month	2011	2012	2013	2014	2015
January	6,798	9,703	25,726	21,536	35,921
February	5,089	14,417	24,089	27,037	37,676
March	12,534	12,310	45,413	35,757	75,867
April	17,946	15,036	23,276	35,961	51,719
May	20,520	13,115	28,350	27,971	41,842
June	4,274	13,426	29,105	29,666	40,800
July	12,703	20,527	31,411	26,060	28,492
August	20,404	15,530	29,358	29,871	29,819
September	14,384	15,169	29,395	35,511	26,969
October	19,067	16,967	28,031	35,418	39,064
November	9,559	25,189	37,855	31,137	48,748
December	44,905	34,328	46,847	51,136	81,479
Total	**201,899**	**205,717**	**378,856**	**387,061**	**538,396**

Battambang is, however, targeted as the main provincial rice production area to successfully achieve the production and export objectives of the country. So far, the Cambodian government has set up and put into application a new extension system to support indirectly and directly the progresses of mechanisation in the whole country. Agricultural machines now contibutes significantly to the capacity of the farmers. Historically, the PhD study found that the agricultural machinaries such as tractor and hand tractor contribute a lot to crops diversification and forest degradation in this province.

Around 1998-2004, the number of tractors was increased slighly for the whole province as shown in the Table 10 below. Then, we can observe that, from 2005, there is another increase in the number of tractors and hand-tractors owned by the farmers. Furthermore, we can see that the number of pumps, harvestors, combined harvestors and threshers also increased significantly. And more recently, the rice millers have increased rapidly from 564 to 728 units, and those are medium and big scale in this province.

Table 10: Number of Agricultural Marchinaries in Battambang province from 2000 to 2018

Year	Agricultural Machineries in Battambang province (2000-2018)									
	Tractor	Hand tractor	Pumper	Harvester	Thresher	Rice Dryer	Rice Miller			
							Small	Medium	Big	Total
2000	736	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2001	780	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2002	780	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2003	766	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2004	1,030	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2005	1,142	7,640	5,444	1	541	2	364	0	200	564
2006	1,046	7,629	5,694	13	569	4	435	0	158	593
2007	1,121	10,540	9,022	15	739	7	364	0	199	563
2008	1,126	10,567	9,946	11	745	7	303	0	199	502
2009	1,345	12,514	10,278	31	801	11	383	0	207	590
2010	1,665	18,120	9,759	121	929	18	402	0	235	637
2011	1,894	22,164	13,042	198	977	24	397	0	252	649
2012	2,108	25,700	10,929	304	1,075	34	374	0	280	654
2013	2,637	27,364	10,780	329	888	44	349	171	142	662
2014	2,725	29,261	10,755	374	1,083	63	380	189	159	728
2015	2,725	29,261	10,755	374	1,083	63	380	189	159	728
2016	3,234	33,697	11,625	445	828	65	380	189	159	728
2017	3,353	37,679	11,672	605	814	66	380	189	159	728
2018	N/A	N/A	N/A	N/A	N/A	67	N/A	N/A	N/A	N/A

To conclude about the the changing agricultural situation, the Table 11 summarizes all the successive events that, from the Angkorian Empire period until present, impacted the most on the organisation of agriculture.

Table 11: Summary of evolution of land use and rice policy in Cambodia since the Angkor Empire until present (withfocus on lowland areas)

Chronology	**Evolution of land use and rice policy**
Angkorian Empire period (9th to 15th century)	Combination of floatting rice, season rice and receding rice around the Tonle Sap, already present with the same cultivation systems as in the middle of the 20th century, is seen as one major reason of the prosperous Angkor civilisation..
The French Colonial period (1863/1883-1953)	The colony brought peace and stability for the country, and set up land property policy. Rice paddies, tobacco, jute, cotton, sesame, sugar cane, indigo, rubber, and other foodstuffs were sources of taxation. The country's economy was boosted up by the growth of agriculture.
The Sihanoukist Period (1953-1970)	End of French colonial and received independance in 1954. Country's economy continued to export rice and rubber to France, while rice and fishery and other crops remained for local consumption. Rice production was over-supplied at the country level, and exports increased.

The Khmer Republic (1970-1974)	High population struggled to land access against to private land ownership. Most people were removed to the cities, low stability in the main products like rice, rubber, and other crops.
1975-1979 (Khmer Rouge)	Isolation of the country. People were moved to the countryside. Huge irrigation works were developed, and rice production was encouraged, exported to China, while millions of people finaly died from malnutrition and hunger.
The people's Republic of Kampuchea (1979-1989): Vietnamese intervention and Khmer Rouge revolutionary	- Recovery first started by collectivising the means of production and setting up production collective groups : the *krom samaki*, that shared the land and organised the production on a collective basisFrom 1980 to 1993, Khmer Rouge army was reformed to jointhe Krom Samaki with the integration of local authorities, they managed the state's support and land distribution to farmers. - Government started to distribute land and encourage individual initiatives in rice production. - Vietnam left the country, while the return to peace led to high population movements, settlements, and migrations from urban cities to forest lands and to Tonle Sap.
Kingdom of Cambodia (1993-Present)	- Peace agreements were achieved. The economy is pushed from over rice producing, fishery, and natural extraction. - State restarted the land distribution to farmers. - Land Economics Concession (LEC) policy with 99 years holding was offered to national and international companies. As result, the natural resources were depredated, mostly in the highland, little in the lowland. - High Yield Rice (HYR) varieties were introduced from 1999 at potential areas such as the provinces around Tonle Sap. Non photoperiodic, they can be cultivated 2 to 3 cycles per year. - Population was increased to almost double, led to high demand in food, so people started their crops intensification with double rice cropping systems. - People started to access to loan from microfinance, while some failed in debt. - Jute production was known as the common crops after rice in Battambang was ended in 2007. - Land mine was also a main issue since after KR until year 2000. - Land pressure caused by the increase of crop cycles and shifting from monoculture to multi-culture. - Started natural disaster and soil erosion, etc. from year 2000. - Increase in private agri-machinery since year 1990. - To target ASEAN and European markets; rice is seen as the main export products and the rests are industrial crops. - Rice was targeted as major agri-product for country's market supply. - Infrastructure and irrigation systems have been developed, but not enough. - Increase in rice exports 1 million tones to international markets since 2005 until today.

3.2.2. Fishery and natural resource management over 40 years in Battambang and in Cambodia

In developing countries including Cambodia, fishing and fishery products often play an important role in food security, particularly in low income households, e.g. small-scale commercial and subsistence fishing are often the last resort of employment choice but yet become the main income resource for those households (Baran, Starr and Kura, 2007).

In the past century of Cambodia, the king was believed to be the owner of all natural resources including land and forests. Concretely the King was entitled to manage most of the profits from the Tonle Sap, such as through fishing business with Chinese tycoons.

In 1908, the French replaced the traditional fish-farming practice with a new system of commercial fishing lots (mainly in Tonle Sap) in order to generate public income. Initially, the revenue was rather modest due to the rushed implementation of the reform, but soon it developed into significant amounts. At first, this new policy was intended to strip the Chinese owners of lot licenses; they however continued to dominate the industry (Lapointe *et al.*, 2014).

During the 1910s and the 1920s, many of the large and valuable fishing lots were in the hands of Chinese elites, since they were the wealthiest and longest dominant in this community in Kampong Thom, Siem Reap, Battambang, and Pursat provinces. After the Chinese and Vietnamese, Khmer Muslims and Buddhist Khmer people ranked third and forth in prominence, respectively. The latter could afford to acquire only small and low profit lots.

In early 1920s, the French colonial power finally focused more on conservation work, creating conservation areas and ratifying new fishery laws and regulations, for instance, reducing fishing lots size and promoting flooded forests protection in order to preserve certain areas and protect fish stocks. Just only after when the fishing lot contracts expired in 1920, the plans were being able to be implemented.

Few years later, the conservation areas started to noticeably appear in Tonle Sap. On the other hands, Sub-Decree No. 100 issued on June 7th, 1940 aimed at regulating operations of the fishing lots. In particular, the Sub-Decree defined the boundaries of the flooded forests around TSL, also the clearance ban of these areas to maintain them as spawning sites, and finally established the location of protected areas in the five provinces surrounding TSL. Illustration 7 shows the location of the fishing lots at TSL of Cambodia from 1980 to 2012.

Flooded forests have been well protected during the post-independent era until the outbreak of civil war in the 1970s. The fishing lots system was then gradually abandoned during 1970–1979, because of the civil war in the early 1970s and the subsequent Khmer Rouge regime. The Khmer Rouge took over most of the commercial fishing lots and forced the majority of population to live in cooperative units to work in the rice fields or dig canals instead.

Fishing was strictly forbidden. Although fishing activities were still available in small number of fishing units, the catches were reserved to top Khmer Rouge leaders and for export to China. By the early 1980s, after more than 10 years of halt in commercial fishing, fish stocks in Tonle Sap, and people were able to catch adequate harvests with traditional gear.

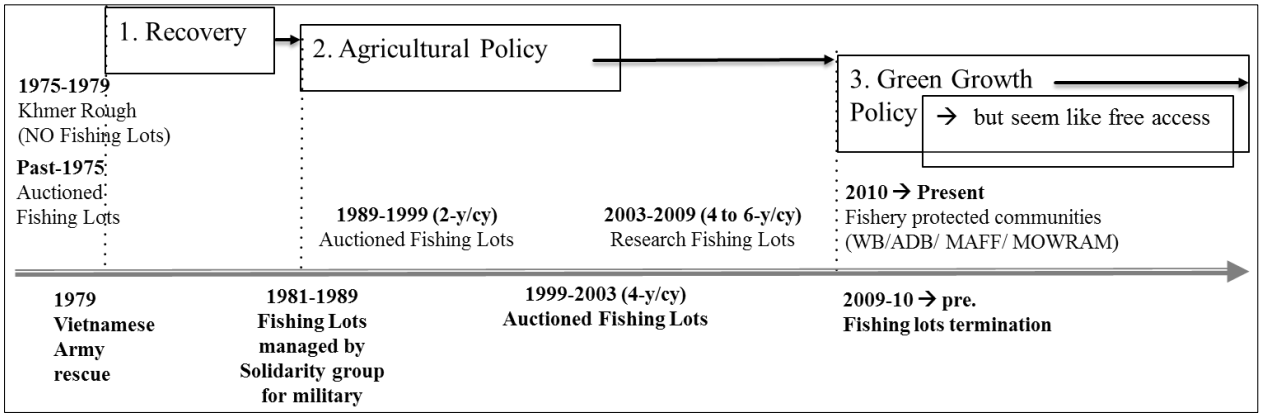


Illustration 6: Period of change on fishery in around 40 years (only from Khmer Rouge until present)

From 1985, private controm of fishing lots became officially permitted by the government , which was aimed at natural resources protection and conservation, and better control in aquaculture production supply for fish demand. Likely, this seemed to be primarily a taxation to state and also a mechanism for job opportunity creation for the new immigrants and Former Khmer Rouge armies. The PhD study also found that the co-leaders of "Krom Samaki (Solidarity group)" were known as the fishing lots controlling owners/contractors.

The Fishery Law of 1987 incorporated certain elements of earlier fishing laws and introduced new aspects, such as defining the various types of fishing activities. Moreover, this laws want to regulate the fishing gear and fishing activities, by classifying the fishing scale into three categories for the sales (Mak, 2011).

In principle, to run a fishing lot, an operator was required by law to obtain a license, which was granted on the basis of applications and a subsequent bidding process. In principle again, the highest bidder was granted with the license which was usually valid for 2 years. For renewal, the

owner of the fishing lot had to went through the applications/bids procedure again. Winners of the bid could either exploit directly their fishing right, or subcontract it by smaller pieces to private fishermen.

In the early 2000s, people extended complains over fishing access and limitations began to explode. Conflicts arose more often while lot owners tended to extend their boundaries to the point where the water reaches, often significantly violating on the fishing grounds of the local individual fishermen (Piseth, 2003).

Table 12 and Illustration 7 indicate fishing lots area, attribution on GIS location and sizes in Battambang since 1985 to 2010 measured by the Battambang Provincial Department of land management, land administration, and Civil construction and BDOP, 2015.

Table 12: Area of fishing lots in Battambang province

Lot Name	Area (Ha)	ID of fishing lot	Shape Leng	Shape_Area	Perimeter
4	11727.03	75	50753.26421	117270258.7	50753.26606
6	10001.79	76	47535.51926	100017927.6	47535.52162
1	11122.59	77	46670.85396	111225903.8	46670.84999
2	50133.64	81	93210.61636	501336446.8	93210.61434

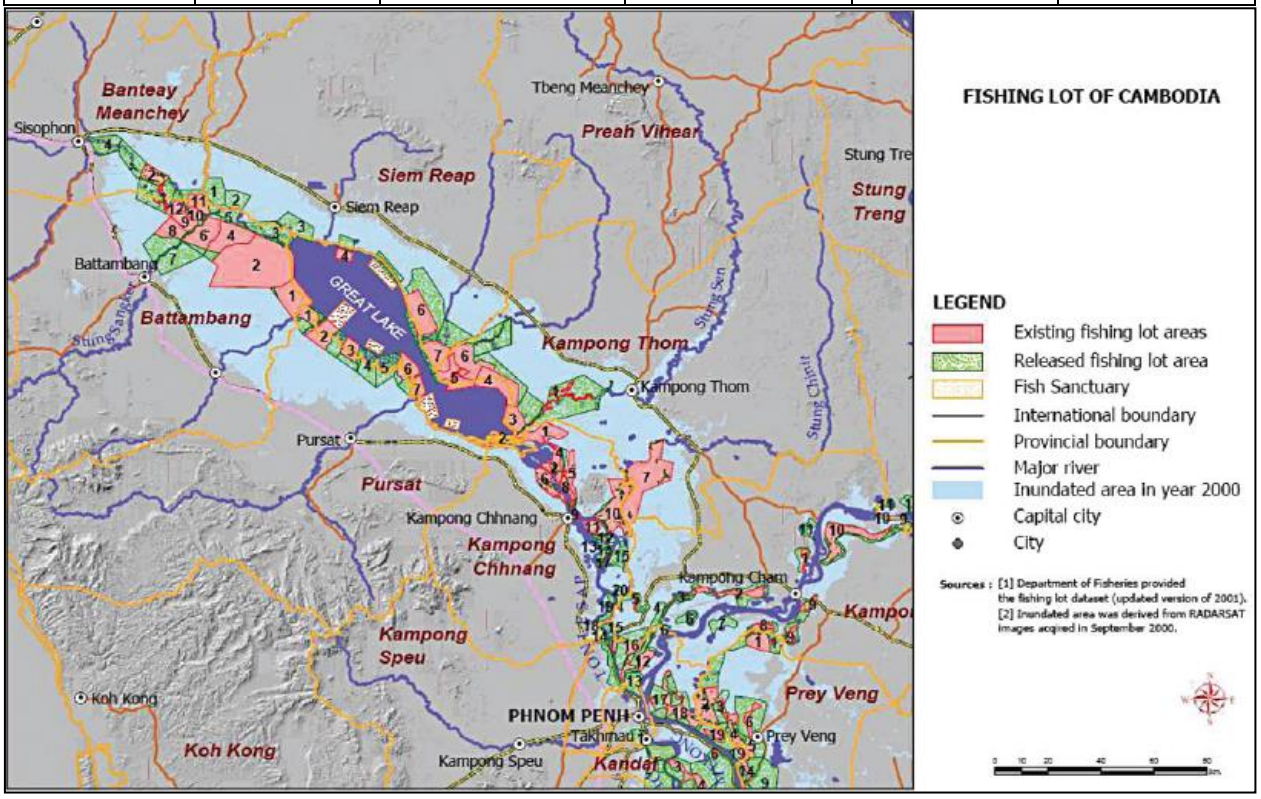


Illustration 7: Fishing lot at Tonle Sap Lake of Cambodia

Source: (Mak, 2011)

However, our interviewees in Aek Phnom and Sangkae indicated that some lot owners have been able to operate the same fishing lot for over a decade, suggesting that these people had somehow won the bidding many times. This begs the question of how it was possible for these owners to manage to pay such amount so that the operation could last for a decade.

In fact, the amount of the fee was determined based on the size as well as the location of the fishing lot and then was clearly stated in the burden book. They were allowed to pay the fee three times a year to the Ministry of Economy and Finance, usually between the end of April and early June. Beside that, whereas the fishing lot operators had to work hard to afford the fee, they were also responsible for other duties such as preserving the fish stock, protecting the flooded forests, and preventing forest fires.

A former fishing lot owner in Battambang estimated that his expenditures were around 500 Damleung of gold per year while continuously sub-leassees had to pay 30 Damleung of gold per year to the fishing lots owners (Mak, 2015). More than half of this amount was for bamboo fencing (which needed to be replaced almost annually), and other equipment needed for fish harvesting and preventing fish migration. The remainder covered labour wages, food, medicine, petrol/gasoline, and “political costs”. Some lot owners lacked the funds to take delivery of the license when they first bid for it, while others had only half of the total amount needed to claim their targeted lots.

Lot owners generally did not operate the lots themselves, preferring as our interviews indicated, to sell parts of their lots to sub-lot contractors and to keep only the most productive locations for themselves, their families and relatives. Likely, even sub-lot contractors re-allocated their sub-lots to other fishermen, or allowed for fee ordinary fishermen to catch in specific locations or during certain seasons (Piseth 2003). Although some small-scale fishermen also operated within the proximity of the lots and benefited from the lots system, this group is significantly more or less a million people who involved in fisheries.

Normally, the fishing lot owners could run the lot for around 4 to 6 years, during the open fishing season from around end of April to December each year. This temporary lease gradually became full tenure, since it tended to be extended during the closed fishing season. In consequence, these owners controlled the fishing lot in both closed and open fishing seasons, especially, during closed fishing season around September, they tried to use the illegitimate power to manage and take action if the fishermen damage the lot.

Mak (2011) argues that this kind of authorization were not stated in Fisheries Law, when he conducted his study in Siem Reap province. However in our PhD study area, we found the fishing lot owner could run the lots for a whole year even in the fish reproductive stage, by paying "Under Table Money" to the corrupted officers in charge of the control. Our correspondents reported that large scale lots like in lot number 1, 3, 4 to 2 could carry out the fishing throughout the year in anywhere in the fishing lot areas.

The divided fishing areas in all fishing lots in Battambang are leased out to several lessees and sub-lessees, especially the number 2 which is one of the largest, located along the Sangkae River. During the fishing lot period, the owner shares capital, responsibilities and benefits with the lessees, and in most cases, the lot owner leases out sections of the fishing grounds using annual contracts. In some cases, the leaseholders sub-lease parts to others.

The sub-leased lots were fenced and painted to mark the ownership. Within this boundaries, they practice a total harvest fishing, e.g. using numerous illegal and unsustainable fishing methods and practices (including very small fence slat sizes or mesh, sweeping the fenced areas and draining pools). In the present, the role of Fishery Administration in developing and improving the fishing lots is more or less limited to data collection and a few patrols on the field.

To protect the fishing lot, Piseth (2003) said that the owner also hires guards and sometimes equipped with guns. During the fishing season, a total of 60 to 200 labour, of which fifteen were women, were hired. These workers fulfil multiple functions as set by the fishing lot owner, but, their main tasks are to maintain the fishing lot fences, guard the fishing lot areas and fishing operations, and provide labour – for carrying fishing equipment, for the fishing and fish processing operations.

In addition, after the fishing operations have finished, the owners and leaseholders may sell their fishing rights to individual fishermen or groups of fishermen, but under certain conditions. According to villagers in Praek Toal commune, many villagers get along very well with the fishing lot operators and make an arrangement so they can fish there after the fishing lot owners' harvest has finished. Illustration 8 shows the summary of the ownership structure of the fishing lot; it provides general overview how the fishing lots were organized and benefit sharing among owner, sub-leases, guards, government, and workers.

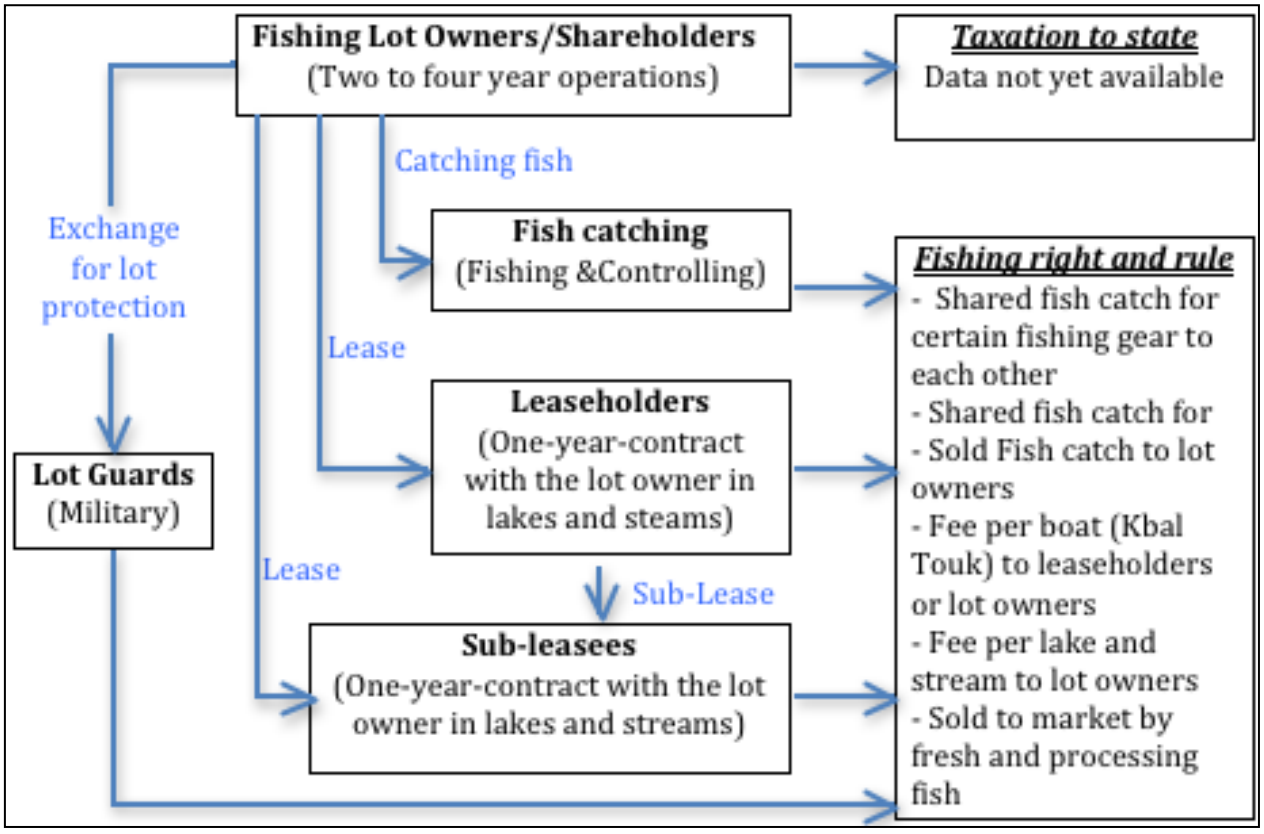


Illustration 8: General ownership structure of the fishing lot

Source: (Mak, 2011) and PhD survey in 2015-2017

The fishing lot owners are either themselves powerful stakeholdersor are a family member of a powerful person, sometimes at different levels and with different people. At the national level, for example, the fishing lot owners' power can be assured by a high-ranking government officials or patrons whom could have significant role/position at the FiA in order to support their business. In this context, the fishing lot owners necessarily need to build connections to gain political power by means of using their power inheritance or financial resources to procure it. The reason for gaining political support is because Since most decisions are taken at the national level, an adequate political support is most often necessary to maintain the long-term control over the fishing lots.

At the local level, the power of a fishing lot owner can be revealed in the number of labourers employed and the size of the armed group used to protect the fishing lot area, as well as the type of engagement that takes place with the commune chief or the district governor. Power in this sense can be seen as a form of dependency. In addition, military power is displayed alongside the gunmen patrol at the fishing lots. With gunmen in place, individual fishermen cannot come near the lots.

When section of the fishing lot is leased out, it is logically that the leaseholders shall be aware of the guidelines and legal framework and get to implemented as defined in the burden book. In contrast, the responsibilities that have been passed to new lot owners are commonly reduced. There are many cases in which the fishing lot operators have not followed the burden book; although they are the only people responsible for its upkeep.

The years from 1998 to 2000 were marked as the fishing lot expansion period. According to our interviewed fishermen, licensed fishing lot borders were often close to their houses. The fishing areas of the lots made it hard for them to sustain their livelihoods. Despite, lot owners placed armed guards patrol to protect their property from poachers (Piseth, 2003).

The increasing number of conflicts induced recommendation from researchers (Degen et al. 2000; Virkom and Sithirith 2008) on putting more efforts as a means to improve the management of fishing lots due to their economic importance as well as their significance in flood forest protection and stable food security. For the fishing lots system, however, a proper management could have been effective in protecting the conservation areas and flooded forests from deforestation.

In response, in 2000, the government decided to reduce the size of the fishing lots and to re-assign these to the community (Ratner, Oh and Pomeroy, 2012). Our PhD study defined that small-scale fishermen were annoyed by the lot owners' restrictions on their mobility, by the over-expanded lots boundaries, and their use of armed forces to strictly guard the lots. While the majority of the fishermen supported this re-assignment policy of abolishing the fishing lots, nearly all fishing lots owners and sub-lot contractors suffered.

Then, in early 2009, the Tonle Sap Authority (TSA) was put in place, representing a new institution layer in the lake's complex governance structure. The main version and objectives of the TSA were: (1) to consolidate the government's protection and management goal of the TSL particular ecosystem; (2) to balance between development and conservation; (3) to coordinate future projects around the area (ecotourism, agriculture, urbanization….); (4) to integrate management of the river basin around the Tonle Sap Lake.

However, Mak (2011) and Keskenen (2010) argued that the TSA was created with the given expression to the need by the government for an institution with a mandate at play in the basin. And the fact that the TSA was eligible to report directly to the Prime minister Hun Sen also suggests an ability to garner the necessary political support in the discharging its function, in general thought

this may also provide a mechanism for political agendas to be manifested more directly in the lake management. But the TSA is unlikely to be very helpful in conserving the flooded forests as fish breeding space. However, this institution has faced fundamental constrains to enforce laws against illegal flooded forest clearance or illegal fishing. Lack of formal institutional coordination is a concern, while failure in the communication between the internal TSA itself and with the sectoral ministries, for example, the Fishery Authority (FiA) of MAFF.

The long existence of private fishing lots in Tonle Sap literally induces both negative and positive impacts. On the positive side, it was the only system in Tonle Sap that could generate public national income, and, at the same time, could take part in fish and flooded forests conservation. In our interviews, the fishing lot owners often argued that the fishing lots provided some protection of fish stocks through the control of poachers and prevention of large-scale loss of inundated forests. When the fishing lots covered extensively over the lake's surrounding area, inundated forests were well protected.

In May 2011, the government issued Order 01 to organize fishery management and to suppress illegal fishing in Tonle Sap lake. A special committee was formed to investigate the situation around the lake, to note the fishing lots creating problems (ranged from conflicts with the local people to the destruction of the ecological system through improper practices - Chhin 2012). The report stimulated three initiatives to suppress illegal fishing, and ultimately resulted in the government's announcement in 2012 to ban private fishing lots in TSL altogether.

Finally, in March 2012, the government cancelled the entire fishing lots system in the Tonle Sap to allocate the lots as community fishing grounds and to reserve certain areas for conservation. From the government's perspective, this measure should reduce the conflicts in the fishery sector, improve the livelihoods of ordinary fishermen by allocating more fishing grounds to their communities, and promote conservation through the creation of many conservation areas.

Fiscally, the contribution of the private fishing lots the the public budget was found less than USD 1.5 million per year – which, according to the Prime Minister, was equivalent to what the government received in custom duties in a single day (Royal Government of Cambodia, 2010). Hence, the government had no real economic concerns to cancel the Tonle Sap private fishing lots. All former owners interviewed during our fieldwork suggested that it was politically motivated. This observation was supported by many of our respondents who believed that the government had manipulated access to resources to pacify the fishermen in exchange for votes at that time.

During our interviews, the former fishing lot owners reported that, to secure an operating license, a fishing lot owner needed to have a long negotiation, and to never forget to offer "Under Table Money" to an upward series of government agencies which were involved in the process of awarding these licenses. One interviewee described the process as follows: first, the lot owner paid around 5,000 to 10,000 USD every year to the provincial fishery administration to get their approval.

Normally, the tea money is paid through a fishermen leader in a particular village. Then the provincial Agricultural Officer pass for another top signature, where the amount was half of the tea money paid to the Fishery Administration Office. Then, turn to the provincial governor whose signature was secured for at least 20,000 USD. The final stop was the Fishery Administration in Phnom Penh, where the price of the signature was negotiated with the head of administration, with the cooperation of the Ministry of Agriculture, Forestry, and Fisheries, prepared the necessary documents to the Council of Ministers for final approval.

Figure 6 below shows the annual inland/fresh fish catches from the Tonle Sap Lake of Battambang province and in whole Cambodia. The country's inland fish catches from 1993 to 1998 were rtather stable at around 75 thousand tons annually. Then, with the fishing lot size expansion in 2000, the numbers of inland fish catches were increased from 231,000 tonnes to 405,000 tonnes in 2010. In the line, we can remarkably see that the number of inland fish catches in Battambang fluctuated changes in parallel with the catches at the country's scale.

Additionally, the data also shows that the fish catches have increased from 445,000 tonnes to 528,000 tonnes in only three years in 2011 until 2013. By contrast, it has decreased from around 120,000 tones (from 505,000 to 487,000 tones) in 2014 and 2015. Likely, the fish catches in Battambang have decreased to around 140,000tones also in 2014 and 2015. The consequences, the fish production has increased only a few years after the fishing lot determination and then it declined from year to year. We may assume that fish stocks of Tonle Sap in Battambang province and other TSL area in Cambodia will not now return to the level they had before.

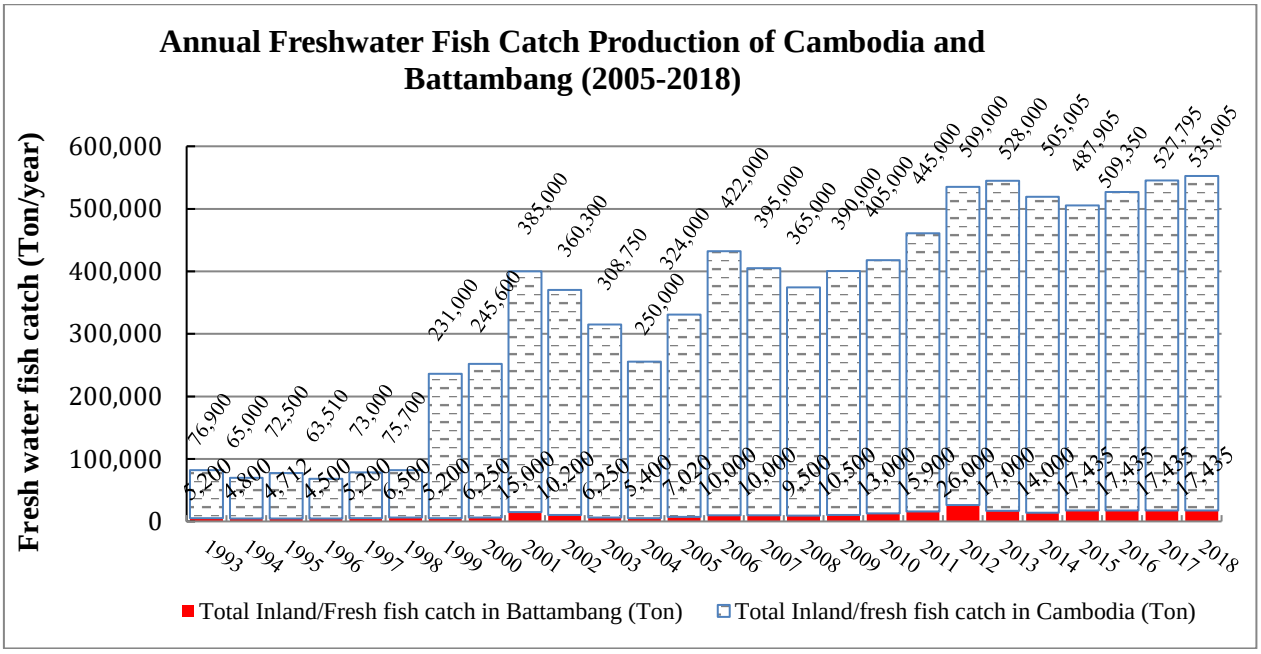


Figure 6: Annual Freshwater Fish Catches in Cambodia and in Battambang province

Source: MAFF, 2005 to 2018

After the termination of the fishing lots from 2010-2012 (again some areas were initially started to terminate the fishing lots since 2010, while the termination was totally done in 2012) the RGC decided to set up the political authorization management and patrolling actions at the community conservations in most part of the country. The fishing lot termination was known to increase quality on NR management and improve local livelihoods.

With this fishing lot termination, many scholars argue that Cambodia was at risks to loose its natural fisheries resources (Keskinen 2003, 2006, 2010; Sithimith, 2006, 2011, 2015). We also found the same that there has been a decline in fish catches by household over the last 5 years, as known since after the termination of fishing lots. The correspondents also reported that illegal fishing activities have increased under the management of fisheries communities, illegal fishing done by both local fishermen and outside farmers-fishermen from other provinces.

To be worse, the degradation of local natural resources would impact on the local households' livelihood, which depends on those resources; the poor and in particular of the landless and asset-less households. Then, it impacts on the supply chain and distribution of inland fish to food nutrition and consumption, also to traditional market and national fish market demand. In the context of the natural resource degradation situation, environment turns to become a significant source of vulnerability. While inhabitants around the Lake have adapted themselves to seasonal

changes of the lake, they have poor capacity to react to irregular environmental events (Nuorteva, Keskinen and Varis, 2010). So what could be a good mechanism for natural resources management?

Hereafter in Table 13 the history of fishing lots since French colony 1908 until present is summarized, and the impact of the fisheries policy on the changes on fishing catches and practices is described systematically.

Table 13: Summary of the history of fishing lots since year 1908 to present

Chronology	**Evolution of fishing lots**
1908- 1920	- French replaced the Khmer traditional fishing farming by commercial fishing. And Cambodians started fishing trade with China from 1910. - Chinese controlled the valuable fishing lots, together with Khmer-Muslim and Vietnamese.
1920 - 1930	French started to pay more attention on natural resources conservation/
Before 1975	Auctioned fishing lot
1975-1979	No fishing lot (Khmer Rouge), but not free access
1980-1981	State fishing enterprise-fish products from the fishing lot were given to the state.
1981-1989	Fishing lot managed under the Solidarity Groups, with fish products given to the State based on the quantily and quality. Fish products also used to support military.
1989-1999	Fishing lot returned to being an auctioned lot; put-up for auction every two years.
1999-2003	Fishing lot is appointed as a 'research fishing lot'. Mandate given to manage this fishing lot for 4 years.
2003-2009	- Fishing lot still a research fishing lot, but mandate changed from 4 to 6 years. End date for current fishing lot owner is 2009. - Generally, there were around at least 60 to 150 workers (for example 45 men and 15 women) employed in each fishing lot.
2010 - Present (goes to end of fishing lots, and start conservation program)	- Current fishing lot owner had owned their lot since 1995, but these rights totally ended in early 2012. - Tonle Sap Authority was created in 2009. - Ministry of Water Resources and Methodology (MoWRAM) and Fisheries Administration (FiA) of MAFF authorized to protect the flooded forest and fishery resources in TSL areas. - Fishery communities were formed since before fishery termination.

Source: (Piseth, 2003; Mak, 2015) and the PhD survey 2015-2016

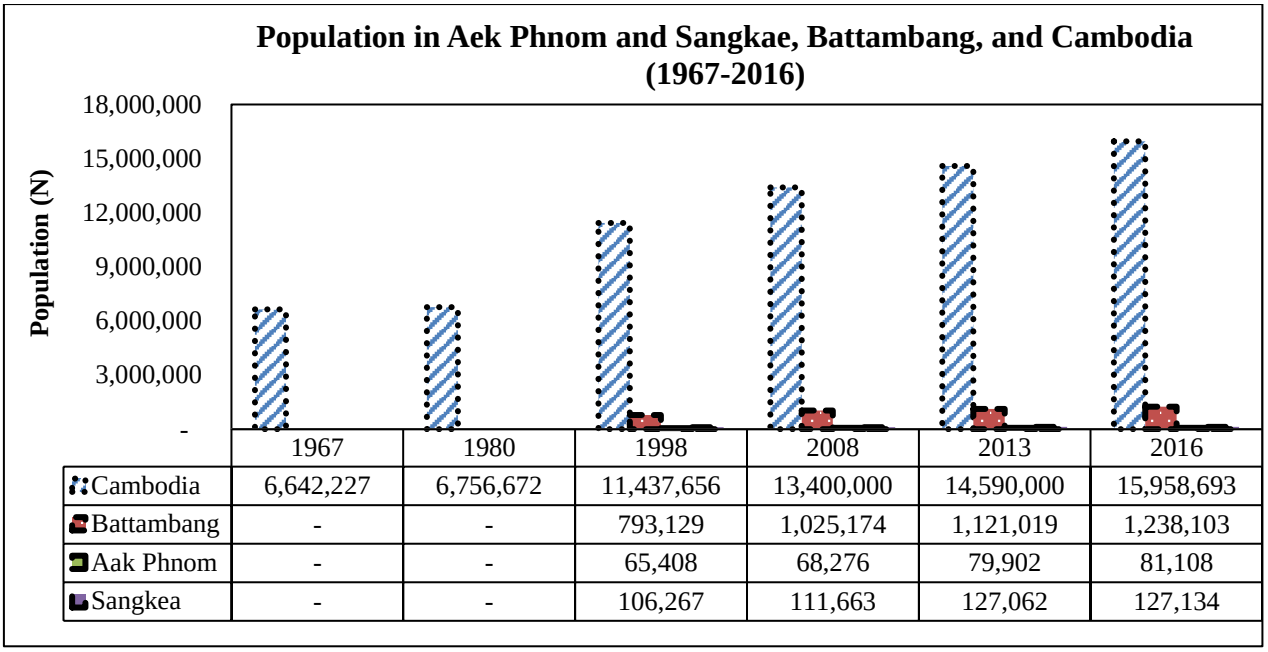
3.2.3. Demography context changes around the Tonle Sap of Battambang

People living on and around TSL have therefore adapted their lives to the environment there, particularly the changes that take place in its hydrological regime, building what Kummu *et al.*, 2006; Paula, Marko and Olli, 2010; Mak, 2011 called 'TSL human-environment system'. However, the human-environment system of the Tonle Sap is in turn influenced by the human system, by livelihood activities and by the environment. The livelihoods of the people on and

around TSL are closely linked to the environment and to the hydrology of the area at the different seasons. At the same time, their lives depend on the resources provided by the lake.

With a population almost 16 million inhabitants whose 65% is younger than 30 years old, Cambodia is very homogeneous regarding its ethnic and cultural components: 95% of the population is Khmer and Buddhist “lesser vehicle”. 80% of the population is rural, and they are farmer (Pillot, 2007). However, according to new MAFF, 2018 reported that number of farmers has decreased to less than 40% of the population in the rural constryside, absobed by service and garman sectors. The Cambodian population has increased significantly from the end of the Khmer Rouge period, with a growth rate about 5.5% annually. In 1967, Cambodian population was found around 6 million, it reached around 9 million before the Khmer rouge. Aaround two millions of Cambodians died or migrated out during this, which led to a decrease of population down to around 7 million in.

The Figure 7 shows the increase of population up to 11 million in 1998, which corresponds to an increase of around 60 % in 18 years. It then continued to grow up to 13 million in 2008, 14.5 million in 2013, and up to almost 16 million in 2016 (MOP, 2014 and 2016), which represents a slightly slower growth of 45% in 18 years. In Battambang, in the same period the growth has been even more important (+56% between 1998 and 2016), showing that the internal migrations to the province have been important: , with a growth rate of 2.3% annually.



	1967	1980	1998	2008	2013	2016
Cambodia	6,642,227	6,756,672	11,437,656	13,400,000	14,590,000	15,958,693
Battambang	-	-	793,129	1,025,174	1,121,019	1,238,103
Aak Phnom	-	-	65,408	68,276	79,902	81,108
Sangkea	-	-	106,267	111,663	127,062	127,134

Figure 7: Population in Aek Phnom and Sangkae of Battambang province, and Cambodia – average of the 40 previous years

Source: Battambang Provincial Department of Planning, 2016

In the selected study area, Aek Phnom and Sangkae districts, according to the data of the Battambang provincial department of planning in 2016, population was found 65,408 in Aak Phnom grows to 68,276 in 2008, 79,902 in 2013, and 81,108 in 2016. Likely in Sangkae is grown from 106,267 in 1998 upto 11,663 in 2008, 127,062 in 2013, and 127,134 in 2016. Based on these data, it shows us the rapid population growth in the areas leads to highly demand in foods, space, employment, natural resouces, social support, and so on.

In our areas of study, there was no estimation of the rural population before the first census in 1998. However the data show an increase of population of about 25% since 1998. Due to the returning refugees after 1992, we consider that the increase between 1980 and 1998 was more than the national rate . If we assume that it has been around 60% during this period, it means the population a the end of the KR period must have been around 107000 people in the two districts of Aek Phnom and Sangkae. In the whole period 1980-2016, this means a total growth of 95%, almost doubling, in 36 years, with two very different periods +60 % before 1998, 25 % after.

The increase of local people's household size in both town and rural area, numbers of local and international tourists are coming to visit in short or long term. The new settlement of immigration from different provinces in Cambodia and other foreigners is also led to the population growth; most of them enter to the Battambang provinces for seeking for new job opportunity serving services in restaurants and hotels, building works, chips and fish store, industrial factories; and they also settle in other illegal activities such as forest and flooded forest logging, wildlife and fishery hunting, mine or labor for mine exploring, etc. In the context, a good RGC's mechanism in social affair and security will be needed for responding to this future social change.

3.2.4. Flooding pulse conditions and climate change in the Mekong basin and on the Tonle Sap Lake

A review of rainfall data in Battambang province (see Figure 8) shows that annual rainfall and temperature over the last 16 years has been variable, but does seem to be increasing. The heaviest rainfall was seen in 2011 and 2016-2017, and this coincided with the flooding in the Battambang town and other towns around Tonle Sap. The same figure also shows that the average temperature seems to have slightly increased in the meantime, of around around 1.2^0C annually.

However, changes in the flood pulse on the TSL does not much depend of the rainfall pattern in Battambang itself. First, the river basin is much broader, and the collection of water at the moment of the flood is more connected to the rainfall in the Himalays and on the Annamitic chain in Laos or Vietnam than in Cambodia itself. The temperature itself in Tibet is also more important to determine the melting of the snow than the temperature in Battambang. , However, only around 25% of the Mekong's wet season flow and less than 50% of its dry season flow originates from PRC.

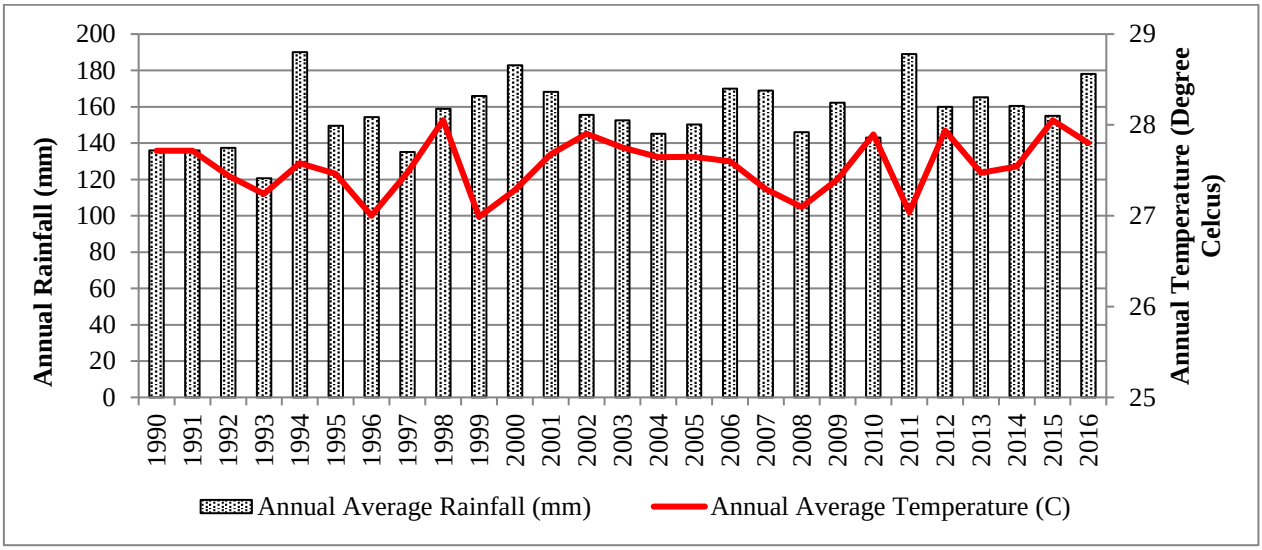


Figure 8: Annual Temperature and Rainfall – Battambang - average of the 16 previous years
Source: Battambang Provincial Department of Water Resources and Meteorology 2016

Even more, there are also quite a few river control structures that have been built or are planned in People's Republic of China (PRC) and Lao PDR. These structures could have a substantial impact on the hydraulic regime of both Mekong and TSL. Irrigation schemes can increase infiltration or possibly even drain to other catchments, while hydrodams in the upper Mekong basinalso alter the total and seasonal sediment load of the stream.

