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MAINTAINING ECOSYSTEM SERVICES PROVIDED BY RICE PRODUCTION SYSTEMS IN CAMBODIA: IDENTIFYING COSTS FOR FARMERS AND CONSUMERS' PREFERENCES

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Résumé

Cette thèse s'intéresse à la capacité des producteurs de riz au Cambodge de maintenir un certain niveau de services écosystémiques avec des pratiques appropriées. Notre étude empirique a été réalisée dans le cadre de l'agro-écosystème de la plaine inondable du Lac Tonlé Sap. Celui-ci fait partie du hotspot de biodiversité d'Indo-Burma et est listé par l'UNESCO comme réserve de biosphère. Ainsi, les enjeux de développement économique de la région intégrent la conciliation de l'augmentation de la productivité rizicole et du maintien des services écosystémiques.

Premièrement, nous avons mené une étude exploratoire de l'émergence au Cambodge des notions de services écosystémiques, de services environnementaux et de paiement pour des services environnementaux. Deuxièmement, nous avons utilisé la méthode du diagnostic agraire afin de comprendre les décisions des agriculteurs concernant l'adoption du riz biologique dans une zone à fort risque d'inondation. Dans un troisième temps, en combinant le diagnostic agraire avec le cadre théorique des services écosystémiques et dis-services écosystémiques, nous avons identifié les services et les dis-services fournis par les systèmes de production rizicole. Nous avons alors proposé une analyse économique des coûts d'opportunité des agriculteurs correspondant au maintien de ces services écosystémiques. Enfin, nous avons mené des enquêtes auprès des consommateurs afin de fournir une compréhension initiale de la demande locale pour des produits agricoles contenant des services écosystémiques. Ces résultats d'enquêtes ont montré une préférence des consommateurs cambodgiens pour ces produits.

Nos recherches ont été réalisées en plusieurs étapes. Tout d'abord, en 2010, nous avons mené 34 enquêtes auprès de bailleurs de fonds, d'ONG et d'institutions publiques. Entre 2010 et 2012, nous avons conduit des enquêtes auprès de 208 agriculteurs. Enfin, nous avons terminé avec des enquêtes auprès de 300 consommateurs.

En conclusion, cette thèse démontre sans ambiguïté le rôle des agriculteurs producteurs de riz dans la fourniture de services écosystémiques. Assurer ce rôle génère pour les agriculteurs un coût d'opportunité important. Ces résultats nous amènent à formuler plusieurs recommandations politiques concernant la labellisation des produits agricoles.

Mots Clés : Cambodge, Lac Tonlé Sap, Politiques de conservation, Services Ecosystémiques, Systèmes de production rizicole, Coûts d'opportunités, Services écosystémiques basés sur les produits.

Abstract

This thesis questions the fact that Cambodian rice farmers may maintain a level of ecosystem services provided by agro-ecosystems with appropriate farming practices. Our empirical study has been conducted on flood plain of Tonle Sap Great Lake, which is an Indo-Burma Biodiversity hotspot and registered as Biosphere Reserve of UNESCO. It is a big challenge for farmers to increase rice productivity in this region while maintaining a high level of ecosystem services provision.

Our research has firstly started with an exploration of the following issue: the emergence in Cambodia of the notions of ecosystem services and payment for environmental services notions. Secondly, we have used the agrarian system framework in order to tackle the issue of farmers' decision in adoption of organic rice on agro-ecosystem with a high risk of flood. Thirdly, by combining the agrarian system methodology with ecosystem services-ecosystem dis-services framework enable to identify the ecosystem services and ecosystem dis-services provided by several rice production systems. And then we proposed the economic analysis of opportunity costs for farmers to maintain ecosystem services provision. Finally, we have investigated the domestic market to give an understanding of consumers' preference of product-based ecosystem services. This investigation has pointed out the Cambodian consumers' preferences for a label referring to product-based ecosystem services.

To reach the study objectives, we have collected several types of data. First, we realized deep interviews with 34 people from NGOs and public institutions in 2010. Then in 2010 and 2012, we studied the production side to identify ecosystem services with 208 farmers interviews. Finally, in 2012 we carried out 300 consumers surveys for the demand side.

In conclusion, this thesis has highlighted the unambiguous role played by farmers in ecosystem services provision especially in the case of rice production systems. This role can be ensured at an opportunity cost for farmers and this result leads to several policy recommendations concerning labeling and policy options.

Key words : Cambodia, Tonle Sap Lake, Conservation Policies, Ecosystem Services (ES), Rice Cropping Systems, Opportunity Cost, Product-based ES

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List of acronyms

ADB	Asian Development Bank
ACIAR	Australian Center for International Agricultural Research
AFD	Agence Française de Développement
ASEAN	Association of South East Asian Nations
ASPSIM	Agricultural Production System SIMulator
AVSF	Agronomes et Aétérinaires Sans Frontières
CARDI	Cambodian Agriculture Research and Development Institute
CDC	Cambodian Development Council
CDRI	Cambodia Development Resource Institute
CI	Conservation International
CIFOR	Center for International Forestry Research
CIRAD	French Agricultural Research Centre for International Development
COP	Conference of the parties
DANIDA	Danish International Development Agency
EDS	Ecosystem Dis-services
EEPSEA	Environmental Economics Program for Southeast Asia
ES	Ecosystem Services or Environmental Services
ESF	Ecosystem Services Framework
ESR	Early season rice
(ESR+RR)	Early season rice + Receding rice
EWMI	East West Management Institute
FA	Forestry Administration
FiA	Fishery Administration
FAO	Food and Agriculture Organization
FFI	Fauna and Flora International
fl	Family labor
FR	Floating Rice
FSR	Farming Systems Research
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
GI	Geographical Indication
GRET	Groupe de Recherches et d'Echanges Technologiques
GVA	Gross Value-Added
GR	Gross Remuneration

IFAD	International Foundation for Agricultural Development
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
JICA	Japan International Cooperation Agency LWF
LTD	Long term rice with direct-seedling
LTT	Long term rice transplanted
MAFF	Ministry of Agriculture Forestry and Fishery
MoE	Ministry of Environment
MEA	Millennium Ecosystem Assessment
MTD	Medium term rice with direct-seedling
NTFP	Non Timber Forest Products
MTT	Medium term rice transplanted
NFP	National Forest Program
ONFI	ONF International
OR	Organic Rice
PES	Payment for Ecosystem Services
REDD	Reduction of Emissions from Deforestation and forest Degradation
RR	Receding rice
RDX	Research Department Explosive
SERENA	Environmental Services and Uses of Rural Areas
SIDA	Swedish International Development Agency
SRI	System of Rice Intensification
TEEB	The Economics of Ecosystem and Biodiversity
TNT	Trinitrotoluene
TWGFE	Technical working group forestry and environment
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
URA	Royal University of Agriculture
URPP	Royal University of Phnom Penh
USAID	United States Agency for International Development
VA	Value-Added
WCS	Wildlife Conservation Society
WTO	World Trade Organization
WWF	World Wildlife Fund

General Introduction

This thesis is looking for the possibility to apply Ecosystem Services (ES) framework into an agricultural economic analysis of the agro-ecosystem of rice production systems in Cambodia.

This general introduction compiles 5 parts together. First is **background and problem statement** related to agricultural sector of Cambodia. Second part details the **objectives of thesis**. Then, third part discusses about the **theoretical framework** that mobilized for this study. Part four is Methodology that details the initiative approach proposed for PhD's flied research. The last part describes **thesis structure** combining different papers.

Background and problem statement

Cambodia covers 181,035 km^2 in total surface with 14.68 million inhabitants in 2013 (ADB, 2014). Cambodia is an agricultural country, which is identified as an important global biodiversity hotspot. The three quarter of country's surface are forest areas that surrounding the country. At the southwest is an Elephant mountain. And at west is Cardamom Mountain. Then at the north is Dangrek Mountain. Along with the plateau of Ratanakiri and Chlong highland at the east (National Institute of Statistic, 2008; Pillot, 2008). This small country is considered as important for global conservation because it lies within the Indo-Burma hotspot and contains four of the global 200 Ecoregion where located the habitats of terrestrial, aquatic, marine and bird species. (Clements *et al.*, 2010; Wright *et al.*, 2010). National Institute of Statistic (2008) declares natural and others habitats cover 18.126 million hectare in total (see Map 1-introduction about Cambodian Natural resources and flooded forest border, p.20).