3.2.4.1.Flood pulse change and hydrological processes

As shown in the Figure 9, over last 16 years, the water level of TSL at Battambang province a mean level of over 7.5 meters a.s.l. in the years 2000, 2001, and 2002. By contrast, it has been less that 6.5 meters asl from the year 2003 to 2010. These were considered as a low flooding by the farmers and fishermen, and relevant stakeholders. Västilä et al. (2010) also mentioned that high level of the TSL in Pursat and Kampong Chhnang provinces in the year 2011 and a low level from 2003 to 2010.

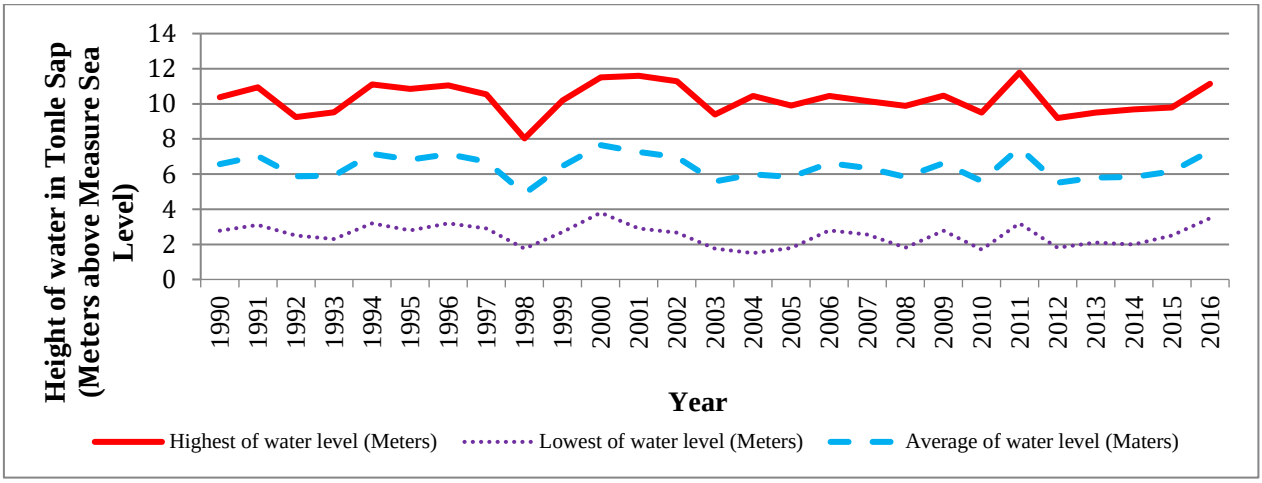


Figure 9: Flood pulse level evolution diagram – Battambang city station – 1990-2016

Source: Battambang Department of Planning (Battambang Provincial Departement of Planning, 2015)

More recently, the average water level has just risen to over 7.5 meters in 2016 and 2017. Indeed from the survey, the flood level, in those mentioned years, was considered as favourable for the rice cultivation and also for the fishing activities. We were also confirmed that there was draught in the years from 2013 until 2015 in the study areas. Consequently, we conclude that when the average water level is lower than average 6.5 meters; it is seen as damaging for the fishing and agricultural activities.

The Mekong River Commission (MRC) also reported that the climate change has an impact on the flood levels of the Tonle Sap. MRC carried out an overview of the expected consequences of climate change between 2020 and 2050 in 2009[8]. The main predictions in Cambodia is that Climate change is expected to result in modifications of the weather patterns in terms of temperature, rainfall and wind, not only in terms of intensity but also in terms of duration and frequency of extreme events;

(a). Mean annual temperatures could increase between 0.3 and 0.6°C by 2025;

(b). The mean annual rainfall in Cambodia will be unchanged or decrease by up to 8%. The largest increase is expected in the wet season, but will also occur in the dry season in Upper Mekong.

[8] C. T. Hoanh, et al. 2010. "Impacts of Climate Change and Development on Mekong Flow Regime. First assessment–2009." *MRC (Mekong River Commission) Technical Paper No. 29 (June)*. Mekong River Commission, Vientiane, Lao Peoples Democratic Republic.

(c). Precipitation increases are projected predominantly in the central agricultural plains stretching from the southeast to the northwest, where rainfall has historically been below the national average; these areas are already vulnerable to floods and drought.

The increased flow in the Mekong River will improve water availability in the dry season, but also increase the risk of floods in the wet season. The areas affected by flooding are estimated to increase by 9%, not including effects of a possible sea level rise. Areas with flooding depths higher than two meters are estimated to increase by almost 40%[9].

Water flow alteration, both in quality and in quantity, has negative impacts on households who are living in the floodplain area of TSL, especially in zone 2 which predominantly relies on agriculture as their main source of income (Arias *et al.*, 2013; Cochrane, Arias and Piman, 2014; MAFF, 2014b). Recently, 6,200 km^2 of rice field were flooded and 3,700 km^2 of paddy were destroyed in 2011.

The damaged proportion reached more than 30% in Sangkae district, located in floodplain area (MAFF, 2012; Battambang Department of Water Resources and Monteorology, 2015). Table 14 shows the statistics of damaged area of rice field in Battambang province in 2011, when there was seriously proned in flooding. Figure in the Table 14 shows that the damanged area in the study area accounted to over 50% of total paddy cultivated area.

Table 14: Rice planting and damaged areas in 2011 rainy season for 14 districts in Battambang province

N^0	**Districts**	**Planting area (ha)**	**Damaged area (ha)**	**Percentage (%)**	**Replanted area (ha)**
1	Banan	28,824	0		0
2	Thmor Koul	64,503	9,456	14.66	2,217
3	Battambang	6,294	0	0	0
4	Borvil	29,850	0	0	0
5	**Aek Phnom**	**11,067**	**5,180**	**53.19**	**1,260**
6	Moung Russey	52,500	10,282	80.41	1,600
7	Ratanak Mondul	4,423	0	0	0
8	**Sangkae**	**32,980**	**10,082**	N/A	**700**
9	Samlaut	2,921	0	0	0
10	Sampao Loun	3,288	0	0	0
11	Phnom Preik	2,500	0	0	0
12	Kamreang	4,652	0	0	0
13	Keas Kralar	20,544	0	0	0
14	Rukhakiri	21,861	0	0	0
	Total	286,207	35,000	87.77	5,777

[9] See the footnote 15

Source: Battambang Department of Planning (Battambang Provincial Departement of Planning, 2015)

3.3. Discussion and Conclusion

Understanding the key drivers of change is essential to capture the causes of these changes. This chapter analysed the linkages between rural livelihood activities and the ecosystem services of TSL from the past to the present. According to this historical background, we identified three main key drivers:

1. Rice and fisheries policy changes, since after Khmer Rouge regime, with the introduction of an agricultural policy (rice encouragement for food security and export), the attempts to organise the conservation of natural resources.
2. Flood pulse changes affected by the climate change and hydrological dam development (Västilä *et al.*, 2010; Kuenzer *et al.*, 2013; Grill *et al.*, 2015; Ji *et al.*, 2018; Hecht *et al.*, 2019).
3. And, lastly,the demographic changes in the study areas as at national level of Cambodia (NIS, 2008b; United Nations, 2013). From the literature review based from various authors and from field surveys, we can assume that the general agricultural context is encouraging agricultural innovations and changes of the management of natural resources by farmers and fishermen.

Since the Angkorian Empire until today, Cambodia has adapted its rice and fish production to changes in its environment.

We could see the farmers have diversified and intensified their cropping systems from one to two cycles per year for sufficient household consumption and market supply. However, at the same time, farmers have faced several issues regarding to new insects and dieases, climate and floodpulse changes, ect…

Cerently, the high yield rice varieties (like Early season, Water receding rice, and Dry season rice) and intensified crops in dry season, are leading crops for supplying domestic consumtion and export, which have increased their production, since the beginning of its boom since around 2001, and now one cycle rice is at around 1/3 of floating rice and long-term rice has be reduced. This decrease of floatting rice surfaces from 1980 to 2005 is well-known trend. Thanks to the increasing of high yield rice varieties production from mainly year 2010s to present, so it convinced the farmers to change to another leading crop.

However, farmers reported that this decrease and inset, and rat destroyed to the rice monoculture due to long dry period and less predators. The issues are affected by the uneven flood pulse and climate change. The study of Keskinen *et al.*, (2010) reported that there is an impact on water resource and flow in lower Mekong reiver and TSL area caused by the climate change. Farmers are aware that changing from one crop to another one does not solve the decrease of the yields, and that they have to change their agricultural practices. They are looking forward external answers because they didn't find yet technical answers; They are reluctant to rotation as there is no market for other crops; they started to use fertilizers and herbicide/pesticide without a good management.

As the population doubled since the collapse of the Khmer Rouge regime in 1979, the tensions on land access soon became sharper. Moreover, powerful people close to the political power could get an easier access to unexploited land resources. This leads to highly demand in double land, foods (maily rice, livestock, and fishery in the areas), social support, and natural resources ustiliation, leads to face increase in crop production, but negatively impact on flooded forest degration, and descrease in fishery compared to household catchment.

On their side, Cambodian fishermen have also demonstrated their own capacity of adaptation.. After a relatively bright era until 1970, when the access to fish intakes was strongly regulated,the production collapsed during the Khmer rouge period, then resumed in 1980.

Governance of the Tonle Sap is complex and has been changing over times from a focus on fishery management and rice exports, based on the commercial exploitation of fishery resources, to community-based fishery management and conservation of biodiversity. Recently, the Royal Government of Cambodia terminated the 100-year-old fishing lot system in the lake and returned the whole lake to open access and conservation.

After the fishing lots termination in 2010, fishing areas have been freely accessible to all fishermen and farmers. The traders become powerful persons in terms of setting up supply and market chains. Profits for the fishermen look reduced. Despite the liberalization of the credit market and the deregulation of the fishing rights, the poor particularly the small fishermen living in marginalized areas such as floating villages and floodplains continue to have limited access to fishery resources, technologies, capital markets, marketing opportunities, and transport infrastructure, etc..

Since the termination of the fishing lots system, deregulation has reduced volumes by competition, and difficulties in access to technology, inputs and services crucial to the improvement of fish value chain .

In conclusion, farmers and fishermen, in the study areas of the Tonle Sap lake, have shown their capacity of adaptation to the institutional and ecological context in which they organise their household livelihood activities, but they have also faced shocks and stress caused by the current changes.

In last decade, there were uncertained land use and land tenure, which caused to unclear land allocaion and distritution. In the meantime, the public institutions of the Royal Government of Cambodia have been progressively reinforced during a first period, with laws organising the access to land and the rights of fishing. This certainly allowed a strong increase of the production, especially of the rice, with cropping systems moving from one crop per year to two crops a year in most of the agroecological situations.

For the fishing, the regulation of the governemtn put in place after the Khmer Rouge collaped, through the allocation of specific fishing lots, has finally led to a complex system of access, with various levels of sub-leasing and numerous opportunities for corruption. While this clearly started to threaten the stock of fishes, the deregulation that was ordered in 2010 certainly not improved the protection of the natural resource. The conflicts over the use of water for irrigating rice and catching fish are still widespread, in particular for the poorest households in term of land and assets. Therefore, the need of still improving the governance over the access to resources is urgently demanded by the local people and communities, and is also required also for the country's sustainable growth.

Chapter IV: The diversity of stakeholders' stategies

4.1. Introduction

Cambodia's small-household farming sector is a central pillar of the larger rural economy. It represents not only a source of livelihoods for around 75% of the population, but it is central to food security, contributing with agricultural production to both subsistence household consumption as well as to the increasing demands of a growing urban population (NIS, 2010). As agents actively shape the land use patterns, which are at the core of many environmental challenges (Erb, 2012), small household farmer-based food systems play a crucial role for sustainability, not only in Cambodia, but also globally (Mayer et al., 2015).

Yet, many small household farmers across Cambodia face nowadays multidimensional challenges in creating and maintaining sustainable rural livelihoods. Hit by a wave of land grabbing, fishery decrease, availability of agricultural land for small household farmers and access to natural resources such as fisheries and forests including flooded forest, wildlife, and that have traditionally supplied them with important livelihood resources, has rapidly declined on the country level (Ear, 2007; Scheidel, Giampietro and Ramos-Martin, 2013; Jiao, Smith-Hall and Theilade, 2015). In spite of small land entitlements, local farming systems are nevertheless required to produce sufficient food for household consumption as well as enough agricultural goods for the market for income generation. While commonly taken development paths, such as green revolution techniques or rural-urban migration to increase incomes with non-farm work, offer some solutions to the challenges of land shortage, they also produce new problems across other dimensions. For example, an increasing use of fertilizers would allow boosting paddy rice yields, which are below Southeast Asian average. However, it also comes along with increasing expenditure on agricultural inputs, which many smallholders in Cambodia cannot afford (Theng, Khiev and Phon, 2014). Moreover, increases in well-known environmental pressures on soils and water bodies follow (Tilman, 1999), as well as rising greenhouse gas emissions through fertilizer and pesticide production and application (Snyder *et al.*, 2009).

Yet, the past household strategies for survival since the 1980s have been partly studied and documented. The floating life of people was investigated by Mak (2001, 2005, 2011, and 2015) to capture the fishing life experience at the level of the households within the communities around the Tonle Sap lake. His study used the sustainable livelihood approach to review all household shocks and stresses to the changes, that are influenced by the levels of household, the social networks, the community,the livelihood development. Piseth (2003) addressed the institutions and

the rules for accessing the natutral resources. From the context of vulnerability and social security perspective; several have focused on conflicts and local vulnerabilities, and overland exploitation (CCHR, 2013). The investigations on systems based on rice and Chamkar crops in the low floodplain of Cambodia were synthetised by Pillot, (2007).

Livelihood of the people is significantly linked to the natural resources, whereas these are available under seasonal cycles. The access to the natural resources –and the benefit from them- both directly and through the ecosystem services they provide, is one very important source of livelihood (Egoh *et al.*, 2008; Fisher, Turner and Morling, 2009). Beyond nature, economic context and policies can create stresses and shocks that impact on the rural life (Millennium Ecosystem Assessment, 2005). Few research scholars suggested that "a livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities, assets and entitlements, while not undermining the natural resource base" (Ellis, 1999; Morse, Mcnamara and Acholo, 2009). Folke *et al.*, (2002) specified that the livelihood strategy could be analysed as attempts to add options, and build buffering ability to deal with perturbations. The small-household livelihoods are built with very complex systems which can be analysed through historical trajectories (Ferraton and Cochet, 2002; Cochet and Devienne, 2006; Barral *et al.*, 2012). Additionally, the capacity to adopt a system that absorbs disturbances and reorganizes itself when there are changes still retain essentially the same function, is also part of the resilience. Hence resilience in the future can be identified as a system's ability to cope with change (Folke *et al.*, 2002).

Fundamental to the sustainability question is whether alternative pathways exist. This chapter aims at understanding the tranformation of livelihoods including all activity systems such as cropping systems, animal systems, fishing systems, non-agricultural activities, and the land use changes, since the Khmer Rough period until present. *In fine*, we expect to provide deep understanding of the strategies to adapt to the key challenges. However, beyond addressing only the challenges faced, we also present a series of innovations, adopted by agricultural and fishing villagers to deal with the challenges.

After having looked at the history of the landuse in the study area, the diversity of the livelihood systems will be reviewed and a typology of the households will be presented.The economic models of each type will be analysed to explain the situation of the householders, especially how the competition over the Tonle Sap's resources generates winners and loosers. At

final of this chapter, we shall also assess the economic capacity of the stakholders to meet the subsistence and reproduction needs, thus highlighting different levels of poverty.

4.2. The Changing Land Use

The study targets three zones I, II, and small part of zone III:

- zone I as permanent flooded water where agricultural and fishery activities take place;
- zone II is considered as land-water zone, more or less subject to the annual flood,
- and lastly zone III on the terrasses that remain out of the flood coming from the Lake..

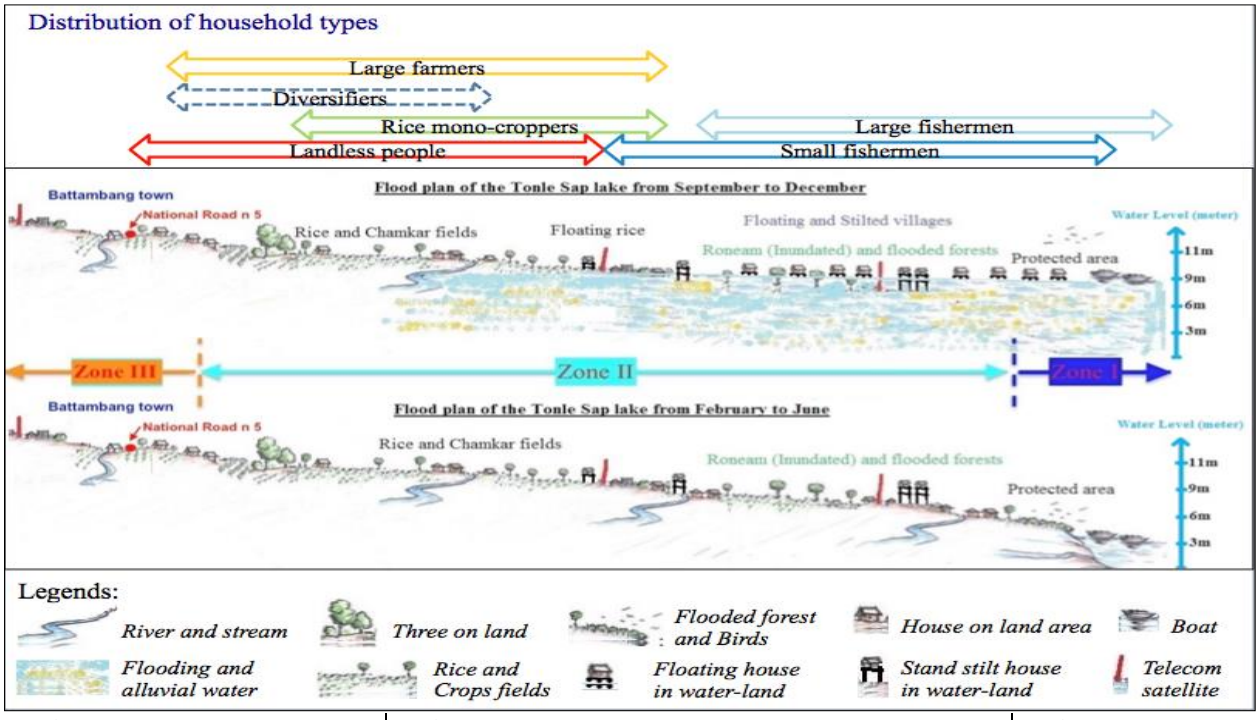
From the landscape observations in the zone II, we note that there are two main topography situations that we shall call “middle land-water”in the upper part, and ” low land-water” in the lowest part. We try to provide an overview of these zones via a transect map in *Illustration 9* ,where the household types is distributed along the topographical profile, together with the variation of the flood in the rainy season and in the dry season.

At first, field observations allow to locate the households and the production zones in the different ecosystems of the floodplain. Economic activities, and livelihood of households, are depend on the location of the villages.

The transect map (Illustration 9) shows that villages in the agricultural are situated relatively close to each other , and that their territory covers both Middle Water-land and Low Water-land fields. This leads to good living conditions for the people who extract benefits from their agricultural activities/productions, typically rice-based cropping systems, cash crops, fishing, animal and aquaculture, and non-farm and off-farm activities.

Indeed, the villages in this agricultural area show a higher living standart and a higher livelihood diversification compared to other villagees in the fishing area. Access to social and public services, like roads, hospital, credit, and agricultural markets is also easier there.

Differently, the fishing villages are located further (between 10 to 32 km) from the NR5. The fishermen irregularly move their residence between rainy and dry season. In fact, large fishermen are mostly living in the villages of the eastern part (Aek Phnom), whereas smaller fishermen are more widespread on the territory. If some of them can be living in the fishing villages of the eastern zone, others may be living in the villages of the agricultural area. Social and public services are limited due to they are located with less and without road during rainy season and few road accesses in dry season.



Rainy Season Zone II and III: Middle water-land or middle field - Agricultural villages and area - Higher altitude - Flood level > 1 m - Cultivated areas for long-term and short-term rice (early season rice and dry season rice), - More Mixed crops and Vegetable Chamkar - More fruit trees and vegetation - Use high chemical fertiliser/lower soil fertility - Less fishing activities	**Rainy Season** Zone II: Low water-land or low field - Agricultural villages and area - Lower altitude - Flood level > 3 m - Cultivated areas for floating rice, long-term rice, receding rice, but less short-term rice (early season rice, and dry season rice) - More Mixed crops and Vegetable Chamkar - Little fruit trees and vegetation - Natural grazing and flood forest land - Use lower chemical fertilisers/higher soil fertility - More fishing activities	**Rainy Season** Zone I: Permanent flooded - Fishing villages and area, more fish in rainy season - Lowest altitude - Flood level <9 m - Bird, fisheries, Wild animals - Ecotourirsm - Flooded forest
Dry Season Zone II and III: Middle water-land or middle field - Agricultural villages and area - Higher attitude - Flood level <0.3 m - Cultivated areas for dry season rice and intensified crops Chamkar - More fruit trees and vegetation - Use high chemical fertiliser/lower soil fertility - Less fishing activities	**Dry Season** Zone II: Low water-land or low field - Agricultural villages and area - Lower attitude - Flood level < 1 m - Cultivated areas for dry season rice and intensified crops Chamkar - Natural grazing and flood forest land - Use lower chemical fertilisers - Higher soil fertility - More fishing activities	**Dry Season** Zone I: Permanent flooded - Fishing villages and area in both season, less fish - Lowest altitude - Flood level <2 m - Bird, fisheries, Wild animals - Ecotourism - Flooded forest

Illustration 9: Dsitribution of househol types and zone characterisation

4.1.1 History of Land Use changes at Rohal Soung Kanglec village in Aek Phnom district (Middle water-land area)

Rohal Soung Khanglec village is located in Prek Norint commune. The Sangke River flows through, which provides a main water source for domestic uses and also to feed into small irrigation systems, especially to irrigate dry season rice. The Sangke Riveralso provides a pathway for the fish to migrate from the TSL to flooded forest, to the open fields and the other river channels in the rainy season. Thus, the Sangke River is a great fishing ground for local people. Illustration 10 illustrates the four maps of land use changes of Rohal Soung Khanlec since after Khmer Rouge regime until now.

- **1980-1995: The first resilience after the Khmer rouge, from the collectivisation of the means of production to the liberalisation**

This period was the one during which the local people recovered year after year from the loss of most of their cattle and equipment during the Khmer rouge regime.

At the end of the Khmer Rouge in 1979, the population in Rohal Soung Kanglec was only of 19 households with 220 people[10]. The main agriculture product at that time was floating rice., Every year the land was flooded up a depth of 5 m in the ricefields and 2.5 m in the villages, so people couldn't grow any other type of rice. Another reason was that local farmers did not have short-cycle varieties yet at this moment, which could have been grown just before of just after the flood.

However, people also growed also some cash crops consisting especially of water melon, corn, cucumber and pumpkin (Kabocha squash) that were sold in small amounts to a nearby market. Sometimes traders could come and buy these commodities directly in the village. Some farmers grew a few vegetables during the rainy season, for family consumption, in spite of difficulties to manage the water level in the river the dry season, since, in the rainy season, . Some of them grew some vegetables but mostly or selling to local villagers, hence in small amounts only.

[10] To be compared to the 284 households in 2015, with 1342 people...

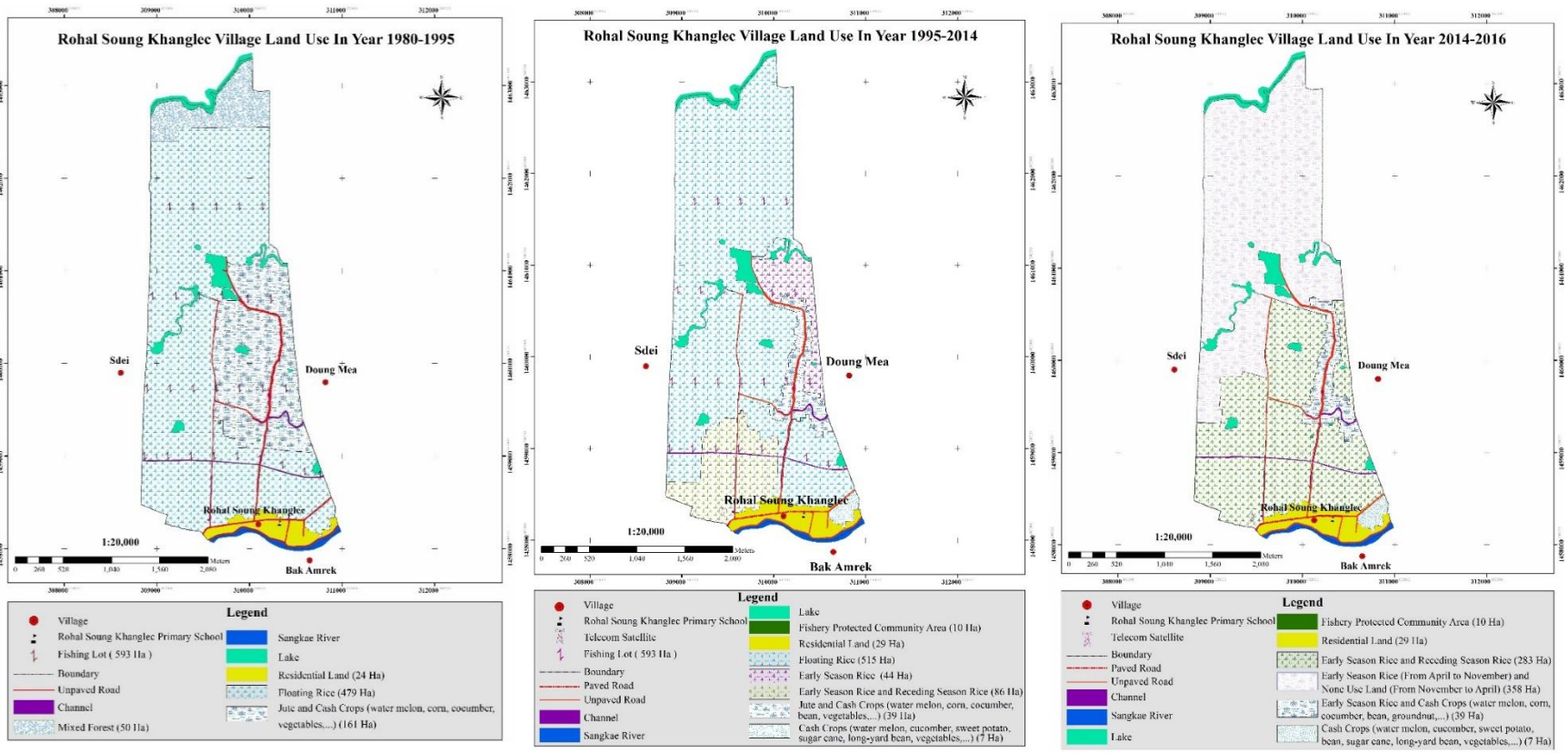


Illustration 10: Land use map of Rohal Soung Kanglec village from 1981 to 2016

Source: Survey 2015-2017

Until 1985 rice cultivation was also done partly in the framework of the cooperative groups of production (*krom samaki*) that the government had put in place at the fall of the Khmer rouge regime (1980). Ploughing equipements had been collectivised, thus the land were ploughed and sown collectively, then it was distributed to be cultivated individually by the families until the harvest.

From 1985, the policy changed when ploughing cattle and equipments started to become more available, the farmers could produce totally individually but they were still obliged to sell to State until 1988. After 1988, the rice market was liberalised and farmers could sell to private traders coming more numerous from Thailand.

The main road was still difficult during the rainy season, but people transported their products by using the Sangkae River instead. The main irrigation canal (created by the Khmer Rouge, before the year 1980) was restored in these times while it was not really used by lack of water pumps. The production was therefore mostly based on the ecosystem services brought by the flood.

- **Second Period 1995-2014: Building differenciation**

After the peace agreements (1991), the population of the village increased more quickly, as a number of returnees came back or settled from outside..

Until 2007, rice cultivation was still mostly based on floating rice. However, progresses in productivity were done when, at the end of the 1990, farmers started to use the hand tractor instead of draught cattle for ploughing the land (only 20 percent used tractor). The harvest remained by hand, whereas well-off farmers more frequently hired laborers from other families, especially for floating rice which was especially difficult and long to harvest. Hiring people in the village was easy then.

Paddy sales mostly depended from external traders (Thailand). Cambodian traders also to buy directly in the village, especially regional millers who had shut off buying the rice from the farmers in 1995. The road was reconstructed and thus became more comfortable for the traders to come and buy the rice, especially after the year 2008 when the price of the rice grew sharply[11]. In the opposite, receding and early rice seeds were exchanged between the farmers rather than they were bought from seed companies.

The sudden rise of the price in 2008 strongly encouraged the intensification of the rice production. The floatting rice was massively abandonned then, to be replaced by a double cycle of short term varieties that could be cultivated before (early season rice) and after the flood (receding rice) instead of during the flood (floating rice). Since the new developed systems were much more demanding in labour that the previous floatting rice, this transformation in turn called for more mechanisation. It also had become less easy to find external labour (the young labour migrated to Thailand or to the big cities to find a job). From the year 2010, farmers started to use combined harvesters, when some people could buy new machinery.

Later, the floating rice land was decreased from around 500 ha to zero, when a fishery protected community area of around 10 ha was created, and when the floating rice tended to be replaced by early season rice and receding season rice before and after the flood respectively, using new short cycle non photoperiodic vareties that had been extended or tha they could buy from eachother: Seinpi-dao, IR66, Senkra Op, OM etc.

Furthermore, farmers also grew cash crops for commerce, especially jute. Even though the State owned jute factory had been closed, still some traders continued to come to buy their products until three years later. Normally, the farmers cultivated the jute in the rainy season whereas, in the dry season, they cultivated other cash crops like melon, corn, cucumber, long bean and sugarcane. Melon, sugarcane and corn used to be sold on foot by contract before harvest, while long bean, cucumber and vegetables were sold after harvest to collectors, who used to come to the village. Some (bigger) farmers sometimes could send their products directly to retailers.

- **Third Period from 2014 until now: diversification and intensification**

After 2014, the farmers definitely changed all their floating rice to cultivate short-term varieties (early season rice and receding season rice). The decrease of the level of the flood was one reason for this change– possibly among others. What is sure is that at this same period, the level of the flood, which until then reached 2.5 m, decreased down to only 0.5 m. Directly linked with the size of the flood, the duration of the flooding period, between the moment the water arrives on the plot and the moment it recedes, also dropped down seriously (the duration varies with the topogaphical position of the plots, but the reduction was general) until a stage when it is not enough for growing the floating rice that takes 5-6 months for giving the yield in each cycle. For that

reason, the farmer changed to grow the new short duration varieties which can be grown two times per year and that , at least in good conditions, give more yield than the floating rice.

In this period however, the farmer grew more rice, cash crops and vegetables since the demand of market increased compared to before. The population indeed grew up, more collectors came to the village, so more marketing opportunities were offered, but now they have more problems of water shortage due to the drought, or less flood. In addition, during this period, farmers have used more pesticides, herbicides, or chemical fertilizers to compensate the decrease of the soil fertility, and more pest and diseases occured.

Table 15 below shows all the land change system of Rohalsoung Khanglec village located on Middle land-water of the zone II.

Table 15: Land use change system in Rohal Soung Kanglec village in Middle land-water

Indicators	**Duration of changes**		
	1980-1995	**1995-2014**	**2014-present**
Population (household)	From rapidly 19 increased to 250	285	320
Residential land (ha)	24	29	29
Agricultural land (ha)	640	690	690
Forest land (ha)	50	Almost 0	Almost 0
Fishing lot (ha)	593	593	0
Fishery Community Protected Area (ha)	0	0	10
Fertiliser use	Own (cow dung)	Own and artificial	Overuse of fertiliser
Technology advance	Simple equipment	Simple equipment + machinery	Modern machineries
Land intensification	The same	The same	Change
Market	No access to better markets	Able to access to better	Able to access to better
Floodwater	Sufficient	Sufficient	Insufficient
Constraints	No and rarely	No and rarely	Flood, drought, diseases, and pest, rat.

4.1.2 History of Land Use change of Beung Teum village in Sangkae district (Low water-land area)

The second village, Beung Teum, is situated in the low-waterland area, one can identify four main periods of land use. However, these periods differ a bit in their time frame. Boeng Teum village was chosen among the three others to better illustrate the changes in local farming systems. It is illustrated by the four maps of land use changes of Beung Teum after Khmer Rouge regime in 1980 presented above in Illustration 11.

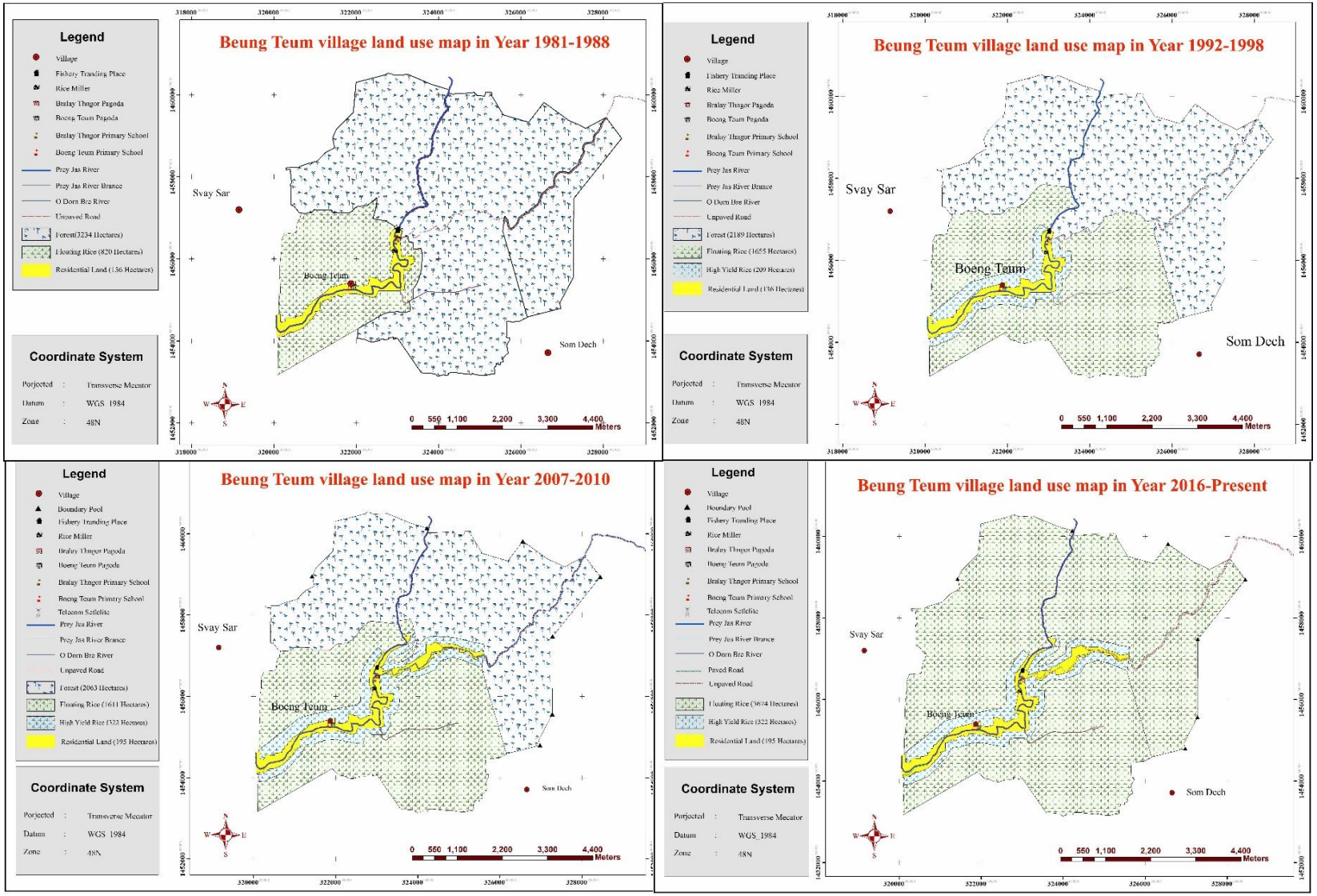


Illustration 11: Land village use map of Beung Teum village from 1981 to 2016

(Source: Survey 2015-2016)

- **First period (1981-1991)**

The first period started in 1981 and lasted around 1991. At that time, there were approximately 215 households in the village with a residential land equal to 136 hectares. From the precise measurements that we did on the field with the elderly villagers, the majority of the land of the village (3,234 ha) was covered by forests, while agricultural land occupied 820 hectares. Like in Rohal Soung Kanglec village, agricultural land was used for floating rice cultivation , at a close distance from the village. People always practised traditional techniques and used internal human resources. . Cattle or buffalos were used as the main draught power , especially for land preparation and transportation of agricultural commodities.

- **Second period (1992-2006)**

During the second period in 1992-2006, the new agricultural policy of the government was implemented in the study area. Beyond the liberalisation of the rice market, which we already saw that it had a strong impact on the market integration of the households, this policy allowed distributing the forestland to farmers for their private agricultural cultivation. As a result, during this time, agricultural land increased mainly for rice cropping systems. Floating rice rapidly rose from 820 to 1,655 hectares (+101%). In the meantime, forest area decreased to 2,189 hectares (-32%) resulting from agricultural land expanding as well as residential land demands driven by rapid population growth. Furthermore, farmers started to cultivate the high-yield rice cropping systems such as early season rice and receding rice on the approximately 209 hectares. The areas of high-yield rice cropping systems was located near the residential area. Compared to the previous period, the infrastructure improved and developed in the village, which provided the availability to farmers to access better to markets for selling their agricultural products and purchasing agricultural inputs such as chemical fertilisers, pesticides and herbicides. Additionally, farmers changed and adopted new technologies using modern agricultural equipment, such as hand tractors, pesticide/herbicide hand sprayers and spraying machines. They still hired tractors from the other villages for their land preparation. These inputs were used particularly for high-yield rice cropping systems such as early season rice and receding rice. Regarding to agricultural adoption, there were approximately 40% of farmers who started to use these kinds of inputs for their rice production. The rice cropping systems still relied mainly on annual floodwater and rainfall in rainy season. For irrigation, the stream Steung Chas located near the village and had played a crucial role in providing fresh water from Tonle Sap Lake to the rice plots.

- **Third period (2007-2010)**

In the third period (2007 – 2010), the inundated forest was continuously cleared due to increasing of demand for agricultural land and population growth. Compared to the previous period, forestland declined by 6% and reached 2,063 hectares. Area for floating rice slightly decreased to 1,611 hectares as farmers have switched to cultivate high-yield rice, such as early season rice and receding rice. High-yield rice cultivated area grown up rapidly by 54.1% to 322 hectares.

Furthermore, the residential land also was expanded to 196 hectares. In this period, farmers still practised the same techniques, but noticeably used more modern machinery, especially tractors and hand tractors. Anyways, they also started to use or to hire external labour in their rice production mostly during the harvesting period. Similarly to the second duration, farmers continued to receive the agricultural technical training from relevant stakeholders as well as have the ability to access to the better market. Regarding to the changes of flood pulse and climate, farmers faced with constraints such as flood, drought, diseases and pest (rats).

- **Fourth period (2011-present)**

The last period after 2011 until the present, the forest in the floodplain areas in Boeng Teum was slashed-and-burned mainly for growing rice and and fishing. As a result, rice fields for rice quickly increased up to 3,674 ha during this period while the high-yield rice land and residential land remained constant. Farmers have practised the same farm techniques as in the previous period, but ultimately they changed their simple agricultural equipment to modern agricultural equipment. They reduced using external labour for harvesting or cultivating with draught cattle to the tractors and harvesting machines that became available for hiring at reasonable price and less time-consuming.

During this period, the farmers are widely able to access to the necessary markets for selling their agricultural products and purchasing the inputs. The number of cattle and buffalos declined. In the meantime, during the last few years, the flood pulse and climate have been drastically changed, which strongly affected on their paddy rice. Particularly their paddy rice was damaged and destroyed by flood, in 2011.

Table 16 below shows all the land change system of Boeng Teum village located on ow land-water of the zone II.

Table 16 : Land use change/system in Boeng Teum village in Low land-water

Indicators	**Duration of changes**			
	1981-1991	**1992-2006**	**2007-2010**	**2011-present**
Population (household)	215	420	630	840
Residential land (ha)	136	136	196	196
Agricultural land (ha)	820	1,864	1,933	3,996
Forest land (ha)	3,234	2,189	2,063	almost 0
Fishing Lot area (ha)	With forest land	With forest land	With forest land	0
Fisery Community Protected Area (ha)	0	0	0	Around 15
Fertiliser use	Own (dung)	Own and artificial	Artificial only	Overuse of fertiliser
Technology advance	Simple equipment	Simple equipment + machinery	Modern machineries	Modern machineries
Land intensification	The same	The same	Change	Change
Market	No access to better markets	Able to access to better	Able to access to better	Able to access to better
Floodwater	Sufficient	Sufficient	Sufficient	Insufficient
Constraints	No	No	Flood, drought, diseases	Flood, drought, diseases, and pest

4.3. Characterization of the major systems of household in the study area

4.3.1 Agricultural systems and household changes since after Khmer Rouge

After the Khmer Rough (KR) regime was taken over by the Vietnamese armies, the country was controlled by Vietnam from 1979 until around 1990. The KR armies and a lot of civil Cambodian people were pushed out up to the areas closed to the Thai border, but not to the lowlands of Cambodia, including the zones of the study area. However, some former Khmer Rouge armies and few civil people were still living in the deep flooded forest of the permanently flooded water zone, occupying the fishing, NTFP and firewood collection, animal grazing and cultivating small floating rice field at that time.

In 1980, the "Krom Samaki" (Solidarity groups) was formed to organise ploughing when there was very little draught cattle, on collective rice fields until 1983. At that moment, the government started to distribute land to each individual farmer in the whole country. There has been no record of the distributed surface to people even though this task was managed by the public authorities. Stakeholders and correspondents reported that government distributed land, giving official land ownership of "residential land" on about one Rai (0.16 ha) per family, while 3 to 5

ha of paddy field per family were allocated with an occupation right and not a full property. People who had started to immigrate from the refugee camps near the Thailand border were also given rights over land. They mainly practiced the rice mono-culture and fishing as the main sources of income.

Around 1985 to 1986, government even created more "Krom Samaki" (Solidarity group) to integrate officially the remaining Khmer rouge soldiers to civil life. The population increased again due to repatriation, which led to generate struggles for the land access especially in the natural forest resource area.

In 1989, because of the chaotic land tenure situation resulting from the previous political upheavals, the government updated the land tenure code in 1989. The land ownership documents ruling before 1979 were cancelled. The land was redistributed on the basis of one Rai (0.16 ha) of residential land in full ownership and around 3 ha per family in use right for the cultivation. However, the local administrations most often failed to provide the official land ownership documents, hence most of the farmers who had logged the flooded forest to increase their holding remained unofficial holders. Small business and other non-farm activities were not big at that time. Floating rice and fishing activities in permanent flooded water were still the most important source of food and income. There was a consistent risk of flood during the rainy season and drought in the dry season. Generally, agricultural infrastructure that was built during the KR regime was very useful at that time.

At the same period, the RGC permitted officially the return to private control rights on fishing lots, which was aimed at natural resources protection and conservation, and at better controlling the supply for fish demand. Likely, this was also seen to be a mechanism for creating income opportunities for the new immigrants and the former-KR soldiers, and a source of taxation for the state. But in fact, the co-leaders of Krom Samaki (Solidarity Groups) were the first to get the new lots, while common farmers could still only access to fishing and paddy rice cultivation in the permanent land, outside the fishing lots areas. When their villages were located in the fishing lot areas, most of small fishermen families sold their labour force to the fishing lot owners or sub-leasees.

Until during this period, people did not diversify their activities with multiple systems of activity, they mostly worked on one single cropping or fishing system, according to their individual household capacity. In all zones of the study area, long-term rice, floating rice and jute production

were commonly cultivated, whereas vegetable home gardens completed the family consumption. Non-farm and off-farm activities were limited

From around the 1990s, Non-Governmental Organizations and Public extension services started to introduced High Yield Varieties of paddy rice to farmers in some upland areas close to national road, where farmers could access to irrigated water. Their cultivation was not really successful there, since they required quite a lot of fertilisation and the pumping costs were high in the dry season, when the water level was low.

However, these varieties, which where short cycle and non photoperiodic character, could extend in a larger area. Around the Lake, some farmers started to use them at other moments than the rainy season when, up to then, rice was traditionnally cultivated, and where pumping and irrigation was easy.

- Either in three months time *before* the flood (i.e. April to July): this system being called as "early season rice" : the rainfalls can bring a part of the water required but complementaty irrigation is required, which can come from pumping from canals connected to the lake.
- Either in three months time *after* the flood, when the water receids: this system, called "receding rice" requires full irrigation since the rains have stopped at that moment. The exact moment the flood receides being earlier in the upper part of the topographic profile, and later in the lower part. The exact period of this new cropping could vary slightly: transplantation occuring between end of August until October and harvest between October and December.

Both systems are sometimes combined with a traditional wet season rice. It is then qualified of "second rice" or double cropping. However, the traditional rice (floating and wet season rice) have been reduced more and more. Simultaneously, local farmers who had invested in HYRs cultivation increased the use of chemical inputs.

In 2007, the jute factory, established since the French colonial period, bankrupted. Replacing the income from the jute certainly encouraged farmers to replace the floating rice by double rice cycle cropping systems combining early season rice and water receding rice. These also drove the farmers to deserve other incomes from non-farm and off-farm activities.

In 2010, RGC decided to terminate the allocation of fishing lots to private contractors, and to move these zones to public access to the resources , while a system of authorizations over controlled community conservation zones zones was supposed to allow conservation. However, it might have low margin to the local fishermen and farmers in the present since the fishery have

been degraded. The issue also drove the fishermen to undertake other non-farm and off-farm activities to diversify their incomes.

4.3.2 Rice-based cropping systems and their patterns

The rice farmers' livelihoods are organized around the cultivation of rice in the early wet season (early season rice), the wet season (floating, long-term, medium, and short-term rices) and dry season (receding) rice, combined with fishing, fish processing, fish marketing, and with the collection of forest products and firewood, aquatic fisheries and animals (including insect and wild animal) and plants. A livelihood pulse follows the annual flood pulse, with the livelihoods closely connected with the annual hydrological cycle of the lake. Different rice varieties are cultivated in the study area.

4.3.2.1 Short-term rices

The cycle of these rices is around 2.5 to 3 months duration. The first cropping system bases on short term rices is the Early Season Rice (ESR) . The second is the Water Receding Rice (WRR), and the third is the Dry Season Rice (DSR). The three are cultivated currently in the whole study zone 2 where there is accessible.

The cultivation of the *Early Season Rice (ESR)* happens during the rainy season from April to July or early August. At that moment , the rains are still uneven, and therefore complementary irrigation is needed most of the time for the cultivation of the ESR.

The *Water Receding rice (WRR),* in most of the cases, catches the the flood (and its sediments) when it returns back to the Tonle Sap. The land preparation starts in late August or early September and harvest occures in December or early January. It is produced in the Middle water-land fields of the zone II. Since a part of the water needs is caught from the natural flood at the beginning of the cycle, this system does not require as much irrigation water as when the rice is cultivated in the full dry season.

The *Dry Season Rice* (DSR) is cultivated from January to late March. Since there is no rain at this period, full irigation is then compulsory. This cultivationt can only be done where irrigation systems or natural ponds or waterways make water available at the moment the lake's system is at its lowest elevation.



Illustration 12: Short-term rice paddy field in rainy season in the study area
Source: PhD survey in 2015-2016

We found that there is no important difference in the technical practices between the early season rice, the water receding rice, and the dry season rice, technically and economically.

All can be cultivated in the same areas (middle water-land and low water-land), with the same varieties, with the same technical itineraries (complementary irrigation needed), and as we shall see later, they present very similar economic results.

Therefore, we simplify further the description of the results by considering together, in Middle water-land and Low water-land , early season rice, water receding rice and dry season rice, in one unique category.

- Between these three possible possible systems characterised by a single harvest per year, several combinations can be done for generating *double cropping systems* that combine two cycles on the same plot per year. These double cropping systems are more land-productive because of the double harvest.
- Succession of *early season rice and water receding rice (ESR&WRR)*.
- Succession of *early season rice and dry season rice (ESR&DSR)* on one parcel is the most frequent system that includes *dry season rice* (dry season rice is rarely cultivated without an early rice).

Succession of an *early season rice,* as first cycle, and cash crops as the second cycle (such as Mungbean, Water Melon, Soybean, Sesame, ground nut, and maize, and farmers may cultivate

on very small plot of vegetable), can exist. It is defined by our study as an *early season rice and intensified crops Chamkar (ESR&Inten-crops)*. Generally then, the early season rice technical itineraries are very similarto the normal *Early Season Rice*, meaning farmers start the land preparation in around Mid-April and harvest in late July. They then mostly keep their land uncultivated until November or early December, so that they avoid the most heavy rains, and they start the second cycle only then. This cropping system limited closed to plots situated close to the irrigation system since the access to water is compulsory for the second cycle, and most often necessary for the first.

All these short-term rice cropping systems use a lot of chemical inputs recommended by Thailand and Vietnamese businessmen who sell inputs packages consisting of seeds and chemical inputs.

4.3.2.2 Rainy season/Heavy/Long-term rice cropping systems

Rainy season rice cropping systems correspond to the traditional rice production. Within this category, there are two main groups, corresponding to two different cycles: one Medium maturity and another Long/late maturity.

Medium Term rice is a traditional rice in this region for household consumption and local cakes in national events line in the Water Festival in November. This rice is called medium duration of maturity with 120 to 150 days of life cycle and its flowering time is between 10th and 15th October since it is sawn in May–June (see

Table 18) and it is photoperiodic. This rice is mostly cultivated in Middle Water-land fields of the zone II (> 90%) because it can't bear deep water for long time. Meanwhile, we also find this rice in Low Water-land fields of the zone II where water is not high. In some cases, it can be followed by a *dry season rice*, then making it a double rice cropping system.

Heavy rice is the common name for long cycle varieties (more than 5 months)that can be cultivated in all fields of the zone II. Thanks to their long straw, long cycle varieties can survive with a water depth up to 60 to 70 cm at the maximum of the flood. Most of these varietiesstart in April and end in December. Direct seedling is predominantly practiced where the water is low in early rainy season since there it can be sown on muddy land. Elsewhere, transplanting is adopted for the zone 2 and some lowland in zone 1 where they can transplant in 20 to 30 cm of water height.

Since workers become rare in the region, farmers more and more prefer direct seeding, when it is possible.

Other varieties, with less straw can also be cultivated as second cycle after an early season rice. It is then sown around early August and harvested in late December with the same practices of land preparation and weeding.

Illustration 13 shows an image of heavy rice being cultivated in early rainy season in the study area, when it is not yet covered by the flood .



Illustration 13: Long-term or Heavy Rice paddy field in early rainy season (on left) and around mid- rainy season (on right) in the study area

Source: PhD survey in 2015-2016

Technically and economically, we found that there is no important difference between medium and late maturity rices with regard to the technical practices, and it performs also the same economic results. Therefore, we decided to consider them together in one single category namely long-term rice [LTR].

Since labour becomes rare in that region, farmer commonly use direct seeding at 97% while the transplanting is only around 3% . Transplanting requires to prepare a nursery, which requires much more attention to weeds control to facilitate the germination. It then requires labour for the transplantation (20 to 30 persons-day/ha) , against 1 man-day/ha for the direct seeding. Fianally, due to the photoperiodic character of the varieties cultivated during the monsson, transplanting needs to be done no later than the first week of September to give enough time for the vegetation otherwise the yield will be reduced Hence, farmers only choose to transplant when they are late or

when the water floods their land earlier than expected and that they could not have the time to saw directly before.

In the heavy rice cropping systems, farmers do not use much chemical inputs. We met only few farmers who use herbicide or/and pesticide when it is needed and fertilizers “when they have money”.

4.3.2.3 Deepwater or Floating rice cropping systems

Floating rice is one rice system where submergence in-depth usually exceeds 100 cm and continues for durations of more than 5 months. Theses rice varieties can elongate their stem up to 8 cm/day when the flood comes so that they keep their leaves above the surface of water and escape drowning. These cropping systems are also flexible enough to face unpredictable environmental changes, such as drought or overflooding. Since a large part of the dry matter produced is actually used in building the long straw, the yields in grains are generally much lower than the short cycle varieties, but the labour required is also limited.

Floating rice is a cropping system of the rainy season. However we consider it separately from the long term rice since it is adapted to the deep water lowlands of the zone II.

This rice cropping system is the most extensive one that requires little labour and capital. As soon as at the first rains come, farmers start ploughing land two times in order to incorporate weeds into the soil and let them decompose inside. After harrowing, they sow the seed in April or lately in May and wait for harvesting in December. Since 2006, some farmers have started to use herbicide instead of ploughing two times. This rice cropping system is the most resistant to high floods but is however risky due to possible damages by the rats who can climb on the straw to eat the panicle. In the Illustration 14 shows an image of floating rice field under 1.6 metters of water level in the study area was naturally flooded by Tonle Sap water in around August and early September.



Illustration 14: Floating rice paddy field in rainy season in the study area
Source: PhD survey in 2015-2016

Because it is cultivated wher the water is deep during the flood, floatting rice can cultivated where with fishing can also be done at that period. During the fishing lots period from 1980 to 2010, it is more exact to say that the fishing lots were attributed in the floatting rice area than to say that the floating rice is cultivated in the fishing lot areas: the floating rice was there long before the government started to allocate fishing rights. Since then, year after year, it has been replaced by long-term rice, medium-term rice, and short-term rice.

4.3.2.4 Synthesis about the rice based cropping systems of the area

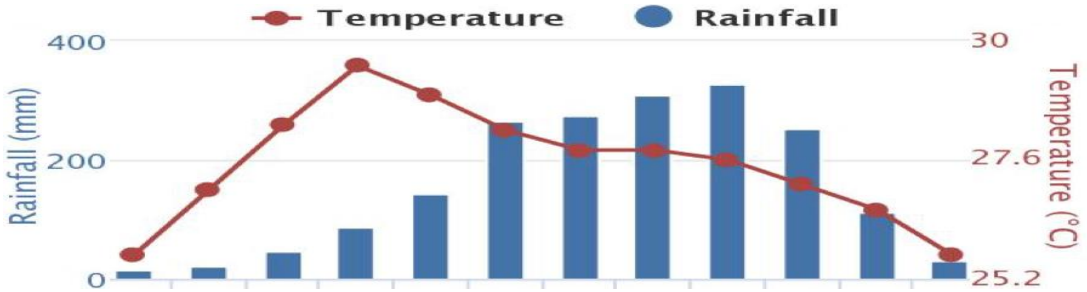
To conclude on this question, eight different rice based cropping systems as identified in the Table 17 below.

Table 17: Summary of rice cropping systems in the study area

Category of rice cropping system partterns	**Rice cropping systems**
One cycle	1. Long-term rice with direct-seedling (LTR)
	2. Early season rice (ESR)
	3. Floating Rice (FR)
	4. Water Receding rice (WRR)
Two/Double cycle	5. Early season rice + Receding rice (ESR&WRR)
	6. Early season rice + Dry Season rice (ESR&DSR)
	7. Early season rice + Long-term rice (ESR&LTR)
	8. Early season rice + Intensified crops Chamkar (ESR&LTR)

Table 18 below summarises the calendar of practices of one cycle and double rice cycle cropping systems in rainy and dry seasons, in parallel with temperature and rainfall patttern.

Table 18: Rice cropping calender and climatic pattern in Battambang



Period and Season		Dry Season				Rainy Season						Dry Season	
	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One cycle cropping systems	FR					LP; So	W; M (water adjustment)						H
	LTR					LP; So	F; I; W; M (water adjustment)						H
	ESR				LP; So	F; I; W; M			H				
	WRR									LP; So	F; I; W; M		H
	Corn	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	Groundnut	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	Soybean	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	Mung bean	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	Sesame	LP; So	F; I; W; M		H								
Two/ Double cycle systems	ESR&LTR					LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	ESR&WRR					LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
	ESR&DSR	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H				
	ESR&Inten-crops	F; I; W; M			H		LP; So	F; I; W; M		H			LP; So

Legends:
LP = land preparation**; N** = Nursery**; So** = Sowing**; T** = Transplanting**; W** = Weeding**; H** = Harvest**; F** = Fertilization**; I** = Insecticide**; M** = Maintaining (Water adjustment)

Table 19 lists the numerous rice varieties cultivated in the above systems. Three kinds of rice cropping systems are cultivated in in the Middle-Water land and Low-Water land: long-term rice, early season rice and dry season rice. Anyway, there are five rice cropping systems: long-term rice, early season rice, receding rice, early season rice with dry season rice and floating rice, which are cultivated in Low-Water land.

There are just only three kinds of rice cropping system such as long-term rice, early season rice, and early season rice with dry season rice existing in Middle-Water land. Figure 10 shows that in the Low Water-land fields, the highest number of one cycle rice cropping systems is floating rice (64%), long-term rice (73%), and water receding rice (35%), but with less short-term rice (around 30%). Only from 20 to 30% of the farmers grow double rice cropping systems in these areas.

Table 19: Rice varieties released during in the study area from 1980 to 2016

Agro- ecosystems	Sub-divided groups and pratices	Type of rice varieties	
Lowland rice	**Early maturity** ○ (Duration 2.5 to 3 months) - Short-term rice in rainy season - Dry season/irrigated rice; - Water Receding rice	1. IR52 2. IR66 3. IR72 4. IR104 5. KRU 6. IR Kesar 7. Baray 8. IR OM	9. Chul'sa 10. Rohat 11. Rumpe 12. Plis Brang 13. Damneorb Brang 14. Kramom Yuon 15. San Kra Orb
	Medium Maturity ○ Duration 3.5 to 4.5 months ○ Practices; - Medium-term rice in rainy season - Water Receding rice *Note: these three varieties are premium and aromatic*	16. Santepheap1 17. Santepheap2 18. Santepheap3 19. Popoul 20. Sarika 21. Phka Rumchek 22. Phka Rumchang 23. Phka Rumduol 24. Kroab Troab 25. Neang Long 26. Pka Dong 27. Pka Lmeang 28. Pka Molis	29. Pka Kgnei 30. Rangchey 31. CAR1 32. CAR2 33. CAR3 34. CAR11 35. Pka Rudoul (Jamin) 36. Sen Pidao 37. Neang Gnouy 38. Somaly 39. Chanvay Pdao 40. Krajak Chab
	Late Maturity ○ Duration 5 to 5.5 months ○ Practices; - Medium-term rice in rainy season - Water Receding rice	41. CAR4 42. CAR5 43. CAR6 44. CAR7 45. CAR8 46. CAR9 47. CAR12 48. CAR13 49. Kong Khsach	50. Phka Sla 51. Neang Khorn 52. Neang Mao 53. Gnoa Prum 54. Damneorb Kmao (Balck sticky) 55. Kamping Pouy 56. Ort Chmous
Deepwater rice/floating rice	**Very Late Maturity** ○ Duration 5.5 to 6 months ○ Practices; - Floating rice in rainy season	57. Don 58. Khao Ta Pech 59. Te Wada 60. Sa Gnek 61. Sa Chhampa 62. Gnok Gnorgn	63. Neang Leay 64. Romlong Phnom 65. Veal Veng 66. Sa Krajol 67. Sa Kragnagn

Source: Surveys 2014 to 2016

Our main assumption is that the technical itineraries of these cropping systems are related to the water management. Under deep water conditions during the flood, farmers do not have much choice but cultivating extensive systems with one crop/year and with varieties adapted to high water level. Where the water is not so deep and more easily managed, farmers more easily intensify by using short cycle varieties and moving to double cropping. In the Figure 10 below shows that Long-term rice and Floating rice were cultivated more in Low water-land area. And the Double cycle rice were cultivated more in Middle water-land area, where they can access to water and irrigation system.

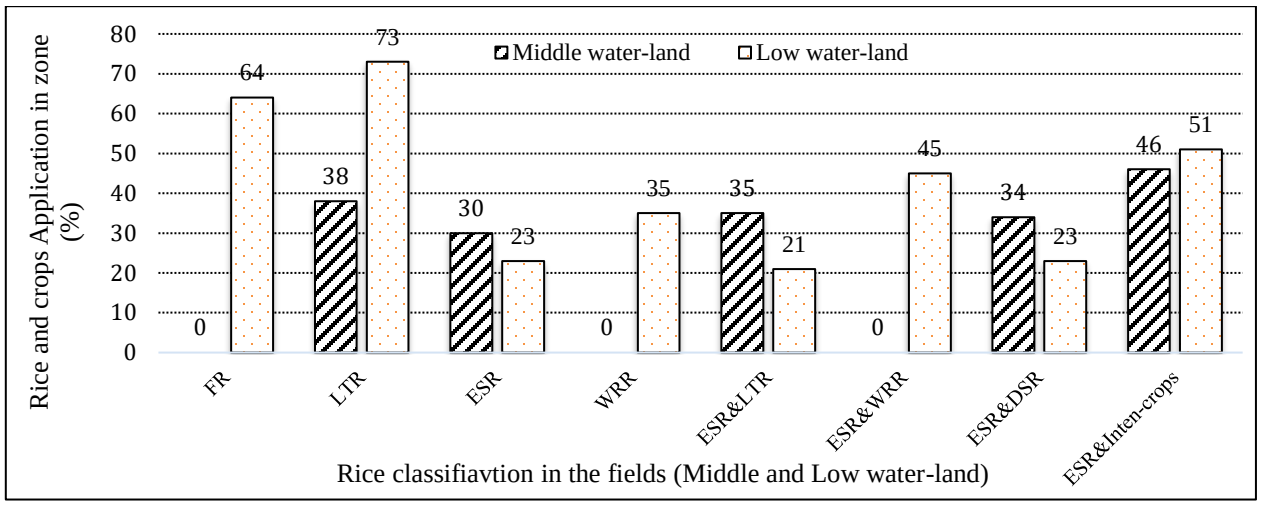


Figure 10: Rice and crops application in the zone

4.3.2.5 The constraints, changes and economic comparison of rice cropping systems

Figure 11 represents the limitations of the rice production as they are perceived by farmers in the two agro-ecological zones. Farmers identify five main challenges in their rice cropping systems: drought, flood, pest (rats), insects and weeds.

The majority of farmers in Low water-land have faced main constraints such as drought (87%), pests (85%) and flood (86%), while 86%, 65% and 67% in Middle-water land also face the same challenges. Since the other constraints could be controlled by farmers, the farmers in Low water-land faced with insect (19%) and weed (8%) against 3% and 6% in the Middle water-land. Thus, farmers in Low water-land area are more vulnerable than farmers in the Middle water-land and they also face higher rat constraints. Figure 11 illustrates the percentage of each of the main challenges to the different rice crops in the recent years, as perceived by the local farmers.

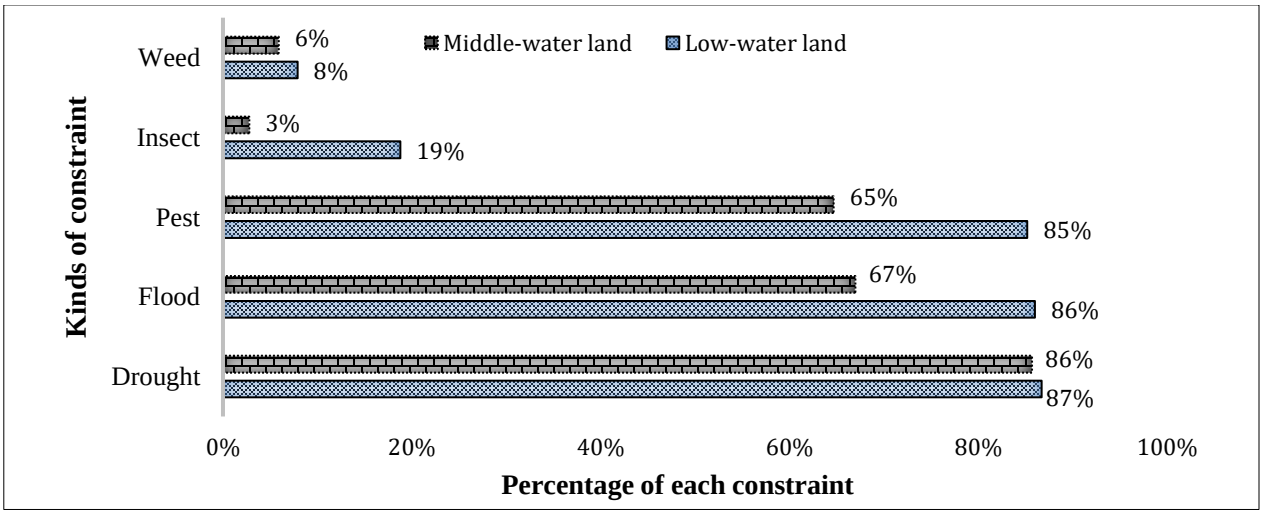


Figure 11: Farmers' perception of the main constraints in rice production in both study areas

4.3.3 The other activities of the farming systems: non-rice crops, animal husbandry, non-farm and off-farm activities

In this part of our study, we introduce the other activity systems of the agrarian system: mixed crops and vegetable chamkar cropping systems, fishing systems, aquaculture, animal rearing (livestock and poultry) and other non-farm and off-farm activities that are part of the complete farming systems.

4.3.3.1 Mixed Crops and Vegetables Chamkar cropping systems

As we have seen in the previous section on rice and intensified crops, "chamkar" corresponds to the fields that are not inundated at the rainy season, nor by the rain nor by the flood, and where cash crops can be cultivated.

On these plots, we can find *Mixed Crops and Vegetables Chamkar (Double Chamkar [DC])*, cultivated with several cycles per year on the same plot. It is represented on small lands (mean size is 0,48 ha/household) located on the hills where it is never flooded by water, but close to the channel or irrigation system. Two different subsystems can be identified; one that we call *Monoculture Chamkar* and second named *Rotation Chamkar*. For more detail, see Table 20.

Table 20: Calender of Double crops and vegetables and fruit trees

Period and Season		Dry Season				Rainy Season						Dry Season	
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mixed Crops and vegetables Chamkar	Monoculture					LP; So	F; I; W; M			H			
	Rotation	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H	LP; So	F; I; W; M		H
Fruit trees	Banana	H	H		P	H	P	H		H	H	H	H
	Coconut				H	H							
	Sapodilla	H	H	H									H
	Custard Apple				H	H	H						
	Mango			H	H	H							
	Others		H		H		H	H	H		H	H	H

Legends:
LP = land preparation**; N** = Nursery**; So** = Sowing**; T** = Transplanting**; W** = Weeding**; H** = Harvest**; F** = Fertilization**; I** = Insecticide**; M** = Maintaining (Water adjustment)**; Fe** = Feeding**; C** = Take care (Looking after; Treatment.etc)**; S** = Selling**; S** = Selling**; High** = High peak of yield and activities**; Low** = Low peak of yield and activities**; High Fishing** = High peak of yield and activities**; Low Fishing** = Low peak of yield and activities**;**

The *Monoculture Chamkar* is a single mixes crops like egg-plant, mung bean, maize, water melon, chilly, and other small vegetables, mostly for household consumption and small sellings on

the local markets. It is cultivated in the rainy season: starting land preparation in May and harvesting after 3- 4 months . After that, farmers keep the land fallow during the dry season.

Another pattern consists of cultivating the different species by bands, one band being installed after the other (see Table 20 and Table 21). The cultivation land area is of an average surface of 0.20 ha/household. When it is done surrounded by fruit tree on the sides of the home yard, it also can be called “home garden Chamkar”. However, finally the rotation performs almost the same economic results, leading us to group the two monoculture and rotation Chamkar systems in one single type.

Table 21 shows the cropping patterns of double cash crops and vegetables Chamkar cropping systems related to the farmers’s strategy and their area of land use.

Table 21 : Cropping patterns of double cash crops and vegetables: related farmers and areas

Kind of Chamkar	**Type of double Chamkar**	**Cropping pattern**	**Related farmers [44 households)**		**Area**
			Number	**Percentage of land area used (%)**	**Average of total land area (ha)**
Mixed crops and Vegetable Chamkar or Double Chamkar	Monoculture	Eeg plant/Mung bean/**0** **	2	13%	0.3
		Sugar cane/maize/**0** **	1	15%	1
		Mung bean/Eggplant/**0** **	2	11%	0.5
		Mung bean/Maize/**0** **	4	14%	1.3
		Water melon/Jute/maize/**0** **	3	18%	0.36
		Groundnut/maize/**0** **	2	13%	
		Jute/Water melon/Eggplant/Cabbage/ Chilly/ Cucumber/ Long yard been/others/**0** **	2	5%	0.5
		Total monoculture	**16**	**89%**	**4**
	Rotation	Eggplant/Cabbage/Chilly/ Cucumber/ Long yard been/ lemon grass/tomato/ garlic, cauliflower, salad others	10	5%	0.16
		Mung bean/Maize	8	10%	0.36
		Mung bean/Maize/ Groundnut/Sesame	6	8%	0.48
		Sesame/maize/sweet potato	4	12%	0.5
		Total monoculture	**28**	**35%**	**2**
**** 0 =** Fallow (Leave land free for a moment, more in dry season when there is no water availability)					

In the specific areas, close to a river, with hydromorphic or black sandy soils, some farmers also grow vegetables (onions, cabbages, garlic, cauliflower, salad).

This activity has developed on the last 10 years, and is very profitable and lucrative, but it is as well a very risky.:

- High cost of inputs (the seeds),
- A lot of insects attacks issues,
- The production is quickly perishable,
- The market is not stable.

In opposition with the flooded areas, farmers do not mention a fertility decrease on the soil of the chamcars. It could be linked with the use of animal manure on those relatively less extended plots, which are also close to the pasture areas.

Beside the annual crops, farmers have developed as well perennial crops systems since the 1990s. First, few trees were planted around the house for the self consumption, but when farmers can invest in irrigation and small machinary or equipment, mango, coconut trees, banana trees could be more systematically planted. But very few farmers invest immediately on maize and sugar cane, getting their income during the vegetative period from association with annual crops (groundnut, sesame, chilly) or from perennials (papaya). Illustration 15 shows an image of intensified crops cultivated in dry season after the first cycle of rice.



Illustration 15: Intensified crops field in dry season in the study area
Source: PhD survey in 2015-2016

4.3.3.2 Animal husbandry and Aquaculture: a profitable living capital and consumption

- Animal husbandry

Cattle had a specific function just after the Khmer rouge period for the ploughing the lands and as a living capital. With the increase of the urban population, the markets for beef meat became more lucrative. As well, taking care of cattle is almost at no cost and without a lot of work as they were fed most of the time on natural pastures.

Cattle are most generally kept by children with a sharing system between neighbours. The sharing system can itself include two different options: in the first option, landless families provide two to three children to look after other households' cattle. With generally from 10 to 30 heads, they can earn 500 Khmer Riels (0.12 USD) per day. In the second system, cattle owners look in turn after their cattle, in this case, they don't have to pay each other.

The only costs in these systems is the reproduction cost, which is as well not expensive as it is a natural reproduction. Now, most of the farmers explain that they "they don't have time to manage any animal husbandry because they are very busy with rice production, Chamkar, and other non-farm and off-farm activities in the recent day". On the contrary, we observe that Rice mono-croppers households have more cows than the other households.

The reason is that these households produce floating rice with only one cycle per year, and thus they have little to do during the dry season: therefore, they have more time to look after the cows in the fallows of the floating paddy fields, and to give them additiontal rice straw and grass. During the rainy season, cattle are released in the grazing areas mostly in zone I and small part of zone II. Illustration 16 shows an image of free cattle raising in rice field in the study.



Illustration 16: Cattle in rice field in early rainy season in the study area
Source: PhD survey in 2015-2016

For the farmers, cattle represent a good opportunity to save and build the capital to invest later in additional land, or to cover exceptional health expenses . Generally, they have about 3 to 4 cows, then sell the old ones and keep the female and young cows for reproduction. The cows give birth every year. Generrally, they stay close to the pastures area and can therefore manage their cattle more easily.

Poultry (chicken and ducks) are the most represented animals in the area after the cows. This husbandary does not performs high margin, but it allows farmers to secure their money needs when they face urgent requirements. But it does not exceed the self-consumption goal as farmers do not have more than 20 chickens. The reason seems to be the low profitability.

Farmer can also decide to undertake pig rearing. They most generally breed through an extensive way. The feeding is done with local banana trees and weeds collected in the fields, added to crops by-products together with the kitchen waste and with broken rice.

- **Aquaculture**

Crocodiles rearing is the most represented form of aquaculture, performed by large fishermen households, who live in the permanent flooded area of zone I. This production requires regular guardians, strong wooden and iron cave, meat foods, and high investments for starting production, while the other households can not do so.

The large fishermen generally provide dead fish that they catch from the Tonle Sap river, and sometimes buy trapped rats from the farmers during the dry season. The crocodiles are reared for a whole year. The products are the meat (150 to 500 USD/head) and the eggs (5 to 35USD/egg) sold to middlemen in Siem Reap. Breeders can also keep a young adult crocodile for reproduction.

Smaller units of production (5 to 10 heads) can be found among the Large farmers household types, who have capacity to face higher costs of production for buying feed such as rats and fish, but it does not give high profit as much as the Large fishermen's rearing. The Illustration 17 shows image of baby and adult crocodile rearing in the study area.



Illustration 17: Baby (on left) and Adult (on right) crocodile in the study area
Source: PhD survey in 2015-2016

Fish rearing is done mostly by the large fishermen, while this rearing become the second benefit sources for this household type. Similarly to the previous, they feed the fishes with their death fisheries that they found from the river as well as from wastes from the crocodile rearing. It is however a limited activity. It could not be done by general people, which costly and hilgh labour force, but also requires more firm material and guardient every day. Generally, the larger scale of fish rearing is located in low water-land area compared to land area, where fishermen can mange the water and foods better.

Table 22 summarizes the main activities in the animal husbandry and aquaculture in full year from Dry season to Wet season.

Table 22: Calendar of animal rearing and Aquaculture

Period and Season		**Dry Season**				**Rainy Season**						**Dry Season**	
	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Animal husbandry and Aqua-culture	Fish	Fe; C		S				Fe; C		S		Fe; C	S
	Crocodile	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S
	Gee	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S
	Cattle	S	Fe; C		S		Fe; C		S		Fe; C		S		
	Buffalos	Fe; C			S	Fe; C		S		Fe; C		S		Fe; C	
	Sow pig	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S e	Fe; C	S	Fe; C	S
	Fat pig	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S
	Chicken	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S
	Duk	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S	Fe; C	S

Legend:
LP = land preparation**; N** = Nursery**; So** = Sowing**; T** = Transplanting**g; W** = Weeding**; H** = Harvest**; F** = Fertilization**; I** = Insecticide**; M** = Maintaining (Water adjustment)**; Fe** = Feeding**; C** = Take care (Looking after; Treatment.etc)**; S** = Selling

4.3.3.3 Fishing activities

Fishing activities can be classified into three main categories of size: *small scale fishing*, *non-specified fishing*, and *large scale fishing* (Table 23).

Table 23: Calendar of fishing activities

Period and Season		Dry Season				Rainy Season						Dry Season	
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish-ing	Big scale- Fishing	Fishing High; S	Fishing low; S							Fishing high; S			
	Small Scale- Fishing	Fishing low; S								Fishing high; S			
	Non-specified Fish	Fishing low; S								Fishing high; S			
	Gee	High; S			Low; S						High; S		
	Snail & Crab	Low; S				High; S						Low; S	
	Cricket & Insect		High; S				Low; S				High; S		
	Mice/Rat	High; S			Low; S						High; S		
	Frog	Low; S						High; S					

Legends:
S = Selling**; High** = High peak of yield and activities**; Low** = Low peak of yield and activities**; Fishing High** = High peak of yield and activities**; Fishing Low** = Low peak of yield and activities**;**

Small-scale fishing comes from catching fishes both on the lake and inland. It is performed by households who live on the floating and stand-stilt villages in the fishing area of zone I, but some also live in the agricultural area of the zone II. Particularly, the small fishermen do more and only catch fish.

They complement this activity by collecting eels, snails, crabs, crickets, frogs, snakes, and rats, and also wildlife (turtles, bees, birds,..) on the lake. The small fishermen go for fishing with very limited fishing tools: fishing nets, fending nets, folks, bamboo traps. Their boat does not have engine, but they go to the deep flooded forest during the whole year.

Non-specified fishing activities correspond to the supplementary fishing activities that some farmers may do during the periods of lower activity in the fields . Generally, farmers go for fishing in the area not far from their village, where they can go and return by small boat in one or two days. They use almost the same fishing tools as the Small fishermen.

The duration of non-specified fishing is shorter, only or mostly in rainy season, than the fishing done by Small and large-scale fishing. Both farmers and fishermen catch and sell their fish immediately to the traders. And they keep some for their daily food consumption and fish fermentation processing for the coming year.

Large-scale fishing refers to the fishing activities which require big fishing tools and machineries such as motorboat, big fishing lot fence system with pens (Nor Rav) and long fishing nets, etc. It also requires high investments to start the production. These fishing activities can be done by the powerful people who have good connections with certain authorities, who can allow them to openly practice a theoretically illegal fishing.

The large scale fishing can be done significantly in the fish peak season at the rainy season when the water tides up to upperland area around late August, and recedes back to Tonle Sap in late November or early December. The catches decrease in the dry season. The large fishermen generally sell 80% of their fish catches to traders, and keep 19% for crocodile and fish rearing, and the rest less than 1% for household consumption and local market.

In the Illustration 18 shows some imanges of fhsing activities in the study area.



Illustration 18: Fishing activities at fishig villages in rainy season in the study area
Source: PhD survey in 2015-2016

4.3.3.4 Non-agricultural (Non-farm and Off-farm) activities

Beyond their agricultural and fishing activities, farmers and fishermen have also diversified their incomes with *non-agricultual activities* (Non-farm & Off-farm).

Non-farm activities can be defined as all activities associated with waged work or self-employment in income generating activities (including income in-kind) outside agriculture and fisheries.

Off-farm activities can be defined as a portion of farm income that household obtains from agriculture and fisheries but from outside the household's farm per se, like selling labour to other farms, or transforming the africultural products or doing short-term business from the products harvesgted. Migration is also considered as an off –farm business, provided the migrants remain engaged in their own farm. So, the migration to Battambang town, Siem Reap, Phnom Penh, other provinces, and Thailand can be considered as Non&Off-farms activities because: the migrants generate the income from their job and send remittances back to the family for maintaining the farms and daily households' expenses in the villages.

Among the farmers we interviewed, 100% of them had Non&Off-farm activities. Around 30 to 60% of their total income was generated by these activities. In the agricultural villages, the Non&Off-farms activities were more diversified. Table below provided summry of the Non-agriculutral job in the study area. Table 24 provides highlited summary of all non-agriculutral activities done by by local household in the study with more detail below.

Table 24: Summary of Non-farm and Off-farm activities

Kind of Activity	Name of Non-farm and Off-farm activities	Location of the activity	Classifica-tion of income	% per house-hold	Most done by households
Agricultura l land rent	Rent of Chamkar land	Local	High *	0.67%	Large farmers
	Rent of Paddy land	Local	Medium *	0.85%	Large farmers, Diversifiers
Small and medium Business	Grocery and Local petty trading (including petroleum street seller)	Local	High	13%	Large farmers, Large fishermen, Diversifiers
	Garage	Local	High	1%	Large farmers, Large fishermen
	Intermediary	Local	High	1%	Large farmers
	Rice mill	Local	High	0.3%	Large farmers
	Mechanic	Local	High	1%	Large farmers, Diversifiers, Large fishermen
	Small fish trade	Local	High	15%	Rice mono-croppers, Small fishermen
	Agri-input seller	Local	Medium	0.4%	Large farmers, Large fishermen
	Palm collector	Local	High	1.8%	Rice mono-croppers
Services	Agri-wage labourer	Local	Low *	38%	Rice mono-croppers, Diversifiers, Small fishermen
	Hand tractor/tractor Rent	Local	Medium	8%	Large farmers, Diversifiers
	Masonry	Local	Low	0.3%	Rice mono-croppers, Diversifiers, Small fishermen

	Barber	Local	Low	0.5%	Rice mono-croppers, Diversifiers, Small fishermen
	Tailor	Local	Low	2.3%	Rice mono-croppers, Diversifiers, Lrage farmer
	Cows guard keeper	Local	Low	0.3%	Rice mono-croppers, Diversifiers
	Carpenter	Local	Low	0.4%	Rice mono-croppers, Diversifiers, Large farmers
	Construction worker	Local/ Battambang	Low	15.3%	Rice mono-croppers, Diversifiers
	Local food seller	Local	Low	1.8%	Diversifiers
	Moto taxi	Local	Medium	0.56%	Rice mono-croppers
	Port worker (*Kamakar Yeur*)	Local	Low	2.3%	Small fishermen
	Other daily workers (restaurant/market/ect)	Local/ Battambang	Low	28%	Rice mono-croppers, Diversifiers
	Junk collectors	Local	Low	0.28%	Rice mono-croppers, Diversifiers
Production	Roof panels production	Local	High	0.1%	Large farmers, Outsiders
	Local cakes cooking	Local	High	1.2%	Rice mono-croppers, Small fishermen
	Wood coal	Local	High	2.3%	Rice mono-croppers, Small fishermen
	Fermented Fish processing	Local	Medium	9.8%	Rice mono-croppers, Diversifiers, Small fishermen
Salary and migration Jobs	Primary school teacher	Local	Medium	0.28%	Diversifiers, Large farmers
	Nurse/Doctor/midwife	Local	High	0.2%	Outsiders
	Boat driver	Local	Medium	0.56%	Rice mono-croppers, Small fishermen
	Car driver	Local	Medium	0.2%	Rice mono-croppers, Diversifiers, Small fishermen
	NGO officer	Local	High	0.1%	Diversifiers, Large farmers, Outsiders
	MFI officer	Local	High	0.1%	Outsiders
	Civil servants	Local	High	0.89%	Diversifiers, Large farmers, Outsiders
	Textile industry/Garment employee	Phnom Penh, Siem reap	Medium	32%	Rice mono-croppers, Diversifiers, Small fishermen
	Textile industry/Garment employee	Khmer-Thai border	Medium	56.5%	Rice mono-croppers, Diversifiers, Small fishermen
	Workers (Construction/Mart/restaurant)	Khmer-Thai border	Medium	45%	Rice mono-croppers, Diversifiers, Small fishermen
	Unidentified Workers	Thailand	High	52%	Rice mono-croppers, Diversifiers, Small fishermen

***** Level of income is identified based on daily income wage that people earn locally per day with average 25,000 riels/day (6.10USD/day), if it would be higher or lower than average of wage, it was considered as a high or lower income.

- **<u>Small and medium business activities:</u>**

Grocery, garage and petty trading are implemented about 13% of total households according to the strategic location of the house for such a small and medium business. This kind of business generates an income of 100 to 250 USD/month to the households such as Large famers (along the road) and Large fishermen (along the river bank). It has a huge impact on the total income of the household, but it is sensitive to the competition, which is in progress in both villages (see Table 24 above). These businesses are implemented by the medium and large farmers.

The diversification as service providers is also done by the richest farmers. They hire out their hand-tractor or tractor, which provides a very high income. They can also build a warehouse and are strong enough to borrow cash from the local banks (such as Prasak, Hatha Kasekar,

ACLEDA, LOLC microfinance). They can as well build a drying area with cookers systems, and are a direct partner with agro-industrials.

Fishing trade is also one among the high implantation and income generation for the medium and rich people, but it is also high competitive and sensitive business due to the increasing number of trader. 15% of total households have implanted this business, especially Large farmers and Large fishermen, which generated an income about 200 500 USD/month. The way they trade the fish at lower price than on the market and provide loan at the same time seems like a trap to the poor small fishermen households. The rest of business implanted by local people are small with 0.2 to 2% of the total households with income about 50 to 150 USD/month.

- **Selling labour services**

Before the development of the double rice cultivation and the fishing lot termination, all interviewees confirm that there was more labour exchanged. When the rice was diversified to double cycle, the use of tractors, hand-tractor, threshers, and harvesters increased sharply, and the exchanges of labour services decreased accordingly. After that the fishing lots were terminated in 2010, the demand for labour by the big fishermen alsodecreased sharply. Consequence of this double movement, a number of individuals have prefered to leave the household to find alternative income elsewhere, especially in emigration. The remaining households have diversified their small services; selling labour in agriculture about 38% of them, and workin in the construction in Battambang city for about 28% of them.

- **Formal employement and migration:**

Few people have a formal job in Aek Phnom and Sangkea; like a contract as NGO staff, as schoolteacher, trading rice. The income generate from these jobs is high in comparison with the agricultural incomes, but they are rare.

On the contrary, wee found that one third of family members have emigrated to other cities (Khmer-Thai border, Phnom Penh, and Siem Reap cities) and Thailand (very few to South Korea and Japan), to work in the textile industries and garment factories, or as daily workers in restaurants (see Table 24 above). A level of remittance is found differently between the migrant to Cambodian cities and to Thailand or other counties; the one to two migrants to Cambodian cities can send about

40 to 75 USD/month; while the same migrants to Thailand or other countries send about 85 to 150 USD/month.

The migrations can also impact negatively the labour availability in the farm, while only olders run the farm alone, and mostly organise hiring machineries from the service providers. The migration is increasing from year to year, the young and young adult have left at least 1 to 2 people of total family members to find migratory works in other areas of Cambodia and abroad. Our calculations are that by now about 45 to 60% of total youth and adult have left the villages. This trend happens in both agricultural and fishing villages, and it seems that most of the migrants are permanently leaving without or rarely returning back to their villages.

4.4. Economic output of the major systems of household activities

The economic evaluation of systems of household activities (cropping systems, animal husbandry systems, fishing systems and non-farm/off-farm activities) aims at determining value-added by the farmer and fishermen households. It relates these results to the quantity of production factors (e.g. land, capital and labour) that were mobilised in the production process. Even though creating this value-added is not the only reason that governs the decision that one specific stakeholder can take, households are always concerned by the input costs and returns of all production systems to decide on the choice of their systems.

In this analysis, the two main indicators that are mainly used to compare the efficiency of the cropping systems are land and labour productivities, and intermediate and labour costs (investment), while comparing these to the total annual income and labour productivity of the animal husbandry, aquaculture, and fishing activities. However, we do not calculate any labour productivity for the non-farm and off-farm activities due to the fact that these activities are too diverse, complex systems, and only worth marginal comparison, while one is not the same as others. Obviously, we can only assess the level of income from each non-farm and off-farm activities that can enlighten the capacity and the strategy of the household types in the following chapter.

4.4.1 Economic comparison of rice based and cash crops based cropping systems

Table 25 provides comparision of the cropping systems identified above on the four main economic parameters that can contribute to explain the choices and decisions taken by the various categories of farmers: land productivity, labour productivity, investment costs and labour costs.