Nevertheless, this country get through the long history of war as well as civil conflict and the natural resources governance and conservation evolve along with its complex political history. Armed conflicts often happen in the areas of high biodiversity, which is naturally wildlife habitat. Those opposing army use forest as their places to hide from governmental army. After the country has peace in 1991, Cambodia is facing to natural resources and ecosystem services degradation because of over exploitation of forest and natural resource to generate economic growth (Colby *et al.*, 2009; Milne and Adams, 2012). Despite of that,

agro-ecosystem conservation action is still nonexistent in agricultural policy.

Since 1998, stable political environment takes place and increases the market-driven economy. Subsequent to the civil war, the country is brought to the poverty with more than third of population are under the poverty line (ADB, 2004; UNDP, 2012). The poors in Cambodia are not clearly defined from groups to outsider. For instance, food security, land holdings, and levels of debt are embodied in local categories of ***neak min*** (people who have); ***neak kuesom*** (people with enough), ***neak kroo*** (poor folk) and ***neak toal*** (poorer than poor) (Turton, 2000 p.15).

Cambodia was the Asian least developed country with a GDP 380$ per capita in 2005. So far, Cambodian economy has been mainly based on agriculture to sustain its growth. This sector represented the major part of the GDP in 1991 (52%), 44% in 1998, and then 33% in 2004. From 1996 to 2000, the rate of the economic growth was 3.4% per year (Pillot, 2008). From 2004 to 2011, the GDP per capita increased up to 2000 USD per Capita and Cambodia became the fiftieth among 174 countries. In addition, the poverty rate has decreased brutally from 52.2 to 20.5%. However, 90% of Cambodian poor still relies on rice production. The main factors driven poverty reduction are 23% from improvement of rice production and 24% from slightly increasing in rice price (World Bank, 2013). Nevertheless, the country's poverty rate dropped to 18.9% in 2012 and is still likely to decrease while the economy is growing (Ministry of Planning, 2014). Agriculture, rice in particular is still an important factor for economic growth although its contribution to the Cambodian GDP decreased 31.6% in 2013 as a result of the boom of manufactured, construction and services (tourism) sectors. Agriculture itself grew 4% from 2008 to 2013 and contributed to reduce 1% poverty (MAFF, 2013).

Forest and natural resources degradation

Cambodian economic was strongly affected by its history of violence and conflict. Its recent turbulent history is firmly associated with cold war since 1970s until 1990s, which explains the actual social and environmental issues (Allen and Long, 1989; Miles and Thomas, 2007; Pagiola *et al.*, 2007). In 1863, the country was under French protectorate until 1953 (Neupert and Prum, 2005) when Cambodia gained full independence under the leadership of King Father Sihanouk. In 1970 General Lon Nol, supported by the US, leaded military coup and became President of Khmer republic. Again, the country has been

drawn toward war. Cambodia has also suffered from Vietnam War; in 1973, US forces secretly bombed some areas in an attempt to stop guerrilla incursions over the border.

17 April 1975, the country was totally cut off from the rest of the world and was putted into a dark period called year zero society. The country was declared as "Democratic Kampuchea". This regime evacuated the cities and closed down formal education, declaring the abolition of religion and of social class distinctions. There was only one class in the society, "the peasant", and land became state collective asset. Consequently, 1.5 million peoples or 20% of the population had been killed by a combination of starvation, overwork, disease and execution. 5 years from 1970 to 1975, the country did not have time to develop because of civil war and the spillover of the American–Vietnamese conflict. Ended by Vietnamese invasion in 1979, it left behind the fearful, lost and destabilized peoples with low level of education or illiterate.

The People's Republic of Kampuchea was installed and leaded by Vietnamese army. The Khmer Rouge continues to fight on even after the Vietnamese army left Cambodia in 1989. In 1993 a new constitution restored Sihanouk to the throne and free elections produced a coalition government (jointly headed by Hun Sen, originally installed by the Vietnamese, who remains Prime Minister today) (Billet, 1995; Ear, 1997; ADB, 2000, 2004; Neupert and Prum, 2005; Miles and Thomas, 2007).

On the others hand, over 50 years from pre-1953 to 2005, wildlife abundance and species richness decline. Remarkably, the sharpest period was in 1970s under Lon Nol and Pol Pot regime. The cause of this lost was associated with proliferation of guns, emergence of wildlife trade for external market; and government policies mandating hunting by local villagers (Colby *et al.*, 2009).

Paradoxically, the heavy US bombing and the murderous agrarian of the Khmer Rouge are not the principal causes of forest and natural resources degradation. Cambodian forest, fish and gem mines survived the 1970s. Only during the prolong civil conflict of the 1980s the country was in uncontrolled situation aggravating over timber extracting, over fishing, over mining and new agricultural land expansion that cause serious deforestation and natural resources degradation. For instance, the Tonle Sap Lake and Flood plain met the serious problem of sedimentation causing by mining and timber extraction in Pailin under the governance of Khmer Rouge Army. By mid-1990s, Cambodian forest resources were used

to sustain the power of army and political elite. Cambodian timber represents 43% of total exportation. Being in peace from 1991 until end of 1998, US$2.5 billion of national GDP comes from timber under concession and contract exportation (Le Billon, 2000; Douglas, 2006; Ear, 2006).

December 1998, there was a total integration of Khmer rouge army and the military was reformed. However, internal political conflicts, including a coup, disputes and tensions continued. Uncontrolled corruption and bad government affect the country and forest as well as natural resources degradation (Neupert and Prum, 2005).

On the others, until 1990s, rural population enlarge their rice field land toward the flooded forest area of Tonle Sap flood plain and forest area at the country periphery without knowing that they are private state land, which initiate land tenure and expropriation when government give right to economic concessioners. Government perceive land and related natural resources of private state land as opportunity to attract national and international investment through economic and commercial land concession (forest extraction, agro-industrial plantation and halieutic extraction). Each concessioner can possess until 10.000ha and renewable until 99 years. Those concessions cover 20% of available agricultural land, which is 36% of fertile land (Le Billon, 2000; Diepart, 2011).

On the other hand, small landholders are the most vulnerable to land loss because the loan is generally provided by elite peoples in the village while official microcredit are situated only at urban area. Thus, with high interest rate they often do not have capacity to generate the income for reimbursement. So, land become subject of reimbursement instead of money.

At the end of 1990s, face to official statement of failure in natural resources management through concession, Royal Government of Cambodian instruct several reforms related to decrease surface of concession or suppression concession (forestry and fishery) in some cases and increase local communities power in natural resources management in sustainable way.

This model believes in ecosystem managers as peoples who know the most on how to preserve their own resources. But at some point it is also the way that the state externalizes the cost of conservation to local community and to Non-governmental Organizations (NGOs). In addition, those cost of conservation are often incorporate in the cost of production translated to **opportunity cost** for farmers producing rice on the central flood plain and shifting agriculture on north-west peripheral plateau (Diepart, 2010, 2011).

Rice as main production in Cambodia across history

The Cambodian Tonle Sap flood plain represents only one quarter of country surface but two thirds of population leave there rely on halieutic resources and fertile alluvial soil. This soil origins from the ancient erosion from the massifs around and from flood pulse where closer to the lake. As this fertile soil and water from flood pulse are propitious for rice production, 80% of total rice field situated on this ecosystem. Anyways, this ecosystem faces to high risk of prone flooded water. Those wetland rice farmers produce their own rice with adopted photoperiodic varieties, that permit the vegetation stage correspond to annual flood during rainy season and maturity stage starts early dry season. This life cycle allow harvesting on dry land.

Rice is always the important production of Cambodia along with its history since Angkorian period. Some author affirm that with an immense reservoir of 300 hectares able to store 10 millions meters cube of water, called "Baray" and other smaller reservoirs with complex canals, this system can irrigate thousands hectares of rice field. Some authors announced that during that period Khmer people, by using Baray irrigation system, could cultivate rice 2 to 3 cycles per years. This explains the power of Khmer empire of Angkorian period. Some authors also augured those reservoirs was for urban consumption.