Table 25: Economic results of rice and crops cropping systems

Items	One cycle cropping				Double cycle cropping				
	FR [37 HH]	LTR [64 HH]	ESR [79 HH]	WRR [15 HH]	ESR&LTR [12 HH]	ESR&WRR [30 HH]	ESR&DSR [12 HH]	ESR&Inten-crops [12 HH]	DC [44 HH]
Total land size (ha)	**74**	**124**	**269**	**32**	**36**	**58**	**19**	**8**	**35**
Total Gross Output [GO] (USD)	22,906	43,912	93,802	14,919	14,237	34,305	9,704	8,424	46,847
Total Intermediate Cost [IC] (USD)	**6,759**	**21,395**	**49,103**	**5,998**	**6,928**	**19,080**	**7,070**	**1,851**	**9,529**
Seed (USD)	2,591	5,348	20,247	2,506	2,478	5,038	1,502	712	3,283
Hand tractor/ Tractor (USD)	2,147	4,855	8,143	618	1,710	3,438	1,635	325	2,215
Harvestor (USD)	930	4,672	10,008	1,567	996	4,968	1,744	35	61
Thresher (USD)	92	772	488	84	156	48	52	8	326
Fertilizer (USD)	38	4,258	7,808	700	1,353	3,786	1,270	302	1,207
Herbicide and Insecticide (USD)	212	1,287	2,404	524	213	1,802	868	469	2,438
Rental land (USD)	750	203	6	0	23	0	0	0	0
Total Labor Cost [LC] (USD)	**7,604**	**18,233**	**21,774**	**4,750**	**6,775**	**11,859**	**3,827**	**4,979**	**16,636**
Land preparation (USD)	656	1,790	4,953	769	753	1,528	511	232	877
Sowing/Planting (USD)	509	1,481	3,069	349	593	1,111	356	400	1,740
Weeding (USD)	-	4,119	5,784	2,856	1,688	5,269	1,029	209	792
Harvest & Threshing& Transportation (USD)	6,440	10,843	7,969	776	3,741	3,950	1,931	4,138	13,226
Total number of labour (mnd)	**2,964**	**3,175**	**7,969**	**741**	**1,378**	**2,653**	**837**	**829**	**4,329**
GVA [GO - IC]	16,147	22,517	44,698	8,921	7,310	15,224	2,634	6,574	37,318
Land productivity (USD/ha)	**217**	**181**	**166**	**281**	**202**	**262**	**137**	**794**	**1,061**
Labour productivity (USD/mnd)	5	7	6	12	5	6	3	8	9
Intermediate Cost [IC] (USD/ha)	**91**	**172**	**182**	**189**	**191**	**328**	**367**	**223**	**271**
Labour Cost [LC] (USD/ha)	102	147	81	150	187	204	198	601	473
Required labour (mnd/ha)	**40**	**26**	**30**	**23**	**38**	**46**	**43**	**100**	**123**
Net Income (USD/ha)	115	34	85	131	15	58	62	193	588
Total gross output (USD/ha)	**308**	**353**	**348**	**470**	**393**	**590**	**503**	**1,017**	**1,332**
Total intermediate cost (USD/ha)	91	172	182	189	191	328	367	223	271
GVA (USD/ha)	**217**	**181**	**166**	**281**	**202**	**262**	**137**	**794**	**1,061**
Total Income/household/Year (USD/HH/Year)	436	352	566	595	609	507	220	548	848

Legends: FR = Floating Rice; **LTR** = Long-term Rice; **ESR** = Early season rice; **WRR** = Water Receding Rice; **ESR&LTR** = Early Season Rice& Long-term rice; **ESR** = Early Season Rice& Water-Receding Rice; **ESR&DSR** = Early Season Rice& Dry Season Rice; **ESR&Inten-crops** = Early Season Rice& Intensified Chamkar; DC = Mixed Crops and Vegetables/ Double Chamkar;

Based on the result in table above, the *Mixed crops and vegetables Chamkar* or *Double Chamkar* is currently the system that brings the highest gross value-added per unit of land, and also the highest labour productivity: 1061 USD/ha and 9 USD/man-day, respectively.

This is also a system that is the most requiring in cash advance (271 USD/ha), when we consider together the hired labour and the intermediate costs. In comparison, the land productivity of the *Double Crops* and *Vegetables Chamkar* is twice the one cycle and double cycle systems, a half time more than the productivity of the paddy fields. This high return explains why farmers have been interested in this Chamkar system. However, this production system requires much labour intensive, high technical level, and water availability for regular irrigation. Not many farmers are able to do it due to water constraints, and can only do it on very small plots. As said, it is commonly cultivated in or near home yard to easily access to pond or well water.

Secondly, *Early season rice and intensified crops Chamkar* is the following system that brings higher the gross value-added and higher labour per unit of land productivity: 794 USD/ha and 8 USD/man-day. This system also requires low cash advance (only 223 USD/ha), which is very low compared to the costs of other rice and crop systems.

Both these results that explain that farmers have shifted from their one rice cycle cropping systems tos to double cycle cropping systems. This also explains that the one rice cycle cropping systems could not provide enough income since the year 1990 when the number of family members had doubled.

Thirdly, *water receding rice* and *early season rice and water receding rice* cropping systems are also the systems that bring high gross value-added per unit of land and very high labour productivity (even higher then the two previous systems): 281 USD/ha and 12 USD/ man-day for only water receding rice (262 USD/ha and 6 USD/ man-day). The cash advance of *water receding rice* is low (189 USD/ha), while the early season and water receding rice is double (328 USD/ha). This system is seen one of this the most profitable among the rice cropping systems, a reason why farmers have shifted from traditional rice like floating rice and heavy rice to the water receding rice one. The *water receding rice* system does not require labour intensification and techniques, and it drives to reduce the cost of production. By contrast, *double cycle of early season rice and water receding rice* requires higher input costs such as chemical fertilizer and insecticide, and higher labour.

We were confirmed that, 10 years ago, this double rice system brought a gross value-added of about 600 USD/ha, with a yield 4.5 to 5 tons/ha, but this yield has decreased down to 2.5 tons/ha for the last 4 years, due to the changes in the environment.

Fourthly, *floating rice cropping systems* offer a somehow moderate gross value-added per unit of land whereas it offers a good labour productivity (217 USD/ha and 5 USD/man-day). The cash advance is very low (91 USD/ha). This system seems interesting for the farmers with large lands but low capital (or giving priority to other uses of their capital)

Lastly, the lowest productive rice cropping systems are the one cycle long-term rice and all double cycle short-term rices such as *early season rice, early season rice and long-term rice,* and *early season rice and dry season rice,* which bring low gross value added (from 137 to 160 USD/ha) and low labour productivity (from 3 to 5 USD/man-day), which is even lower than the local labour wage (25,000 Riel = 6.10 USD/day). These systems offered higher returns in the period 2000 to 2013, when the soil fertility was higher. But since then, with a higher crop intensity without fallow, added to the decrease of the siltation from the flood, more more pesticides and chemical fertilizer are now used, which in turn increase the cost of production.

Such a low return make these systems highly fragile for at least two reasons:

- The first one is that there is no reason why the yields of rice should be sustainable on the long term. Rice has been cultivated on poor soils, with less siltation, and without fallow. It can only require more and more chemical fertilizersin the future, generating higher production costs and lower returns for farmers.

- The second reason is high labour costs in all rice production systems represent the main share of the costs of production (from 100 to 200 USD/ha). Even though the land productivity is high, the net income corresponding to rice is low (the highest being 115 USD/ha with the extensive floating rice, and others are very low, even the net income of early season rice and dry season rice is a loss of 62 USD/ha).

We can conclude that, for the households who use a lot of external labour, the future of these systemswill be very sensible to the price of the labour. Such an evolution has already startedon the last five years.. In the case the labour price continues to rise, the profitability of these systems would certainly drop down at a level that would probably mean their collapse, unless mechanisation or subsidisation of the inputs would reduce these costs.

4.4.2 Economic comparison of animal husbandry, agriculture, and fishing systems

4.4.2.1 Economic result of animal husbandry systems

Turn to the economic comparison of the animal husbandry systems, the study analyses the total economic results of the combination of livestock and poultry rearing.

As shown in Table 26, the animal husbandry systems do not currently offer high total annual income per household, neither labour productivity: 600 USD/HH/year and 4.73 USD/man-day respectively. These systems however can still represent a good additional source of family income. For the farmers, cows represent a good opportunity to save money for buying land or to be able to face urgent expenses like health care. Poultry (chicken and ducks) are the most represented animals in the area after the cows for feeding their family daily foods. This husbandry performs not very high margin, but it makes farmers secure for their urgent needs. With the medium income and labour productivity, it contributes to reducing the daily food expenses.

Table 26: Economic results of Animal husbandry/production and Aquaculture

Items	**Ani-Pro** [188 HHs]	**Aqua-Rearing** [35 HHs]
Total Gross Output [GO] (USD)	135,021	77,210
Total Intermediate Cost [IC] (USD)	21,915	27,006
Forage and Feed Cost (USD)	16,611	12,821
Vaccination (USD)	479	407
Treatment and Deworming (USD)	532	2,092
Purchased Animal/Breeding (USD)	4,089	9,979
Other expenses (USD)	203	1,709
Total Labour Cost [LC] (USD)	119,675	22,205
Total number of labour (mnd)	23,935	4,441
GVA [GO - IC]	113,107	50,204
Labour productivity (USD/mnd)	4.73	11.30
Toal Income/household/Year (USD/HH/Year)	601.63	1,434.39
Legends: **Ani-Pro =** Animal Production; **Aqua-Rearing =** Aquaculture Rearing		

Finally, this explains that animal husbandry does not largely exceed the self-consumption goal and that it does not not extend to larger scale. . Farmers decide to keep husbandry depending the capacity of their households, when they have availabilities of labour and pastures, and when these are not in competition with other activities.

4.4.2.2 Economic result of aquaculture rearing systems

Contrary to those of the cropping systems, the economic outputs of the aquaculture and fishing systems cannot be presented per unit of land. Instead, we calculate the total added value per household. Table 26 shows that aquaculture system bring very good total annual income for household and high labour productivity: 1,434 USD/HH/year and 11.30 USD/man-day.

Crocodile is the most represented in the aquaculture rearing both in the agricultural area and in the permanent flooded area, where fishermen are able to find fish, rats, and other wild animals for feeding their animals. With the high income and labour productivity, farmers and fishermen may have advantage expanding this system to larger scales, when they may have access to the required fishery resources for feeds.

4.4.2.3 Economic results of fishing activity systems

The economic results shown in Table 27 indicate that *Large scale fishing system* offers higher returns than the small scale and non-specified fishing systems.

Table 27: Economic results of Small scale, Large scale, and Non-specified fishing

Items	SSF [49 HHs]	LSF [23 HHs]	NSF [147 HHs]
Total Gross Output-GO (USD)	49,665	109,456	303,751
Total Intermediate Cost [IC] (USD)	11,932	25,701	59,919
Petrol (USD)	2,861	8,141	23,095
Buying and Repaired fishing tools (USD)	6,267	4,742	28,254
Fish bait (USD)	44	200	80
Others (USD)	228	8,018	2,859
Depreciation of tools (boat machine) (USD)	2,533	4,600	5,631
Total Labour Cost-LC (USD)	39,595	24,150	99,665
Total number of labour (mnd)	7,919	4,830	19,933
GVA(GO-IC)	37,733	83,755	243,833
Labour productivity (USD/mnd)	**4.76**	**17.34**	**12.23**
Income/household/Year (USD/HH/Year)	770.07	3,641.52	1,658.73

Legends:
SSF = Small Scale Fishing; **LSF** = Large Scale Fishing; **NSF** = Non-Specified Fishing

The large-scale fishing brings the highest income for production per household, and also the highest labour productivity: 3,641 USD/household and 17.34 USD/man-day, respectively. However, this production is the most requiring in cash advance (3,000 to 8,500 USD for the starting production, with maintenance costs (fixing a damaged net, machineries, and other tools) around 3,000 USD every year, when we consider together the hired labour and the intermediate costs. In comparison, the return income and labour productivity of the *Large scale fishing system* is twice the *non-specified fishing* done by the farmers, and three times of the income from *small fishing* done by the small fishermen.

This high return explain that fishermen have been interested in fishing systems, which generate the most profit for their family. Indeed, historically, it also explains that former fishing lot owners and sub-leasees rarely intended to invest in their fishing and sub-fishing lots. Even

though, many scholars discuss that fisheries in Tonle Sap have been degraded and some species are endangered, which impacts negatively on livelihood.

However, the current economic return results are still already high, and what was obtained during the fishing lot period was certanly even higher. The high return also explains that it has negative impact on the fishery resources themselves, since it encourages to intensify and expand the catches even more. it also explains that these fishermen did not drop off/stop this activity when the fishing lots were terminated.

Secondly, *non-specified fishing* system is the second highest fishing system that brings total income per household and a labour productivity of 1,658 USD/household and 12.23 USD/man-day respectively. According to our survey, this system also requires low cash advance (only 200 to 500 USD/year), which is very low compared large-scale fishing systems. With the highest economic return and labor productivity, it explains that the diversification of farming into non specific fisheries is a very important source of income for the local people.

On the economic point of view, the medium and rich people have been relying on this activity for their progressive growth since long time ago. The labour productivity from this *non-specified fishing* system makes people stay in the farm without having to migrate to find other jobs.

Lastly, the lowest return among the fishing systems is for the *small-scale fishing*and: 770 USD/HH of income return to household and only 4.76 USD/man-day of labour productivity. The low income and labour productivity indicate that the sustainability of this system is at stake in the future, especially when the fish resources decrease:

4.5. Characterization and Economic strategyes of household types

Based on the surveys and interviews, we identified six types of household. One type correspond to landless people; three types correspond to farmers, who can be distinguished by their different cropping strategies, whereas the last two types correspond to fishermen. All of them have diferent trend of lives across the same period of times.

Table 28 below summaries the historical background of the finding household types and their evolution from the end of the Khmer Rouge period until today. The description of individual household paths of accumulation from the past until today is addressed in more details in the following sections of this chapter.

Table 28: Historical characteristics of the household types and strategies

Typology of household (Past years)	Past Activities	Current Activities	Typology of household (Present)
Former Rice farmer (large majority are Khmer people)	• Floating and heavy rice in rain season • Small vegetable and cash crops Chamkar at home garden • Fishing	• No agricultural land • Small home vegetable Chamkar • Selling labour • Migration	**Landless people**
	• Floating and heavy rice in rain season • Small vegetable and cash crops Chamkar at home garden • Fishing	• Floating and heavy rice • Small vegetable and cash crops Chamkar at home garden • Fishing • Selling labour • Migration	**Single croppers**
	• Floating and heavy rice • Small vegetable and cash crops Chamkar • Fishing • Small business	• Heavy rice or Long-term rice • Two cycle rice; - Early season rice and Long-term rice, - Early season rice and Water Receding rice, - Early season rice Dry season rice, - Early season rice intensified Chamkar - Double crops Chamkar • Selling labour • Small local business and high rate of migration	**Diversifiers**
	• Floating rice and heavy rice • Small vegetable and cash crops Chamkar • Fishing • Small business • Member of Solidarity group or commune council or village chief • Medium and high business	• Heavy rice or Long-term rice • Two cycle rice; - Early season rice with Long-term rice, - Early season rice with Water Receding rice, - Early season rice and Dry season rice, - Early season rice with intensified Chamkar, - Double crops and vegetables Chamkar • Civil servants/commune council or village chief • Small/Medium business in agricultural villages • Low rate of migration	**Large farmers**
Fishermen and workers of fishing lot	• Working (selling labor) fishing lot • Fishing	• Small scale fishing • Selling labour • Migration	**Small-Scale fishermen**
Fishermen (large majority are Vietnames origine)	• Owner of fishing lot • Sub-leasees of Fishing lot • Member of Solidarity group or commune council or village chief • Fishing	• Big scale fishing • Crocodile and fish rearing • Small/Medium business in fishing village	**Large-Scale fishermen**

Based on these results, we can identify household types that group together the current household strategies. This helps to better explain the individual historical household situation from the past until present, and their current decisions taken by the households to support their

individual family needs from today towards. We found that there were four households have strong background from rice-based production systems, while there were two households from fishing system. Unlikely, the trend explained that their households have various results to become stronger, while other become week and to worse. The results of household's charateristic and ecnomics strategies will be descriped in more detail in each household sessions. Yet, a Table 29 below summarizes the characteristics of all six household types and the current the classification of farm strategies.

Table 29: Summary of the characteristics of the six household types identified.

Landless people: Investment on non-farm and off-farm activities.
- Agricultural land: 0 ha.
- Family member: 5
- Depend on fishery, selling labor and migration.
- The need to get more land and income from other sources for ensuring enough income.

Diversifiers: Diversification of two cycles of rainy season and dry rice crops combined intensified and double Chamkar crop fishery, and non-farm and off-farm activities.
- Agricultural land: 2.5 ha with 2 to 3 plots of paddy located in high land closed to irrigation.
- Family member: 5
- High capacity in labor in mobilization working on intensified and double Chamkar crops with rice based cropping system.
- Capital accumulation by focusing on rainy season rice, fishing, and with low non-farm and off-farm activities include migration
- The need to get more land and income from other sources for ensuring enough income.

Large farmers: Diversification of two cycles of rainy and dry season rice crops combined intensified and double Chamkar crop fishery, and non-farm and off-farm activities.
- Agricultural land: 5.3 ha with 3 to 8 plots of paddy located in low land to up-land water area.
- Family member: 6
- High capacity in labor in mobilization working on intensified Chamkar crops with rice based cropping system.
- Capital accumulation by focusing on rainy season rice, fishing, and with high non-farm and off-farm activities include migration.
- High investment on rice production systems.

Single croppers: Investment on one long-term rainy season rice crops combined with fishery, and non-farm and off-farm activities.
- Agricultural land: 2.4ha with 2 to 4 plots of paddy located in deep plot on the low water-land area further from residential land and near the flooded/inundated forest.
- Family member: 5
- High capacity in selling and sharing labor to/with others farmers
- Capital accumulation by focusing on rainy season rice, fishing, and with low non-farm and off-farm activities include migration
- The need to get more land and income from other sources for ensuring enough income.

Small fishermen: Investment on fishery production, and selling labor and migraton.
- Agricultural land: 0 ha.
- Family member: 5
- Low capacity in labor in mobilization working on small fishing system and selling labor to large fisherman and rice farmers.
- Depend on fishery, and with non-farm and off-farm activities include migration.
- The need to get more land and income from other sources for ensuring enough income.

Large fishermen: Investment on fishery production, and non-farm and off-farm activities.
- Agricultural land: 0.3 ha in Siem Reap *(Rare)*
- Family member: 5
- High capacity in labor in mobilization working on intensified fishing system and selling labor to large fisherman and rice farmers.
- Depend on fishery, and with non-farm and off-farm activities include migration.
- The need to get more land and income from other sources for ensuring enough income.

To provide more edvident of economic strategies of the houhosehold types, the Table 44 summerizs and presents the contributions of the various activities to the total income of the

households, while the net income is calculated by substacting the household's consumtion/expenditures (it is given more detail in session 4.9). The household's economic strategies is providing in the intergrated description in each household type session.

Table 30: Summary of Absolute and relative income by household types.

Income category	**Landless people (N=29)**		**Single croppers (N=76)**		**Diversifiers (N=109)**		**Large farmers (N=52)**		**Small fishermen (N=55)**		**Large fishermen (N=25)**	
	Income (USD/ Year)	Percentage (%)	Income (USD/ Year)	Percentage (%)	Income (USD/ Year)	Percentage (%)	Income (USD/ Year)	Percentage (%)	Income (USD/ Year)	Percentage (%)	Income (USD/ Year)	Percentage (%)
A. Household income[a] (A= 1+2+3+4+5+6)	**2,088**	**100**	**3,454**	**100**	**4,006**	**100**	**5,163**	**100**	**2,208**	**100**	**7,352**	**100**
1. Crops	**0**	**0**	**1,189**	**34**	**748**	**19**	**2,666**	**52**	**0**	**0**	**0**	**0**
Floating Rice	0	N/A	414	N/A	-	N/A	162	N/A	0	N/A	0	N/A
Long-term Rice	0	N/A	437	N/A	-	N/A	285	N/A	0	N/A	0	N/A
Early Season Rice	0	N/A	-	N/A	389	N/A	1,195	N/A	0	N/A	0	N/A
Water Receding Rice	0	N/A	171	N/A	21	N/A	338	N/A	0	N/A	0	N/A
Early Season Rice and Long-term Rice	0	N/A	-	N/A	-	N/A	176	N/A	0	N/A	0	N/A
Early Season Rice and Water Receding Rice	0	N/A	-	N/A	5	N/A	394	N/A	0	N/A	0	N/A
Early Season Rice and Dry Season Rice	0	N/A	-	N/A	13	N/A	116	N/A	0	N/A	0	N/A
Early Season Rice and Intensified Crops	0	N/A	-	N/A	63	N/A	-	N/A	0	N/A	0	N/A
Double crop and vegetable Chamkar	0	N/A	166	N/A	257	N/A	-	N/A	0	N/A	0	N/A
2. Livestock and Poutry	**225**	**11**	**542**	**16**	**338**	**8**	**346**	**7**	**317**	**14**	**129**	**2**
Cattle	152	N/A	409	N/A	147	N/A	292	N/A	242	N/A	0	N/A
Buffalo	0	N/A	29	N/A	13	N/A	0	N/A	0	N/A	0	N/A
Sow/piglet	0	N/A	30	N/A	25	N/A	36	N/A	15	N/A	0	N/A
Fatten pig	43	N/A	44	N/A	23	N/A	0	N/A	43	N/A	117	N/A
Chiecken	17	N/A	25	N/A	13	N/A	14	N/A	17	N/A	12	N/A
Duck	13	N/A	6	N/A	118	N/A	4	N/A	0	N/A	0	N/A
3. Aquaculture	0	0	0	0	**61**	**1.5**	**32**	**0.6**	**4**	**0.2**	**1,726**	**23.5**
Fish	0	N/A	0	N/A	61	N/A	0	0	4	0	137	0
Eel	0	N/A	0	N/A	0	N/A	0	0	0	0	0	0
Crocodile	0	N/A	0	N/A	0	N/A	32	0	0	0	1,590	0
4. Natural Resources	**99**	**5**	**387**	**11**	**1,728**	**43**	**624**	**12**	**791**	**36**	**4,527**	**62**
Fish catch	10	N/A	198	N/A	1,420	N/A	452	N/A	505	N/A	4,055	N/A
Eel catch	0	N/A	52	N/A	86	N/A	46	N/A	137	N/A	150	N/A
Shrimp catch	0	N/A	0	N/A	4	N/A	0	N/A	-	N/A	14	N/A
Snail/crab catch	0	N/A	0	N/A	12	N/A	4	N/A	63	N/A	8	N/A
Snake catch	0	N/A	0	N/A	29	N/A	0	N/A	11	N/A	0	N/A
Fresh water animals catch	0	N/A	0	N/A	0	N/A	0	N/A	1	N/A	0	N/A
Cricket/Insect catch	1	N/A	35	N/A	39	N/A	5	N/A	1	N/A	0	N/A
Frog catch	0	N/A	0	N/A	10	N/A	0	N/A	15	N/A	1	N/A
Mice/Rat catch	3	N/A	3	N/A	11	N/A	0	N/A	1	N/A	0	N/A
Flooded Forest	85	N/A	98	N/A	117	N/A	116	N/A	56	N/A	300	N/A
5. Businese and Used labour	**1,165**	**56**	**608**	**18**	**911**	**23**	**1,371**	**27**	**612**	**28**	**741**	**10**
Fruit/Palm juice collection	185	N/A	0	N/A	42	N/A	0	N/A	0	N/A	0	N/A
Small business/Glocery	240	N/A	164	N/A	199	N/A	470	N/A	254	N/A	424	N/A
Salary job	497	N/A	155	N/A	105	N/A	191	N/A	145	N/A	74	N/A
Pension fund	44	N/A	0	N/A	0	N/A	21	N/A	0	N/A	91	N/A
Agricultural labour wage	103	N/A	164	N/A	84	N/A	48	N/A	88	N/A	0	N/A
Motor taxi	0	N/A	7	N/A	83	N/A	0	N/A	0	N/A	0	N/A
Construction work	0	N/A	85	N/A	198	N/A	298	N/A	55	N/A	0	N/A
Garment/Factory	0	N/A	0	N/A	96	N/A	204	N/A	0	N/A	0	N/A
Others	96	N/A	33	N/A	106	N/A	140	N/A	70	N/A	152	N/A
6. Remittance/Migration	**599**	**29**	**728**	**21**	**220**	**5**	**125**	**2**	**483**	**22**	**229**	**3**
B. Household expenditure	**2,415**	**116**	**2,277**	**66**	**2,454**	**61**	**2,311**	**45**	**1,792**	**81**	**2,957**	**40**
C. Net Income (C=A-B)[b]	**- 327**	**- 16**	**1,177**	**34**	**1,552**	**39**	**2,852**	**55**	**416**	**19**	**4,395**	**60**

[a] Total income is a sum of crops, livestock and poultry, aquaculture, natural resources, business and used labour, and remittance/migration.
[b] Net Income is a substraction of total income and household expenditure.

4.5.1 Landless people

Landless people (represented by 29 households in our sample of 346 stakeholders) have two possible origins: A first sub group can have been farmers in the past, and hence it benefited from the land distribution in 1985 and also inherited from their parents after Khmer Rouge. However, these households may have had not enough land and capital to secure their viability after 1990.

81% are Khmer ethnic, 16% are Khmer Muslim (Cham), and 5% are origional Vietnamese. These families are very poor. They often share their habitation land by building an additional wooden house beside the one of a host that offers them a little piece of land. Together, they plan to join their efforts to improve their situation. However, they are living mainly from selling their labour force, especially for the harvest of the first cycle crops and on rice and intensified crops tasks (harvest and sowing) at the second cycle.

Moreover, this type includes together stakholders aged between 60 to 70 years old , living in very poor conditions. They may just be looking after their grand children whose parents migrated to other parts of Cambodia, or to Thailand. They depend mostly on remittance and small cattle raising for surviving, their income always is very low, with an average about 600 USD/year.When a specific event happened to them (e.g. health problem in the family), they had no other solution but to sell their land (sometimes, without any healing). Sometimes, they could be immigrants that came after the land distributions, while they did not have the power to get an access to the land to be deforested. Since then, they live by selling their labour force or by migrating to cities in Cambodia or Thailand.

According to the survey, they can sell 30 to 40 days/year (20 days during the first cycle and 20 during the second one), which may be underestimated. In most of the cases, these people are young “young adult and adult” and have many young children. The youngest is managed by one family to look after the cattle through a “sharing system”, while the older serve as additional external labour force. Meanwhile, they are especially fragile in case of disease or accident. Moreover, one to three adults of these families migrate to other areas, mostly Thailand, to find jobs and hence provide financial support, the rest of the family in the village. Likewise, they could sell their labour in agriculture and construction works in Battambang and Siem Reap, but they reported us that they are not skilful workers.

Those landless people may manage a land that belongs to someone else. They actually “occupy” the land for a transitional period on behalf of one absent owner who would have lost the land if it had not been cultivated within three years after its official reception. Depending

on the individual agreement with the owner, the transitional farmer knows that the agreement can end at any time depending on the willingness of the owner. Their goal is therefore to save enough money in order to purchase their own land elsewhere and to have the possibility to transmit lands to their children. No long-term investments in these farms are under plan.

Without any surprise, with an average of only 2,000 US$/year, landless people households make their lowest total annual income performance compared to other households.

The Table 30 shows their total income is not earned from any rice and crop productions, while it highly depends firstly on non-farm and off-farm activities such as small business and selling their labour in non-agriculture (accounts to 56%), and secondly migration which contributes to about 29% on their total income. The other activities about 11% from livestock and poutry, and very little amount about 5% from non-specified fishing of the natural resources.

Among the households investigated, we found that their annual expenditure was obtained very hight amount around 2,415 USD/Year accounts to 16% over their total income and it was even over the expendicture of the other targeted households. This was due to their they are in high debt around 1,500 USD annually.

To conclude shortly, this Landless household type correspond those who do not depend on land and fishing activities, while the non-farm and off-farm and migration have turned to be very important sources of their total annual income. However, land was not represented, and it seemed even low or no access to land possibly for this household type. Their non-farm and off-farm activitiesm plus small Animal husbandry might not made them gain their boost economy to get land. Finally, their net income reaches a negative value of around -330 USD than their total income.

This said, this household type was correspond to low level of resilience to the stress and shock situation. Indeed, if there was pressure from some shock and stresses such as natural disasters, serious illness, and other social challenges, their low income, may not be enough to recover, placing the household in more and more difficult conditions.

4.5.2 Single croppers

The second group of stakeholders (with 76 households in the sample) correspond to small farmers mostly specialised on floating and long-term rice. Historically, they have invested in floating rice and long-term rice cultivated in the rainy season only. They do not invest so much in the intensification paths of the paddy cultivation, such as the early season rice and the receding rice, nor in fisheries, and non-farm and off-farm activities. The condition of their

cropping pattern either does not provide or provides just enough income for the basic expenditures of the household (food, clothes, and health, etc.). But low remittance from their migrated children to support the farming and household consumption. They are 98% are Khmer and 2% are Cham.

The valorisation of the available time they may have is a key for their economical viability. In this regard, again this group is still focusing on floating rice and long-term rice. The size of their plots is quite the same: around 2 to 4 plots for a global surface around 3.5 ha, located in the low land and water-land areas, further from residential land and close to the flooded forest, where they mostly rely on rainfall and water-flow from Sangkae river and Tonle Sap Lake, since they cannot access to irrigation. In addition, this group of households has in average 5 family members and has low capacity to invest.

We found that this type seems represented also more eldest age household head between 50 to 70 years old (very few of young age in each family) as similar as the landless household, who have arrived since the first settlement in the village in 1980, and they could keep the same land, they have never developed their farming activities; meaning they received and work on the same land, because their land mostly located in the low flooded area near the inundated forest. Since then unitl present that might existing the same situation in the future, they have invested bigger plot of traditional rice like floating and Long-term rice, and small plot of the double crop and vegetable Chamkar.

Only small cash crops and vegetables around their residential home may be undertaken, as well as small animal production and non-specified fishery during the rice fallow periods. One can also attempt to invest in perennial crops, but it is providing delayed income and seems to be limited. There is also high rate of migration in this group of households; they confirmed that one to two members of their family have been to mostly Thailand, Phnom Penh city and Siem Reap to earn money and send back to their family, when the remittent is used to support the family's agricultural production and daily expenses.

The Single croppers households can make an average total income of about 3,600 USD annually, from mainly their single rice and other crops (34%). Second source of income is the remittance from their relatives who migrated mostly to Thailand, with about 730 USD accounting as 21% of the total income, while they could also make around 18% more from their small business and selling their labour in the agricultural and non-agricultural wages. Animal husdandry could make about 14% of their income, and non-specified fishing from natural resources about 11%. Our study also estimated their household expenditure is around 2,370

USD, that led their net income meets to average income about 1,170 USD/year over one year round.

This said, the pressure from land impacted negatively on this kind of single croppers, and they are the most preserve the floating and long-term rice systems. Their total income remained low and the capacity to invest in the new non-agriculture activities is still limited. The low productivity of rice and other crops cultivation would lead them to diversify their labour to find other jobs outside to get remittance to support the farming activities and household consumption.

Therefore, we could assume that there is also low opportunity for this household to get more land, and natural rosources seems not benefit to them, while we expect that these farmers would not resist very long, they would continue to sell part of their belonging land, leading to abandon their cropping cultivation as worse as the landless people did so far.

4.5.3 Diversifiers

The third group includes farmers who diversify as much as possible their agricultural production, especially by going for a second cycle of cultivation in the dry season after the receding of the flood back to Tonle Sap lake. With 109 households in the sample, they are the group most represented in the area. Most of them got their rice lands and started the cultivation from the distribution in the 1980s. These households started by growing heavy and floating rice like the rice mono-croppers did after Khmer Rouge in the 1980s, but since then they widely shifted to two cycles per year. These households have around 3 hectares of cultivated paddy and intensified Chamkar. They are 97% Khmer and Cham 3%.

Among the correspondents of this diversifiers household type represented younger household head age, compared to the last two types, between 40 to 60 years old, who have arrived or born in the village after 1990. They can keep the same given land from their parents with around 2 to 3 ha, they have slightly developed their farming activities; meaning they received and work on the same land, luckily their paddy fields have been located close to the villages.

They seem to generate enough income to secure the whole expenditures of the household and make them ready for investments. They also use highly their family labour force to run all the activities of the household, but they still require more labour hire from groups of landless people and Single croppers for land preparation, weeding, and harvesting. This is costly in their production.

Generally, their agricultural plots are located near permanent sources of water where they can easily manage irrigation for the dry season crops. Their farms have a positive balance due to their non-specified fishery and animal production like cattle, when they can easily manage full year to look after their cattle at the same time of doing fishing at the fields. In addition, their income is also generated positively from the combination of high yields at both the first cycle of early season rice and the second cycle with rice or other intensified crops such as corn, soybean, groundnut, watermelon, sesame, jute, etc.

The early season rice and the intensified Chamkar crops production provide high income, but it comes at a time the household is facing cash shortages (after having paid for the land preparation, seeds, fertilizers and herbicides for the both cycle of crop productions), and is expecting for the harvest. Selling some of the early rice can help farmers to delay the intensified cash sale to get higher sale prices on the market. However, this requires manual weeding all along the cropping cycle, and at least two to three active family members are necessary for the cropping. However, non-farm and off-farm activities are also an important source for the family, it is just they could invest more in local area more than migration.

Again, the most profitable diversification is the early season rice, intensified crops, and mixed cash and vegetable crops. The rice production can be significantly profitable if the yield is high (2.1 MT/ha, got from short-term rice and water receding rice. In consequence, the balance can be high and well secured: almost all of them invested a hand tractor and apply fertilizers in their rice and crops production.

As shown in Table 30, the result of the total income analysis, shows the total income per household member per year was high. The average of total income annually produced is around 4,000 USD annually, from mainly double cycle rice such as early season rice, long-term rice, early season rice with water receding rice, early season rice and long-term rice, early season rice and dry season rice, and early season rice and Intensified Chamkar, and Double crop and vegetable Chamkar, Second main source of their income is from non-specified fishing of natural resources accounts to about 43%.

However, their business was also performed high about 23%, but the income from animal production was less accounts to about 9% such as cattle and buffalos and other poultry for home consumption, while aquaculture about 2% mainly fishing rearing. Even though, the economic performance from non-specified fishing is greatest, but rice and intensified crops Chamkar are permanently main and long-term sources of income in general for this household type. On the other, we estimate that they did not depend on remittance from their family migration while there few very few of them have migrant outside.

As shown the result of their economic performance with average about 1,000 USD/year are generated highly from rice in rainy season and intensified crops in dry season.

Since they were given by their parents and might be some plots were distributed by the State small plot of land, and they have bought the expensive land year to year to intensify their double cropping system such as double rice cycle and intensified crops Chamkar as their main source of food and economic income. We estimated this household expenditure with around 2,400 USD accounts to only 60% of their income, therefore, it results that their annual net income remained around 1,550 USD every year.

This said, this kind of Diversifiers household types had more diversity of economic activities, who preserve the double short-tem rice in rainy season and also to intensify their crops Chamkar productions in dry season, small animal and aquaculture for household consumption. However, the main sources of income are generated in parallel from the non-specified fishing of natural resources, and also from non-farm and off-farm activities.

On the other hand, we estimated their total income remained very high and seems likley long-term in comparison with the small land households like Single croppers and Landless people, and sometimes it was even higher than some Large farmers household. Their land is considered as very important factor for pulsing crop productivity such as double cycle rice and other crops cultivation, in combination with high income from non-specified fishing and non-farm and off-farm would lead them to diversify their land and expanding their business sustainably.

Therefore, we assumed that this household has long resist to adopt with the diversification changes in cropping systems impacted by the flood pulse pattern and other economic barriers, when they get opportunity for this household whereas they were eligible to diversify their farming activities to/with more small business and medium business.

4.5.4 Large farmers

The large farmers (with 52 household in the sample) have all a positive and very high balance, based on their land size (from 5 to 15 hectares, with 3 to 8 plots of paddy located in low land to up-land water area). They are 93% Khmer, Cham 5%, and orignal Vietnamese 2%. All of them have invested in various types of agricultural activities whereas they also run medium and big business activities. Initially, some of them may have been former members of Khmer Rouge military and solidarity groups, and they may remain government officials until

now, like village chief, commune chief and council, village guard, police officer, and even higher position at provincal hall..etc.

Among correspondents of this Large farmers household type could be identified that they had almost the same historical background and social context, but the difference was at the household land level and capital to invest on the future activities, which represented elder age between 50 to 66 years old, who arrived since the first settlement in the village in 1980 as the same period as the Landless people, and Single croppers households.

Their land received with already big size compared to the Sigle croppers, Diversifiers and former landless housholds, but among the group of this Large farmers household have the lowest land from 2 to 5 ha generally located in different area of low flooded field and some are further from the residence. In the past, they invested in only one cycle rice and fishing, with the interest of getting more profit from double rice cycle systems, they have invested more to those double cycle cropping with small progress. With their oldness and less family labour intensification, and rice production damaged in several years, the sub-group A have developed slowly farming activities, and meanwhile they don't have more income from non-farm and off-farm activities, led them to low income, which cannot even cope their household consumption.

The Large farmers, who are in middle age between 30 to 50 years old, and around 20% of them were young couple with 4 children, they have expanded their land from state land distribution and buying from other farmers in from 1996 to 2002 when the land was cheaper the today, and some parts were given by their parents who were/are also the landholders. Today, they represent as a big land farmers owning more than 8 ha, thanks to the success of their double rice cycle and intensified crops Chamkar, this boosts their income higher with the average of 4,500 USD/year contributed from the double short-term rice and local business as civil servant and other small and medium business.

Likely, both of elder and middle age of Large farmers household type have had the capacity to invest into high diversification from their initial long-term rice and floating rice towards early season rice, receding rice, dry season rice, then to expand land with multi-crop production systems. Their technical performances however (yields) are lower than what they are for the previous group, mostly because of the dimension of the area that they grow in Chamkar crops and dry season rice. Among the previous three groups of households, the large farmer has very high balance of annual total income from their big rice production and non-farm and off-farm activities. They also have big agricultural equipment, hand tractor, and tractor (80% of them already invested in tractor, or sometimes they also have two hand tractors plus on one tractor).

The diversifications of these farmers have the same importance as the diversifiers. Their investment capacities are indeed high and are suitable to take risks, but these farmers are also often in the process of sharing their land among their relations, while they can share the labour and big machinery. All use fertilizers whereas they have all the same rainy season rice, receding rice, dry season rice, and intensified crop in dry season. Compared to three previous groups, they have capacity or enough money to hire labour from the landless and the rice mono-croppers for working in their production.

We observed, as shown in the same Table 30, that this kind of farmers have all a positive and very high balance with big land size more than 10 hectares. The average of total income of this household is around 5,200 USD annualy in which mainly contributed by rice and crops production estimated 52% of their total income such as; firstly early season rice, water receding rice, early season rice and long-term rice, early season rice and water receding rice, floating rice about, Long-term rice, early season rice and intensified crops Chamkar. Secondly, their business and labour sale also contributed about 27% annualy that premeraily from small business in their village. Thirdly, their non-specified fishing activities from the natural resources were estimated about 12% annually, but animal productions was about 7%, and very less aquaculture about 0.6%. However, this type did not depend much on the remittence from their migration famly, and we observed that their family member are very few migated to outsite, while most of them go for continuing their formal eduction and skill training in Battambamg town and Phnom Penh.

From the economic point-over, we understood that household type had the highest economic income performance, and their net income also resulted with high about 2,900 USD/year remained from their total household expenditure, in which they might easily develop faster and they might also have more capital to invest in buying more land and expansing their existing and new business. With this, we assumed that thes trends clued them to longest term to resist with the changes in the area. Moreover, they might have capacity to resist with the stress and shock situation in the present and future.

4.5.5 Small fishermen

This type of fishermen (with 55 households in the samplerelies mainly on income from the fishing activities and from selling their labour to the large fishermen and to the farmers of the agricultural land area, and also from migration. They are 82% Khmer, Cham 10%, and orignal Vietnam 8%. They were former workers for the fishing lots owners and in some cases, they sub-leased fishing lots before fishing lots termination in 2010.

They fish with small boats, getting about 1 to 5 kg fish per days in the rainy season, and around 1 to 2 kg during the dry season. They also rely on different resources such as gees, frogs, snakes, turtles, honey, rats, and other wildlife during both seasons. They live permanently on the floating and stilted-villages, located close or even inside the inundated forest. They raise a few pigs, chicken and ducks also on floating houses/board with worse house materials during rainy season and on high land during the dry season. Most of them have good fishing sharing system by engaging with their relatives and neighbours; meanwhile they don't need to hire labour.

They could earn total income of 2,200 USD/year from only four main sources of income such as from; firstly small scale fishing around 36%, secondly selling labour in non-farm and off-farms activities and fish paste proccessing about 28%, thirdly 22% from remittance of migration, and the rest about 14% from animal production (mianly cattle and poultry) and 0.2% from small aquaculture.

Moreover, they face difficulty to access loans from official micro-finance institutions. Instead they can only access to private lender such as fishery traders and large fishermen, with high interest rate around 60 to 180% per year. The main sources of income for their household come from fishery products. They can earn a maximum total net income of 2,200USD.

As shown in Table 30, among the households we investigated, there are 49% represents low total income. We observed that around corresponds to 50% of Small fishermen household type is under the poverty, represents a very worse households in terms of economic performance and household assets and consumption, who can survive with very low source of income from only small fishing activities, small livestock raising, and the remittance from their migrant children and relatives. For instance, about 80% of this household type has migrated to Thailand and Phnom Penh, Battambang, and Siem Reap cities.

Yet, we estimated that their net income resulted remaning around 400 USD/year after their annual household expenditure. On the other, we observed that they situated in further area in the flooded forest of Tonle Sap basin, where they are rarely access to market, public hostpical and other services, but also low access to credit. These households were rarely connected to social actities, only they communicated directly to fish traders for foods, credit, and others.

This said, this type had very low level of resilience to the shock and stress. Their low income with the current trend of fishery degradation, would impact very negatively on their lives. This might lead this household to fall into a very bad situation of food insecurity. The fishermen in are more unskilful people, they knew only fishing, who caugh fishery and other wildlife for the rest of year, selling labour, and small fishing processing trade in both seasons.

Therefore, we assumed that the Small fishermen household represents higher level of poverty and lowest household economic performance, asset, and low access to get the public and social support services. Their households economic income generated from very limited fishing catch, when their non-farm and off-farm income highly contributed from the migration. The trend leads to short-term resist to the changes in their villages, respectively they were more and more fragile and vulnerable.

4.5.6 Large fishermen

This type (with 25 households in the sample) corresponds to a group of stakeholders who rely mainly on large-scale fishing. They are 81% Khmer, Cham 5%, and Vietnam 14%. They can fish about 50 to 550 kg per day in the rainy season and up to 50 kg in dry season. They can find fishes slightly better then small fishermen can do, and also earn higher income from non-farm and off-farm activities, have higher capacity to intensify to aquaculture like crocodile and fish rearing. Estimated 83% of their fish catch is sold out to market, and the rest 17% is kept for home consumption and aquaculture feed.

They were/are former Khmer and Vietnamese fishing lot owners and sub-leased before fishing termination in 2010. They currently have become fishermen with high capacity of investment. They also live permanently on the floating and stilt villages, located in the inundated forest with the small fishermen, but this group of households more often performs activities in deep water Sangkae river and in the Tonle Sap lake basin, where they can also extend their business, have access to health care, and send children to school to the neighbouring Siem Reap province. Their fishing materials and engine board are seen extremely huge size compared to the equipments of small fishermen.

With the previous strong profile as former fishing lots owner and sub-leasers, the correspondents confirmed that most of large fishermen have very good connection and relationship with corrupted authorities such as fishery administrators and river police officers.This allows them to expand their fishing illegally with fishing lot fence system with pens (Nor-Rav), where not or rarely small fishermen could do the same as them. All of them already invested in a big boat with engine and huge fishing tools. They increase their annual income with aquaculture, like crocodile or fish farming that they feed with a part of their fishing intakes at both seasons.

Among the correspondents of this Large fishermen household type, several sub-group can be identified their dynamic represented between 40 to 60 years old, and they have more family

working labour with two to three young children working with them. They represent as more household who generate good balance from the four farming activities, considered as skilful fishing. They invest in full year fishing with big traditional fishing tools and good engine boat, but they had more illegal fishing tools. In addition, they invest more in poultry and livestock on their floating house/huts, and fish rearing is found around their residence. And they have involved to some kind of skilful selling labour work like boat-maker and local house builder, in which their income from non-farm and off-farm is higher.

There were around 30% of these households are in middle age between 35 to 50 years old who are former fishing lot owner and sub-leasees, and some are also the new couple who got their fishing heritage tools and business from their parents. With their strong background as former members or leader of Solidarity group and former KR armies, currently this households are able to keep their strong networking with the corrupted authorities, allows them to do more illegal fishing. They correspond to a very strong and rich capital fishermen group who can invest in both large-scale fishing and business in the fishing villages.

Their businesses are generally medium and big such as gasoline selling, boat selling, fish trading, phone shops and small floating restaurants generally done by women, young daughters, and old parents. Their big investment in large-scale fishing provides were very good benefit to their households, where they could sell directly the captured fish by themselves to markets in Siem Reap and Battambang, and they keep small part of the captured fish for their crocodile rearing. Thanks to the good result of economic generation, their total incomes are very high from all large-scale fishing, crocodile raising, and local business. Yet, their net income remained very high abour 4,300 USD/year, that we expected that they would have more capacity to resist to the stress and shock, moreover, they would more capacity to invest in their business in their floating villages and otherwise future moving to land areas.

This type of lareg scale fishermen is a large household type, who relies mainly on income from the large fishing activities, and their income is the higest compared to other five household types. The main sources of income for their households are mainly from fishery products about 62%, aquaculture (mainly crocodile rearing) about 23.5%, from non-farm and off-farms such as business on floating villages contributed about 28%, 22% from remittance of migration, and the rest from animal production, for a total income about 7,300 USD/year.

This said, this kind of Large scale fishermen households had more diversity of economic activities in both Large-scale fishing and crocodile rearing, and local small and medium business in the fishing villages. We expected their total income remains very high and long-term in comparison with the small fishermen households, and sometimes it is even higher than

some farmers. Therefore, we assumed that this household has long resist to adopt with the diversification changes in fishing systems impacted by the flood pulse pattern and other economic barriers, when they get opportunity for this household whereas they eligibled to diversify their fishing activities to/with more small and medium business.