Likely, Khmer agro-ecosystem and archeological evidence can give clear understanding that the Great Lake flood plain can ensure the adoption of 3 types of rice cultivation as following: floating rice with low labor need while the receding rice and terrace rice (also cultivated during rainy season) requires higher, where those can be cultivated closer to the lake and inundated lastly by natural flood pulse. In addition, rice cultivation took root in Cambodian culture, tradition and religion from Hinduism to Buddhism. There are a lot of practices of sharing labor and products that the poorest can have enough to eat by coming to help the richer. Rice production systems ensured auto-consumption despite the collapse

of Angkorian period and the moving capital of royal family until French protectorate (Pillot, 2008).

The kingdom of Cambodia from 1953 to 1970 was one of rice-exported country by low increasing yield from 0.95 to 1.1t/ha, remarkably the increasing of cultivation is thanks to tractor introduction. Floating rice cropping system plays an important role to ensure the household consumption with low labor needed, which frees labor to produce more receding and terrace rice for exportation. During Khmer rouge regime, low land rainy season rice has become monoculture crop in a whole country, and the population were forced to do over work (Mak, 2001; Pillot, 2008).

Crossing those events, Cambodia was out of the way of Green Revolution and stays on their own traditional practices of agriculture whether there had been the adoption of High Yield Varieties (HYV) since 1991 (Mak, 2001). 1980s under the socialist system, the country started to rebuild up continuously. Increasing in rice producers in the population and rice needs boost the rice field land demands, which provokes degradation of grassland, flooded shrubs and flooded forest agro-ecosystem. However, with less availability of land prompts decreasing the surface per household.

Rural population makes their livelihood based on agricultural activities mainly the rice production. It covers 85% of cultivated land for ensuring country food security serves as main staple in every meals keeping the poor outside the food insecurity (Turton, 2000; Diepart, 2011). From 2000s, the irrigation system constructed by Government and private rice producers enable famers to enlarge cultivated surface as well as to improve land productivity by doubling or tripling rice cycle per year. For those, who are not able to expand land, will choose to migrate toward periphery zone to concur new land in forest area on northwest plateau and mountain. This issue has increased deforestation and natural resources degradation (Pillot, 2008; Diepart, 2010, 2015).

In Cambodia, rice productivity improvement is also implemented and supported (financial, institutional and technical) by the NGOs in order to improve farmers' livelihood through price premium for organic rice. The recruitment of the poorest farmers naturally own less than 2ha of rice field are done to collective action and create organic farmers associations producing organic rice by the NGOs (Rigby and Caceres, 2001; Cheattho, 2011; COrAA, 2011a). While the low yield of organic agriculture compare to conventional one (de Ponti

et al., 2012) might lead to its low adoption. In Rural area of Cambodia, finding manure and compost materiels become big challenge due to small scale of animals household raising. Moreover, the 6 months of dry season could drive rural area out of vegetation. Between 2007 to 2008, without ability of finding manure/compost farmers get 2.3t/ha and 3.5 to 5.4t/ha with manure or compost application (Cheattho, 2011).

Being a rice producer country, rice production is still smallholder of 1.6 hectare per family and 73% of them could only produce for personal consumption needs in 2014 because of lack of cultural techniques (Diepart, 2015). In term of quality, Cambodian rice, representing by Organic rice certify by COrAA win the World's Best Rice Awards for two consecutive years 2012 and 2013. COrAA, CEDAC are two the most actives NGOs in organic rice producers re-enforcement. In addition, CEDAC declare in Phnom Penh Post, a local newspaper, on 13 Feb 2015, that they shipped 540 t of fragrant organic rice to international market in 2014, which is 20% more than 2013.

From auto-consumption to market integration rice production

The economic globalization and increase of middle class in urban area increase food demand, goods and services. This trend changes agricultural sector from auto-subsistence for food only to be food and goods supplier for population and others sectors.

Between twentieth and twenty-first century, South-East Asia population move within the countryside and to town in order to find opportunity for land and for new business. It causes by war and civil conflict that impact negatively the countries such as Cambodia and Lao PDR since 1950s. The thousands of land mines buried on farmland cause horrible injuries. This situation forces peoples to move hoping to find land possible to work. Excessive mines explosion cause serious human and livestock destructive as well as disruption soil structure and soil erosion. The explosion release also non-biodegradable toxic into the soil such as TNT, RDX, tartly, depleted uranium and heavy metal such as cadmium, lead, mercury and nickel. Those toxic led to high loss of agricultural production. The rapid change of Southeast Asia led to unsustainable agriculture.

Hence, upland shifting agriculture reduces in fallow period because of the pressure form population growth and new migrants needs for land. Moreover, industrial agriculture develop speedily in form of monoculture of cash crop such as peanut, cassava, pineapple,

maize, mung bean; and large scale plantation for rubber, palm oil and coffee in particular. These two trends cause quick forest and resources degradation along with soil erosion.

Wet land agriculture evolves to intensive agriculture and monoculture cash crop because of lack of awareness by people in integrated agriculture increasing organic manure from animal and then they invest in chemical inputs rather than efficient and effective farm resources management. Private machinery services providers such contract tractor ploughing and harvesting develop rapid following the need to increase working surface with low farm investment as possible (Douglas, 2006; Pillot, 2008).

Because of the integration into the ASEAN free trade area (Fukase and Martin, 2001), because the population is expected to double in 20 years (MacAlister and Mahaxay, 2006) and because of the willingness to export rice up to 1 million tons in 2015 (RGC, 2008), the Royal Government of Cambodia has set up a zero tax regime for all agricultural inputs and machinery to encourage agricultural intensification (MAFF, 2011). This will put pressure on natural resources because of rapid land use change. To achieve agricultural intensification goal, 10 high yield rice varieties (HYV) of short-term rice are identified as priorities to be promoted (MAFF, 2006, 2011), which will harm natural varieties of rice selected from natural genetic bank. Instead, it will also damage the ecosystem of TSL because agro-ecosystem for rice production situates on its floodplain.

In the last decade, security and Infrastructure improvement (road to remote area) ease the rural poor to improve their agricultural-based livelihood. Land distribution in 1980 following by high population growth and migrants resulting put pressure on land and led to current land scarcity; which cause social and economic disparity between agricultural farms (Jaqumin and Penot, 2007).

In 1999, Cambodia accession to ASEAN free trade area. Since, the majority of export is textile (Fukase and Martin, 2001). And the economic growth creating work with low salary permit population to get out of monetary poverty line by earning more than 2USD per day but they are still solvent poor. This situation enhance the socio-economic inequality between family units (Diepart, 2011).

The country still focuses on Economic growth as priority to get out of poverty by integrating to the international market. The Royal Government of Cambodia (RGC) has

identified Agricultural sector, in the strategic plan for development, as a main sector to ensure the economics growth by intensification and increasing the productivities then irrigation system is priority. From 1979 to 2003, the irrigated surface increase from 120,000 (5.8%) to 217,000 ha (7.1%) and Government foresee to increase for 1.8 million hectare (RGC, 2008; Diepart, 2011). Rice yield varies based on adapted techniques to different varieties from 1.2t/ha for floating rice to 6t/ha for receding rice with high yield varieties. The yield increases in average from 1.4 in 1995 to 2t/ha in 2001 permit to export 2149 t of paddy in 2000. To achieve the goal of exporting up to 1 million tons of milled rice in 2015, 10 high yield rice varieties (HYV) are identified as priorities to drive productivity increasing (MAFF, 2006, 2011).

The productivity slightly increases from 3.15t/ ha in 2014 to 3.18t/ha in 2015. Furthermore, Cambodia rice granted the phyto-standard inspection and exported 205,717 tons of milled rice to 57 countries in 2012 and 378,000t to 66 countries in 2013 (RGC, 2014). In during 7 months in early 2015, Cambodia export 312,317t milled rice that increase 53% compare to the same 7 months in early 2014. Royal Government of Cambodia still commit increase their exportation capacity to meet 1 million tons of milled rice.

Strategic plan 2014-2018, MAFF commit to improve agricultural sector to grow for 3 to 5% by increasing productivity, diversification and agricultural commercialization. MAFF commit to make economic growth benefit all level of population and catch 1% of poverty reduction every years by increasing exportation of value-added of agricultural production such fragrant rice, organic rice, rubber, pepper, coffee...etc. (MAFF, 2015a).

With this determination, Cambodia risks to lose its natural varieties of rice that the farmers have selected from the natural genetic bank. By the way, this sector will be guided toward intensive model with chemical input, irrigation and only 10 high yield selected varieties of rice are encouraged to produce to guarantee the exportation.

However, organic rice production is viewed as a key driver of rural development in Cambodia. For instance, the National Export Strategy and the Green Growth Roadmap consider organic agriculture as one of the main sectors to be prioritized (Green Growth Secretariat, 2009; MAFF and MWRW, 2010; MAFF, 2011). The organic production is often engaged by NGOs action for poverty reduction the price premium given by

consumers, and they target in particular exportation even if they can't ensure local demand (Rigby and Caceres, 2001; Giovannucci, 2007; Thavat, 2011).

Hypothesis and Objectives

Cambodia is an agricultural country possesses rich natural resources such as forests, biodiversity, freshwater and wetlands providing important Ecosystem Services (ES) to local, regional and global levels. The country is facing ES degradation because of natural resources extraction and land use change in agriculture to ensure guarantee economic growth. Adoption of intensive rice production will pollute more and degrade more biodiversity as well as agro-biodiversity. These issues augment Trade-off between development and conservation of ES. Or it still possible to find the win-win strategy for agricultural development and ES provision by maintaining the existing systems providing ES from land use techniques? And how consumers perceive those ES?

ES concept is used in forest conservation domain and PES programs are implemented for forest conservation (Bann, 2003b; Clements *et al.*, 2009). In addition, Eco-label "Environmental Friendly of Ibis rice under Wildlife Conservation Society management, to give incentive to maintain farmers engaging in Ibis conservation in Kulen Prum Tep protected area (Clements *et al.*, 2009).

Our **hypothesis 1** is ES notion and PES scheme emergence only in forest ecosystem to accompany law enforcement but not yet in rice production agro-ecosystem of Tonle Sap Great Lake.

In order to verify this hypothesis, we set up the **Objective 1: Analysis explorative on emergence of ES and PES concept in Cambodia:**

> In this objective, we begin with trying to identify emergence ES and PES notion in Cambodian context. Afterward, our study tries to identify PES forms implementing in Cambodia.

When we look at the agro-ecosystem, farmers' decisions to adopt organic or inorganic rice cropping system, not depends only on price premium that they get from organic label but depend on a number of economic and non economic criteria that should be clarified; land productivity, labor productivity, gross product, profit, food security and resistance to

adverse circumstances (irregularity of flood pulse), social recognition and prestige, etc (Cottin, 2010; Cheattho, 2011).

Our **Hypothesis 2** is the Price premium for organic rice of TSL agro-ecosystem is not incentive enough to promote organic rice adoption.

This hypothesis guide us toward a complex analysis of Agrarian System of all types of rice production system in order to get a whole understanding of farmers' decision and compare Value-added generated from each type of production. So, our **Objective 2: Understand rice production system on agro-ecosystem of Tonle Sap flood pulse:**

> To achieve this objective we set up our field research into 3 step. Firstly, we try to identify rice production system on agro-ecosystem of Tonle Sap flood pulse.
>
> In second step, we try to understand organization of organics farmers associations in order to understand in deep their constraints in adoption. At last, we compare economic efficiency of rice production systems focusing on value-added per family labor.

Different rice cropping systems are cultivated on agro-ecosystem of TLS flood pulse, which is the most productive ecosystem proving natural foods and fertile soil for agriculture (Matsui *et al.*, 2006; Pillot, 2008; Someth *et al.*, 2009). Producing rice on that kind of ecosystem is challenge because rice producers could at once degrade and preserve that ecosystem based on their practices in each rice cropping system. And so, connected to rice Ecosystem Dis-Services (EDS) and Ecosystem Services (ES) are also generated in the same time.

Our **Hypothesis 3** is Organic rice production system is not the only one ES provider and producing rice providing ES will generate the opportunity cost for farmers.

To be able to verify this hypothesis, we set up the **Objective 3: Finding the cost of providing ES for farmers:**

> The understanding of rice techniques and land use management is initial to be able to identify ES and EDS provided by rice production. Once we identify ES related to Rice production systems, we end up with the comparison farmer's opportunity cost to maintain ES.

In Cambodian consumer concern about their health and believe in consuming organic products may avoid from health problem and keep the next generation safe from polluted soil, water and air. Unless, organic products still a market niche and only in the Capital (Chhim, 2009; COrAA, 2011).

Our **Hypothesis 3** is organic consumers are rich and educated peoples who work related to agriculture, environmental conservation. And they may have knowledge related to ES and EDS provided by agriculture.

So, our **Objective 4: Define perception of consumer on organic products and ES - EDS provided by Agriculture:**

> Our survey is design to at first identify the market chain of organic and eco-label product in Phnom Penh the Capital of Cambodia. And secondly, our survey leads to identify organic consumers' socio-economic characteristic and their behavior. At, last we explore the perception and awareness of organic consumers related to ES and EDS provided by agriculture.

Theoretical framework

The concept of Ecosystem Services

The genealogy of ES concept was in use since 1970 by the north American conservationists and the economist of environmental economics. Few ES was defined in SCEP (1970p.122-125) such as "pest control, insect pollination, fisheries, climate regulation, soil retention, flood control, soil formation, cycling of matter and composition of the atmosphere". In 1990s, few scholars and authors such as Costanza and Daly (1987); Costanza *et al.* (1997) and (Ehrlich and Mooney, 1997) bring them to be heard broadly by their publication showing how society depend on natural ecosystem and how much is value of ecosystem. This concept become popular in between 2001-2005 when The Millennium Ecosystems Assessment (MEA) details classify ES into 4 mains categories as detail in Figure 1-Introduction below.