4.6. The social differentiation of the households: identification of key factors to develop the livelihoods

4.6.1 Settlement situation and period of new installation

In our findings, we can identify the year of the first settlement of each of the both household heads. We found that the date of the settlement in the village were not significantly different between all households, and also there is not a huge difference between man and woman in both land (or agricultural area) and water-land villages (or fishing area).

Table 31 shows that 38% of the sample are "original villagers", who have been living here more than a generation, i.e. since before KR regime. 22% of the sample arrived with the the immigration wave that occurred from 1980 to 1990 (and they mostly found opportunities in fishing. Then migration decreased to about 19% from 1990 to 2000, whereas less than 11% settled after 2002. We assume that the population growth is now totally internal.

Table 31: Settlement of household head

Year of settlement	Settlement by Man			Settlement by Woman		
	Frequency	Percent	Cumulative Percent	Frequency	Percent	Cumulative Percent
< 1970	30	8.6%	8.6	30	8.6%	8.6
1970 - 1980	131	37.9%	46.6	131	37.9%	46.6
1980 - 1990	76	22.1%	68.6	79	22.8%	69.3
1990 - 2000	68	19.7%	88.3	62	17.9%	87.2
2002+	41	11.7%	100.0	44	12.8%	100.0
Total	346	100%		346	100%	

In our study, we also found that the immigration situation was uneven from different parts/provinces of Cambodia and Vietnam (Table 32). The immigration came mainly from other districts of the Battambang province represent 88% between man and woman and the other provinces nearby; like from Siem Reap (about 3.8%) and Pursat (1%), and as last from Vietname (from 1 to 3%). We assume that in the study area of lowland in Battambang does not receive very big wave of migration from oursider of the province as the same other provinces in upland and Central plein of the country. Most of them were the civil refugees or victimes were forcely removed by Khmer Rouge soiders to North-Western and central plein of the Battambang province. Then after the Khmer Rouge regime collaped, they returned back to their

villages to find better living condition. Indeed, we found that they have settled in the area since just after the Khmer Rouge collaped, while few of them are immigrant who got marriege with villagers, they perminantly stay with their family. A below Table 32 summarized the mirgation into the villages in the study area.

Table 32: Migration provinces before settlement in the villages

Migration Province	From migration province by Man			From migration province by Woman		
	Frequency	Percent	Cumulative Percent	Frequency	Percent	Cumulative Percent
Battambang	305	88.3%	88.3	308	89.0%	89.0
Banteay Meanchey	10	2.8%	91.0	10	2.8%	91.7
Siem Reap	13	3.8%	94.8	11	3.1%	94.8
Pursat	5	1.4%	96.2	1	0.3%	95.2
Palin	0	0.7%	96.9	0	0.7%	95.9
Kampong Cham	2	0.7%	97.6	0	0.0%	0.0
Kampong Speu	1	0.3%	97.9	5	1.4%	97.2
Kandal	1	0.3%	98.3	2	0.7%	97.9
Takeo	1	0.3%	98.6	1	0.3%	98.3
Kampot	1	0.3%	99.0	1	0.3%	98.6
Thailand	2	0.7%	99.7	1	0.3%	99.0
Vietnam	1	0.3%	100.0	4	1.0%	100.0
Total	346	100%		346	100%	

4.6.2 Land distribution rules and ownership documents

4.6.2.1.1 Land distribution rules

The agriculture of both districts of Aek Phnom and Sangkae started again immediately after the KR regime ended. The new government accepted the settlement of the former KR soldiers who did not flee to the refugees camps of the Thai border. At the beginning the cultivation was totally collectivised : the preparation of the nurseries, the ploughing of the land and the transplantation of the rice were done collectively, organised by the Krom samaki. After a few years, the local authorities started to allocate the land prepared that way to indivdual families from after the transplantation phase. The harvest became then individual. A part of the harvest was still obligatory due to the krom samaki, to cover the work done collectively up to the transplantation. However, that first decollectivisation initiated de facto the land distribution. This process started from land areas bordering road number 5 to around 15 km to downstream towards the TSL. At the beginning the areas closer to Tonle Sap lake were not addressed by clearance and distribution, but this latter was extended when immigrants started to arrive and illegally occupy areas of land.

Authorities formed as Solidarity Groups confirmed that land was mostly distributed to former KR soldiers and members of Solidarity Groups close to the local authorities at that time.

The distributions amounted a maximum of 3-5 hectares per household, depending the size of the family. The study found there were two stages of land distribution is the two districts, and also happened the same process occurred in district nearby like Mong Roussei and some parts of Tmar Koul and Battambang districts. A first stage, around 1981 to 1987, government distributed one Rai of residential land per family and one hectare of paddy land per member of each family. Around 1994-1996, a second round of distribution was organised also for the same size, and clearly by encroaching on the flooded forests that had remained uncultivated. Farmers explained that it was possible to get more land without major problem, but, probably, without getting any official documents.

Land has to be cultivated within the 3 years following the distribution; otherwise the land was taken back by the authorities.

4.6.2.1.2 Results of Land distribution

Correspondents reported that the local realities were often sligthly different compared to the theoritecial and official model. Thus, the former KR soldiers could encroach more than 5 ha of the flooded forestland freely, and after few years of practice they were allowed to sell their land to the other villagers. The former KR armies got land and started immediately to cultivate rice and other cahs crops, and also rent their land (around 30% of their received land) to new settlement citizens.

Later, when land could be sold, correspondents also report that there were several conflicts between the former KR soldiers and the other farmers. For example, it could happen that a land encroached cultivated by one farmer in the 80s could be considered as to be distributed to new comers in the second round of distribution in the 90s. Some therefore lost their land, without any compensation.

4.6.3 The kind of land they sold

However, in 1980 and then in 1985 those who were already there, including the former KR soldiers, took the best lands (well drained black soils Chamkar and paddy lands), where they could access to irrigation system, whereas the following ones took more hydromorphic soils located further away and in the flooded forest at downstream of TSL.

Later on, when they however could have access to some capital, these “external’ farmers could compensate the poor potential of their soils, by investing in the vegetable production, investing in digging ponds, buying water-pump, pipes, and other machineries. With a low

starting capital, their cattle could become the only hope to improve their situation, as the rice production did not provide high returns. Their strategies were therefore to save enough money to rent a Chamkar land or to purchase a new land in another village were the land was cheaper.

Those who could not get into that virtuous cycle became endebted and they slowly lost their access to land. The surveys among the lanless group show that 46% of them sold less than 2 ha and 12% sold more than 2 ha (Table 33)

Table 33: Agricultural land sold by household types

Household types	**Agricultural land Sell (ha)**		**Total**
	< 2	2+	
Landless people	46.3%	12.2%	58.5%
Single croppers	7.3%	2.4%	9.8%
Diversifiers	9.8%	0.0%	9.8%
Large farmers	14.6%	2.4%	17.1%
Small fishermen	2.4%	0.0%	2.4%
Large fishermen	0.0%	2.4%	2.4%
% of total			100.0%

After the Landless people, only the Large farmers' type has sold land, but the process is there very different. The land correspond to encroachements – legal or illegal- that, thanks to their social power, these farmers have done in the 1990 and that they could sell back after 2010 to re-invest elsewhere (small business, equipment, or building new house) as summarised in Table 34.

Table 34: Year and Purpose to sell agricultural land by household types

Household types	**Year of selling land(%)**				**Purpose to sell land (%)**								
	< 2000	**2000-2004**	**2005 - 2009**	**2010+**	**For children schooling**	**For pay for previous debt**	**No longer able to work on it**	**Organize wedding ceremony**	**Health sock and treatment**	**Building a new house**	**Too far from residential place**	**Afraid of government seize the property**	**Create business**
Landless people	19.5	12.2	12.2	14.6	0.0	34.8	4.3	0.0	13.0	0.0	0.0	0.0	0.0
Single croppers	4.9	0.0	2.4	2.4	2.2	0.0	2.2	0.0	6.5	0.0	0.0	0.0	0.0
Diversifiers	0.0	0.0	2.4	7.3	0.0	6.5	2.2	0.0	2.2	2.2	0.0	0.0	2.2
Large farmers	0.0	2.4	2.4	12.2	0.0	4.3	0.0	2.2	2.2	0.0	4.3	2.2	0.0
Small fishermen	0.0	0.0	2.4	0.0	2.2	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Large fishermen	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0
% of Total	26.8	14.6	22.0	36.6	4.3	45.7	10.9	2.2	26.1	2.2	4.3	2.2	2.2

Based on the result, the Landless and Single croppers household types sold their land more others more than the other household types in all you from 2000 and until alsmot recent

year. Unlikely, there are small percentage of Diversifiers and Large farmers household types also reported that they also sold land in most recent year for example after 2010s. The main purpose of selling land represents hight for Paying for the previous debt accounts for 45%, secondly accounts for 26% for health sock and treatement, and the rest for sending children schooling and daily consumption. Therefore, it means that we assusme that the main factors contribute to selling land of the household types are more for debeness and health treatement. This shows low of social and public severice in the study area, that needs urgently support to them.

4.6.4 The kind of land they bought and giving system to children

Among the farmers' category, the single croppers households type show the lowest capacity to buy agricultural land compared to the Diversifiers and Large farmers. Table 34 and Table 35 show that only 25% of them could buy land since around 10 years ago, whenever their household have started to migrate to Thailand, Phnom Penh, and some other Asian countries to send their remittance to the family to buy land. The land they bought, obviously for rice since they have not diversified, was in most of the cases in the flodded forest areas encroached by the big farmers in the 1990.

Table 35: Agricultural land bought by household types

Household types	**Agricultural land buy (ha)**		Total
	< 2	2+	
Single croppers	25,9%	0,0%	25,9%
Diversifiers	25,9%	14,8%	40,7%
Large farmers	58,5%	24,8%	83,3%

By comparison, the diversifiers show higher capacities. 40% of them had capacity to buy less than 2 ha and they could do that, when their high yield rice varieties and cash crops gave very good yield, therefore in turn multiplying capacity to expand.

Table 36: Year and Purpose to buy agricultural land by household types

Household types	**Year of buying land**			**Purpose to buy land**			
	< 2005	**2005 - 2009**	**2010+**	**Farming activities**	**For monetary value (land price increase)**	**For keeping for their children**	**Make a residential place**
Single croppers	0.0%	11.1%	14.8%	12.5%	0.0%	5.0%	2.5%
Diversifiers	0.0%	11.1%	29.6%	20.0%	2.5%	10.0%	10.0%
Large farmers	3.7%	11.1%	18.5%	25.0%	2.5%	2.5%	0.0%
% of Total				23	2	7	8

Lastly, the Large farmers had better capacity to buy land than the two previous types. During the land distribution period, they got more opportunities to catch the good land, and to

get rights to encroach the flodded forest where the access to water was the easiest once the land has been cleared and can be cultivated in early rice + receding rice. Most of them were/are member of Solidarity group and or happened to have local political power.

Table 36 below shows that 73% of this household type could buy land in the past 25 years, and until today they still have more opportunity to buy.These households switched fast from small scale traditional rice production to intensification. Additionally, their lands were for intensive paddy cultivation, located where they could cultivate two cycles of rice.

As a result of these very different trends of land accumulation, the capacity of the farmers to equip their children with a minimum quantity of land, that can allow them to start a new cycle of accumulation, is uneven. In the Cambodian tradition, parents generally try to give property to the newly married children as the capital for starting their own farm. Large farmers seem to have been able to correctly fufill this obligation.

Table 37 shows that about 30% of them could give less then 3ha, about 7% could give more then 6 ha to their married children. By contrast, the Rice mono-croppers and Diversifiers performed less in terms of land given to their married children. About 33% of the Diversifiers could give land, and always less than 3ha. It was even worse for the Single croppers, with only 22% of them who could giveland.

Table 37: Agricultural land given to children by household types

Household types	Land Given to children (ha)		
	< 3	3 - 5	6+
Single croppers	22.2%	0.0%	0.0%
Diversifiers	33.3%	0.0%	0.0%
Large farmers	29.6%	7.4%	7.4%

4.6.5 Household labour force.

4.6.5.1 Overview of labour use strategy

The typical farmer and fisherman household is typically made of the husband, the wife, three children from whom one is working, and an old person whose care is provided by the family. But there are many variations:

- The number of children goes from zero to seven, and two or three relatives (nephews, nieces, and brother or sister-in-law) living all together in the same residence.
- The presence of children with health problems: most of the time poliomyelitis, malaria
- And widows.

In general, a household can have two active members working full-time on the farm. Some big families with a high family labour force have more than four active members. The number of children has a very important impact on the development of the household, as:

- Children are essential to help in rice and other crops cultivation and go fishing with parents, and also to participate to the essential works such as transplanting, weeding, harvesting, fishing, and cows keeping,
- For the long-term strategy: early, families with a lot of children planned to extend the size of their farm without being able to cultivate all.
- Negatively, for the families (with both farmers and fishermen) with too many young children cannot better or slowly develop household livelihood, when they are able to work only on the farming activities, and get lower opportunity for professional skill training and higher education. Those people are predictably end up selling their labour power, for instance, for richer households.

For the farmers; such as Single cropers, Diversifiers, and Large farmers, the children can start the work by taking care of the cattle in the pastures. Later, they can alternate agricultural work with the schoolwork at the same time. They go on working with their parents up to their wedding (around 23-25 years old). But the children can as well be sent to the university (for 10% of the households and each time the sons, rarely the daughters): it is done by the richest families but as well the poor ones using their family network support. By contrast, in both cases, the charges are huge for the household. Farmers are using temporary external labour force as it is necessary for land preparation and harvesting of rice and cash crop cultivation. Moreover, farmers need to speed up the early season rice harvest to get production and an early payment to solve their cash shortages of the end of the year. They have to pay back their credit before the dead line of end December – beginning January.

For the fishermen; both the large fishermen and the small fishermen, children can start since early age from 7 or 8 years old by going fishing nearby their residence in the rainy season and going to a further place with their parents and sibling in the dry season. Later, they can alternate their parents to handle fishing. They also generally work for the family until they are getting married at 23 or 24 years old. There is less opportunity for these households to send their children to school because there is no and rare school; maybe there is one primary school per two/three villages in their fishing area. Some rich fishermen can send their children with their relative network in Battambang and Siem Reap cities.

All the farmers and large-scale fishermen are working individually for all agricultural tasks (including fishing) and hire labour (25, 000 Riels [6.10 USD] to 30,000 Riels [7.5 USD]

per day): there is not any labour association system any longer as it was 15 years ago (except formal solidarity groups to get access to credit from the micro-finance institutions), no collective action either for the purchase of inputs and for the sale of the agricultural products, except within families for the lend of land or agricultural equipment: manual sprayers, motorized sprayers, hand-tractor and tractor. Still, there is another new labour sharing system for the small fishing activities, which is slightly different from old labour sharing system: small fishermen household are going for fishing together, they might help each other, but they don't share the benefit from fishing.

4.6.5.2 Gender issue in the household labour management

Regarding the gender issue, farmers and fishermen claim the equity between the role of the husband and the wife. However, they admit that there are few shares of responsibilities regarding the agricultural tasks:

- The men are responsible of the implementation of the tasks which need more strength, such as:
    - handling of the hand-tractor for the ploughing, the line tracing and the harrowing;
    - handling of fishing activities, of course for both farmers and fishermen;
    - the ploughing with animal traction (rare);
    - the chemical treatments;
    - non-farm and off-farm activities with temporary emigration of the farmer.
- The women are more likely to implement lighter tasks, often with the children, as:
    - the sowing and transplanting (rare for transplanting);
    - the vegetable post harvest transformation;
    - the poultry and livestock;
    - off-farm activities such as the grocery management, external labour force.

Both men and women are involved in the decision-making. In this regard, it appears that women have a greater role. Their decision seems to be well accepted and recognized.

Farmers admit that beyond the legacy of land, the youth have many difficulties to get their own land because of the high paddy and Chamkar land prices. Therefore, there are different possibilities:

- To leave and find some job in big cities of Cambodia: Battambang, Siem Reap, Phnom Penh, Cambodia-Thailand border, in Thailand (in construction, restaurants, hotels),

textile industries or in photography workshops, garages, offices if the children succeeded at school or could benefit from a good family network. In those cases, children can send remittance back to their parents as an additional revenue, or an additional work when they have free time.

- To leave and find new agricultural land less expensive in other villages: in that case, the young couple has to take huge risks as the lands they can purchase are in the zones which may not have been fully demined. The chief of the village of Boribo explained that accidents still happen.
- To stay and set a house beside the parents' house and share the land of the parents: it seems to be the majority essentially when parents managed to gather enough hectares.

All the farms are therefore on the process to be shared between the children, generating different strategies:

- The parents try to develop perennial crops (easier to manage), or an intermediary business,
- The youngsters try to maximize the benefit on their small land with annual crops, and at the same time to develop off-farm activities (mainly groceries, or mechanics).

But the youngsters will have to manage their life with smaller lands and with much lower agricultural potential than the ones their parents had benefited before the legacies.

4.6.6 Different situations of starting capital and the kind of land gain and loss

4.6.6.1 Starting capital for household installation

Capital is the most important source for starting new lives and productions. At the first settlement, people might have different sources of capital. Some access to traditional loans by borrowing from closed relatives and parents first, from 1980 until around 1993. In the period, they rarely borrowed main foods in kind like rice, other crops, and fish. After 1993, the extension of micro finance somehow enlarged the array of options.

Historically, the first activities of the farmers were rice cultivation, generally of small size and located not far from the residence, combined with various non-specified fishing activities. In addition, the production of cash crops and vegetables was also limited to a small home garden close to the residence.

Likely, the fishermen lived naturally and permanently in the flooded forest, where they could make some profit from selling their labour to the fishing lot owner and sub-leasers,

however they did not and rarely borrowed from outsiders. The productions were mostly to meet the household consumption. By contrast, they might have called for some additional income to cover urgent health needs

After the period of installation, from around 1990, people faced more issues in terms of managing health problem, land pressure and natural degradation, and, with the increase of family members, they faced higher capital needs to invest rapidly in starting from small machinery; tractor (for the richest ones at that time), hand tractor (mainly); investing in perennial crops cultivation; and purchase of new land. They started to sell their labour as employees in Battambang or Phnom Penh cities, or at the border of Thailand to support the rice and crop production and daily expenses of the rest of the family in the village. Few of them could get external support from a wealthy relative, who migrated abroad: e.g. they sent remittances from a family member abroad to buy equipments for their relatives in the villages. Without such an additional income and support, most of families confirmed that they would have step by step lost their land by selling it to the richer farmers and new immigrants.

With more limited capital, the farmers would have beneficiated of slower economic accumulation, or would have had to find a non-farm or off-farm activity. Soon after the distributions of 96-98, the farmers could work as external labour force in the larger farms, but, since the cultivated land was still limited locally, without getting enough income. Therefore, they had to migrate out as a seasonal labour force, while the wife was taking care of the farm and the children. As well, the cattle used as animal traction and living capital could help farmers to invest in new land, machinery, or a grocery, etc.

4.6.6.2 Capital for Productions

4.6.6.2.1 Past trend of capital accumulation and investments

According to our investigations, the most frequent investments succession of the farmers since 1980 has been done as follow:

In 1980, most of the farmers had deforested and built a wooden house. At that time, the rice production was more important than nowadays and cash crops were limited , except jute. Fishermen were living mostly in the same situation as today, on the floating houses and boats elsewhere in Sangkae lake.

Later on, at the moment of the first wave of land distribution (around 1985) , the new immigrants generally had sold their original land, their house and part of their cattle (but generally brought at least a pair for the animal traction). With this capital, they could invest

more or less quickly in a hand tractor, which enabled them in turn to increase the size of their cultivated crops in the villages where they settled.

First investments 1983-2000: Thanks to the good yields form the floating and heavy rices, farmers invested in cattle, that helped to reduce the cost of production. From 1987, thanks again to the traditional rice that continuously gave good yields, some farmers could invested straight into bying a hand-tractor. Thus they could increase the size of their land cultivated, saving cost of the ploughings by others (the cost was higher than nowadays taking into consideration the inflation). They also diversified their sources of income by ploughing the land of others. Medium and rich fishermen invested in big fishing tools like engine boat and bigger fencing nets, while small fishermen continued to work with the same traditional materials.

Second wave of investments had to come between 2000 and 2010: Thanks to the extension of short term varieties that allowed to move to double cropping and to extend the cultivation to the early-season and receding periods, richest farmers could in turn invest in rice land expansion in order to prepare the legacy to children and to benefit from the low prices. A lucrative speculation game may have started from this early time. Good paddy land became more expensive for local people, and as the legacy to children was more and more present on the mind of the farmers. Farmers who had not good land had not any opportunity to successfully cultivate short-term rice and other crops or vegetable. Badly, they did not much develop their household economy.

Thirdly from 2010 up to now: with the success of short-term rice and double cropping, farmers kept going on accumulating money and investing in hand-tractors, while selling the cattle. . For the fishing activity, again after the fishing lots determination, the both farmers and fisherman invested significantly in big fishing lot fence system pens (Nor-Rav), fast and large engine boat, and other big fishing tools for facing the fishery boom explosion.

4.6.6.3 Past trend of capital accumulation and investment

More recently, local farmers and fishermen invest more in modern houses with warehouse underneath, high on cement piles, glossy paints on the walls and stairs. Farmers invest in a tractor for the youngest who have the ambition to sell services of transportation.

For the new comers of that time with a high initial capital, who could afford to invest in risky activities such as vegetables, they generally settled on bad quality soils, the other ones being too much expensive. The multiplication of groceries is also a response to the rice and fish economy-pulling context. We could see that children of the present farmers came back from

abroad where they were struggling to accumulate money from “little jobs”, to set a grocery/garage/ selling their services businesses in the village.

Beside these, farmers invest from the beginning in manual sprayers and in herbicides. The efficiency was lower than today because the chemical products quality was poor. Since the good success of the red corn, suitable for herbicides (sown in line, whereas groundnut was mainly sown by a manual tool), the chemical market opportunities soared attracting both new and better-quality chemicals.

Since 2007 until today, more and more farmers have invested in motorized chemical sprayers (150 to 300 USD); Water pumps, water ponds and pipes for their irrigation system: sometimes for irrigation of the early rice but most of the time for the vegetables and orchards, and fertilizers. Farmers do not need to invest in processing equipment, as intermediaries buy the raw products from the farms and process it themselves afterwards with their own equipment. Only for the paddy, farmers have to transport the production to the intermediary, which is in the village. The only equipment for post harvest process are the plastic carpets to dry groundnuts, mung bean and soybeans.

Fishermen invest more in modern engine boat and long fending system net and other illegal fishing tools like electric shocking, which are generally believed they can catch more fish production. Large fishermen buy their rights to do illegal fishing to the corrupted authorities (3,000 to 5,000 USD/year), while poor fishermen (small fishermen) can pay about 50 to 150 USD/year to get reach in fish catching in the protection zone and using illegal fishing tools. This trend is going on worse and worse until today even the fisheries administrator (FiA) has increased the patrolling.

4.7. Situation of the households and assets

In this session, we examine levels of households’ assets and their capacity to access social services.

4.7.1 House characteristic of the household types

The characteristics of the house generally well illustrates the social status of the household in summarized in a Table 38 below. Socially and traditionally, Cambodian people in general tend to invest more on home construction if they would be better well-faire. So, our study considers that it is important to show the situation of the home characteristic compiled with home materails used by the household types. It might contribute to better understanding on the living situation of each household’s situation.

Table 38: House characteristic of the six household types

Household Types	N	Maximum	Minimum	Mean	Std. Deviation
Landless people	27	12.00	8.00	9.58	0.880
Single croppers	76	15.00	8.00	11.39	1.696
Diversifiers	109	14.00	9.00	12.49	1.138
Large farmers	52	15.00	12.00	13.52	0.792
Small fishermen	55	13.00	9.00	10.50	1.149
Large fishermen	25	13.00	10.00	12.42	0.870
Total	346	15.00	8.00	11.84	1.670

Scoring on house materials:
*** Roof:** 5 score for Tiles and Zinc/Metal; 2 score for Natural material/plant/ thatch and Plastic tent
*** Wall:** 5 score for Bricks; 4 score for Wood Planck and Zinc/Metal; **3** score for Bamboo and Palm/coconut leaf; 2 score for Plastic tent; 1 score for Clothes
*** Floor: 5** score for Tiles or cement; **4** score for Wood; **2** score for Bamboo; **1** score for Nothing (ground, sand) and Plastic tent

The anylysis result confirms that the Large farmers households have the best house conditions (score at 13.5). Hence we have rated the house of the households in the villagre surveyed. Not a surprise,Their houses are built with expensive raw materials, with alarge size about 6 m width, 12 m length, and 3 m height, and one to two floors; Roof is 100% covered by tiles and metal; wall 83% made with wood plank and metal and 17% made with brick and cement; floor 37% made of wood and 63% of tile or concrete on both first floor or basement. We also interview them the estimated cost to build their house about 12,000 to 35,000 USD. We assume that they are richer in term of housing property compared to the other households in the agricultural villages, and those are new house build around 5 years ago.

Secondly, the house of Large fisherman and Diversifier household types have similar scores as about 12.40, the difference being that the house of Diversifiers is built on land and the one of the Large fishermen is built in the floating area. The house of Diversifiers are built with expensive raw materials and size about 4 m width, 9 m length, and 2.5 m height and one floors; Roof 9.5% covered by tile and metal, and 5% by plastic tent and plant leave (Palm and coconut leaf); wall 40% made with wood plank and metal, 38% made with plastic tent and plant leave, and 12% with tiles and cement; floor 37.3% made of bamboo, and 5.6% of wood, and the rest are attached to the grounds. We estimated cost is about 4,000 to 8,000 USD.

The house of Large fishermen is build both on stand-stilts and floating condition, some as high as 6 meters; therefore, in the dry season, when there is no water, these houses present an amazing sight as they stand high above one's head. During the floods though, the water almost reaches even the highest houses, and for transportation the villagers use small motorboats and small family pirogues. Floating houses and shops made of bamboo, some

selling fish traps, are located on the lake and are moved along the shoreline according to the water level. People living in the floating houses move up and down, and in some areas, such as in Bak Prea, Tvang, Kbal Toa, and Preak Toal, they may move their houses at least 50 times in a year in order to adjust to the water level. Moving their houses not only costs money, but also causes environmental damage, as people often obtain their building materials from the flooded forest. Floating houses have a size about 5 m width, 16 m length, and 2.5 m height and one floors; Roof is at 90.1% covered by tiles and 0.1% by mixed plastic tent and iron sheets; walls 90% made of iron sheets and 9% of wood plank, and 38% made of mixed plastic tent and iron sheets; floor 82.9% made of wood, 17.1% bamboo. We estimated the costs at about 8,000 to 13,000 USD per house.

The worst house characteristics are those of the Single croppers, getting 11.39 score and Small fishermen, even worse at 9.58 score. Generally, the Rice mono-croppers built their house with the same size at Diversifiers, but they used very cheap raw materials; 92.3% of the roofs are covered by tiles and 7.7% by mixed plastic tent and plant leaves; wall are 61% made of iron sheets and 94% of mixed wood plank and plant leave; floor 65% made of bamboo, 25% wood plank, and 10% attached to the ground. We estimated the cost is at about 1,200 to 3,000 USD; they have been build more than 10 years ago.

The houses/huts of Small fishermen are only the floating hut and boat type, no stand-stilt. They build very cheap and low quality raw materials; Roof 97% covered by mixed plastic tent and plant leave, and only 3% of metal; wallsmade with 96% of mixed wood plank and plant leave, 4% of metal; floor 75% made of bamboo, 25% of wood plank, and 10% attached to the ground. We get the estimated cost to build their house about 300 USD to 1,000 US. In the dry season, when there is no water, they have to find a temporary hill to land this hut. Their floating houses and shops made of bamboo, some selling fish traps, are located on the lake and are moved along the shoreline according to the water level. People living in the floating houses move up and down, and in some areas more than 100 times per year and, sometimes their movement cannot be identified.

4.7.2 Means of Agriculture and transportation, and main home accessories

As shown in the Table 39, we find that, among the six types of households such as Diversifiers, large farmers; and Large fishermen have more expensive and big means of agriculture and transportation, but also the home accessories. Table 39 summarizes the means of agriculture and transportation, Main home accessories, and Water supply and Sanitation.

Table 39: Summary of Means of agriculture, transportaiton, and water suply and sanitation

Characteristic of items	Household types					
	Landless people	**Single croppers**	**Diversifiers**	**Large farmers**	**Small fishermen**	**Large fishermen**
Means of agriculture and transportation						
Small truck	No	No	No	One, but only 1% has	No	No
Small rice miller	No	No	No	One, but only 1% has	No	No
Car	No	No	No	No	No	No
Bicycle	One	One	> two	> two	No	No
Motor	One	One	One	One	No	No
Plough and Rake	One	One	One	One	No	No
Hand tractor	No	One, but only 13% has	One, but only 25% has	One/two	No	No
Tractor	No	No	No	One	No	No
Water pumper	No	No	One	One	No	No
Grass Trimming machine	No	No	One	One/two	No	No
Manual sprayer	No	One	One	One/two	No	No
Spraying machine	No	No	No	One/two	No	No
Boat	No	One	One	One	One	One/two
Engine boat *(Smach and big boat)*	No	No	One, <125HP only 22% has	One, <125HP only 31% has	One, <125HP only 8% has	One/two, >125HP
Stationary gill net *(Maung)*	< 100 metres	< 100 metres	< 100 metres	> 100 metres	> 500 metres	> 1,000 metres
Filtering Gear Grid trap *(Treourng)*	No	No	No	No	> 50	No
Fishing net *(Samnanh)*	One	One	One/two	One/two	One/two	One/two
Fence System pens *(Nor Rave)*	No	No	No	No	> 100 metres	> 1,000 metres
Horizotal Cyclider Trap *(Leour)*	No	No	No	No	One	One/two
Bamboo Tube Eel Trap *(Loan)*	< 20	< 50	< 20	< 10	> 100	No
Small Fence System pens *(Nor)*	No	No	No	No	> 50 metres	> 500 metres
Fish Electric Shocker	No	One, only 5% has	No	No	One, only 75% has	One, only 6% has
Main home accessories						
Table	One	One	One/two	One/two	One	One/two
Battery	One	One	One/two	One/two	One	One/two
Mobile	One	One	One/two	One/two	One	One/two
Fan	One	One	One/two	One/two	One	One/two
Radio	One	One	One/two	One/two	One	One/two
TV	One	One	One/two	One/two	No	One
Access to electricity	- Own battery - 15% Private	- Own battery - 90% Public	- Own battery - 98% Public	- Own battery - 100%Public	- Own battery - 25% Private	- 100% Private
Water supply and sanitation						
Toilet	Forest/ lake/river	One, but only 85% has	One	One	Forest/ lake/river	Forest/ lake/river
Water filter	One	One	One/two	One/two	One/two	One/two
Boil water	Not often	Not often	Yes, often	Yes, often	Not often	Yes, often
Water tent	One	One	< four	< Ten	> Ten	> Ten
Health/Illness	Weak health: go to health centre for serious illness	Weak health: go to health centre for serious illness	Weak health: go to health centre for serious illness	Often go to meet doctor	Weak health: go to health centre for serious illness	Sometimes go to meet doctor
Legends: **HP** = House Power						

For instance, each of the Large farmers have one tractor and also one or two hand-tractors, and other engine equipement for using in their own farming activities. They also have big engine-boat and other big fishing tools. We also find this household type have more capacity to serve their machineries for farm works; for example, tractor for land preparation, sprayer for insecticide spraying to rice and intensified crops Chamkar.

By contrary, the small farmers have very few machineries and small equipement for working in their farm including their small and traditional fishing tools. This explains that the large farmers are in better-off condition in term of fishing equipment and transportation, also more opportunity to get to social service like health care and electricity in comparison with other households.

The Large fishermen perform with good and big fishing machineries and tools in comparison with Small fishermen. They generally have big and expensive engine boat with big fishing lot fence system with pens and other long nets and traps. The Small fishermen generally have not had much develop in fishing tools while using the common traditional tools such traditional boat and fishing net and fishing fock. This also explains that the Large fishermen are in better condition in fishing tools and transportation for transportation to the accessibility of the social and public services in the cities.

4.7.3 Water Supply and Sanitation

The survey study is designed to indentify the level of water source and sanitation of the people and communities in the study area (see above Table 39). We focus on the living environment, issue related to the hygiene and sanitation when daily water and waste management.

As result in the Table 39 shows that the issues of water source and waste become one of the most serious concern for the local people, and because these issues may also lead the people fragile in term of household economic development. For instance, as shown in the result, there are only two households such as Large farmers and Large fishermen who have better condition in term of waste management and hygiene water management, but access to public and private health care services.

The poor/worse-off households have very low capacity to manage their toilet and materials like water filter, water tent, and boil water for their daily use; for example the Landless, Single croppers, and Small fishermen mostly do not have their own toilet wheras they use the free forest/river/lake for doing toilet.

The better-off households like Diversifiers, Large farmers, and Large farmers are found they have more the water containers and toilet for using in their own house, even the Large fishermen live in the fishing village, the also have toilet in the house and using mineral water buy from the market.

Beyond of the low water container materials, the poor households are less or not aware of the hygiene and sanitation. They generally live in the natural condition, because they have most movement from one area to others and low budget to get the good materials, for example like Landless people, Small fishermen, and Single croppers, managing to get good water sources and toilet management become a main challenge for them. Their toilet is generally build next to the kitchen and house, and water cooking and bathing was taken near the toilet, which is almost the same situation in both agricultural and fishing villages.

To be worse, in the fishing villages, people are always use the cooking water and bathing directly from the same area location of toilet waste. However, traditionally most of the households use boilt water (tea water) for drinking, this seems less concern for the households health affect. But still we found that people fell sick caused by the malaria and other infectious diseases in the areas.

Consequently, when they get illness, there are only two households; Large farmers and Large fishermen; are capable to get access to get the health care and treatment at the public and private services. These households can effort to pay for the health care services by themselve, while the other households like Landless people, Single croppers, Diversifiers, and Small fishermen do not or rare to get the services, instead they use thanditional medicines, and getting to the services when they get serious illness.

4.8. Debt context and loan access by the households

4.8.1 Sources of loan

Firstly, we tried to investigate the main sources of loan used by households to get a better understanding on source option and constraint which they obtain to use in their household activity investment. According to the type of household, a majority (17% to 56%), borrow from Trader/seller and private lenders, followed in the second rank by microfinance institutions (MFIs) from 17% to 48%, and the third source is from family and relatives (1 to 24%) and neighbours (7 to 28%), and only very few from NGOs microfinance (7% to 17%), from saving groups/villages bank (2 to 6%). Based on our results, Table 40 shows the summary of the source of loan borrowed by our finding household types. Farmers and fishermen have been using different sources of credit.

Table 40: Source of loan borrowing by household types

Items		Household types					
		Landless people	**Single croppers**	**Diver-sifiers**	**Large farmers**	**Small fishermen**	**Large fishermen**
Source of loan	Family/Relative	6%	24%	19%	12%	18%	1%
	Neighbour	28%	8%	7%	7%	7%	12%
	Tontin	0%	0%	1%	0%	0%	0%
	NGOs	17%	2%	1%	0%	0%	0%
	Trader/Seller, and private moneylender	17%	25%	35%	30%	43%	56%
	MFIs/Bank	32%	36%	30%	48%	26%	17%
	Saving group/Village Bank	0%	2%	4%	3%	3%	6%

The trader/seller and private moneylenders remain the major loan source for three main motives: first, they live nearly and prominently in the villages; second, they don't require any official administrative documents; and thirdly, they don't ask for formal collaterals. Landless people and all three types of farmers prefer to access loans from these traders/sellers and private moneylenders, which they can borrow cash or owe the agricultural inputs (like fertilizer/insecticide, gasoline, etc..) before or during the crop cycle; they can pay back in cash and interest after the harvest. For the two fishermen groups, the Small fishermen generally borrow from fish traders during the low productivity period (between January to May), then they pay back by offering fish at cheaper price (500 to 1000 riels/kg = 0.12 to 0.24USD/kg). This is a very crucial contract, and in general small fishermen loose a lot. Additionally, Large fishermen mostly access to the foods sellers, petty (grocery and gasoline) traders and small businessmen in Siem Reap and Battambang cities, whom they make business with, and to whom they can finally payback debt in cash with interest. We assume all households have access to loan from traders/sellers and private moneylenders since long-time ago, it is still well adapted currently.

The MFIs/banks are thea second main loan provider for all households from very recent year (probably since around 2010), after there was a credit integration policy from the RGC and those MFIs/Bank. The MFIs/bank have three main motives of provided loans; one is rate of loan interest (around 2.4%/month described in next session), second is that the loans can be provided via insured group, and third that easy access can be organised with one agency directly in the villages.

The NGOs, Saving groups and Village Banks, play also an important role in providing loans. However, those sources are not very common yet, and there are very few development NGOs and projects working on this issue in the area.

4.8.2 Interest rate and maturity of credit source providers

We also highlight the difference between the average interest rate charged and and the duration of the loans fixed by credit providers. The high-interest rate and short duration of the loans was one of challenges outlined by rice farmers. Table 41 reveals that the average interest rates charged by moneylenders were high around 5.64% per month, compared to NGOs-MFI and MFIs were 3% and 2.41 %, respectively. Furthermore, the duration of the loans provided by MFIs was longer (21.26 months) than by NGOs-MFI (13.5 months), moneylenders (5.19 months), and approximately 4.25 months for relatives and friends.

Table 41: Interest rate and Maturity of loan borrowing by household types

Loan sources	**Interest rate per month (%)**	**Maturity (Month)**
Relatives, Friends, Neighbour	0.00	4.25
Trader/Seller, private moneylender	5.64	5.19
NGOs, Saving group/Village Bank	3.00	13.5
MFIs/Bank	2.41	21.26

4.8.3 Loan Access by the householelds

Furthermore, thirdly we find out that most rice farmers used the loan for multiple purposes, but the majority of them used the loan for agricultural production include fishing activity. The results in Table 42 shows that from 20 to 48% of respondents primarily used the loan for farming activities, while about 16 to 40% used for coping with household consumption. The third following, from 3 to 19% used for sending their children to school. Likewise, households used the loan for medical treatment from 4 to 15%. There is very few lowest for other purposes are summarized as following in Table 42 below.

Table 42: Purpose of loan borrowing by household types

Items		**Household types**					
		Landless people	**Single croppers**	**Diver-sifiers**	**Large farmers**	**Small fishermen**	**Large fishermen**
Purpose of borrowing loan	Agriculture include fishing	9%	44%	48%	20%	43%	34%
	Investment in business	11%	2%	13%	15%	3%	11%
	Cope the household consumption	40%	24%	18%	23%	32%	16%
	Medical treatment	5%	4%	6%	7%	11%	15%
	Send Children go to school	19%	10%	6%	23%	3%	15%
	Married/ festival parties	0%	3%	0%	2%	2%	0%
	Migration support	0%	5%	1%	2%	2%	2%
	Repay previous debt	0%	1%	1%	0%	0%	0%
	House building	0%	2%	3%	7%	2%	2%
	Cope with crop failure	11%	3%	3%	0%	0%	4%
	Young married couple starting business	0%	0%	0%	1%	1%	0%
	Help child to start agricultural work	0%	1%	0%	1%	1%	0%
	Buy new land	5%	1%	0%	0%	0%	0%
	Keep/ save for children	0%	0%	0%	0%	0%	0%

As result , the loans are used mainly by the households for supporting their agricultural production. Obviously, we found that the three farmer households types always borrow to purchase agricultural inputs for the production. Their savings from the previous year seem never sufficient for the coming season. This happens occasionally to all farmers and also fishermen, they have to borrow loan more or less at the different level based on their individual annual income.

Small farmers like Single croppers and Diversifiers access to loans and use it for their agricultural production in a high percentage (44% for Rice mono-croppers and 48% for Diversifiers). The two fishermen household types also use very high loan for their fishing activities; 43% for Small fishermen and 34% for Large fishermen.

The second main use of the loans by the households is for coping the family consumption. The result shows that the landless people use 40% of loan for daily foods and others expenses. Still, the other five households types also use the same loan for coping their household consumption.

The following fourth purpose of loan use is for sending the children to school among the farmers and landless people and Large fishermen, while not for the Small fishermen. However, the result shows the Small fishermen spend very small amounts for sending their children to school. According our finding, there is no and rare school in the fishing villages, while there are more school on land or water-land area. Some Large fishermen are able to send their children to school in the Siem Reap town, their loan and own cash is highly used for this purpose.

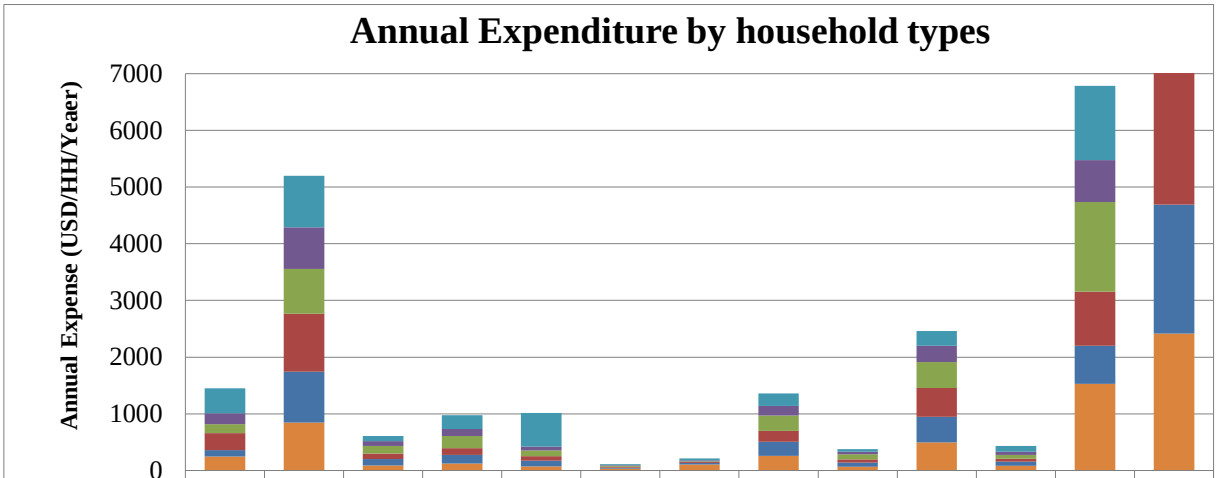
The fifth purpose of the loan use is health care and medical treatments. The result shows that the landless people and three farmers households types are using almost the same percentage of loan for the same purpose for health care and treatment, while the two fishermen households use higher percentage (11% for Small fishermen and 15% for Large fishermen). This explain that the health sock and illness is still a big issue impacting negatively on the household livelihood, as low public health care is provided to the people. Significantly, from this point of view, the worse situation is certainly the one of the fishing villages, where generally the health is not and rarely provided.

Finally, our conclusion is that all the households use loans for many purposes for their household basic needs, and that the borrowing capacity is significantly important beyond the income from household from on-farm, non-farm and off-farm activities. Meanwhile, when the annual income is not enough for covering the annual needs, the loan is used for complementing

the farming activities. For long-term development of the households, the need for cheaper loan support and subsidy is needed for all the household types.

4.9. Householeld comsumption/expenditures

The collection of data on household consumption/expenditure was analysed for measuring the living standards of the households and for monitoring the poverty. In this study, the annual consumption or expenditure is calculated based on the recall questions. The annual average consumption per household is summarized in the Figure 12 below.



	Rice	Daily food	Clothes	Medicine /Treat-ment	Electri-city	Water	Gasoline	Wedding parties	Religion	Children to school	Telecom Credit	Debt payment	Total
Large fishermen	$438	$914	$87	$247	$595	$14	$34	$216	$46	$262	$105	$1,305	$2,957
Small fishermen	$191	$730	$87	$123	$66	$13	$20	$173	$47	$287	$56	$745	$1,792
Large farmers	$158	$793	$133	$213	$104	$18	$8	$267	$88	$459	$70	$1,579	$2,311
Diversifiers	$298	$1,019	$95	$121	$77	$17	$21	$191	$58	$508	$48	$955	$2,454
Single croppers	$117	$899	$117	$149	$103	$16	$28	$250	$76	$451	$73	$669	$2,277
Landless people	$244	$846	$88	$125	$72	$34	$105	$259	$64	$495	$84	$1,530	$2,415

Figure 12: Summary of Annual expenditure by household types

The results determine that all the six households types live with debts. The estimated debt weights on their income of about 30 to 50%. The second consumption is daily foods including additional rice purchase from the market, which are occasionally high. Third in importance are the expenses for sending children to school, and fourth for health care and medical threatment, while the rest are for other social expenses and religion.

The balance between income and consumption seems worse for the poor households such as Landless people, Rice mono-croppers, and Small fishermen who spend more for to debt payment and daily foods, sending their children to school, and also their household health care and medical treatment. This confirms that the poor or worse-off households are generally those who use more their income for consumption, at the expense of the savings for the investments

for the coming year . Meanwhile, the better-off such as Diversifiers, Large farmers, and Large fishermen have more balanced consumption and income, and might have more capacity to develop their household livelihood.