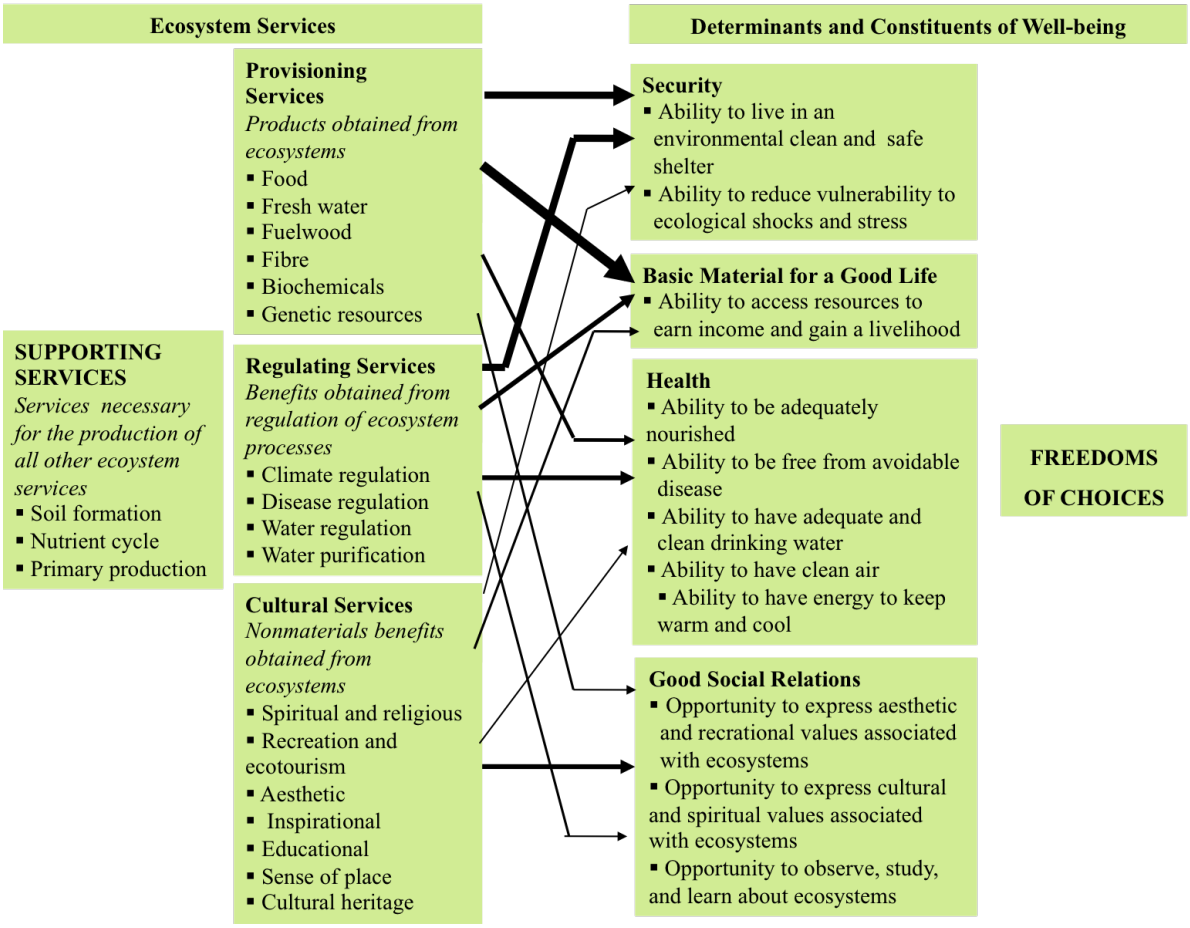


Figure 1-Introduction: Ecosystem services contribution to human well being
Adopted from (Millinnium Ecosystem Assessment, 2005)

MEA shows the narrow link between ES and human well-being clarifying how us, human, withdraw benefit from ecosystem as goods and services to ensure human well-being The concept is widely use to define the payment for protected area and forest in the third world countries where the ecosystems are still rich in biodiversity.

From 2005, ES concept gets media coverage and used worldwide for sustainable development and green growth link the contribution of natural capital into development framework. Since 2008, ES notion become central preoccupation in policy for development and conservation such as the creation of IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services). This concept become convincing by means of human well-being dependency to ES. The terminology of ES evolve from one to others authors but it still align with the definition of MEA screening the strong link between ecosystem and human well-being (Millinnium Ecosystem Assessment, 2005; Méral, 2012, 2013; Méral and Pesche, 2013; Rives and Méral, 2013).

Ecosystem Services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life — Daily (1997).

Ecosystem Services are the benefits human populations derive, directly or indirectly, from ecosystem functions — Costanza et al. (1997)

Ecosystem Services are the benefits people obtain from ecosystems — MEA (2005).

Ecosystem Services are components of nature, directly enjoyed, consumed, or used to yield human well-being — Boyd and Banzhaf (2007).

Ecosystem Services are the aspects of ecosystems utilised (actively or passively) to produce human well-being — Fisher et al. (2009).

Ecosystem Services are the direct and indirect contributions of ecosystems to human well-being — TEEB Foundations (2010).

Source: Rives and Méral (2013 p.1)

While, another concept also emerge in the conservation sphere is Environmental Services, which is about the externalities related to activities aim for the first place to reduce greenhouse gas emission and preserve watershed, biodiversity as well as landscape. This concept is also fundamental for conservation particularly, it question about compensation or payment the actors providing services by services beneficiaries (FAO, 2007; Rives and Méral, 2013).

Ecosystem Services and Agriculture

The concept Ecosystem Services initiated by MA is to apply in conservation related to forest ecosystem rather than in agriculture. This concept demonstrates the benefit that human withdraw from the primitive ecosystem in order to promote natural ecosystem conservation. However, in agriculture, the concept of Environmental services is more likely advantage for the reason that this concept looking at remunerates the ecosystem system manager to increase positive externalities and reduces negative externalities (Millinnium Ecosystem Assessment, 2005; FAO, 2007; Bonin and Eloy, 2013).

Preserve the primitive or wild ecosystem is important for human well-being but agricultural ecosystem safeguard is also critical. Under pressure of population growth, climate change, agricultural market demand, biodiversity and landscape will undergo. Respond to the pressure, agriculture adopts modern and intensive practices, which decrease biodiversity. This type of agriculture decreases landscape heterogeneity make distance

from traditional beliefs and rituals respecting ecosystem in exchange of protection from accident, natural catastrophes, illness and misfortune.

Being a largest user of land and fresh water, agriculture is accuse as polluter and degrading natural resources because of its negatives externalities but agriculture can be ES provider by enhancing the positive externalities (FAO, 2007). Biodiversity is important to increase productivity, food security and financial benefit. The traditional practices ensure ES such as application of manure improving soil physical and chemical properties such as improve porosity, water retention and gas exchange, bacteria's activity and number of macro-fauna (FAO, 2007).

Anyways, in third world countries the traditional agricultural practices are still there, which need to be identify and evaluate as technically sustainable for agro-ecosystem management. The traditional varieties (provide yield stability, are resistant to biotic and abiotic stress, have good resilience, and are adapted to low input agriculture) are replaced by hybrid high-yield varieties that require irrigation and high agrochemical inputs, which become dangerous for human health and ecosystem. (Jackson *et al.*, 2007; Liu *et al.*, 2013).

While, it still possible to reduce the trade-off between negative and positives externalities by identifying, finding and developing the alternative land use or techniques harmonizing agricultural development and Conservation (Huan *et al.*, 2005; Halwart, 2008; Izquierdoa and Graua, 2009; Illukpitiya and Yanagida, 2010). Organic agriculture is presented as an important ES provider (Sandhu, Harpinder S. *et al*, 2009). In Europe, Agri-Environment shows that organic farming system and management of semi-natural habitat can help to preserve and restore biodiversity (Antle and Stoorvogel, 2006). In China, organic agriculture has been also considered as solution for agro-biodiversity conservation of modern production, which relies on ecological process, biodiversity and biological process to adapt to local condition (Liu *et al.*, 2013).

The framework of environmental services by Wunder (2005); FAO (2007); Pagiola *et al.* (2007) are likely adapted to forest agro-ecosystem where changes in ecosystem management are likely remarkable in short period of time. Since a lot more services provided by agriculture are still mystery. Meanwhile, the concept Ecosystem Services is broader and services provided by agriculture could be defined as subset of it.

The provisioning services provided by farmers in term of "rice ensuring the main staple" are valuated by market price. The others ES generated during the processes of producing rice are not valuated yet despite their use. ES provided from rice production system on the flood pulse agro-ecosystems benefit both farmers themselves and Cambodian population in general. Those Ecosystem Services come along with rice such as food quality such as: tastes related to varieties; and certain cultivation techniques; and sanitary quality as well as cultural identity, which concern consumers intrinsic (Bonin and Eloy, 2013).

By combining with the one from Millennium Ecosystem assessment, by following the definition of ES given by Fisher *et al.* (2009) and re-analyzed in Fisher *et al.* (2011), those ES provided from rice production systems are actively and passively used by human to ensure their well-being. They use them without paying any cent to ES providers for ensuring the structure and the process of ES provision. The process of defining the human beneficiaries is essential to valuate those services and define the potentially as well as their potential WTP as mentioned in Fisher *et al.* (2009) "*without beneficiaries they are not services*".

Ecosystem services and Dis-services approach

This Ecosystem Services (ES) and Ecosystem Dis-services (EDS) (see Figure 2-Introduction) studied by Zhang *et al.* (2007) demonstrates entirely link between agro-ecosystem and agriculture. This concept of Services and Dis-Services between agro-ecosystem and agriculture, or precisely agro-ecosystem managers, allow finding out the economic and policy instruments to increase the positive externality of altercation between them. This framework permits to promote conservatives agricultural practices (Bonin and Eloy, 2013).