4.10. Collective action: difficulty and challengs in community management

The ability of individuals to organise collective actions that is often required for irrigation, fishery and forest management, but also for running microcredit schemes, raises raises a number of questions on the cultural and social mechanisms governing the local institutions.

As much as the ability of peasants to innovate at an individual or family scale generates little doubts (we recalled many illustrations in previous and the next chapters), the innovations that affect the collective organization generally meet falsely passive resistance of individuals. The lack of organization and even the refusal of any form of collective organization is deplored. The history is accused: the dramatic Khmer Rouge period is said to provoked an unavoidable reluctance vis-à-vis any form of collective organization.

However, it also happens that collective decisions are taken, that work is decided at the local level; we even saw collections to organize extending a pagoda, digging a canal to or repairing a dike or building a school. What are the driving forces behind these mobilizations? Looking at the past institutional changes that have successfully transformed the conditions to the production alows to identify the leverages that can generate these decisions, then to carry out the execution: the villages, the communes or the districts, the organizations of users, the professional associations, the Central State, commonly seen as “the Government”?

4.10.1 A way to form community

4.10.1.1 A little solidarity in the villages

In the study area, as well as in general Cambodia, the village is, as we have seen, a rather vague concept. First, any inhabited area (a house is enough) can claim the name *Phum*. "The word *Phum*, note Delvert (1983), refers to a rural area inhabited in general, with very vague boundaries, more than a finite set of houses or a well-defined organizational entity." Second, the geographic reality of demographic groupings is often unclear when houses stretch along a road or bank. "The freedom of movement afforded by the absence of fences or barriers between houses, a lack of knowledge of the nature of the (mostly related) links between neighbors, the ignorance of the codes governing their whereabouts and their transactions lead to outside observers to design an intense network of exchanges, verbal and material, founding a collective identity" (Crochet, 1997). But the reality is often different. Sociologically, houses groupings

most often reflect a sum of family networks, sometimes even a single one, rather than one single community *per se*.

The village remains primarily a group of families for whom notions of community and village community remain quite external. As proof, the surprising small number, within the villages, of endogenous collective design and implementation facilities. Several observers sometimes argue that a stronger collective organization once existed but was broken by the war and the Khmer Rouge; it would then be in the rehabilitation phase. Yet the traditional social cohesion at the village level seems to have never really existed: Whether the *Phums* are tiny or they group several hundred houses, one fact appears certain: the lack of rural community. No common house, no common ground.

In conclusion, the village can hardly be considered as an area of solidarity that can anchor collective actions. The decisions of the "village" are in fact those that mobilize the administrative authorities: military affairs and public order, legal issues, etc. For example, Land distributions, where they occurred by Krom Samaki “Solidarity Group” in the 1980s, fell into this category.

The village is not necessarily the best scale to manage a collective action. "So, in the case of a dike management committee or other types of infrastructure, it is essential that the management unit be based on the technical unit," (Fontenelle, 2001).

4.10.1.2 A role of the pagoda and its limitation

Without finding in the village the space of collective organization that we may seek at the local level, we may assume that we can find it at the level of the pagoda.

Crochet (1997) summarizes this position well: "A consensus has gradually been established to consider the pagoda as a privileged place of community life. The village and its inhabitants would identify with such a monastery, where they would send their sons to take the frock, where they meet for the parties, for which they contribute.”

The pagoda, located outside the village often only gathers old women and and old men. The members of the pagoda committee come from the old families of the village, those who enjoy both more land and more consideration. However, we can perfectly make a difference by going to another pagoda than the village. Apart from contributions to the repair of buildings, the villagers do not take part in the life and activities of the pagoda: they pay an average of four visits a year to it (Crochet, 1997; Pillot, 2007).

Furthermore, Crochet (1997) continues: "Proud of the beauty of their temple, the peasants certainly contribute to its construction and operation, but it is to acquire merits, not solidarity. The call to the monks, for weddings or funerals for example, does not proceed from a recognition of a political power of the monk, but from a contractual service relationship: we seek their mediation during long illnesses, waiting that they practice substitution rituals. They are brought to the house, preparing for them offerings that are similar to a salary, except that the more important they are, the more they will earn merit for a future life. "

4.10.1.3 Unjustifiable consensus and a requirement for the collective project

In reality, our study found that most collective actions can only be decided with the *joint assent* of the two "spheres of influence" that are the administration and the pagoda. These achievements are either directly related to the pagoda and its enclosure, or of public utility (road, school, dispensary, pond, well, house of the traveler ...). First of all, they lead to a dialogue between the moral and political authorities: the commune chief, the chief of the monks, the head of the Pagoda Committee, some former influential people, and so on. The assent of all the protagonists finally obtained, the project can then be presented to the village assembly where it is generally adopted by consensus and applause. From that moment, it imposes itself on everyone.

The pagoda and the administration represent, if not "authorities", at least incontestable spheres of influence. A collective project can not take place if there is an opposition that is constituted and recognized, even if it is a minority and even if the project is of obvious public interest. The search for consensus is therefore essential. It is above all a matter of preventing open opposition and apparent conflict.

While cooperation between actors can be real as long as it is consensual, it is also precarious: in "traditional" society, its life span does not exceed that of a specific and well-defined project. It could not be otherwise, because consensus is established only in relation to this project. If it is not sustained by the will of a superior "authority" (such as that of the State), then punctual cooperation does not give rise to a stable institution that imposes itself to regulate collective problems.

Far from Western vision of collective management, in traditional Khmer society, what counts is the delegation of power to a leader who is responsible for protecting and harmonizing the group. This vision hurts all the more Western conceptions of participatory democracy that the power of this leader does not proceed from a legitimacy that would be conferred on him by the group: it holds on the contrary to its status, itself produced its chance or the kharma that

comes from the merits acquired during his previous life. This is why the "elections" of village leaders can not have the "democratic" meaning that Westerners would like to see there. The applause that sanctions the choice of a leader in a village assembly marks the recognition and acceptance of a leader, but they are not a designation. As proof, it is extremely rare for several candidates declare themselves at such assemblies. On the contrary, everyone expects to know which candidate is nominated in advance.

4.10.2 The conditions of collective management

Previous analyzis sometimes discourage overworked observers who analyse the Cambodian society as a closed society, in which very few jurisdictions, apart from the individual and the family, are likely to lead to a development organization. Népote (1992) reports the same of "national suicidal tendencies", for a society whose organization and ideology could only lead to its loss, especially when compared to that of its powerful neighbors, Vietnam and Thailand. And to explain the secular decline of Cambodia since Angkor period, and even the bloody Khmer Rouge period, as expressions of this collective suicide.

This pessimistic vision is fortunately contradicted by the number of economic transformations that can be observed over the last 35 years. When groups of farmers set up an organization to cope with a difficulty that is widely felt, their participation is always enthusiastic. There is usually no difficulty in mobilizing them, or in making them work together. Attention is flawless in credit training sessions.

For irrigation, the farmers are involved in the discussions and then in the responsibilities for the rehabilitation of a dike or canal, and are concerned about the proper distribution of responsibilities. The collective days of work of common interest, they proceed from the initiative of the pagoda or the administration, are generally carried out in the good humor and the assiduity, even on the part of peasants who will not benefit from the work done.

It is true that in such a context, all the peasants are treated on the same plane; no one has to invest in important responsibilities and nobody is in charge of a function that distinguishes him from the group.

Beyond the implementation phase, the smooth running of the organization requires that members' involvement be extended over time: channel maintenance, management and recovery of working capital for water services, repayment of loans and payment of interest in accordance with their commitments for credit services, but also for managing the patrolling schedule for fishery community.

The first condition of the strong farmer mobilization in terms of work, contributions or fees is related to the continuity of the service. The latter must demonstrate irreproachable quality, and beneficiaries receive an undeniable and secure advantage. This seems obvious, and yet many "participative" projects fail to underestimate the technical and economic constraints.

The second condition is that the participation of the members in the functioning of the organization that is put in polace goes beyonf the initial membership.

4.10.3 A condition and recognition by the State

Recognition by the state of local organizations, whether territorial or technical, is absolutely essential to enable them to impose themselves in the face of individual logic. Since the state is considered to be a particularly powerful network of influence, an individual is more inclined to accept constraints from the latter than from his peers. The mandate given by the state to an association, for example, to manage equipment on its behalf, however, must be unambiguous to be effective.

To what extent can the State institutions respond effectively to the expectation thus placed in them? To pose the problems in these terms inevitably brings into question the laws and the rules and the mode of operation of the State for generating and implementing public policies; in our study zone the land distributions, both in 1985 and in 1995, then the securisation of the remaining flooded forest, during the period of active immigration, and more recently the organisation of restricted areas for fishing fall generate a number of questions in this domain.

The first is that the only areas of public life to have, a meaning for the villagers are the pagoda and the king: the political life is experienced as a succession of family histories and the Cambodian political space as an expansion of kinship relations. The state is therefore not perceived as a regulatory structure, but as one of authority.

The second is that this authority is itself perceived as a patrimonial asset that is distributed to large local networks . Such was, for instance the delegation to the local authorities in charge of allocating the fishing rights when these were in place. The distinction between the public good and the private good is then blurred. In some cases, the networks that structure the state correspond to the organizational charts of public institutions. The services then appear as separate compartments governed both by a hierarchy based on age and on family and customer loyalties. In other cases, networks can be cross-organizational and invisible on the surface. In any case, however, the mobilization of the administration cannot be done without decrypting of this organization.

The last is that the position that is expected of the state, that of "regulator" rather than that of direct manager, does not correspond to the historical culture of the Cambodian administration and, in general, the young managers are still poorly trained to perform the duties that goes together with this position. The role of field technicians, in particular, is turned upside down: yesterday in charge of "informing" farmers and transmitting central instructions about which varieties should be grown, it is now a matter for them to "support" initiatives and empower organizations to make their own choices. The change is not easily accepted…

4.11. Discussion and Conclusion

In our study, this Chapter focused mainly on the analysis of the diversity of the strategies developed by the households since Khmer Rough regime period until now, and the situation of types of household that result from the succession of transformations that occurred in these lowlands.

Small households' livelihood is composed of a complex and multiple combination of systems of activities relying on the capacity of the household, assets, agricultural activities, and other social factors for their decision-making choices (Barral *et al.*, 2012). The scholar Ellis (1999, 2000, 2001) argues the diversity of livelihood strategies and income composition of each livelihood allows rural households to reduce risks in a rural economy setting. And income from remains the largest contributor to the household total income, and income from paddy rice cultivation is still by far the primary source of farm income (especially for subsistence). People, especially in/around Tonle Sap Lake significantly generate their income from rice, fishery, forestry and natural resources activities, and migratory works, while livestock, poultry and small home garden remain for household consumption. In countryside, many households plant both rice and cash crops (e.g., mung bean, cassava, corn, soybean, groundnut, etc); however, they are prone to fluctuations of the commodity prices and to climatic/floodpulse variations. The level of income inevitably drops when those natural resources become degradated and more difficult to access. The results also points out the emergence of non-agricultural activities (Diepart, 2010).

We have identified and the main influential factors on the dynamics in the area have been the demography, the public policies on land and water, and finally the changes in the environment.

After the land distributions at two different periods during 1980 to 1998, farmers could invest in traditional paddy production such as floating rice and heavy rice while fishing was the main source of food consumption. Since then, with the pressure of changes due to increasing

demography, economic activities, prices of agricultural products and fishing, and land use and land management and fishery policy during the 1990 to 2012, farmers and fishermen diversified their farming systems.

Farmers have started to intensify their one cycle paddy to double cycle paddy and cash crops on uplands. The strong farmers invested in the best paddy lands. They started to expanse by buying good land from small farmers, logging the flooded forest land, and started to grow double rice cycle with short-term rice varieties, and, sometimes corn, mung bean or other cashcrops ect in the second cycle. The Large fishermen had more opportunities through their strong background as former KR soldiers, and close to the authorities during the fishing lot period. After the fishing lot termination, they diversified to large-scale fishing and aquaculture (crocodile rearing), and other non-farm and off-farm activities. The Small fishermen, on their side, had overcome to catch more opportunities, they have remained in the small-scale fishing and selling labour and migration for coping their family consumption.

Progressively, with the stability of the situation, the rehabilitation of amenities, the demining process and the success of the short-term rice and other cash crops, more and more farmers have intensified their farming to the double crops production systems. Farmers, therefore, increased the size of their cultivated land, which was ploughed with few animal traction (cows and buffalos), and more and more with the hand tractor of their own or by paying the services of hand tractor owners to other farmers.

From 2000, in summary, farmers can have adopted four possible strategies:

- Investment in hand tractor (to plough faster, to have it done in time, or renting to others) and in additional hydromorphic land to secure the food supply.
- The purchase of a lot of additional lands to anticipate the legacy issue to children (more than 3) in case of big families. It could be both on paddy and intensified crops lands as prices were still low
- The development of Mixed crops and vegetable Chamkar (*second wave*): mainly cash crops such as maize, mung been, watermelon, jute, and sugarcane, and other fruit trees. This strategy seems to have had important economical advantages untillnow.
- The poor households, who get lower productivity from their cropping systems, depend more on the selling labour in agricultural and non-agriculture or to get remittence from family abroad to support their farming activities.

For each of these strategies, farmers had also to prepare the legacy to their children. Between 1 to 2 ha of paddy lands are given per child, sometimes with an additional 1 hectare of land (for the richest families). Therefore, while the size of the farm tend to drop down, new farmers appear and start a new dynamic:

- Young couples with high capital: share of equipment, financial support from outmigrants, and still good soils. These do not need to sell their labour force, or to develop animal husbandry.
- Young couple also but with low capital: no equipment to share, need to work as external labour force, need to develop grocery if well localized and have sufficient starting capital. The situation of these kinds of farmers is fragile and sometimes ends up with the sale of the land (e. g. of Single croppers who sold their land for the health treatment of one of the members of their family).

All of farmers and fishermen have been facing the same continuous decrease of yields in rice and fishery products. Now, farmers are looking for solutions to maintain their incomes: more and more farmers use fertilizers and insecticides on their crops. A number of them also diversify their crops.

The fishery yields, on their side, have alsodecreased due to natural degradation done by over fishing. This has become more and more serious in flooded forests, while it impacted negatively on the fishermen's livelihood.

However, the poorest households who have no land and very small land holdings and no livestock, capital or savings, are found mostly among Landless people, Single croppers, and Small fishermen categories. These can be considered as worse-off households in term of intensification in farming systems, income, means of agriculture and transportation, but also low access to social and public services.

The medium and rich households who have better and bigger land, large-scale fishing, and investment in small and medium businesses, are found among the Diversifiers, Large farmers, and Large fishermen. The households located downstream appear to be poorer than those located upstream. Among the six types of households, some of the poorest families are found among the very small fishing households in "floating and stilted villages", scattered around and along major river channels.

Migration was widespread and most villages report that over 50% of households migrate to other provinces, Phnom Penh, or nearby countries (Thailand, less to Malaysia, Japan, and South Korea), and this is going to happen increasingly every year. The rest of them who stay in

the village also provided labour selling for rice, cassava and corn and wage labour in garment factories, or as domestic help in the farm, or as construction workers, etc.

Even though land-based households produce rice, due to small land holdings and low yields, the rice does not generally last the whole year. Most households report food shortages for at least four months a year, and people are living most of the time with a debt that they need to pay. In addition, due to the lack of clean drinking water, sanitation and accessible health care, the incidence of diseases (particularly communicable diseases; fever, headache, malaria, body aches, swollen lymph) is high, leading to low productivity. Pre-natal and post-natal care was also very limited and not easily accessible in neither in villages nor to outside.

Yes, we identified livelihood strategies of six household types based on individual characteristic, strategies of activity, and economic situation of households. These strategies mainly involve various rice and crop cultural practices, fishing, animal husbandry, aquaculture, and other non-specified fishing of the natural resources/environmental productions, and non-farm and off-farm including migration activities opportunities.

We focused on systems of activity and economic strategies of the household responses to shocks and stresses caused by the evolutions in the context of floodpulse, institutional and policy, and demography.

Results indicate increasing options and flexibility of each type of household to the shocks and stresses Non-farm and off-farm activities and migration become very important sources of income for the household;. Yet, the agricultural and non-agricultural wages, and migratory work are now the most important income for the worse-off household. Among the six types ofhouseholds, there are three better-off households, who have long-term adaptive capacity to resist to the shocks and stresses, while three types do not.

In conclusion, our study is one of the very first quantitative empirical studies systematically analysing the livelihood strategies of the landless people, farmers, and fishermen adaptation to the current changes. The findings also suggest policy implications for improving the range of livelihood choices available to lower income groups to move out the vicious poverty.

Chapter V: Anlysis of spatial economic impact of flood pulse changes on local household livelihood and Cambodian country economy

5.1. Introduction

The importance of TSL for Cambodian people are well described in the literature for a long time (Bonheur et al, 2002; Hap et al, 2016). Over 4.3 million people live in 1,555 villages and rely on ecosystems of the TSL to large extension for their livelihoods; food production and income generation (NIS, 2008a). Those people who live around the TSL and rely on this ecosystem to large extent for their livelihoods (Pillot, 2007). More than a classical lake, its special feature is based on a flood pulse connected to the level of the Mekong River during dry and rainy season (Lamberts, 2006).

Using typology provided by MEA (2005), one can identify several ecosystem services provided by the TSL. Firstly, *supporting services* can be mentioned. They are linked to all the non-material and consumptive which play important roles to support others 3 main following services: soil formation, nutrient cycling, photosynthesis etc. (Ahmed *et al.*, 1998; Hap et al, 2016). Secondly, TSL provides *provisioning services* that are related to all products and resources local people extract from their environment include fish, Non Timber Forest Product (NTFP), fuel wood etc. WCS (2010) estimated that between 289,000 and 431,000 tonnes of fish were caught annually in TSL. It is the fourth most productive captive fishery in the world, providing some 70% of the protein intake for the entire Cambodian population, whereas the floodplain in TSL contributes to 1/3 of GDP of agriculture (Van Zalinge *et al.*, 2000). The third main category encompasses *regulating services.* They are the ways in which living organisms can mediate or moderate the ambient environment that affects human performance: flood regulation, climate regulation, water purification and so on/ and more. World Bank (2006) also reported that the lake provides habitats for more than a hundred species such as water birds, 89 of which are abundant and 14 of which are considered to be of international significance, a large variety of fish who migrate in large numbers from throughout the lower Mekong system to spawn during high season, returning with the receding waters to the open lake and river system beyond. Moreover, water regulation and siltation services with impact on soil fertility for rice production, and transport by inland waterway are other regulating services. Cultural services are all the non-material, and normally non-consumptive, outputs of ecosystem that affect physical and mental state of people; spiritual, recreational, educational services etc. For instance, TSL and river play roles in Cambodian cultural ecotourism activities: birds, floating villages, Tonle Sap River trip (Conway and Chor-ching, 2006).

These benefits that people get from the TSL are essential for sustaining their livelihoods. Livelihoods are organized around complex aquatic agricultural systems characterized by occupational pluralism and diversified income-generating activities. In turn, these AAS are essentially based on complex combination of a variety of rice-based cropping systems and fisheries systems, but also include cash crop/home garden, natural pond culture and aquaculture, livestock and collection of non-timber forest products. This positive relationship between TSL ecosystem and livelihoods is closely linked to a regular seasonal variation in the lake's water level (Nuorteva, Keskinen and Varis, 2010). If the flood

during the rainy season is too high, risks of impacts on infrastructure (destruction of roads, houses' flooding…) are high. At this opposite, a long period of drought leads to a decrease of fish catch or a lack of water for rice cropping (Mak, 2011).

Maintaining a regular water level is literally challenging with the changes. Over recent decades the TSL faces dramatic hydrological changes due to several reasons: climatic events, hydropower dams in the Mekong, overfishing, deforestation of flooded forest, etc. (Serrat, Gallego-Lizon and Moffatt, 2005; Kummu *et al.*, 2008; Nuorteva, Keskinen and Varis, 2010; Sothorn *et al.*, 2011). The reports also argued that these changes have seriously impacted on local livelihoods relying on natural resources.

If these mechanisms are well documented nowadays, few data about socio-economic impacts of these changes are available. Bonheur et al (2002) and Keskinen and Varis (2012) brought new knowledge concerning the TSL' governance and policies. Others like Keskinen (2006) focused on zoning TSL related to village's location. Marschke and Berkes (2011) and Nuorteva et al. (2010) provide a useful analysis on livelihoods strategies based on qualitative data. (Neang, 2015) tried to investigate strategies in a quantitative analysis but only for rice cropping.

Rice cultivation have become implicit and source of vulnerability due to the high cost of input uses and significantly impacted by the natural disaster and climate changes (MRC, 2003), whereas it have had the issues to small household farmers' livelihood (Nuorteva, Keskinen and Varis, 2010). Despite the promising trends in the country's rice cultivation, a number of challenges could weaken the competitiveness and marketability in Cambodia and the neighboring countries. In consequence, small farmers hold small land size have badly faced more and more challenges to get their good revenue and productivities from mainly rice and crop cultivation for fill fully feeding their family. This leads them to diversify their labor to find the migratory job and some has abandoned from the agricultural to depend on only the non-farm and off-farm activities.

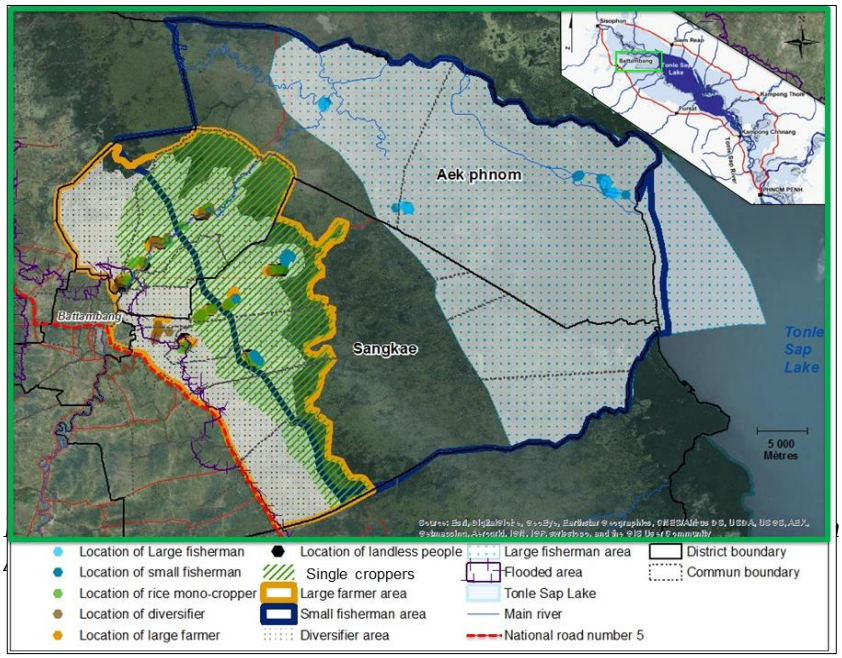
In this chapter, we mainly analyzes the economic and landscape spatial analysis impacted by the flood pulse changes of highly focused on economic calculation; we compare the household income performance and level of resilience in between Bad year in 2013-2014 and Good year in 2016-2017 in TSL ecosystem functioning; by capturing the location and producion zone of the household types, essentially analyzing the challenge on land use and fishing. Empirically, the study aims to answer the following questions: why and how the current flooding situation has possible impacts on rice production, hosehold income, and Cambodian Gross Domestic Product (GDP).

5.2. Results

5.2.1. Household strategies: a diversified situation based on the distant location from the TSL

A first analysis allows capturing the location of households and production zones in different ecosystems of the floodplain. Economic activities and broadly livelihood of households are clearly depending on the location of the villages. The map Illustration 19 below shows that the villages in the agricultural area are situated relatively close to each other in the agricultural area and at some distance from the lake. This leads to good living conditions for people who extract benefits from their agricultural activities/productions, typically rice-based cropping systems, cash crops, fishing, animal and aquaculture, and non-farm and off-farm activities. Therefore, the agricultural land covers the whole zone II and little part of zone III (see Illustration 19), at a distance between 5–15 kilometres (km) from the National Road number 5 (NR5) to downstream of TSL, where rice can be cultivated in both rainy and dry season. The villages in this agricultural area show higher living style and livelihood diversification compared to fishing area. Access to social and public services like road, hospital, credit, and agricultural markets is also easier there.

Source : Google Map elevation : Location attitude 17m/56ft with Latitude : 13.09573 North ; Longitude : 103.20221 East.



Differently, the fishing villages are located further (between 10 to 32 km) from the NR5. Their area covers the whole zone II of water-land shown in the map where generally only fishermen live there and extract unevenly benefits from the fishery products (see Illustration 19). The fishermen irregularly move their residence between rainy and dry season. In fact, large fishermen are mostly living in the villages of the eastern part (Aek Phnom), whereas smaller

fishermen are more widespread on the territory: some of them can be living in the fishing villages of the eastern zone already mentioned, while others may be living in the villages of the agricultural area. A detailed analysis of the six households' economic strategies were demonstrated in previous Chapter (chapter 4).

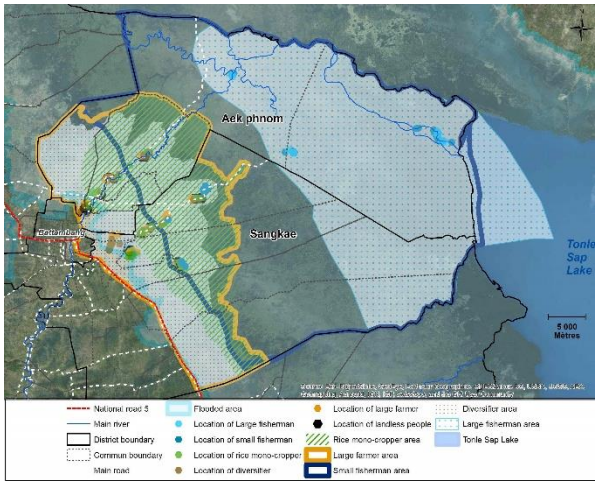
5.2.2. Mapping the impacts of the Tonle Sap water regime on households

Flood pulse changes can be caused by different factors such as the climate change and the construction of hydropower dams along the Mekong River ahead of Battambang province. It is believed to impact on local livelihoods and also to lead to changes in the environment. In this paper, the historical changes of livelihood in TSL of this province were investigated at the landscape and economic levels. The key informants were interviewed about unusual environmental events in the past, most importantly years with significantly higher level of water (like in 2016-2017) or lower water levels than normal (like in 2013-2014 and also 2015), as well as their impacts on households.

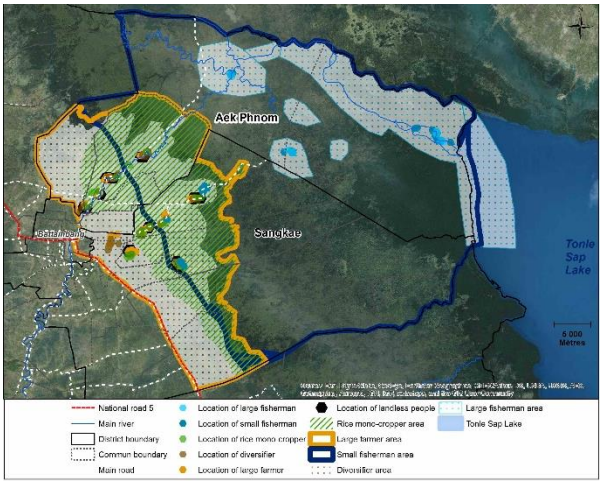
The research was conducted with different stakeholders; Battambang provincial sectoral departments; especially Departments of agriculture, forestry, and fisheries, Department of Water Management and Meteorology, and last Department of Land Management, Land Administration and Construction, Non-Governmental Organizations, fishery protected communities, authorities in both districts, and correspondents of the six households. The study also conducted GIS village mapping on land use changes and localization of the households. Likely, the study collected the GIS data-points of every correspondent, and also used Google Earth to represent households' access to production zones and resources.

The Illustration 20 shows the differentiation of flood pulse varieties in rainy and dry seasons of good year and bad year. The maps of Illustration 20A, B, C, and D illustrate the impact of a "good" year or a "bad" year on the expansion of the flood and the households' production zones in the study area. Indeed, the maps of Illustration 20E and F illustrated example locations of Rice mono-croppers, and Large fishermen in the case study. The "good" or "bad" characterize the availability of water during the dry season, a good year being when the water remains available in the lowest canals and rivers up to the NR5, facilitating irrigation.

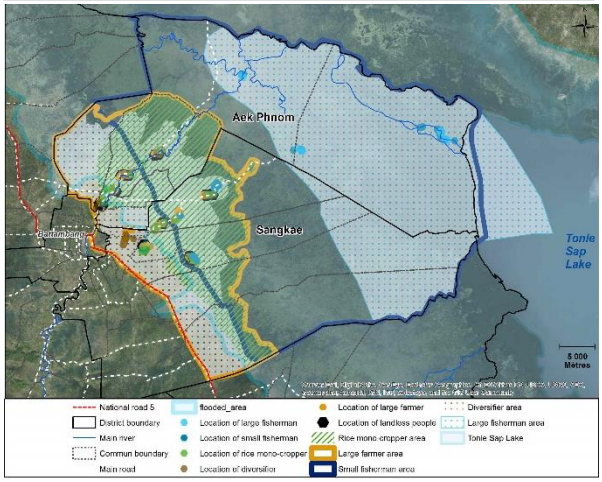
A. Map of rainy season in good year (2016-2017)



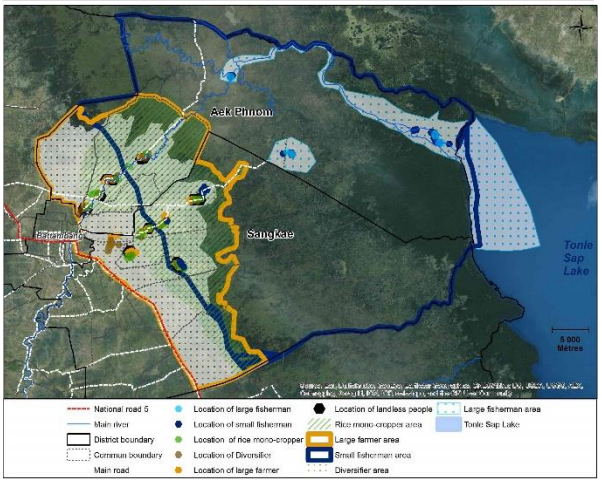
B. Map of dry season in good year (2016-2017)



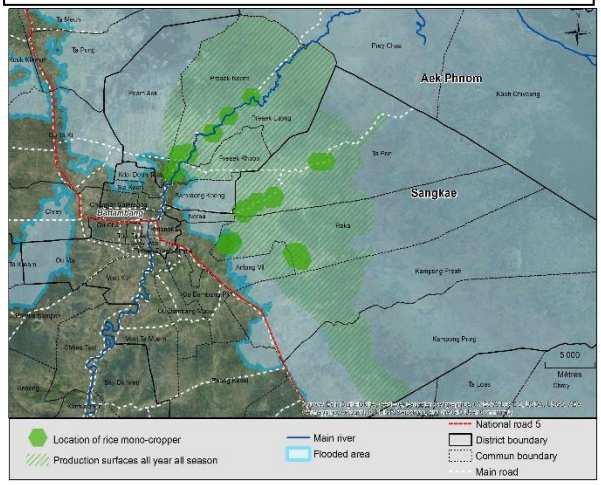
C. Map of rainy season in bad year (2013-2014)



D. Map of dry season in bad year (2013-2014)



E. Signle croppers households in good and bad years



F. Large fishermen households in good and bad years

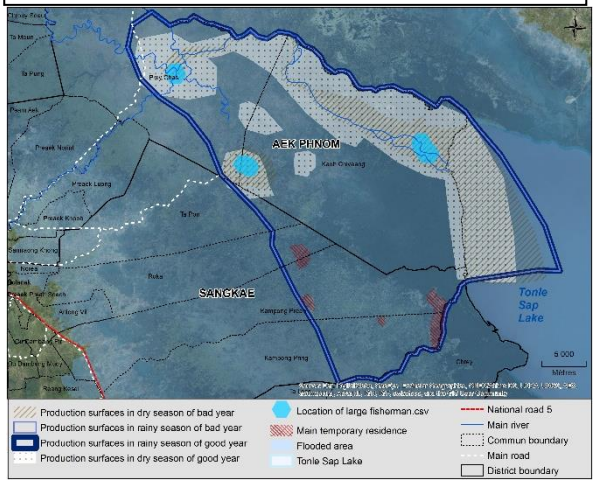


Illustration 20: Maps of Good year and Bad year of Aek Phnom and Sangkae districts

It is important to note that flood pulse being closely linked with local livelihoods, however, that flood is generally considered to be a both positive and negative phenomenon. For this reason, the terms ‘bad year” should be precisely characterised by significantly less

water/flood than a “mean year” and “good year” refers to a high, but not too high, flood level’ with clearly more water and/or higher water level than normally. In this study, the informants were interviewed individually and groups to describe ‘good’ and particularly ‘bad’ years and floods. However, the stakeholders reported similarly that the bad year happened once in 2005 and in a few years again from 2012 to 2015. And the good years happened in 2010 one, and then in 2016-2017 when the water level in the Tonle Sap was remarkably high.

In terms of water level, the difference is not very high between the two types of year; but due to the very flat slope, this little difference can have a very important impact on the territory beneficiating from the flood –and access to water in the following dry season. The water depth in a reference point of the flooded area was estimated at average 2.6 m on the “good” years where the flooding can reach around 1 kilometre over the national road number 5 (see *Illustration 20*A), whereas it was only average 1.3 m on the “bad” years where the flooding can reach around 2.5 to 4 kilometres under the national road number 5 (see *Illustration 20*B). In the case of bad years, the area covered by the flood are more limited, and, since they are less covered, the total quantity of siltation is reduced, impacting the fertility of the soils at the following crop season. The *Illustration 20*E and F are used to give the illustration of the location of the both households’ location zone, who stay in the same places even flooding is low or high. In the meantime, in the fishing area, the depth was estimated to between average 4 to 5 m on the “good” years, and only 2.2 meters on the “bad” years. Globally speaking, the difference of level can be estimated at around average 1 to 1.5 m at the peak of the flood. This is 50 cm less than what the records of the Battambang Provincial Department of Water Resources and Meteorology (BPDMOWRAM) the Ministry of Water Resources and Meteorology (MOWRAM).

Ad descrbed about the evolution of flood pulse from 2000 to 2016 in Figure 9 of Chapter 3, data from BPDMOWRAM shows that over the last 16 years, the maximum water level of TSL at Battambang has exceeded the average level with 7.5 meters above sea level (m.a.s.l.) in the years 2000, 2001, and 2002, and then in 2011 and 2016. By contrast, it has decreased to less than average 6 m.a.s.l. from 2003 to 2010.

Västilä et al. (2010) also noted the rising water level in TSL in Pursat and Kampong Chhnang provinces in the year 2011 and the succession of low floods from 2003 to 2010. Returning to a better situation, the flood pulse has just risen to over average 7.5 *m.a.s.l.* in 2016 and 2017 as observed by the study surveys. We can assume that a water level lower than average 6.5 *m.a.s.l.* also would be a disaster for farmers and fishermen in both fishing and agricultural areas.

A review of rainfall data from BPDMORAWM also indicated that rainfall over the last 15 years has been variable, but has increased since 2011 and once again in 2016 and 2017. The heaviest rainfall was seen in 2011 as flooding in the whole Cambodia.

In terms of extension of the flood, the differences between the villages are clearly visible (see Illustration 20). In the agricultural villages where the rice mono-croppers, diversifiers, and large farmer households depend on agriculture, there are actually not much difference is the areas where farmers undertake the different cropping systems. This means whatever the flood is good or bad year, they still stay and work in the same agricultural plots. This is easy to understand, since these cropping systems are actually starting in the early season at the latest, at the moment the nurseries for the early rice are prepared, or the land preparation for sowing the floating rice occurs. These operations need to be done several weeks before people can assess the importance of the flood that year. Nevertheless, the flood impacts truly on their production, which in turn impacts the income. For instance, higher application of chemical inputs may be required, to somehow compensate the lack of natural siltation, whereas the yields of the traditional and high yield rice varieties tend to decrease.

Beyond the impact on agriculture, finding shows that there are effects on the livelihoods of the small and large fishermen's households. Especially the small fishermen have low capacity to adapt to bad floods, mainly due to the external limitations they face, such as lack of agricultural land, challenges with fisheries management and related power inequalities, poor transport capacities, lack of fishing equipment, and low income from other sources. In the "Map of large fisherman in all seasons of good and bad year" of Illustration 20, the production zone of the large fisherman is highly modified by the level of water. With higher water, they can expand their fishing area and benefit from new opportunities for diversifying their fishery production. Low floods, when they occur can lead to damages to the stand-stilt houses and other infrastructures. On the other hand, the floating houses in the villages closest to the lake remained highly unaffected by high floods, and actually benefited from them in terms of increased fish productivity in the good years.

People in TSL area have adapted themselves to the past changes, which offer an opportunity to assess their vulnerability and their adaptive capacity towards future changes. The current level of resilience in the study villages was considered in two ways: as the adaptive capacity of the villages in different parts of the floodplain, and as the adaptive capacity of the social groups and households within the villages. In both of these cases, considerable differences between the levels of resilience were found. In terms of the household strategy in different parts of the floodplain, we found that agricultural areas are higher level of resilience

to risks and access to social services due to their diversification in agricultural productions and due to the importance of non-farms and off-farm activities. For instance, when the agricultural crops were destroyed, farmers were able to find more sources of income by selling labour and increasing other non-farm and off-farms activities including migration from people to Battambang and Siem Reap cities, Phnom Penh city, and Poi Pet, and to Thailand. Moreover, they benefit from an easier access to social services from the public administration than the fishermen do when facing the risks.

On the long-term, beyond the possible impact of climate change, structural changes might affect the Mekong River levels. The extension of irrigation schemes upstream the TSL, in China, Myanmar and Laos will increase infiltration or even possibly drain to other catchments a part of the river flow. Dams and reservoirs currently under construction will certainly contribute to ore regulation between rainy and dry seasons, while it will also alters the total and seasonal sediment loads of the river. Since the raising water brings alluvial fertility for crops and favours fishery production in the lake, it provides benefit and impact on habitats and biodiversities. The raising flooding allows people to diversity of productions, for example, rice and fish. The less flooding condenses people's diversity.

5.2.3. Economic impacts of the water regime

According to the differences in the level of household strategy between the agricultural and fishing areas, internal differences between the households and social groups within the villages were observed. We found that the poorest households turned out to be the most vulnerable in all study areas. The poor households among single croppers, small fishermen, and landless people often rely on single livelihood source only, while the better-off households like diversifiers, large farmers, and large fishermen households, typically had more possibilities for supplementary livelihood strategies.

The better-off households also had more savings and other assets to access to public services, while the poor households depended on external assistance in the cases of emergency. Many of the low income households like Single croppers, small fishermen and landless also suffer chronically from food shortages from mainly rice and fisheries as well as from other aspects of poverty, such as unclean drinking water, health problems and lack of secondary education opportunities, making them particularly vulnerable to additional shocks and stresses.

Livelihoods of the six types of households who are depending on resources, expressed another important strategy for coping and adapting to the flooding. These include relying more strongly on secondary livelihood sources not affected by the environmental changes as well as

extending to altogether new livelihoods. In agricultural area, rice can provide main source of income and food security and fishing can provide additional income and just for food sources for the households in times when agriculture is affected, for example, by floods, while for instance the fishery and other aquatic wildlife and creatures for additional income was considered important for people in fishing area.

The changes in flood pulse in bad years can impact negatively on yields of crops and fisheries, rotation of crops, insect and disease invasion insect and disease, and decrease in market prices of crops and fishery, and also the period of employment in non-farms and off-farms. In addition, different forms of short-term paid employment in agriculture and fishing were mentioned in all study areas as an important additional livelihood sources. The source of employment varies according to the livelihood background and the production location; in agricultural area employment is linked to all farming, and non-farm and off-farm activities, while in fishing area the employment is generally only fishing-related and includes working for large-scale fishing operations (see Table 43).

Table 43: Economics results on the impact of Good and Bad year on the six household types

	Good Year 2016-2017			Bad Year 2013-2014					
Household Types	**Total income of Agriculture and Natural resources ($/HH/Year) A**	**Total income of Non and Off-farms ($/HH/Year) B**	**Total income per Household ($/HH/Year) C [a] = A+B**	**Total income of Agriculture and Natural resources ($/HH/Year) D**	**Percentage of Loss in Agriculture (%) % of D**	**Total income per Non& Off-farms ($/HH/Year) E**	**Percentage of Loss in Non& Off-farms (%) % of E**	**Total income per Household ($/HH/Year) F [**]= D+E**	**Percentage of Total Loss (%) % of F**
Landless people	248.14	1,879.18	2,127.32	230.74	7	1,766.81	6	1,997.55	6
Single croppers	2,773.25	1,423.90	4,197.15	1,985.52	28	1,333.93	6	3,319.45	21
Diversifiers	3,585.25	954.24	4,539.49	2,585.53	28	868.85	9	3,454.38	24
Large farmers	4,335.21	1,t574.93	5,910.14	2,407.60	45	1,415.45	10	3,823.05	35
Small fishermen	1,244.11	1,163.35	2,407.46	979.48	21	1,028.62	12	2,008.10	17
Large fishermen	6,711.16	1,029.70	7,740.85	6,191.18	78	909.17	12	7,100.35	8

[*] Total income in good year is a sum of total income of agriculture and natural resources and total income of non and off-farm farm including migration in good year.
[**] Total income in bad year is a sum of total income of agriculture and natural resources and total income of non and off-farm including migration in bad year.

Based on the economic impact analysis in Table 43, we found that the large farmer households are highly impacted by the bad flood in 2013-2014 compared to good year in 2016-2017, there is 35% equals to around 2,087 USD decreasing on the average annual income from around 4,197 USD in good year to around 1,985 USD in bad year. These households rely much on hired labour from outsiders to operate the whole farming production, high costs of inputs and labour, and high capital investment. During the bad year, there were major concerns in rat/rodent, insect and disease, and weeds due to low flooding and drying of the plots several

times, leading loss of yields of the rice and other crops. For instance, the rice yields decreased by around 600 kg to 1,500 kg per hectare on the average 3.3 tonnes of the total yield per hectare. Despite this negative economic impact, they still perform a higher annual income compared to the other groups of households.

Secondly, diversifiers and Single croppers households are impacted by the flood of bad years in compared to good years, losing around 20% of the annual income from around 4,200 USD in good year to around 3,400 USD in bad year. Many of the these households also suffer chronically from floating and heavy rice and fishery catch shortages as well as from other aspects of poverty such as health problems and lack of sources from non-farm and off-farm activities. However, these groups of households are more adapted to the situation; they are households relying on main used their family sources to operate farm such as labour, forced animal and own hand tractor, and small capital to invest on the productions.

Beside these groups, thirdly small fishermen were more impacted by low flood in bad year; their average annual income decreased 399 USD, equal to 16% compared to their income in good year. This is mostly due to lower availability of fishery products, but also to lower income from non-farms and off-farms activities. In the meantime, while suffering also from the decrease of the fish catches in bad years, the large fishermen are more capable to resist to the situation of low flood to the sources of income from aquaculture such as crocodile and fish rearing, and non-farm and off-farm activities.

Lastly, the landless people are in the worse absolute position, with a decrease of their income from only 2,127 USD in good year to around 1,997 USD in bad year. These households are living in the worse situation: they are generally the oldest people who are looking after their grand-children while their children have migrated to Phnom Penh or to Thailand. They can only sell their labour to agricultural and non-farm activities and receive remittent money from their migrated children. Most of these strategies were related to the informants' current livelihoods as well as the other livelihoods practiced in the area.

In the fishing villages next to the lake, many hoped to broaden their livelihoods into fish raising, fish processing and utilisation of wetland products, while in the agricultural villages raising livestock and broadening to other crops such as vegetables were considered as possible diversification strategies. Starting small business such as shop keeping and involvement in different forms of paid labour was also mentioned by informants in all study villages. One approach to diversifying the livelihood base is through migration, which was recognised as a potential future adaptation strategy in all study villages (Rigg, 2006). Table 44 shows the

economic gain and loss of the different two years and critical level of resilience of the six types of households.