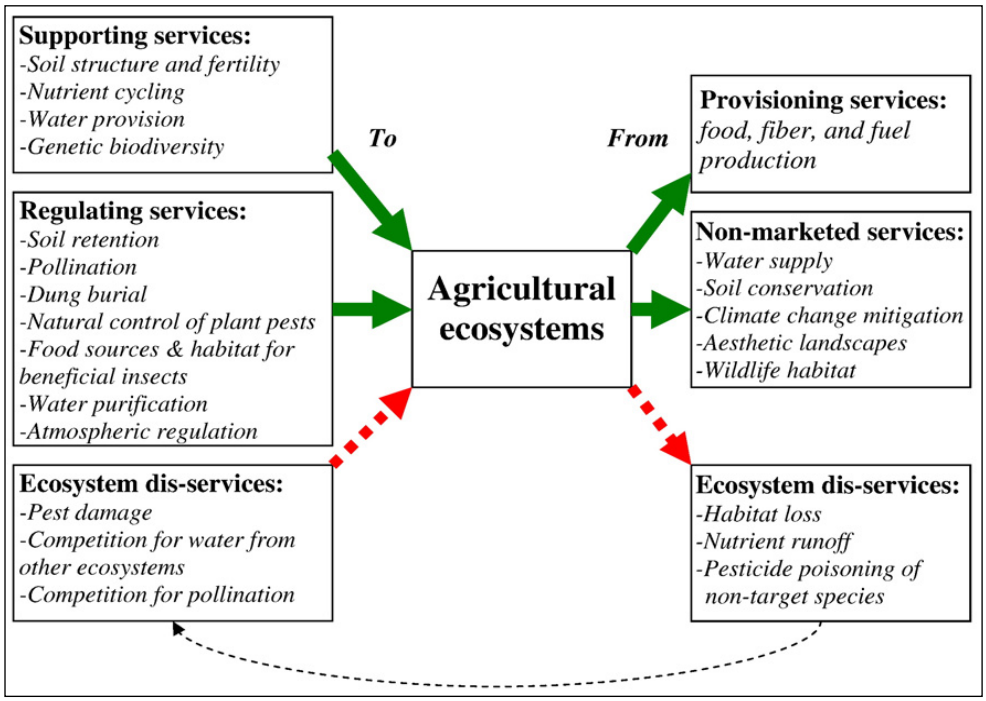


Figure 2-Introduction: Ecosystem Services and Ecosystem Dis-Services to and from Agriculture
Sources: Zhang et al. (2007 p.254)

Agrarian System Analysis and Diagnosis approach

The agrarian system diagnosis and analysis or shortly called Agrarian System provides an understanding of "Mode d'exploitation du Milieu" in French term, which means about the farmers' way of land use.

This method proposes (See Figure 3-Introduction, p.17) firstly **Landscape reading.** This is a stage of understanding the agro-ecosystem and zoning. Started by observation of the agro-ecosystem and vegetation, the question "why" guide us to meet the elder and local people for better understanding of land use change in study zone. The second step is **Historical study** because the current agricultural situation is the fruit of a long or medium term evolution. This study is trying to identify the key factors of change, which create the actual agricultural practices. Lastly, **Production system modeling and performance economic calculation,** this stage leads straight to economics field. The comparison of performance economic (Value-Added (VA) and Agricultural Revenue per family labor) of production system will clarify and explain why in the same region farmers practices different production system (Cochet *et al.*, 2007).

The whole study is trying to explain, "Why individual farmers adopt specific rice production systems?

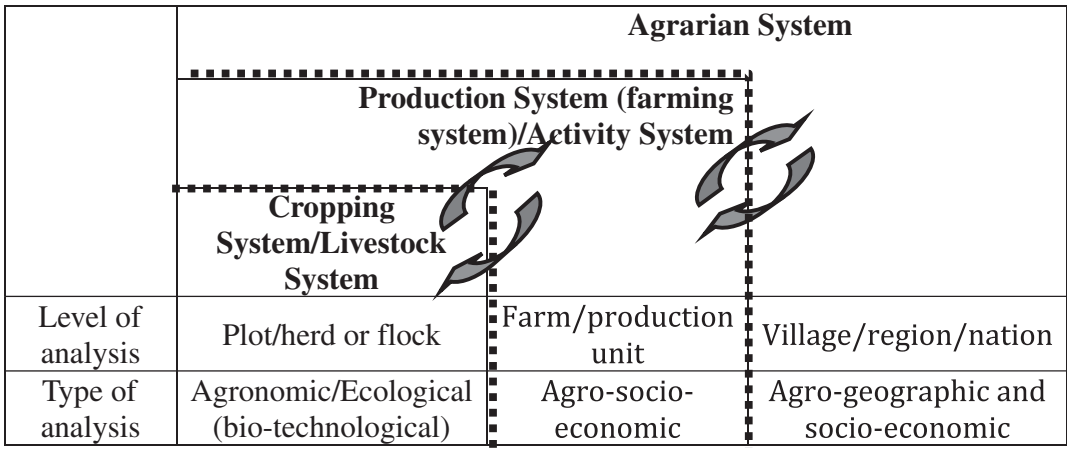


Figure 3-Introduction: Nested scales of analysis
Adopted from (Cochet, 2012), p. 133

Methodology

Thesis framework

The methodology that we adopt permit a well understanding the Tonle Sap Lake flood plain agro-ecosystem, its function and its ES as well as EDS flow into agriculture. Then a well understanding of agricultural techniques permits to identify ES and EDS from agriculture that affects this agro-ecosystem and human society. The methodology of Agrarian System Analysis and Diagnosis combining with the ES and EDS framework allow to study in details the linkage between Agro-ecosystem - Agricultural practices - ES/EDS. And then, it we will be able to calculate the opportunity cost for farmers to assure ES provision (see Figure 4-Introduction).

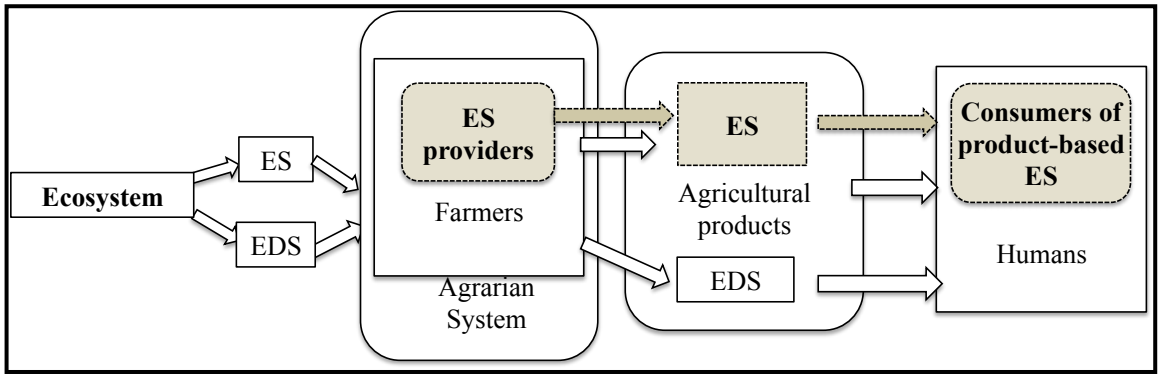


Figure 4-Introduction: Dissertation research framework

A well-defined agricultural product-based ES started from well understanding a complex practice of agro-ecosystem use, which leads to a well understanding of ecosystem characteristic. Thus we can better manage, maintain, restore or evaluate ES. But a well-defined ecology-society linkage is crucial stage to bring to the beneficiaries an understanding about the flow of ES into their well-being that they can express their appropriated WTP (Fisher *et al.*, 2009; Fisher *et al.*, 2011).

National survey in 2010 "feasibility study" for Emergence of ES notion and PES implementation in Cambodia

This stage serves as the feasibility study of this dissertation in order to understand the role of the evolutionary process and the role of institutions and Institutional arrangement of PES scheme in Cambodia. We did the national survey of 34 semi-direct interviews with development NGOs, conservation NGOs, Government and Donors (see guidelines in annex B.1). Then we completed with the literature review of related local reports. From this national survey, we found that in Cambodia there is no ES and PES concept implemented in agricultural sector despite Cambodian is agricultural-based country and the most important agro-ecosystem is the Tonle Sap Biosphere.

From this result, emerge the idea of developing the appropriated research methodology that allows identifying ES provided from Cambodian agriculture. Those 3 stages are following:

Apply agrarian system approach in combination with ES and EDS framework

The ES provision in that study area are related to Agro-system and farmers decision to adapt to that agro-ecosystem by setting up different rice cropping system, which provide different ES. In order to analysis these different flows of (dis) services, we adopt field methodology from Agrarian System Analysis and Diagnosis (Cochet and Devienne, 2006a; Dufumier, 2006; Cochet *et al.*, 2007; Cochet, 2012) combining with framework of Ecosystem Services and Ecosystem Dis-Services proposed by Zhang *et al.* (2007).

In Figure 5-Introduction shows analytical steps in applying agrarian system research methodology. Starting with landscape reading and qualitative interview with elders allow a better understanding of land use change in study zone that help to identify ES and EDS provided by agro-ecosystem. In order to identify ES and EDS provided by rice production system, we start by identifying rice cropping system in order to construct comprehensive

productions system modeling. Following by studying in detail farmers' practices and techniques permit to identify ES and EDS related those rice production model.

At the end, we calculate performance economic of production model. This stage leads us straight into economics field. The comparison of performance economic (Value-Added "VA" and Agricultural Revenue per active) to define the **Opportunity cost of maintaining rice production system model providing ES by giving up rice cropping system providing, which provide EDS.**

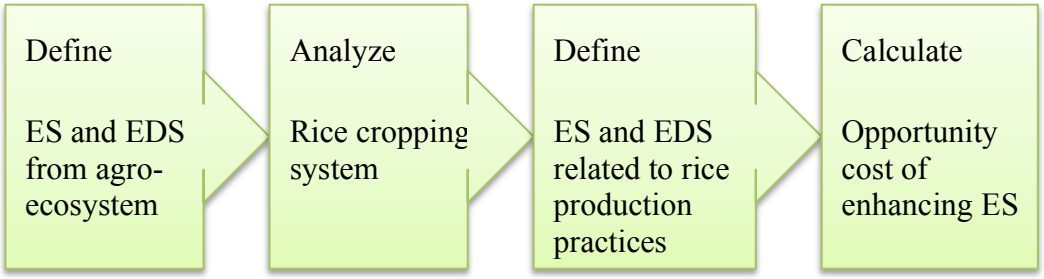
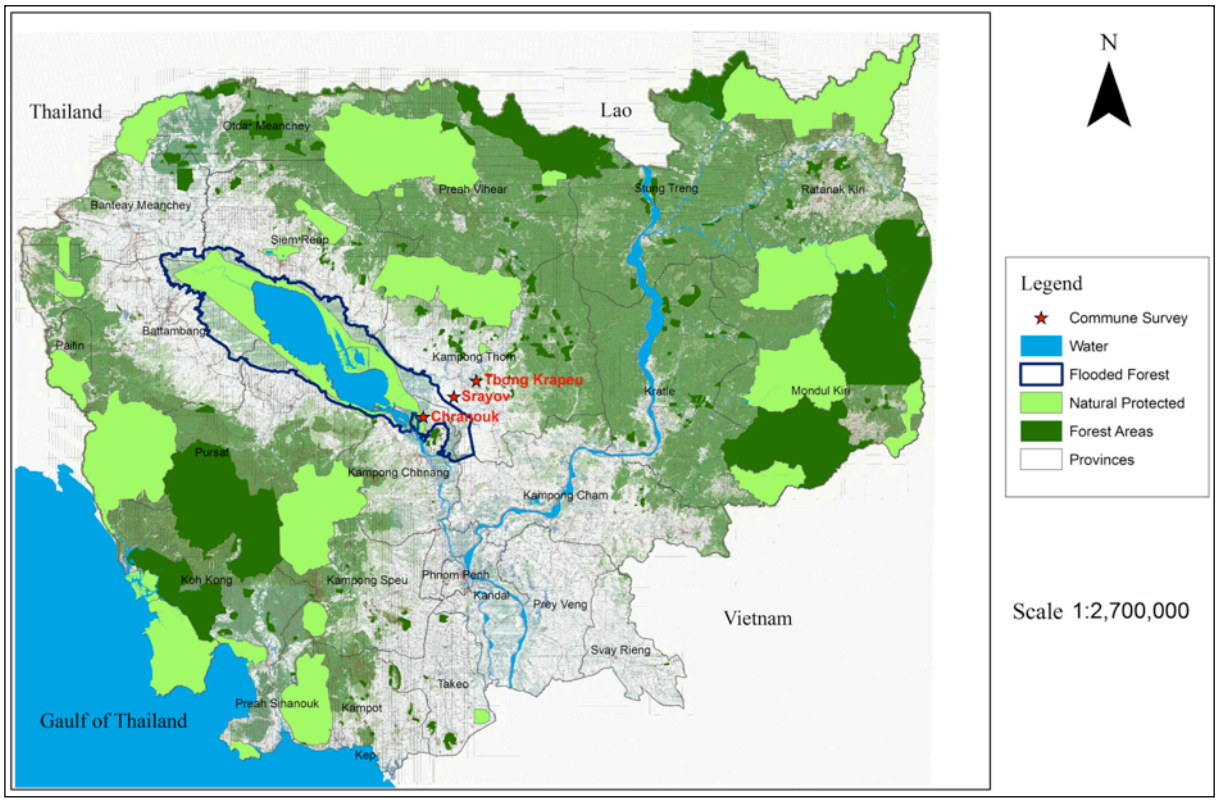


Figure 5-Introduction: ES and ED's identification approach

Our study zone situates in Kompong thom province, one of the 5 provinces surrounded the TSL flood plain. Two districts, Steung Sen (Srayov commune: Sroyov Tbong, Roka and Rolous village) and Santuk (Thbong Krapeu commune: Phanhagy, Ompus and Porkhav villages). Farmers leaving in those districts own the rice field until the lake in the flooded forest zone (see location in Map 1-Introduction). On this flood plain, rice field ecosystems are not just for rice production but also for food security and medicinal species (Halwart, 2006, 2008). That flood plain is major inland fishing area for the local people and rice-based aquatic specie that serve for protein sources of the local people who has limited access to market food because of the distance and/or too poor to buy food.

Rice field agro-ecosystem is also source of green manure as well as compost composition for organic and other traditional rainfed seasonal rice cropping system. Cambodia rice field supply such as frog, snake, eels, rats/mice as well as insect to the neighborhood counties such Thailand and Vietnam with their strong believe that Cambodian farmers use less chemical inputs than their farmers.



Map 1-Introduction: Cambodian Natural resources and flooded forest border

This thesis made by 2 times of field works of agrarian system analysis and diagnosis in order to achieve our objective of identifying production systems modeling and then looking provide ES or EDS related to those production model. And finally, calculate the opportunity cost. This research framework propose following field research:

- ***2010 Feasibility study for ES and rice cropping system.***

We conducted the fieldwork within 2 dimensions:

- Organic Farmers Association: 43 farmers in Producer group supported by CEDA and 35 farmers in RSSA supported by COrAA.
- First agrarian system analysis: 57 farmers in 5 villages of Srayov commune in Steung Sen district.

The result from those 2 studies, focusing only about the organic rice production and its ES demonstrate the complexity of the study area could not be explained by "Organic rice» cropping system alone. A complete regional agrarian system analysis is needed.

- ***2012 Agrarian System Diagnosis focus on the agro-ecosystem of Tonle Sap flood plain and Ecosystem Services***

We interviewed 208 (36 qualitative interview and 172 in deep interview) farmers living in 2 districts, two districts, Steung Sen (Srayov Tbong, Roka and Rolous village) and Santuk (Phanhagy, Ompus and Porkhav villages). We choose randomly our samples in different village along the floodplain of TSL and make sure that we get the heterogeneity of the farming system, which use a complex agro-ecosystem of TSL floodplain (flooded grassland, flooded shrub land and clear flooded forest). The detailed guidelines and questionnaires are in annex B.2, B.3, B4 and B.5 from page 153 to 174.