Table 44: Analysis of Critical level of resilience by households

Household Types	Minimum Poverty Threshold (MPT) of households (USD/HH) A	Total Income in Good year (USD/HH) B	Total Income in Bad Year (USD/HH) C	Comparison Total Income in Bad Year to MPT (USD/HH) D * = C - A	Critical level of resilience (%) E ** = D/A
Landless people	1,559 (5 members)	2,127.3	1,997.6	438.3	+ 22
Single croppers	1,715 (5.5 members)	4,099.5	3,221.9	1,506.7	+ 47
Diversifiers	1,715 (5.5 members)	4,414.5	3,329.4	1,614.3	+ 48
Large farmers	1,871 (6 members)	5,727.8	3,640.7	1,769.6	+ 49
Small fishermen	1,559 (5 members)	2,339.0	1,939.6	380.3	+ 20
Large fishermen	1,559 (5 members)	7,523.9	6,883.4	5,324.1	+ 77

Legende:
* Comparision of total income in bad year to the MPT is a substraction of total income in bad year and MPT per household.
** Critical level of resilience is a mutiflication of comparision of total income in bad year to the MPT and MPT per household.

To get more global overview on the loss for all our respondents and critical level of resilience to disasters, we can assess approximated loss of their total income compared between good year and bad year, which is a huge loss impacted by low flood in bad year.

For each of the six types characterized, we have correlated the total income from the livelihoods to access to all farm, off-farm and non-farm. In a context where the land and fishery production factors are now getting rarer and rarer or when land and fish would have to carry other environmental services than the strict provisioning services, this allows to identify who are the types which are now the more sensible to land access. We also compare the total income coming from the livelihoods include non-farm and off-farms with a theoretical overall Minimum Poverty Threshold (MPT) (Gibson, Fedorenko and Rohde, 2006; Kimsun, Tong, 2011; MOP, 2013, 2014).

When the families are getting an income, which is below this MPT, they are supposed not to cover their basic needs, unless they recapitalized their assets by selling the land and wealthy assets or increasing the cultivation cycle, hence not reproducing fertility. In contrast, when they get an income higher than the poverty threshold, they have a surplus for possible capitalization. The minimum poverty threshold was calculated at from 1,559 USD to 1,871 USD/household/year depends on the number of household members per family, which derives from average size of family members of five to six (see back to the Table 26) multiplying by the cost of consumption per capita of rural people 311.85 USD /person/year[12].

[12] The households would need 311.85 USD/person/year (0.85 USD /day) for expenditure.

On the other hand, we also compared the total income in bad year with the MPT, in order to identify which type of households has highest capacity of resilience in case of bad year. The calculation shows that the income in the bad years is still higher than the MPT for the six types of households. The income of bad year subtracts the MPT, then the percentages of gaining and losing were considered as critical level of resilience.

The landless people and small fishermen perform the lowest around 440 USD/year equals to +20 to +22% of their total income over their MTP for both household types in bad years. This was due to their less intensification and lower diversification in their systems of activities; they are more relying on only one traditional rice cropping and fishery system, and lower income from non-farms and off-farm. Secondly, among the better-off, there are three types getting an income more than +47% over the critical level of resilience. This seems explains that the land and fisheries are playing essential roles to contribute to the income for these three types of households. The more they have means of production, the more they can intensify their income from those systems. And lastly, the large fishermen have an income +77% higher than the MPT. This indicates that the low and high level of flooding does not much impact on their annual total income, while their income is already high and they might be able to shift from one to another activity, while off-farm and non-farm activities are good option.

Consequently, the variability of the water regime of the TSL provided both positive and negative impacts on the household livelihoods, the impact being more important for those households who depend significantly on the provisioning services in the lake. Badly, the situation is worse on the people who have low capacity to shift from these non-choice activities like landless and small fisherman households. Regardless, these impacts on households lead them in a situation more and more fragile when the bad years are going to be more often occurring. Indeed, it drives them to migrate to other places.

Cambodia's economy grew by an estimated 6.9% in 2016 (20 billion USD), the same pace as in the previous years. A mild slowdown in industry and services was mitigated by a slight pickup in agriculture. Gross Domestic Production (GDP) is foreseen to grow by an additional 7.1%/year in 2017 and 2018[13] (MOEF, 2016).

Agricultural production accounts for 35% of Cambodia's GDP, but employs 56% of the labor force. Reviving agriculture is critical to sustaining rapid growth and poverty reduction

[13] Asian Development Bank (ADB) also reported the National Gross Domestic Production (GDP) of Cambodia: https://www.adb.org/countries/cambodia/economy

(MOEF, 2016). Main products from the sector are rice, rubber, corn, vegetables, cashews and cassava. Agricultural gross production grew by 8.7% between 2004 and 2012, driven by crop production, mainly of paddy rice (annual growth of 9%), maize (20%), cassava (51%), sugarcane (22%), and vegetables (10%).

At the country level, rice is clearly the most important source for food and income security for the people of Cambodia. Despite, we analyse the impact of the bad flood years on the Cambodia's GDP. The total Cambodia's GDP in "good" and "bad" years was calculated by multiplying the GVA per year that we found out from each rice production at plot level differently with the total number of country paddy land surface (MAFF 2016). Indeed, the result of total GDP loss was calculated by calculating the difference in GDP between good and bad years. Table 45 shows the calculation of the economics results of the contribution of rice the Cambodian national GDP.

Table 45: Calculation of contribution of rice to the Cambodian national Gross Domestic Production (GDP) between Good and Bad year

Rice category	GVA Good Year per Ha (USD/Ha)	GVA Bad year per Ha (USD/Ha)	Loss in bad year per Ha (USD/Ha)	Number of land surface in Cambodia (Ha)	Total contribution to Cambodia 's GDP in Good year (USD/Year)	Total contribution to Cambodia's GDP in Bad year (USD/Year)	Total GDP Loss from good to bad year (USD/Year)
Floating rice	370.64	236.11	134.53	46,759	17,330,635	11,040,270	6,290,365
Wet season rice	468.27	232.77	235.49	580,227	271,701,466	135,061,294	136,640,172
Early Season rice	333.17	152.73	180.43	1,898,188	632,411,244	289,918,942	342,492,302
Dry Season Rice	423.35	248.51	174.84	489,455	207,209,682	121,634,375	85,575,307
Total				**3,014,629**	**1,128,653,027**	**557,654,881**	**570,998,146**

Legende:
GVA = Gross Value Added

As finding, we got a contribution of rice to the national GDP of the country is of 1,128,653,027USD on the good years, but is limited to 557,654,881USD in bad years. Consequently, it results that the country's GDP would lose around 570,998,146USD on these bad years, which represent almost 3% of the total national GDP. This shows how much the impact of a good years and bad year can affect national economy, impacting for as much as 40% of the annual growth. The worsening, all agricultural productions have been dragged with bad climate condition during last 10 years until year 2015, but only two years that it returns to good flooding, this trend also leads to country's GDP reduction.

5.3. Discussion and Conclusion

Based on the agrarian system analysis on the rice-fishery-based systems in the study areas on both agriculture and fishing, the research also argues that the Tonle Sap area is highly

vulnerable to negative changes in the water environment. This vulnerability is further intensified by the country's low capacity to adapt to environmental shocks and stresses (RGC, 2001; Mak, 2015). In the area, people are generally well adapted to the seasonal changes caused by the flood pulse, and both the livelihood sources and the level of livelihood have a strong seasonal nature (Keskinen *et al.*, 2011).

In this article, our research findings indicate, however, that this adaptive capacity has limits, and the people and their livelihoods are actually relatively vulnerable to significant changes in their environment, including the flood pulse system. Nuorteva et al. (2010) also argued the vulnerability of household is highly driven by the change in climate chances and resources declining. The findings also show that livelihood diversity and a sufficient living situation provide the foundation for the people's household strategy and capacity to adapt to these kinds of environmental changes.

The level of livelihood diversity in the study areas is already now relatively high, as individual households commonly complement their main livelihood sources with supplementary livelihoods strategies, knowingly on non-farm and off-farms include migration to Battambang and Siem Reap cities, Phnom Penh city, and in Thailand to get more remittance for the benefit of their families remaining in the villages. However, strong dependence on just one main livelihood source, habitually either fishing or rice cultivation, within each village can be seen to increase the people's overall vulnerability to sudden environmental changes, and this situation is going worse in the years of low decadal flood in bad year. Varis and Keskinen (2006) also said the diversifying the livelihood base both within the households and more generally within the villages location and production zones provides thus one central way to increasing resilience to risks of shock and stress from the environment as it has been noted by other studies in Cambodia and elsewhere.

The production zones were given by informants supported by spatial GIS mapping analysis application contribute to offer visible and understanding images of the location of the households in the territory, while it also supports to the landscape reading observation and the correlated definition of the various cropping and fishery systems represented in the territorial units in defining the variety of rice-based cropping and fishery production systems. The changes of these systems when a bad or good flood occurs show the supplementary livelihood strategies which enabled the stakeholders to increase or protect their asset base and, overall, their living situation.

The importance of livelihood diversity has been highlighted by the study. Among the six households, the finding totally demonstrates that most venerable people in term of income

and accessibility to social support services are the households who are low capacity to invest in the diversification of their farming systems and other non-farm and off-farm activities. Their low level of income from their farming production caused by the low siltation from the low flooding, leads to a significant impact on decreasing in their annual income and nutrition, but also force them to leave from resident to take risk with the migration; hardly happens on the groups of Landless people, Rice mono-croppers, and Small fishermen.

This research also leads to further studies on how the supplementary livelihood strategies aiming at diversifying the existing livelihood base should build on the existing livelihoods and on the specific characteristics of each village. They should also consider the initiatives of the villagers themselves. This is particularly important among the poorest groups who already have the weakest level of resilience, and whose living conditions are on many occasions expected to deteriorate further.

An improved standard of living brings several benefits that were also visible in the interviews; it enables better housing, the gaining of additional assets to support and diversify the existing livelihood sources, and attainment of savings that can be used during difficult times. It also has more indirect consequences, leading for example to better health conditions and improved school attendance of the children. All of these factors can be seen to build, directly or indirectly, the household's resilience to environmental shocks and stress. From the result of the critical level of resilience shows simply positively meaning the annual income are always higher than the minimum poverty threshold, however, it shows only slightly positive for the group of landless people, rice mono-croppers, and small fishermen. The consequences, their total income are very low meanwhile it is believed it will not be even enough for the daily expenses; maintaining their farms; and investing in the next coming year. The situation will be worse and worse if the natural resources continue to decline from year to year; it drives more and more difficulties for those households.

Another essential critical analysis, the research tries to look at the impact of low flooding on the rice production roles up from plot to national level by calculating the GDP gain and loss between the two studies year carefully. The result shows that the low flood of bad year affect on country's economy reduction. This clearly shows the impacts of flood pulse pattern caused by different key drivers like climate change or hydropower dam construction are likely to bring new challenges and opportunities as well as to magnify the challenges that people in developing countries are already facing. The majority of the impacts to the people and their livelihoods are mediated through the alteration that changing climate causes in hydrological cycle, and consequently, in the spatial and temporal availability of water. This is likely to be the case also

in Cambodia's TSL area that forms a unique lake-floodplain system with remarkable seasonal changes in its water level.

If we assumed that the sensitivity of correlation with double population of 2,476,206 people in next 20 years (2037) in Battambang compared to the year 2016 (1,238,103 people), this leads to pressure double land they need for investing more in cropping, which significantly impact on more local rice demand while it is not even enough for current household food security consumption and this situation is going be worse and worse. This trend drives the rice mono-croppers to abundance their agricultural activities to non-farms and off-farms activities, but also to increase migration to other parts of Cambodia and other countries to seek for better jobs and lifestyle. The animal husbadry and fishing are also contributes foods and income to the family after the mon-farm and off-farm is ranked as the higest source of income.

In conclusion, we point out that one of the most capable strategies for enhancing the people's adaptive capacity, which is to improve their fundamentals to maintain a productive livelihood, and thus to raise their general living conditions. The current dependence especially of poor households as found in this study suggests a low level of existing adaptive capacity. While providing short-term support, it is not likely to increase the long-term adaptive capacity unless other actions are taken in parallel to increase resilience. Since the households' livelihood are significantly linked with the ecosystem services of TSL, the households' strategy to adapt to the flood pulse changes must thus be considered as a complementary driving force to already existing actions aiming for water management and suitable livelihood development in the great lake and Cambodia.

Chapter VI: General conclusion

6.1. Summary of the study results

Rice–based agricultures in Asia have known, in the past 50 years, an impressive transformation under the influence of the growth of the rural population, the increased integration into markets and the changes in their environment. The pressure on the land has decreased the size of the farms, whereas the extension of a number of crops specifically dedicated to the market has reduced even more the surface and the labour dedidated to food crops. The future of food security, and now the capacity of resilience in front of shocks, relies more and more in the diversification of the systems practiced than on the specialisation on rice.

While the agriculture developed in lhe lowlands, inundated zones and deltas carry the highest population and support a major part of the agricultural production of these countries, more dynamic models of change do exist about upland rice based agriculture than on the lowlands, and Cambodia is not an exception to such a contradiction.

Understanding and modelling the transformation of agriculture of the lowlands meets even more interest when one considers that environmental change has become one additional engine that impacts the transformation of agriculture. Being highly dependent on the avlability of the water resources, lowland agricultures are assumed to be especially sensible to the shocks this domain.

The Central Plain that is flooded annualy by the rise of the water level in the River Mekong, and the basin of the Tonle Sap Lake in Cambodia are exactly representative of this situation. Over recent decades, the Tonle Sap zones' resources like fish stock and flooded forest have been seriously degradated. This situation of socio-ecological changes have worsened as the Great Lake faces important hydrological changes such as changes in thehydrological regime and flood patterns, including the water in-flows and out-flows to and from the lake, that ensure a key service of irrigation and fertilisation to the flodded cultivated lands. These changes are caused by a variety of factors internal to the local societies that directly make use of these resources, like overfishing, deforestation of flooded forest, but also by other external factors, such as the extension of dams and reservoirs upstream the Mekong basin, in Laos and China mainly, and by the changing rainfall patterns.

In the meatime, many households in the rural areas and in the Tonle Sap lake are entrenched in poverty and vunerability (Chaudhuri, Jalan and Suryahadi, 2002; ADB, 2005; Nuorteva, Keskinen and Varis, 2010; Kimsun, Tong, 2011; MOP, 2012; Salmivaara *et al.*, 2016). This is particularly the case for those are living in the villages located in the study zones

like the Landless, Siggle croppers, and Small fishermen households, who are the most affected by the ecological/environmental changes.

Thus, our overal research has aimed at the cotributing to better understanding the transformation of agricutlure and other activities such as fishing, linked with the mangement of the water resources. To see better how the dynamics of the rural livelihood activities can impact on the local poverty and on the levelof resileince to the shocks and stresses is also a major matter of the concern.

The overall research frameworks and methodology borrows from three different theoritical and conceptual frameowkrs namely the ***Agrarain System Framework (AS), Sustainable Livelihood Approach (SL)***, and lastly the ***Ecosystem Services (ES)***. Each of theam offers a number of key concepts that we often combined for the analysis. The implementation of the research used the framework of adated Agrarain System Analysis and Diagnosis (ASAD) to considering indentification of different driver (s) of the changes in the institutional, ecological environement, types of household asset and activities, diversity of houhoselds' strategy, main agro-ecological zones throught the landscape reading, economics performance of farming system. The Sustainable livelihood approach was mobilised to assess the diversity of startegy of the various types of the households including migration, and to discuss the key pvoerty, vunerability, and dvelopment related issues in the lowland. Finally, the Ecosystem Services concept was used to charaterised the provision of the non-market services brought by the environement to the ecnonmics and social stakehoders.

6.1.1. Identification of drivers of changes in the study area

Looking at the historical background of the studied villages, we identify three main key drivers that have induced or extended the change in agriculture and fisheries. The first one is the policies led by the State since the end of the Khmer Rouge regime in 1979: policies on the land distribution, policies on the markets and organisation of the value chains, policies to organise or facilitate the migrations, policies to regulate the fishing activities on the Tonle Sap and inundated areas. The second driver is linked with the flood pulse changes affected by the climate change and the changes in flood pulse pattern caused by the hydrological dam development along Mekong river. The last driver is the demography of the area, marked by migratory movements in and out, putting more and more presure to increase food supplies, and crops and fishery productions to generate more income to sufficient the family's desire.

Since the land distribution by the State from 1980 to around 1990 followed by high population growth and installation of migrants resulting in pressure on land use and land

expansion, led to current land scarcity; which cause social and economic disparity between agricultural farms.

Since then, within thee new policy of the Royal Government of Cambodia, the identified agricultural sector is considered, in the strategic plan for development, as a main sector to ensure the economic growth by intensification and to increase both the production and productivities. The country focuses on economic growth as priority to get out of poverty by integrating mor deeptly the international markets. To achieve this goal, high yield rice varieties are priorities to drive this growth.

Farmers have diversified and intensified their cropping systems from one to two cycles per year, so that they satisfy their domestic household consumption needs, and partly to supply the markets. The replacement of the traditional floatting rice or long term rice cultivated extensively on all the flooded area by two crops of short term rice, one being cultivated before the flood, the other being cultivated after, is now quasi general, leading to a substancial increase of production, but no major progress on the labour productivity.The decrease of the maximum water levelof the flood, and even more its irregular character appears as mone of the main reason to explain this general shift.

This said, less flood also means less services of natural fertilisation by silt deposits left behind by the receiding water. As a second consequence of the change in the flood, the yields of the present leading crops, early season, water receding rice, and dry season rice, have significanty decreased since the beginning of its boom since around 2001. This decrease of paddy yields is a phenomenon well-known for floating rice and long-term rice from 1980 to 2005, but it is now general

On the other hand, in parralel with the success of the double cycle rice and intensified crops, farmers in the study area have started to switch their traditional practical agricultural equipment based on cattle draught power to serve with new motorized equipment and machineries. In the meantime, they start providing services like renting of agricultural hand-tractor, tractor, digging water pond machines, crop processing).

Beside agriculture, fishing on the lake has always been more than a complementary activity : it is the main resource for numerous groups installed in specific villages on the lake. With the increase of poulation and a strong rise in the productivity when the motorisation could expand, the techniques of fishing became more efficient, putting at threat the ressources in fish.Since 2005, the government started to put in place a regulation system for better fishing lots and protected areas management. Fishing lots were designed and attributed to individuals,

in principal on a competitive manner, in reality the lots went mainly to the most powerfull actors, which increased the social differentiation between fishermen. In 2010, the fishing lots were officialy suppressed.

The price of fish has increased significantly today, and prices are determined by the (domestic and export) wholesalers around TSL, and in Phnom Penh, and also by the export wholesalers working on the Thailand and Vietnamese borders. Many of the small traders, particularly those without transport, process fish themselves, and this is an important value addition activity for households. Despite the liberalization of the credit market and the deregulation of the lot fishery, the poor particularly those living in marginalized areas such as fishing villages and floodplains continue to have limited access to well-managed fishery resources, technologies, capital markets, good marketing, changes in flood pulse, and transport infrastructure and have low levels of skills. The termincation of the fishing lots reduced traded volumes through competition, and easy access to technology, inputs and services crucial to the improvement of fish value chain are limited to resource-poor households that lack the social, human, financial, physical and natural capital to benefit from improved value chains.

Likely, the reliance of the poor on fisheries, and, in particular of the landless and assetless households, means that understanding and improving the fishery value chain is a high priority for dependent households. The supply chain and distribution of inland fish is complex and diverse with numerous transactions taking place before fish and fish products to reach the consumer or export markets. Despite poor marketing infrastructure in terms of landing, storage, preservation, transport and retail facilities, the market chain and networks are relatively well managed and based on long-term relationships. These relations are often formalized through traditional credit arrangements between fishermen, collector, processor, trader, wholesaler and exporter that sustain the networks. Our study also finds that the effects of environmental pollution and fish handling on the quality of fish, and the illegal fishing activities have significantly increased by the local people, and also people from different parts of Siem Reap and Battambang provinces, and other provinces.

Besides, the off-farm and non-farm activities provide a significant additional income to the six types of households, which could finance investments on fertility, inputs, and hiring labor and machineries, even for the small farms. And the economic growth creating work with low salary permit population to get out of monetary poverty line by earning more than 2 USD per day but they are still solvent poor. This situation enhance the socio-economic inequality between family units. And people have intended to enter to sell short-term labour for the

agricultural and infrastructure constructions such as in Battamabng, nearby provinces and in Phnom Penh.

The PhD study found that the local people and communities in targeted area have been struggling to get the benefit from their crops and fishery productions and at the same time of conservation of their local natural resources (flooded forest and fisheries) caused by the weak management of institution and policy (rice and fishery policy); flood pulse changes, and increasing in demography. The issues, the people have faced to define a governing system to manage their paddy fields, water, and fisheries due to the undefined land property of the government. Given the weak governance, the whole system still suffers from too much water in the wet season and too little in the dry season. The conflict over the use of water for irrigating rice and catching fish is still widespread in particular the poorest households in term of land and assets.

6.1.2. Understanding the diversity of households' strategy

The results of the research show the agrarian history and main influential factors on the dynamics in the area. Those specific farming trajectories allows to define a first typology of the paddy land dynamics, fishing, animal husbadry, aquaculture, and other non-farm and off-farm activities. Throught the histroical farming and livelihood activity systesms analysis permit us to indentify six houshhold types: one as landless people; three farmers such as Single croppers, Diversifiers, and Large farmers; and two fishemen such as Small fishermen and Large fishermen.

The targeted farmers have started to diversify their one cycle paddy to double cycle paddy and intensified crops Chamkar, the strong farmers being able to take more opportunity to invest in the best paddy lands. They continued to expand by buying good land from small farmers, logging the flooded forest land, and started to grow double rice cycle with short-term rice application, and maize, mung bean, ect in the second cycle, and other small and medium non-farm and off-farm activity systems. The small farmers who had less opportunity to jum over the bad situation of land and crops diversification were slowly developed and falled into the same crop cultivation and even worse to selling labor as a dynmic of non-farm and off-farm activities for surviving. The Large fishermen who had more opportunities, through their strong background as former Khmer Rouge armies, member of Solidarity groups and currently authorities during the fishing lot period, after the fishing lot determination they have diversified to large-scale fishing and aquaculture (of course crocodile rearing), and other non-farm and off-farms. And the Small fishermen had not been overcome to catch more opportunity, they have

kept in the samll-scale fishing, selling labour and migratioin for coping their family consumption.

With the stability of the successful situation of the short-term rice and other cash crops, more and more farmers have intensified their farming to the double crops production system. The yields being high, therefore, local farmers expanded the size of their cultivated land, which was used to plow with animal force (cows) to more and more with the hand tractor of their own (Better-off farmers like Diverisifiers and Large farmers) or by paying the services of hand-tractor owners to other farmers.

However, the poorest households have no land and very small land holdings and no livestock, capital or savings, mostly they are in Landless people, Single croppers, and Small fishermen households. They are found/considered as worse-off households in term of low intensification in farming systems, income, means of agriculture and transportation, but also low access to other social and public services. The medium and rice households have more good and big land, large-scale fishing, and investment in small and medium busniess are found/considered as Diversifiers, Large farmers, and Large fishermen. The households located downstream appear to be poorer than those located upstream. Among the six types of households, some of the poorest families are found as very small fishing in both fishing and agricultural villages, scattered around and along major river channels.

Migration is widespread in the targeted villages, we found that more than 50% of households's member migrate to other provinces, Phnom Penh, or nearby countries (Thailand, less to Malaysia, Japan, and South Korea), and this happens increasingly every year. They also provide farm labour sell for farm harvesting, and wage labor in garment factories, and as construction workers, etc.

Even though land-based households produce rice, due to small land holdings and low yields, the rice produced is not adequate to last the whole year. Most households in the areas report there is food shortage for at least four months a year during the year, and they are lving in very high debt that need to be paid, which caused them to land lost and perminant move from the area to outsite. In addition, due to the lack of clean drinking water, sanitation and accessible health care, the disease incidence (particularly communicable diseases; fever, headache, malaria, body aches, occ rash on trunk, swollen lymph) is high, leading to low productivity. Pre-natal and post-natal care is also very limited and not easily accessible in neither in villages nor to outside.

Finding from our study indicates that there is increasing options and flexibility of each hoursehold to the shocks and stresses in diversification of household activities, we found non-farm and off-farm activites become very good sources of income for the households; the better-off households remain good income from local business while the remittience from migratory works are very good alterative income for worse-off households, while income from agriculutre is reduced. Yet, the agricultual and non-agricultual wages, and migratory work are very good sources of income for the worse-off households. Among the six types of households, we indentify that there are three better-off households, who have long-term adaptive capacity to adopt to the shocks and stresses such as: Diversifiers, Large farmers, and Large fishermen. Indeed, we are also able to indetify the rest three worse-off households who cannot or have short-term adative capacity to the shocks and stresses such as: Landless people, Single croppers, and Small fishermen;

- The Landless people houhseholds are the poorest households in the agricultural villages/area, who can generate the average icome about 2,000 USD/year from only selling their labour as agricultural wage and leave in migrations. This household type corrsponds to low level of resilience. Indeed, if there is pressure from shocks and stresses such as natural disasters, serious illness, and other social challenges, their low income from the non agricultural works and remittance from migration, surely impact the landless people into worse and worse situation.
- The Single croppers households are also the poor former household who live on a small agricultural land with one cycle of floating and long-term rice/heavy rice, small animal husbandry, but highly depend on the remittance from migratory work. Their income is in average about 3,500 USD/year. The total net income remains too low to generate a capactity to invest in the new non-agriculture activities. The low productivity of rice and other crops cultivation will lead them to diversify their labour to find other jobs outside to get remittance to support the farming activities and household consumption. There is very low opportunity for this household to get more land, while we expect that these farmer will not resist very long, and will continue to sell part of their belonging land, leading to abandon their cropping cultivation as worse as the landless people once in the future.
- Diversifiers households perform higher economic income (in average about 4,200 USD/year) mainly from double cycle crops annually such as double short-term rice and intensfied crops, and mixed crops and Vegetables Chamkar. In parallel, their animal husbandry such cattle contributes to offering good income for thir urgent needs like

sending children to school, health care and treatement, and purchasing agricultural input for other crop prodution. Non-specified fishing have high contribution on income for the households after the fishing determination. With their strength linked with double crops diversification, they can to resisit with less dammage on their crops caused by the disasters, but also they can jump over the poverty trap.

- The Large farmers households perform the highest income among all farmer households with average about 5,200 USD/year. Their livelihoods are composed by the diversification of traditional rice and double short-term rice, medium and large scale of animal husbandry, and high income the local business and civil servants, but few migration. They also perform good household assets and means of prodution which they use in their farming and that they can hire to other farmers. Thanks to their big size of agricultural land make them to easily overcome shocks and stresses. Moreover, most of them have more capacity to invest in the vocational training and proffessinal education for the household young memebrs, and more access to other social services.
- The Small fishermen households are poor fishemen in the fishing area, who can generate low income limited to an average 2,200 USD/year from the small fishing and remittance from migratory, and selling labour for both non-farm and off-farm works. These households represent low economic performance, asset, and low access to get the public and social support. The trend lead to short-term resist to the changes in their villages, expectively they will be more and more fragile and vulnerable.
- The Large fishermen household beneficiate of the highest income at about 7,400 USD annually. They generally diversify their economic activities in both Large-scale fishing and local small and medium business in the fishing villages. These households can more easily to adapt to the diversification changes in fishing systesms impacted by the the flood pulse patern and other economic barriers.

6.1.3. Analysis of spatial economic impact of flood pulse changes of the household activities and Cambodian country economy

Taking all the types together, livelihood diversity and a sufficient wealth determine people's capacity to adapt to environmental changes. The level of livelihood diversity in the study areas is already relatively high now, as individual households commonly complement their main livelihood sources with supplementary livelihoods strategies, knowingly on non-farm and off-farms include migration to Battambang and Siem Reap cities, Phnom Penh city, and in Thailand to get more remittance for the benefit of their families remaining in the villages.

Among the six types of households, the finding totally demonstrates that most

vulnerable people, in terms of income and accessibility to social support services, are the households who are low capacity to invest in the diversification of their farming systems and other non-farm and off-farm activities. Their low level of income from their farming production caused by the low siltation from flood, leads to a significant impact on decreasing in their annual income and nutrition, but also force them to leave from resident to take risk with the migration; hardly happens on the groups of landless people, Single croppers, and small fishermen. This is particularly important among the poorest groups who already have the weakest level of resilience, and whose living conditions are on many occasions expected to deteriorate further.

An improved standard of living brings several benefits that were also visible in the interviews; it enables better housing, the gaining of additional assets to support and diversify the existing livelihood sources, and attainment of savings that can be used during difficult times. It also has more indirect consequences, leading for example to better health conditions and improved school attendance of the children. All of these factors can be seen to build, directly or indirectly, the household's resilience to environmental shocks and stress. From the result of the critical level of resilience shows simply positively meaning the annual income are always higher than the minimum poverty threshold, however, it shows only slightly positive for the group of landless people, rice mono-croppers, and small fishermen. The consequences, their total income are very low meanwhile it is believed it will not be even enough for the daily expenses; maintaining their farms; and investing in the next coming year. The situation will be worse and worse if the natural resources continue to decline from year to year; it drives more and more difficulties for those households.

Another essential critical analysis, the research tries to look at the impact of low flooding on the rice production roles up from plot to national level by calculating the GDP gain and loss between the two studies year carefully. The result shows that the low flood of bad year affect on country's economy reduction. This clearly shows the impacts of flood pulse pattern caused by different key drivers like climate change or hydropower dam construction are likely to bring new challenges and opportunities as well as to magnify the challenges that people in developing countries are already facing. The majority of the impacts to the people and their livelihoods are mediated through the alteration that changing climate causes in hydrological cycle, and consequently, in the spatial and temporal availability of water. This is likely to be the case also in Cambodia's TSL area that forms a unique lake-floodplain system with remarkable seasonal changes in its water level.

With a double population of 2,500,000 people in next 20 years (2037) in Battambang compared to the year 2016 (1,240,000 people), the pressure for double cropping will become

even stronger. People will need to invest for investing more in cropping, which significantly impact on more local rice and fishery demand while it is not even enough for current household food security consumption and this situation is going be worse and worse. This trend drives the rice mono-croppers, landless people, and small fishermen to abandon their agricultural activities in order to migrate to other part of Cambodia and other country to seeking better jobs and lifestyle.

6.2. Contribution of dessertation, Perspective, and Policy recommendations

6.2.1. Theroritical and Emperical contribution and Perspective

In the academic aspect and application, this PhD study adapts the Agrarian System Analysis and Diagnosis (ASAD) to implement this research in order to take into account all social, economic and political aspect, which leads to an understanding on agricultural evolution of the region.

We initially examine the scope for the history of transformation, diversification of rural household activities and poverty in Tonle Sap lowland area of Battambang province of Cambodian by identifying the context of the demography, flood pulse change in two different water-level year. In a simmilar context, Cochet (2015) supports that the agrarain system concept can be use to lighlight the histoiral dimension and social transformation to make up different categories of the farmers households.

Indeed, we believe proudly that this research leads primarily in the frame of the same context study in order to identify and group the farm typology or household types'stategies in mobilizing their labour, capital, and investment to run other various family income activities system such as; rice-based croping, livestock, fishery, and non-farm and off-farm. Thus the study contributes to support the Barral *et al.* (2012)'s argument small farmers depends on different conditions of choices by taking different cropping systems and other addional non-agricultual actvivities in order to survive in a specific environment.

While, this study offers a good understanding aspect to fullfil clear knowledge about the historical process of the tranformation and constraints/barriers of the poor. The historical change of context and condition trend analysis reveals all accessible variety of social and environmental resources provioning and accessing interaction linkages between human capital and natural resources/ecosystem services of the TSL.

.At landscape analysis, AS can be used to determine the resources in the areas to support the livelihood activities. And moreover, this study contribute to produce a spatial GIS mapping

analysis to support the agrarain system tools with offerring visbile and understandable images of the location of the households in the territory, while also support maily to the landscape reading tool of the agrarain systeam.

Moeverover, we also develop this methodology based on the threee concepts of agrarian system, sustainable livelihood approach, and ecosystem serivces that complimentory to each other in order to access to understand the determinants of households, political and institutional pressure/constraints influence on the transformation of rice systems and fishery systems. The finding provide hopefully a case study that initially to enrich or enlighten the missing models of rural livelihood activities of the lowland regions in other Southeat Asian countries through deeply understanding the household systems of activity with the combination of agricultural and non-agricultural activities, clear explanation the characteristic and determents of household types, and the economic impacts of flooding on individual household and Cambodia's GDP. That this study provides lots of scientific socio-econo-statistic tool as descriped the stages very detial in the each chapter of the disseration.

6.2.2. Policy Recommendation

The findings suggest policy implications for improving the range of livelihood choices available to lower income groups like Landless people, Rice mono-croppers, and Small fishermen to move out of the vicious poverty. Factors requiring attention to rural investments and services by governments and social development/civil society groups are:

(I) better access to formal and non-formal education and skills building to the worse-off households;

(II) a need for improving access to resources such as financial credit/loan with low interest rate and adapted technical support in agriculture to Single cropper and landless people;

(III) improving alternative income opportunities, and improved infrastructure such as hospital and school, and communication enabling respondents suffering from downward mobility to override obstacles and seek better paying livelihood strategies to all worse-off households;

(IV) considering to strengthen land policy distributioin to those poor households to get the alternative livelihood strategies in agriculture for those who are negatively affected by land lost;

(V) encouraging and involve to create the protected forest and community fishery (CFi) for better local resources management, which believe to generate more income for the household livelihoods who relying mainly on their local resrouces.

A good mechanism for coordination of networks and groups are also recommended in our study to share their knowledge and experiences with regard to fish processing, fish culture, raise animal, rice, and mixed crops and vegetable Chamkar systesm cultivation. There are a number of challenges that need to be addressed and supported from the the development stakeholders, expecailly the Royal Government of Cambodia to maintain both natural including fishery conservation, health of the people and their livelihoods (well-being), and to sustain ecosystem services and economic development.

The good implementation of governance interventions should be urgently demanded by the local people and communities, the supports might be able to rescue them from the had situations of the changes for their sustainable living, but also for country's economic growth in sustainable way for the local people and Cambodia.

Finally, this PhD study also recommends to conduct furture researches/studies precisely the impact of outside migration and inside migration context of the household, and other ecosystem serivces such as; the regulating, supporting, cultural services provided by Tonle Sap lake, especially provide to biodiversity and habitats, soil and river bank erosion, water polution, and so on in the near future.

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Appendix

Appendix 1: Scoring on the economic performance of each system of activities

Rice crops	GVA / Labour ($/md)	Max of working capital/ha	GVA/ ha	GVA / Labour ($/md)	Max of working capital/ha	GVA/ ha	Total Score
Floating Rice (FR) [1]	9.34	249	134.94	**	*	*	4
Long term rice (LTR) [2]	11.33	140.36	176.56	**	**	**	6
Early season rice (ESR) [3]	5.60	160.23	77.03	**	**	*	5
Water Receding Rice (RR) [4]	10.86	179.41	186.71	**	***	**	7
ESR+ Long term rice (ESR&LTR) [5]	11.09	103.85	335.61	**	***	***	8
ESR+ Receding Rice (ESR &RR) [6]	19.47	135.70	331.27	**	**	***	7
ESR+ Dry Season Rice (ESR&DSR) [7]	7.45	175.06	314.56	**	**	*	5
Mixed crops and Vegetables Chamkar (DC) [8]	30.00	47.13	2684	***	***	***	9
ESR+ Intensify Crops Chamkar [8]	18.13	250.49	1365.5	***	**	***	8
Fishery and Animal production	**GVA/ Labor**	**IC ($)**	**GVA/ HH**	**GVA/ Labor**	**IC ($)**	**GVA/ HH**	**Total Score**
Large scale fishing [9]	18.36	1490.00	7160.8	***	**	***	8
Small scale fishing [10]	3.82	226.94	191.74	*	**	**	5
Non-specified fishery [11]	6.25	2987.07	592.40	**	**	***	7
Animal production [12]	3.63	3929.88	335.22	*	**	*	4
Non/Off-farm	**GVA/ Labor**	**IC ($)**	**GVA/ HH**	**GVA/ Labor**	**IC ($)**	**GVA/ HH**	**Total Score**
High Non/Off-farm [13]	3.85	10855	328.35	*	***	*	5
Low Non/Off-farm [14]	2.15	1623	684.79	*	**	**	5
Remittance/ Migration [15]	2.97	0	1378.8	*	*	***	5

Legend:

Scoring for cropping system		
GVA/Labour	*Maximum of working capital (IC)/ha*	*GVA/ha*
<7 = *	<142 = *	<77>170 = *
>7 < 15 = **	>160 < 200 = **	>176 < 350 = **
>18 = ***	>200 < 250 = ***	>350 < 1365 = ***
Scoring for cropping system		
GVA/Labour	*IC ($)*	*GVA/HH*
> 4 = *	<3500 = *	<260 = *
> 4 < 6 = **	>3600 <4000 = **	>300 <400 = **
> 6 = ***	>4000 = ***	>4000 = ***
Scoring for Non-farm and Off-farm activities		
GVA/Labour	*IC ($)*	*GVA/HH*
<2 = *	<0 = *	<400 = *
>2 < 3 = **	>2000 <10000 = **	>600 <1000 = **
>4 = ***	>10000 = ***	>1000 = ***

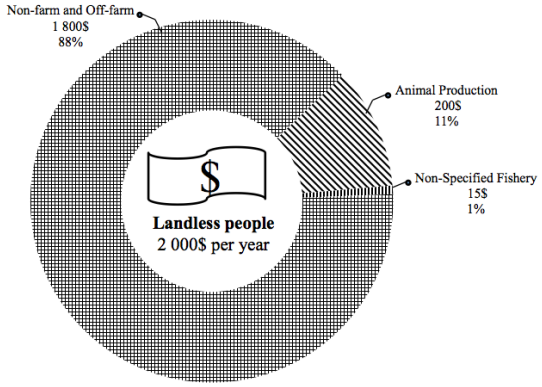
Appendix 2: Summary of characteristic of household types

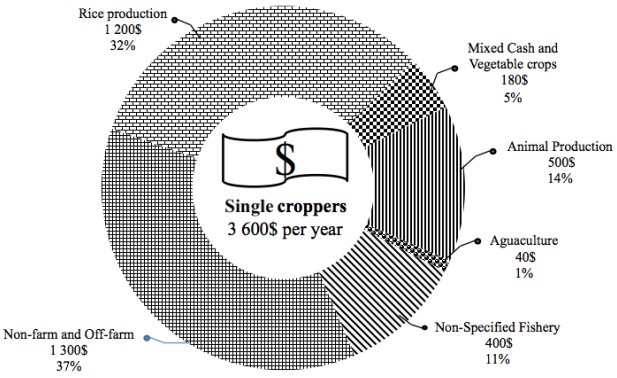
	Household Type and Sample											
Household Types	**Landless people**		**Single croppers**		**Diversifiers**		**Large farmers**		**Small fishermen**		**Large fishermen**	
Sample	29		76		109 (32%)		52 (15%)		55 (16%)		25 (7%)	
Description of variables	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
Household size (N)	5.0	2.0	5.6	2.3	5.5	2.1	6.0	2.0	5.4	1.8	5.5	1.6
Percentage of migration (%)	22.2	11.1	18.1	9.2	6.2	3.4	3.5	1.6	24.6	12.2	5	1.6
Age of HH head (Old)	42.3	18.9	49.7	14.9	48.9	13.5	49.0	14.0	44.4	13.4	45.1	12.0
Education of HH head	2.8	3.2	3.3	2.8	3.7	3.2	3.7	3.1	3.2	2.9	2.9	2.7
Family working labour	3.6	2.0	2.6	0.9	2.3	0.7	3.4	0.7	3.5	1.5	3.9	1.6
Investment capacity (USD/HH/Year)	100	89	552	441	756	865	1,143	852	195	226	1,227	1,273
Total Income (USD/HH/year)	2,088	1,998	3,454	3,286	4,006	3,513	5,163	3,146	2,208	1,559	7,352	4,303
Income from Non-farm& Off-farms (USD/HH/year)	1,823	1,319	1,378	1,567	911	1,297	1,495	2,310	1,095	1,199	969	776
Agricultural area (Ha)	0.0	0.0	2.4	1.9	2.5	2.4	5.2	3.4	0.0	0.0	0.3	1.1
% of FR area	0.0	0.0	78.1	43.1	0.0	0.0	4.7	21.4	0.0	0.0	0.0	0.0
% of LTR area	0.0	0.0	56.8	43.9	0.3	3.2	15.2	35.7	0.0	0.0	0.0	0.0
% of ESR area	0.0	0.0	2.7	16.1	44.6	49.1	36.8	64.4	0.0	0.0	0.0	0.0
% of WRR area	0.0	0.0	32.6	90.9	11.8	99.9	21.8	32.8	0.0	0.0	0.0	0.0
% of ESR&LTR area	0.0	0.0	1.4	11.8	0.0	0.0	15.6	33.2	0.0	0.0	0.0	0.0
% of ESR&WRR area	0.0	0.0	0.0	0.0	1.8	13.4	28.1	39.3	0.0	0.0	0.0	0.0
% of ESR&DSR area	0.0	0.0	1.9	15.9	4.7	28.4	8.9	32.3	0.0	0.0	0.0	0.0
% of ESR&Inten-crops area	0.0	0.0	0.0	0.0	6.2	22.5	0.1	0.7	0.0	0.0	0.0	0.0
% of DC area	0.0	0.0	5.8	15.8	62.8	26.4	0.0	0.0	0.0	0.0	0.0	0.0
Cattle (N)	0.0	0.0	2.0	2.6	0.5	1.2	1.2	2.1	0.0	0.0	0.0	0.0
Buffalo (N)	0.0	0.0	0.3	0.9	0.0	0.2	0.2	0.7	0.0	0.0	0.0	0.0
Sow/piglet (N)	0.4	2.1	0.7	2.7	0.4	1.5	1.0	4.1	0.1	0.4	0.0	0.0
Fatten pig (N)	0.4	1.9	0.3	1.5	0.3	1.4	0.0	0.0	0.5	1.8	0.4	1.4
Chicken (N)	5.0	13.5	7.4	17.7	5.0	12.0	4.7	9.1	4.5	6.3	6.3	13.9
Duck (N)	0.7	3.0	1.7	5.8	0.4	1.8	0.7	2.8	0.0	0.0	0.0	0.0
Crocodile rearing (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.3	0.0	0.0	16.0	28.1
Gee rearing (Kg)	0.0	0.0	0.7	5.9	1.4	10.6	0.0	0.0	11.8	43.1	0.0	0.0
Fish catch (kg)	46	29	182	729	2,429	5,891	1,515	1,942	434	772	4,845	4,765
Gee catch (kg)	0.0	0.0	65	307	43	170	25	74	109	254	100	243
Fresh shrimp catch (kg)	0.0	0.0	0.0	0.0	9.5	86.5	0.0	0.0	0.0	0.0	8.4	42.2
Snail/crab/oyster catch (kg)	0.0	0.0	0.0	0.0	73.7	531.4	40.0	217.2	91.2	508.3	117.6	407.1
Snake catch (kg)	0.0	0.0	0.0	0.0	10.7	61.8	0.0	0.0	0.0	0.0	0.2	1.0
Wild animals catch (kg)	0.0	0.0	8.7	59.4	17.2	172.4	0.0	0.0	4.9	30.4	0.0	0.0
Cricket and Insect catch(kg)	0.0	0.0	0.0	0.0	8.6	85.4	0.0	0.0	4.1	29.4	0.0	0.0
Frog catch (kg)	0.0	0.0	0.1	0.9	0.6	4.2	0.2	1.7	1.1	8.1	2.4	12.0
Mice catch (kg)	10.0	36.3	16.0	118.3	0.0	0.0	4.5	29.0	2.8	16.9	0.0	0.0

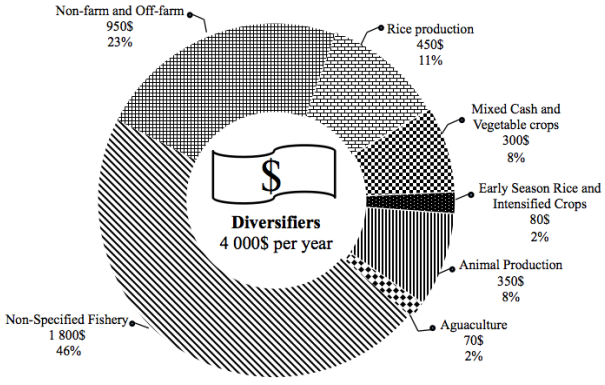
Legends:

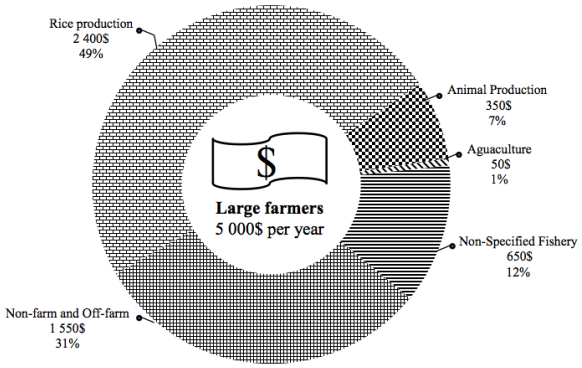
HH = Household; **FR =** Floating Rice; **LTR** = Long-term Rice; **ESR** = Early season rice; **WRR** = Water-Receding Rice; **ESR&LTR** = Early Season Rice& Long-term rice; **ESR** = Early Season Rice& Water-Receding Rice; **ESR&DSR** = Early Season Rice& Dry Season Rice; **ESR&Inten-crops** = Early Season Rice& Intensified Chamka Crops; **DC** = Mixed Crops and Vegetable/ Double Chamkar Crops; **Ani-Pro =** Animal husbandry/Production; **Aqua-Rearing =** Aquaculture Rearing

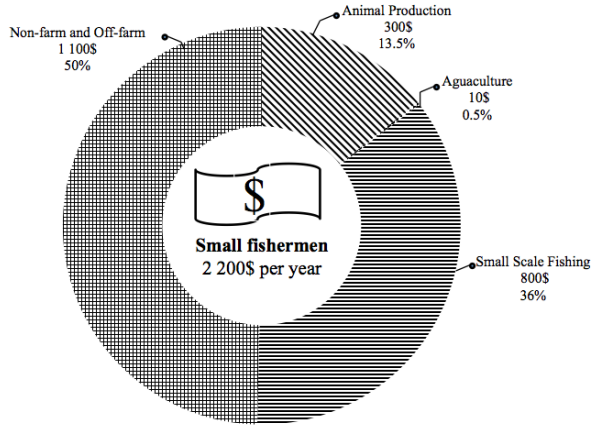
Appendix 3: Income Situation and Income Sources by household types

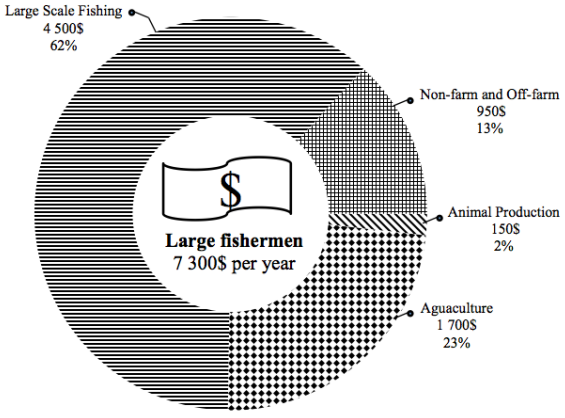












Appendix 4: Table of Results Analysis

- **Residencial land and property right maintained**

Categories		Residential land size (m2)		Total	Residentiql land property right		Total
		< 10000	10000+		No	Yes	
Landless people	Count	24	0	24	18	11	29
	% of Total	6,9%	0,0%	6,9%	5,2%	3,1%	8,3%
Single croppers	Count	80	0	80	43	33	76
	% of Total	23,2%	0,0%	23,2%	12,4%	9,7%	22,1%
Diversifiers	Count	111	0	112	39	69	109
	% of Total	32,2%	0,0%	32,2%	11,4%	20,0%	31,4%
Large farmers	Count	52	0	55	20	32	52
	% of Total	15,2%	0,7%	15,9%	5,9%	9,3%	15,2%
Small fishermen	Count	54	0	54	33	21	55
	% of Total	15,6%	0,0%	15,6%	9,7%	6,2%	15,9%
Large fishermen	Count	21	0	21	21	4	25
	% of Total	6,2%	0,0%	6,2%	6,2%	1,0%	7,2%
Total	Count	343	3	346	175	171	346
	% of Total	99,3%	0,7%	100%	50,7%	49,3%	100%

- **Capacity to find additional land for households**

Household Categories		Capacity finding land		Total
		Not easy to find land	Easy to find land	
Landless people	% of Total	100	0	29
	% of Sub-total	8,3%	0,0%	8,3%
Single croppers	% of Total	94	6	76
	% of Sub-total	20,7%	1,4%	22,1%
Diversifiers	% of Total	92	8	109
	% of Sub-total	29,0%	2,4%	31,4%
Large farmers	% of Total	77	23	52
	% of Sub-total	11,7%	3,4%	15,2%
Small fishermen	% of Total	98	2	55
	% of Sub-total	15,5%	,3%	15,9%
Large fishermen	% of Total	95	5	25
	% of Sub-total	6,9%	,3%	7,2%
Total	% of Total	319	27	346
	% of Sub-total	92,1%	7,9%	100%

- **Loan accessed by household types**

Source of loan	Landless	Single croppers	Diversifiers	Large farmers	Small fishermen	Large fishermen
	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total
Family/Relative	6	24	19	12	18	1
Neighbor	28	8	7	7	7	12
Tontin	0	0	1	0	0	0
NGOs	17	2	1	0	0	0
Trader/ Seller	17	25	35	30	43	56
MFI / Bank	32	36	30	48	26	17
Saving group	0	2	4	0	3	6
Village bank/ Saving group	0	2	1	3	3	6

- **Purpose of borrozing loan used by household types**

Purpose of borrowing loan	Landless people	Single croppers	Diversifiers	Large farmers	Small fishermen	Large fishermen
	%	%	%	%	%	%
Agricultural/ Fishery work	9	54	48	20	43	34
Investment	11	2	13	15	3	11
Feed the family	40	24	18	23	32	16
Medical treatment	5	4	6	7	11	15
Children go to school	19	0	6	23	3	15
Married/ festival parties	0	3	0	2	2	0
Migra-tion	0	5	1	2	2	2
Repay previous debt	0	1	0	0	0	0
House building	0	2	3	7	2	2
Cope with crop failure	11	3	3	0	0	4
Young married couple starting business	0	0	0	1	1	0
Help child to start agricultural work	0	1	0	1	1	0
Buy new land	5	1	0	0	0	0
Keep/ save for children	0	0	0	0	0	0

- **Agricultural equipement by household types**

Categories	Landless people	Single croppers	Diversifiers	Large farmers	Small fishermen	Large fishermen
	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total	% of Sub-total
Small truck	8%	22%	29%	15%	15%	7%
Big truck	8%	22%	29%	15%	16%	7%
Small scred rice mill	8%	22%	29%	15%	16%	7%
Plow and Rake	8%	21%	27%	15%	16%	7%
Oxen cart	8%	20%	29%	15%	16%	7%
Hand tractor	7%	13%	25%	10%	13%	7%
Tractor	8%	21%	29%	15%	16%	7%
Water pum	7%	17%	24%	11%	12%	7%
Grass Trimmer	8%	22%	29%	15%	16%	7%
Pesticide spray	8%	16%	26%	12%	14%	7%
Spray machine	8%	20%	26%	14%	14%	7%
Boat	7%	16%	13%	9%	%	%
Smach	7%	21%	22%	14%	13%	%
Stationary gillnet	8%	16%	14%	12%	8%	3%
Filtering Gear Grid trap	8%	22%	26%	17%	16%	5%
Fishing net	8%	21%	26%	15%	%	%
Fishing Lot Fence System pens	8%	21%	29%	17%	16%	4%
Horizotal Cyclider Trap	8%	21%	23%	15%	14%	6%
Bamboo Tube Trap eel	8%	21%	24%	16%	12%	6%
Small Fence System pens	8%	22%	28%	17%	16%	6%
Fish Ele Shocker	8%	22%	28%	17%	14%	6%

- **Level of subficience from all household activities**

Household Categories		Level of Sufficince from all farm, non and off-farm activities			Total
		No	Yes	Do not know	
Landless people	Count	22	2	0	24
	% of Total	7,6%	,7%	0,0%	8,3%
Single croppers	Count	29	30	5	64
	% of Total	10,0%	10,3%	1,7%	22,1%
Diversifiers	Count	42	46	3	91
	% of Total	14,5%	15,9%	1,0%	31,4%
Large farmers	Count	22	22	0	44
	% of Total	7,6%	7,6%	0,0%	15,2%
Small fishermen	Count	39	6	1	46
	% of Total	13,4%	2,1%	,3%	15,9%
Large fishermen	Count	16	5	0	21
	% of Total	5,5%	1,7%	0,0%	7,2%
Total	Count	170	111	9	290
	% of Total	58,6%	38,3%	3,1%	100%

- **Perception on capacity to find additional jobs**

Household Categories		Possibility to find a job			Total
		No	Yes	Do not know	
Landless people	Count	23	1	0	24
	% of Total	7.9%	0.3%	0.0%	8.3%
Single croppers	Count	51	13	0	64
	% of Total	17.6%	4.5%	0.0%	22.1%
Diversifiers	Count	79	12	0	91
	% of Total	27.2%	4.1%	0.0%	31.4%
Large farmers	Count	33	10	1	44
	% of Total	11.4%	3.4%	0.3%	15.2%
Small fishermen	Count	39	7	0	46
	% of Total	13.4%	2.4%	0.0%	15.9%
Large fishermen	Count	17	4	0	21
	% of Total	5.9%	1.4%	0.0%	7.2%
Total	Count	242	47	1	290
	% of Total	83.4%	16.2%	0.3%	100%

- **Household livelihood strategies and capacity for making subficience**

Household Categories	Do not know	Try to improve rice farming better	Keep improving all the same occupations	Create small local business	Sell labour in off-farm and non-farm	Start cattle raising	Expand cattle raising	Start pig raising	Expand pig raising	Start vegetable Chamkar cultivation	Expand vegetable Chamkar cultivation	Expand local business	Expand agricultural land	Deversify rice-basd cropping system	Migration to other area/countries	Expand agricultural machinary	Keep working on fishing activities	Expand fishing activities	Start fishing rearing	Start crocodise rearing	Expand crocodise rearing	Send children to higher education	Expand chicken raising	Start fishery middleman trade	Find wood and wildlife	Rent land for farming production	Borrow loan when insufficience	Renovate channel system along rice field
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Landless people	0.0	0.0	.7	1.0	4.8	0.0	.3	0.0	0.0	0.0	.7	0.0	.3	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	.3	0.0	0.0	0.0	.7	.3	0.0
Single croppers	1.7	3.8	11	1.7	1.7	.3	1.7	0.0	.3	.7	0.0	0.0	0.0	0.0	.7	.3	0.0	0.0	.3	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0
Diversifier	1.0	4.5	15.5	2.1	1.0	.3	1.0	.3	.3	0.0	.7	0.0	.3	2.8	6.6	.3	0.0	1.4	.3	.3	0.0	.7	.3	0.0	.7	.3	0.0	0.0
Large farmers	0.0	.3	7.6	.7	.7	.7	.3	0.0	1.0	0.0	.7	1.0	.3	4.8	.7	1.0	0.0	0.0	.3	0.0	.3	1.7	0.0	0.0	0.0	0.0	0.0	.7
sSmall fishermen	.3	0.0	2.1	.3	3.8	0.0	.7	0.0	.3	0.0	0.0	0.0	0.0	0.0	2.1	0.0	9.0	.7	.7	0.0	0.0	0.0	0.0	.3	0.0	0.0	0.0	0.0
Large fishremen	0.0	.3	2.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	.7	.7	.3	1.4	.7	.3	0.0	0.0	0.0	0.0	0.0

- **Perception on advantage of natural resources/ecosystem services to agriculture**

Household Categories		Natural resource on Agrilture			Total
		No	Yes	Do not know	
Landless people	Count	2	86	13	76
	% of Total	.3%	19.0%	2.8%	22.1%
Single croppers	Count	2	80	18	109
	% of Total	.7%	25.2%	5.5%	31.4%
Diversifiers	Count	0	93	7	52
	% of Total	0.0%	14.1%	1.0%	15.2%
Large farmers	Count	2	76	22	55
	% of Total	.3%	12.1%	3.4%	15.9%
Small fishermen	Count	24	67	10	25
	% of Total	1.7%	4.8%	.7%	7.2%
Large fishermen	Count	21	58	21	29
	% of Total	1.7%	4.8%	1.7%	8.3%
Total	Count	5	80	15	346
	% of Total	5%	80%	15%	100%

- **Perception on advantage of natural resources/ecosystem services to well-being**

Household Categories		Natural resource on well-being			Total
		No	Yes	Do not know	
Landless people	Count	0	89	11	76
	% of Total	0.0%	19.7%	2.4%	22.1%
Single croppers	Count	3	89	8	109
	% of Total	1.0%	27.9%	2.4%	31.4%
Diversifiers	Count	2	86	11	52
	% of Total	.3%	13.1%	1.7%	15.2%
Large farmers	Count	4	78	17	55
	% of Total	.7%	12.4%	2.8%	15.9%
Small fishermen	Count	0	95	5	25
	% of Total	0.0%	6.9%	.3%	7.2%
Large fishermen	Count	4	79	17	29
	% of Total	.3%	6.6%	1.4%	8.3%
Total	Count	2	87	11	346
	% of Total	2.4%	86.6%	11.0%	100%

Appendix 5: Questionnaire for sectoral departments/ministries and NGOs interview

- Can you present us about your institution/ structure? And what is your current position and your detail role?

Part 1: What is changing on livelihood, agriculture, and environment? and why?

- What do you see being changing in the last 10 years or so (population, Education income/ livelihood, agriculture, natural resources availability, food supply, human health, energy, etc.)?
- What are the main causes of change? (is it local dynamics, or is it due to national/international projects/policy/business)
- What changes do you expect for the future? (dam construction, road expansion, tourism, trade –e.g. for food etc.)

Part 2: What are the policies/goals being discussed?

- Do you have any target or goal (or specific belief and expectation) for the future?
- How are these targets and goals being planned (livelihood, Agriculture, environment)? (i.e. is there a policy process/consultation taking place? In case at what stage of the process are we?)
- In case at what stage of the process are we (livelihood, Agriculture, environment)? What are the timings?
- Is there a policy process/consultation?
- Are the consequences of policies (i.e. implementation) being analyzed/forecasted? Are their cross-sectorial outcomes/impacts being considered? (e.g. the impact may be good in one sector, or for one economic actor, but not for others).
- How to identify implementer? Who approve on strategic plan? What is the process of decision-making? Monitoring and evaluation tools? Who/ how involve in the decision-making?
- What do you think about the important awareness on those livelihood, agriculture, and environmental change?
- For you, what is the interest, notion/ justification, and constraint in work? What is difficulty? And what is opportunity?
- Have you ever heard about the Ecosystem Services? How do you know? What is your definition about the ES?
- What are the issues related to TSL ecosystem management?
- What are the policies related to TSL ecosystem management?
- Which one is successful? How? Why? Who implement?
    - Which one is not successful? How? Why? Who implement?
- What are the environmental issues related to TSL management?
- Key actions related to TSL management?
- What are the challenges of TSL ecosystem on Livelihood (General situation)?
- What is the important contribution of TSL ecosystem in livelihood?
- What are the challenges in policies/strategies implementation in TSL?
- What are the limitations?
- What do you think that we need to do to improve the situation? (We are trying to map the institution working on ES in TSL of Cambodia)
    - Policies?
    - Institution?
    - Implementer?

Appendix 6: Questionnaire for household survey

Introduction of interview

I am ……, a student from the Royal University of Agriculture in Phnom Penh. I kindly ask you to participate in my questionnaire survey on the understanding of livelihood and agricultural activities of people in Tonle Sap lake of Battambang province. Your answers will be kept anonymous and the results will be used to analyse the socio-economic of farming on your livelihood and farming to fill the requirement of our academic study. Thank you for your participation.

I. General information on the interview: to be filled at the end

Study location			
1.	Code of questionnaire	Number	
2.	Interview number of the day	Number	
3.	Date of interview	Day/ Month/ Year	
4.	Enumerator	Full name	
5.	Interview checker	Full name	
6.	Location	Province	Battambang
7.		District	
8.		Commune	
9.		Village	
10.		Phone number (if there is)	

House characteristics

11.	Material for house roof) Multiple choice(.**1** Tiles **2**. Metal **.3** Natural material / plant **4**. Plastic tent **.5** Other (specify) : ……..	
12.	Material for house walls)Multiple choice(.**1**Wood Planck .**2**Metal .**3** Bricks **4**.Bamboo **5**.Palm or coconut leaf **6**. Plastic tent **7**.Clothes **8**.Other (specify)	
13.	Material for house floor)Multiple choice(**1.** Wood **2.**Bamboo **3.** Tiles or cement **4,** Nothing (earth, sand) **5**. Plastic tent **6.**Other (specify)	

Household heads characteristics			Man	Woman
14.	When did you settle in this village?	Year #		
15.	Where did you come from before settling here?	Province		
16.		District		
17.		Commune		
18.	Why do you come to settle here?) Multiple choice(**1**.Seek for non-farm opportunities **2**.Seek for land in agriculture **3**.To work as wage labor in agriculture **4**.To guard others' land **5**.To begin new livelihood as previous location is not favorable (for young couple) **6**.Because marriage with resident here **7**.Did not have residential land in the previous location **8**.To live with relative **9**.Agricultural land is so small in the previous location **10**.No land in the previous location **11**.Other (please specify)……			

II. Household membership and migration

All members of household normally resident, including those away temporarily[14] at work or school/university																
HH mem. ID		**Name**	**Relation to HH (1)**	**Marital status (2)**	**Age**	**Sex** **1. Male, 2.Female**	**Ethnic (3)**	**Level of Education**	**Current Study?** **1. Yes 0.No**	**Recent**				**Has migrated 2005-2015?**	
										(4) Where, now?	**(5)** What are they doing ?	**(6)** Family supports	（7） Effort to family	**1. Yes 0. No**	**(8)** Where, now?
19.	1														
20.	2														
21.	3														
22.	4														
23.	5														
24.	6														
25.	7														
26.	8														
27.	9														
28.	10														
29.	In this household, how many married couples are there?														

Code:

(1): 1.HH head, **2**.Husban/wife, **3**.Son/Daughter, **4**.Stepson, **5**.Adopted son/daughter, **6**.Father/mother, **7**.Brother/sister, **8**.Grandson/Granddaughter, **9**.Niece/Nephew, **10**.Son/daughter in law, **11**.Brother/sister in law, **12**.Father/mother in law, **13**.Other relative, **14**.Servant, **15**.Other (please specified……)

(2): 1.Single, **2**.Married, **3**.Widow, **4**.Divorce, **5**.Seperate

(3): 1.Khmer, **2**.Cham, **3**.Chinese, **4**.Vietnames, **5**.Ethnic minority

(4), (8): 1.Interview village, **2**.In interview commune, **3**.In interview district, **4**.In interview province, **5**.In other province, **6**.Thailand, **7**.Korea, **8**.Malaysia, **9**.Japan, **10**.Other (please specified……)

(5) Agricultural work: 1.Rice farming, **2.**Plantation (Chamkar), **3**.Gardening, **4.**Forestry/NTFP, **5.**Forest workers, **6**.Cattles care giver, **7.**Fishing, **8**.Processing fish product , **9**. Aquaculture (fish or crocodile),

Non Agricultural work: 10.Fish trading, **11**.Carpenter, **12**.Construction worker, **13**.Housewife, **14**.Salaried employment, **15**.Agricultural wage laborer, **16.**Construction wage laborer,

17.Local petty trader(including petroleum street seller), **18**.Food processing (including small scale food processing), **19**.Shop keeper, **20**.Rice mill, **21**.Businessman, **22**.Motodop taxi,

23.Driver, **24.**Mechanic, **25**.Urban services, **26.**Factory worker, **27**.Teacher, **28.**Civil servant or LA, **29.**Nurse/Dr/midwife, **30.**Small industries, **31.**Students/dependent, **32**.Tailor,

33.Port worker, **34**.Brick worker, **35**.Junck collectors, **36**.Other (please specify……)

(6).(7): Support and Effort from family : Cash/ Money.**1**, **2**Rice and food., **3**Cash for transportation., **4**Effort on education., **5**.Other (please specified……)

[14] Short term or long term is include if they are migrated for the purpose of securing household sustainability and contribute to improving the family lives, they have plan to come back to help the family.

III. Land access and land distribution

	Land use	Land size (mxm)	How far from your home? (m or km)	Land property right? .1Yes (Type.....) .0No	Mean getting access? (**Code [1]**)	If buying or leasing, Price/ha/year	Do you currently work on all this agricultural land? 1.Yes/0. No	If (0) why don't you cultivate on it? **(Code [2])**	How many ha fallow?	Previous land use? (Code **[3])**
30.	Residential land	.....m x…..m	…… …							
31.	Agricultural land	Total:…ha								
32.	Rice land	Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	…… … …… … …… … …… …	Plot 1…… Plot 2…… Plot 3…… Plot 4……					Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	
33.	Chamka land	Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	…… … …… … …… … …… …	Plot 1…… Plot 2…… Plot 3…… Plot 4……					Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	
34.	RONEAM Forest land	Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	…… … …… … …… … …… …	Plot 1…… Plot 2…… Plot 3…… Plot 4……					Plot 1…ha Plot 2…ha Plot 3…ha Plot 4…ha	
35.	Pond	.....m x…..m								

Code:

[1]: 1.Buying, **2**.Leasing, **3**.Inherence/Family, **4.**Family sharing, **5.**State distribution, **6**.Local arrangement for distribution, **7**.Forest clearance, **8**.Buy from other person who cleared the forestland, **9**.Other please specify……..

[2] (Multiple choice): 1.Lack of labor, **2.**Too old to work, **3**.Sick or chronic illness, **4.**Low soil fertility, **5.**Lack of capital, **6.**No experience in agricultural work ,**7.** Lack of equipments ,**8**.No longer interested as there are another alternative beside farming, **9.** Yield was destroyed so far, **10.** Other please specify……..

[3]: 1.Residential, **2**.Agriculture, **3**.Forest, **4**.Fallow land, **5**.Other please specify……

36.	How did your **labour** using change in the agricultural production? (Please specify the evolution of **labour** using from interviewee with exact year)	**Past** [15]	**Present**
		....	....
37.	How did your **capital** using change in the agricultural production? (Please specify the evolution of **capital** using from interviewee with exact year)	....	....
38.	How did your **equipment** using change in the agricultural production? (Please specify the evolution of **equipment** using from interviewee with exact year)	....	....
39.	How did your **fertilizer** using change in the agricultural production? (Please specify the evolution of **fertilizer** using from interviewee with exact year)	....	....

[15] Discussion should be based the reality the interviewee on time and period of the revolution of the indicators of faming input; labor, capital, equipment, and fertilizer.

40.	Did you sell any plot of land for the past 10 years?			1. Yes 0.No
41.	If yes, how many did you sell?	Residential land	.....m x…...m	Year of sale:.....
42.		Rice land	.....ha	Year of sale:.....
43.		Chamkar	.....ha	Year of sale:.....
44.		Forest	.....ha	Year of sale:.....
45.	Why did you sell you land? **1**.For children schooling **2**.For pay for previous debt **3**.No longer able to work on it **4**.Organize wedding ceremony **5**.Health sock **6**.Other (pls specify) :……			
46.	Did you buy any plot of land for the past 10 years?			1. Yes 0.No
47.	If yes, what type of land did you buy?	Residential land	.....m x…...m	Year of buying:.....
48.		Rice land	.....ha	Year of buying:.....
49.		Chamkar	.....ha	Year of buying:.....
50.		Forest	.....ha	Year of buying:.....
51.	What purpose did you buy? **1**.Farming activities **2**.For monetary value (land price increase) **3**.For keeping for their children **4**. Other (pls specify) :……			
52.	Are there any marriages in the household in the past 10 years?			1. Yes 0.No
53.	If yes, did you give them some land?			1. Yes 0.No
54.	If Yes (give), how many?	Residential land	.....m x…...m	Year of given:.....
55.		Rice land	.....ha	Year of given:.....
56.		Chamkar	.....ha	Year of given:.....
57.		Forest	.....ha	Year of given:.....
58.	If no (give), why? 1.Not enough land for sub-division 2.Keep for other member 3.They don't interest in farming 4.They already have non-farming activities 5. Other (pls specify) :……			
59.	Do you think that now it is become easy to get more land?			**1**. Yes **0**.No
60.	If yes/no, why? …… …… …… …… ……			

IV. <u>Agricultural activities and income :</u> What are crop productions do you cultivate?

No	Rice crops and rice system	Area (ha)	Productions (T/Kg)	Sold (T/Kg)	Price (Riel /Kg)	Gross output	Expenditure																				
							Seed		Chemical Fertilizer		Organic Fertilizer		Pesticise	Soil preparation (Phoughing)		broadcast and race		Harvesting		Threshing		Transportation inputs and produce		Rantal land	Rental equipment	Gasoline/ water pumping
							Kg	Price /kg	Kg	Price /kg	Kg	Price /kg	Riel	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)			
61.																											
62.																											
63.																											
64.																											
65.																											
66.																											
67.																											

No	Other cash Crops	Area (ha)	Productions (T/Kg)	Sold (T/Kg)	Price (Riel /Kg)	Gross output	Expenditure																				
							Seed		Chemical Fertilizer		Organic Fertilizer		Pesticise	Soil preparation (Phoughing)		broadcast and race		Harvesting		Threshing		Transportation inputs and produce		Rantal land	Rental equipment	Gasoline/ water pumping
							Kg	Price /kg	Kg	Price /kg	Kg	Price /kg	Riel	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)	Labor input (M-day)	Hire (riel)			
68.	Cassava																										
69.	Sugarcane																										
70.	Groundnut																										
71.	Sesame																										
72.	Fruit trees																										
73.	Cucumber																										
74.	Vegetable																										
75.	Reed/lotus																										
76.	Other……																										

<u>Animal production (Long term production)</u> What animals do you raise?

No	Animal	Nb	Nb or Kg sold	Age of sold cattle	Number of Year of sold cattle	Price (Riel/Kg)	Gross output	Labor input (day or month/year)	Expenditure					
									Food	Forage	Vaccination	Treatment	breeding	Others
77.	Cattle													
78.	Buffalo													
79.	Goat													
80.	Other.....													

Animal production (Short term productio)

No	Animal	Nb	Nb or Kg sold	Price (Riel/Kg)	Period of raising (to sell)	Gross output	Labor input (day or month/year)	Expenditure							
								Food	Broken rice/ paddy rice	Rice brain	Fish chips	Vaccination	Treatment	Seed	Other
81.	Sow/Piglet														
82.	Fattening pig														
83.	Chicken														
84.	Duck														
85.	Goose														
86.	Fish														
87.	Frog														
88.	Gees														
89.	Crocodile														
90.	Other….														

Access and Income from common fishing resource

No	Item	Quantity	Nb or Kg sold	Price (Riel/Kg)	Gross output	Labor input (day or month/year)	How far from your home? (m or km)	Expenditure				
91.	Fish											
92.	Gees											
93.	Fresh water shrimp											
94.	Snail, crabs, and oysters											
95.	Snake											
96.	Other……											

Access to common other property resource §§§§

No	Item	Quantity	Nb or Kg sold	Price (Riel/Kg)	Gross output	Labor input (day or month/year)	How far from your home? (m or km)	Expenditure				
97.	Fish											
98.	Timber											
99.	Firewood/Charcoal											
100.	NTFPs											
101.	Wild animal/ fresh water animal											
102.	Snail, crabs and oysters											
103.	Cricket and other insects											
104.	Frog											
105.	Mice											
106.	Resins											
107.	Others…….											

§§§§ The common resources can be accessed especially as additional activities during fallow period from cropping system activities for making income.

V. Non-farm, off-farm activities and incomes

	HH mem.ID	Activities	Labor input (day)	Price/day/month	Income/ month/ year
108.		Palm juice/sugar production			
109.		Small business			
110.		Salary			
111.		Pension fund			
112.		Agricultural wage labor*			
113.		Handicraft			
114.		Moto taxi*			
115.		Construction worker*			
116.		Garment worker*			
117.		Other labor sale			
118.		Remittance from relatives			
119.		Other (please specify)……..			

**Normally these activities are migration to the city, in this regards, this income from this activities can be consider as remittance.*

Household Capital

	Do you have the following capital?	**No**	**Yes**	**If YES, how many?**
120.	Table .**1**	0	1	
121.	Chair .**2**	0	1	
122.	Bed .**3**	0	1	
123.	Musquito net .**4**	0	1	
124.	Battery.**5**	0	1	
125.	Lamp .**6**	0	1	
126.	Torch .**7**	0	1	
127.	Mobile phone .**8**	0	1	
128.	Fan .**9**	0	1	
129.	Radio .**10**	0	1	
130.	Television .**11**	0	1	
131.	Satelite receiver .**12**	0	1	
132.	DVD or VCD Player .**13**	0	1	
133.	Karaoke system .**14**	0	1	
134.	Paraffin lamp/ Candle .**15**	0	1	
135.	Electricity generator .**16**	0	1	
136.	Bicycle .**17**	0	1	
137.	Motor cycle.**18**	0	1	
138.	Romorgue .**19**	0	1	
139.	Pulling cart .**20**	0	1	
140.	Horse/ cow cart.**21**	0	1	
141.	Car (tourist) .**22**	0	1	
142.	Car (transport) .**23**	0	1	
143.	Truck.**24**	0	1	
144.	Small scale rice mill .**25**	0	1	
145.	Other (please specify) ……**26**	0	1	

	Do you **have** the following agricultural equipment?				Do you **least** the following agricultural equipment from s.o?				Do you **lend** the following agricultural equipment to s.o?			
	Agricultural Equipement	No	Yes	if yes, how many	No	Yes	if yes, how many	**Income**	No	Yes	if yes, how many	**Expen-diture**
146.	Plow .**1**	0	1		0	1			0	1		
147.	Rake .**2**	0	1		0	1			0	1		
148.	Oxen chart .**3**	0	1		0	1			0	1		
149.	Hand tractor .**4**	0	1		0	1			0	1		
150.	Tractor .**5**	0	1		0	1			0	1		
151.	Water pump .**6**	0	1		0	1			0	1		
152.	Grass trimming .**7** machine	0	1		0	1			0	1		
153.	Pesticide sprayer .**8**	0	1		0	1			0	1		
154.	Spraying machine .**9**	0	1		0	1			0	1		
155.	Boat .**10**	0	1		0	1			0	1		
156.	Smach (Flat boat) .**11**	0	1		0	1			0	1		
157.	Boat engine .**12**	0	1		0	1			0	1		
158.	Stationary gillnet (Maung) .**13**	0	1		0	1			0	1		
159.	Filtering Gear or Grid-trap (Treourng) .**14**	0	1		0	1			0	1		
160.	Fishing net .**15**	0	1		0	1			0	1		
161.	Fishing Lot Fence System with pens (Nor-Rav) .**16**	0	1		0	1			0	1		
162.	Horizotal Cyclider Trap (Leour) .**17**	0	1		0	1			0	1		
163.	Basket trap (Lorp) .**18**	0	1		0	1			0	1		
164.	Bamboo Tube Trap for eel (Laon) .**19**	0	1		0	1			0	1		
165.	Small Fence System with pens (Baor/ Nor .**20**	0	1		0	1			0	1		
166.	Fishing hock .**21**	0	1		0	1			0	1		
167.	Fishing fock .**22**	0	1		0	1			0	1		
168.	Fish eletricity shocker .**23**	0	1		0	1			0	1		
169.	Other (please specify) .**24** ……	0	1		0	1			0	1		

VI. Food security, water and electricity accesses

170.	Is your rice production enough for the whole year consumption?	**1**.Yes **0**.No	
171.	If no, how many month per year?	……month/year	
172.	If no, how many kilogramme of rice do you buy more?	Weigh : ……kg	
173.		Price : …….Riel/Kg	
174.	Have you borrowed someone to buy food?	**1**.Yes **0**.No	
175.	If no, do you borrow some rice from your neighbor?	**1**.Yes **0**.No	
176.	What kind of water source for family consumption? **1.** Pound/ Well (Personal) **2.** Pound/ Well of communit **3.** Buying Water (Truck and bassin cart for sale) 4. Rainy water (Container) **5.** Natural pound and lake/ River **6.** Other…(please specify) ……		
177.	What kind of power source for family consumption?		

	1. Public electricity **2**. Private electricity **3.** Own generator **4**. Charging battery **5**. Solar system **6.** Parafin lamp/ Candle **7.** Othe (please specify) ……	
178.	Do you have your own family toilet? **1**.Yes **0**.No	
179.	If no, how do you access to do toilet? **1.** Relatives/Neigbours' toilet **2.** Community toilet **3.** Natural pound and lake/ River (in water) 4. Forest and boundary land **5.** Chamkar/ Paddy land **6.** Other, (please specify) …….....	

VII. Household consumption

	Description of daily expenditures	Quantity	Price	Total (Riel/day or Month or Year))
180.	Milled rice (kg)			
181.	Daily food (food ingredients)			
182.	Clothes			
183.	Medical			
184.	Electricity			
185.	Water			
186.	Cooking fuel (fuel wood, Chacoal, gas..)			
187.	Land tax			
188.	Other tax			
189.	Wedding party			
190.	Contribution for relegion			
191.	Social contribution			
192.	Children schooling			
193.	Telephone credit charge			
194.	Transportation (gasoline….)			
195.	Entertainment (traveling …)			
196.	Community member fee			
197.	Other (please specify) ……			

VIII. Access to credit

198.	Are you currently borrowing any money from someone?	**1**.Yes **0**.No	
199.	If yes, How much : ……?	Rate…….....%	Duration :.....
200.	If yes, who do you currently borrow? **1**.Family/relatives **2**.Your neighbor **3**.Tontin **4**.NGOs **5**.Trader/Employer/Agricultural firm **6**.MFI/Bank **7**. Saving group **8**. Rice bank/village bank **9**.Others…..……		
201.	If no, why? **1**. Do not need **2**.Cannot afford **3**.Too complicated to borrow **4**.To high interest **5**.Other pls explain.....		
202.	What means do you use for collateral? **1**.Land title/house **2**.Animals **3**.Motor/car **4**.Marchine **5**.Family assurance **6**.Self-help group assurance **7**.Local authority witness **8**. Other pls specify.....		
203.	For what purpose do you borrow? **1**.For agricultural work, buy agricultural tools/inputs **2**.Investment **3**.to feed the family (buy more food) **4**.to pay for the medical treatment **5**.pay for children go to school **6**.married/festival **7**.for migration **8**.to repay previous debt **9**.House building **10**.To cope with crop failure **11**.For young married couple starting business **12**.For help child to start agricultural work **13**.Other pls specify……		
204.	What you do you with the remittance earning by your family member who migrate(s)? **1**.For agricultural work, buy agricultural tools/inputs **2**.Investment **3**.to feed the family (buy more food) **4**.to pay for the medical treatment **5**.pay for children go to school **6**.married/festival **7**.for migration **8**.to repay previous debt **9**.House building **10**.To cope with crop failure **11**.For young married couple starting business **12**.For help child to start agricultural work **13**.Other pls specify…….		
205.	How much can you save from your revenue each month or year?	Amount (Riel/USDollar/Thai Baht) : ……..?	
206.	What do you do with your saving from your revenue? **1**.For agricultural work, buy agricultural tools/inputs **2**.Investment **3**.to feed the family (buy more food) **4**.to pay for the medical treatment **5**.pay for children go to school **6**.married/festival **7**.for migration **8**.to repay previous debt **9**.House building **10**.To cope with crop failure **11**.For young married couple starting business **12**.For help child to start agricultural work **13**.Other pls specify…….		

207.	Qualitative explantation…….. ……

IX. Social capital

208.	Does your family have poor identity card provided by Cambodian government?	**1**.Yes **0**.No	
209.	If yes, which category?	**1**. = 1 **2.** = 2	
210.	Do any member of your family used to be taking part in group or NGOs or CBOs projects?	**1**.Yes **0**.No	
	If yes, pls list out name of groups in the table below:		

	HH member. ID	*Name of group, CBOs or NGO 's projects*, Village/CC/district or school authority	Participation: Year	Participation: Now, still member? (**1**.Yes,**0**.No)	Mode of participation **[a]**	How often, participation? **[b]**	Nature of group, CBOs or NGO 's projects **[c]**
211.		1…… 2…… 3…… 4……	…… …… …… ……	…….. …….. …….. ……	…….. …….. …….. ……	…….. …….. …….. ……	…….. …….. …….. ……
212.		1…… 2…… 3…… 4……	…… …… …… ……	…….. …….. …….. ……	…….. …….. …….. ……	…….. …….. …….. ……	…….. …….. …….. ……

Code [a]
- **1.** Leader
- **2.** Member of committee
- **3.** Member

Code [b]
- **1.** Never participate
- **2.** Part, Occasionally
- **3.** Part, Frequently
- **4.** Part. Very frequently

Code [c]
- **1.** Agricultural Production and Extension or livelihood improvement
- **2.** Production or trade
- **3.** Community Forestry or Natural Resource Management
- **4.** Finance, credit or saving
- **5.** Health or education
- **6.** Political
- **7.** Religious
- **8.** Others, please specify ……

213.	Do you think that this existing NGOs or Group which you and your family's member belong to is good for villager?	**1**.Yes **0**.No	
214.	If YES or NO, please explain why? …… ……		
215.	Do you think that this existing NGOs or Group which you and your family's member belong to is supportive enough accordingly to your need?	**1.**Yes **0**.No	
216.	If YES or NO, please explain why? …… ……		
217.	Do you think that this existing NGOs or Group which you and your family's member belong to is supportive enough to start agricultural work?	**1**.Yes **0**.No	
218.	If YES or NO, please explain why? …… ……		

X. Access to information

What are your three main sources of information you get concerning the following issues in the table?

	Description of issues	Record appropriate codes below
219.	Prices of goods or crops	
220.	Agricultural extension	
221.	Workfare and Education	
222.	Health and Family planning	
223.	Others, please specify ……	

Code :
1. Relatives, friends and neighbours
2. Trader/ Middle men
9. Groups or associations

3. Village/ Community bulletin board	**10**. Business or work associates
4. Local market	**11.** Political associates
5. Community or local newspaper	1**2**. Community leaders
6. National newspaper	**13**. An agent of the government
7. Radio	**14**. NGOs
8. Television	**15**. Internet
	16. Other please specify
	……

XI. Collective action and solidarity

How do you assess the level of help in among your community member in the following case?

	Issue	Before 1990	During 1990-2000	During 2000-2010	After 2010-present
224.	Religious ceremony				
225.	Wedding				
226.	Funeral				
227.	Serious illness				
228.	Supporting family member				
229.	Supporting other				
230.	Deprivation				
231.	Incident in the community such as natural disaster				

Code
1.Good 2.Got better 3.Got worse 4.Stayed about the same 5.No idea/ Don't know

XII. Perception on agricultural work and Environment

Perception on agriculture

	Do you think agricultural work is difficult in practice? **[a]**	What are the difficuties in agricultural work/ production?	How do you solve those difficulties in agricultural production?	What are the reslut of the solution? **[b]**
232.	1/ Paddy: ..... ***If 0.No and 2. Don't know → skip to Q. 233***	1/ Paddy:	1/ Paddy:	1/ Paddy: .....
233.	2/ Chamkar: ... ***If 0.No and 2. Don't know → skip to Q. 234***	2/ Chamkar:	2/ Chamkar:	2/ Chamkar: .....
234.	3/ Animal raising: ..... ***If 0.No and 2. Don't know → skip to Q. 235***	3/ Animal raising:	3/ Animal raising:	3/ Chamkar: .....
235.	4/ Fishing: ..... ***If 0.No and 2. Don't know → skip to Q. 236***	4/ Fishing:	4/ Fishing:	4/ Fishing: .....

Code :
[a] 1. Yes **0.** No **2.** Don't kknow
[b] 1. Strong effectiveness **2.** Effective **3.**Less Effectiveness **4.** Neutral **5.** Worse

236.	Do you think that agriculture is good option to effort your family?	
237.	If Yes and No, please explain why? ……	
238.	Do you think that now it is easy to find job beside agriculture in your area or somewhere around?	1.Yes 0.No
239.	If Yes and No, please explain why? ……	
240.	Do you think the benefit from agriculture, non-farm, and non-farm activities can make sufficient your household livelihood?	1.Yes 0.No
241.	If No, do you think what is your option and strategy to make effort your livelihood? ……	

242.	/Do you please to movemigrate to other area?	1.Yes 0.No
243.	If Yes and No, please explain why? ……. ……. …….	

Perception on the impact of environment and humen well-being				
	Could you evaluate the of changes of natural resources access in Tonle Sap before fishing lots?	Could you evaluate the of changes of natural resources access in Tonle Sap after fishing lots was closed to open access?	What are the couses of those changes?	What are the impacts from those changes?
244.	1/ Water availability: ……	1/ Water availability: ……	1/ Water availability: …… …… …… ……	1/ Water availability: …… …… …… ……
245.	2/ Soil fertility: …… ……	2/ Soil fertility: …… ……	2/ Soil Soil fertility: …… …… …… ……	2/ Soil Soil fertility: …… …… …… ……
246.	3/ Wild Animal:…… ……	3/ Wild Animal:…… ……	3/ Wild Animal:…… …… …… ……	3/ Wild Animal:…… …… …… ……
247.	4/ Fish accessibility:... ……	4/ Fish accessibility:... ……	4/ Fish accessibility:…… …… …… ……	4/ Fish accessibility:…… …… …… ……
248.	5/ Roneam Forest:…… ……	5/ Roneam Forest…… ……	5/ Roneam Forest…… …… …… ……	5/ Roneam Forest…… …… …… ……
249.	6/ Climate: …… ……	6/ Climate:…… ……	6/ Climate: …… …… …… ……	6/ Climate: …… …… …… ……

Code :
1. Strongly Increase **2.** Somewhat increase **3.** The same **4.** Somewhat decrease **5.** Strongly decrease

250.	To what extent, do you think the natural resources/ecosystem of Tonle Sap contributeinyour agricultur e?	1.Yes 0.No 2. Don't know
251.	If YES, please describe those services? …… …… ……	
252.	If No, please explain why? …….. …… ……	
253.	To what extent, do you think the natural resources/ecosystem of Tonle Sap are neccessary for improving your livelihood and well-being?	1.Yes 0.No 2. Don't know
254.	If YES, Please describe some those services? …….. …… ……	
255.	If No, please explain why? …… …… ……	
256.	To your opinion, what should we do to protect the natural resources of Tonle Sap lake in sustainable way? …… …… ……	

Thank you very much for participation, I really appreciate your time!

Appendix 7: Timeframe and Work Planning

Nº	Activities	Year	2014-2015				2015-2016				2017-2018				Expected outcome
		Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter		
		Duration													
1	Finalize research proposal, study area, literature review, research planning, and collaboration with host institution.														Full research proposal is developed, Bibliography, and fieldwork farmework is done
2	PhD Course work														60 credit course work completed
3	Field research phase I														First publication on scientific journal, presentation at international conference
4	Developing research instrument and data collection														
5	Data analysis and report writing														
6	Comment, revise and finalize Phase I report														
7	Bachelor and Master thesis supervision														Three master thesis report will supervised
8	PhD Course work														20 credit course work completed
9	Field research phase II														Second publication on scientific journal
10	Developing research instrument and data collection														
11	Data analysis and report writing														
12	Comment, revise and finalize Phase II report														
13	Bachelor and Master thesis supervision														Bachelor thesis report will supervised
14	Finalize field research and complete missing data														Additional or missing data are collected for PhD thesis
15	Data analysis and writing PhD thesis														Combination of previous publication with PhD thesis
16	Comment, revise and finalize PhD thesis														PhD thesis is publish
17	PhD thesis slide presentation, and defense preparation														Slide presentation is ready
															Defend session is completed

Appendix 8: Estimate research budget for two phases of mission in 2015 and 2016

Item	Cost per Unit				Total
	Unit	Quantity	Unit		
I. First Field Survey Conduction					
1. Airfare (Paris-Phnom Penh)	Round trip	1	EURO	BGF grant	0 -
2. Train ticket (Montpellier-Paris)	Round trip	1	EURO	BGF grant	0 -
3. Taxi (Phnom Penh Airport-Home)	Round trip	2	EURO	BGF grant	0 -
4. Research assistant (Guaduate student 2 people * 5months)	month	10	EURO	150	1 500
5. Perdium for field servey (7 people * 10 days = 70)	month	70	EURO	25	1 750
6. Perdium for field servey (3 people * 14 days = 42)	day	42	EURO	20	840
7. Accomodation (3 people * 14 days = 42)	day	42	EURO	10	420
8. Communication and local transportation (Phnom Penh- Battambang Province and within the Province)	visit	2	EURO	300	600
Sub-Total 1			EURO		**5 110**
II. Second Field Survey Conduction					
1. Airfare (Paris-Phnom Penh)	Round trip	1	EURO	BGF grant	0 -
2. Train ticket (Montpellier-Paris)	Round trip	1	EURO	BGF grant	0 -
3. Taxi (Phnom Penh Airport-Home)	Round trip	2	EURO	BGF grant	0-
4. Research asistant (master student)	month	3	EURO	150	450
5. Research asistant (bachelor student)	month	0	EURO	0	-
6. Per-diem for field servey (3 people * 14 days = 42)	day	42	EURO	20	840
7. Accomodation (3 people * 14 days = 42)	day	42	EURO	10	420
8. Inerviewers (3 interviwers * 10 days = 30)	day	30	EURO	20	600
9. Communication and local transportation (Phnom Penh-Battambang Province and within the Province)	visit	2	EURO	300	600
Sub-Total 2			EURO		**2 910**
Grand total (1)+(2)			EURO		**8 020**