Consumers' survey

This study look forward to define consumer's preference related to another utility, the one is not direct, but it creates the value-added to the products and services. That one is ecosystem services dimension while consuming one products increase the environmental preservation and social benefits which become the perception of rich and developed countries (Point, 1998; Coestier and Marette, 2004; Kempen *et al.*, 2009). In the same argument, food consumption choices are a whole combination of attributes, which will fulfill consumers' satisfaction. Food itself has nutritional characteristic but it comes along with others characteristic such as price, taste related to biological aspect (variety) or territory (local product identity), good for health, good for environment, good for society (increase farmers revenue and preserve local culture). All these attributes combine together enable to categorize "organic and non-organic consumer" as well as "environmental and non-environmental consumers; distinguish distribution system of different goods (organic, non-organic, quality goods and low price goods) in the situation of competitiveness to target the consumers(Cropper and Oates, 1992; Portney, 1994; Point, 1998; Rambonilaza, 2010; Lusk *et al.*, 2013).

The perception of consumers on environment and ecosystem conservation become a new concept of consumers behaviors of environmental goods aim in compensating the ecosystem services incorporated in consumed foods. The environmental aspect of foods products is interpreted in the eco, organic as well as fair trade label. Some labels are more specific in endangers species conservation (Jason *et al.*, 1999; Dachary-Bernard, 2004; Gómez Tovar *et al.*, 2005; Gibbon and Bolwig, 2007; Clements *et al.*, 2010).

Thus, the notion of **provisioning services, regulating services and cultural services** are

included in the study in order to test the environmental motivation of Cambodian consumers. This part associates ecosystem services in food demand because the consumer behavior help to determine their product-based ES preferences and demand which can inform production chain strategy to meet economic and environmental efficiency.

During May and June 2012, we did the survey 10 markets and super markets in Phnom Penh are chosen to be our survey places to have a representative sample: poor, medium and rich as well as different nationalities (total 300 samples). The detailed guidelines and questionnaires are in annex C on page 183.

Structure of the thesis

This PhD dissertation compiles 4 papers as structured in Figure 6-Introduction. Firstly, in Paper 1 is about trials in defining the emergence of the ES notion and PES implementation in Cambodia. This Stage, was a feasibility study of my PhD dissertation in order to define the one PhD project that made the most beneficial result for Cambodia. As ES and PES are used as pilot projects in forestry ecosystem and nonexistent in agro-ecosystem despite Cambodia is an agricultural country, I chosen to develop my PhD study related to agricultural sector and initiates a framework in order to assess ES related to agriculture.

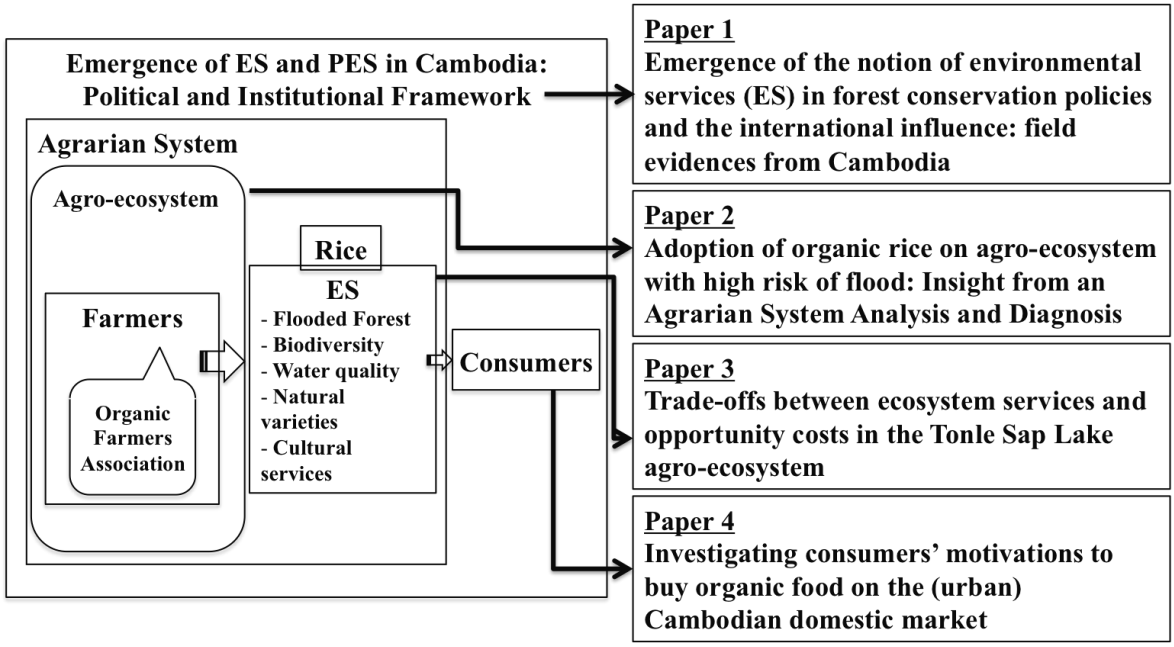


Figure 6-Introduction: Structure of the thesis

Secondly, the Paper 2 treats the question of agrarian system, which helps to better-understand farmer's land use management in order to produce rice on agro-ecosystem of flood pulse with high risk of flood. This paper allows identifying the different rice production system that adapt to that rich agro-ecosystem.

Thirdly, this thesis proposes an initiative approach to identify ES and EDS related to rice production system. The Paper 3 bring theory of ES and EDS framework to incorporate in the agrarian system analysis and diagnosis methodology in order to identify ES provided by rice production system on agro-ecosystem of Tonle Sap flood plain in Cambodia, which is a rich agro-ecosystem and biosphere reserve of South-East Asia. This proposed approach unite agricultural economics with environmental economics as a new approach lead to an ample methodology to provide the outputs for agricultural policy maker in third world countries agricultural-based economic, particularly rice, to develop the appropriated strategic plan and policy toward sustainable agriculture and green growth. This paper puts also accent on opportunity cost for farmers to maintain ES provided by their rice production systems, which can be use as basic information for policy makers to compensate rice production system the most efficiency.

Lastly, the thesis ends up with investigation of domestic market in Cambodia, more specifically in Phnom Penh where there are the most net consumers. This paper gives a basic understanding of local market for the possibility to compensate ES from agriculture in consumer’s point of on rice-based ES.

Paper 1

1. Emergence of the notion of environmental services (ES) in forest conservation policies and the international influence: field evidences from Cambodia

This Paper is based on a first version published in VertigO: Chervier C., Neang M., Déprés C. (2012). Emergence de la notion de service environnemental et des dispositifs de rémunération des fournisseurs. Le cas du Cambodge. Vertigo (http://vertigo.revues.org/). Volume 12, n.3.
(English version)

ABSTRACT

The definition of environmental policies in developing countries is affected by globalization of such issues and the change in governments' interventions. Based on regulatory approaches for ages, environmental policy tends nowadays to promote more incentive tools called market-bases instruments.

This article aims at illustrating the trend in Cambodia from data field surveys conducted in 2010 with a sample of local stakeholders: policy makers, NGO officers and donors. The objective is to understand the emergence of the pair of notions eco-system services (ES) and payment for environmental services (PES) in conservation policies implemented in the country (areas of biodiversity and carbon sequestration mainly) and international influence in this process.

The paper shows that the initial conservation strategies based on regulatory approaches with the establishment of protected areas, have had mixed success in particular to reduce deforestation. Over the recent years, the concept of SE has been quickly circulated within government offices (Forestry Administration, Ministry of Environment). Number of conservation projects conducted by international NGOs (such as CI, WCS) has also sought to recognize the value of protected ecosystems. In this objective, they have experienced payment devices to rural/forest communities sitting on environmentally friendly practices related to the conservation of fragile habitats. Cambodian legal framework has not yet recognized, so far, the concept of PES (based on the beneficiary pays principle) and significant obstacles remain in the development of such mechanisms on a large scale.

1.1. Introduction

The emergence of environmental policies in developing countries is increasingly drawing scholars' interest. Although it is sometimes treated as an independent variable, understanding the process of emergence and integration of new policies in a given institutional context is often justified by its close relation with the success or failure of environmental institutions and policies outcomes and thus used as an explanatory variable (Dolowitz and Marsh, 2000; Steinberg, 2003).

The importance of understanding why and how environmental policy and interventions emerge is particularly highlighted in the context of the wide recognition of global benefits of ecosystems and the subsequent awareness on the emergency to take action on global environment issues, biodiversity conservation and climate change in particular(Millinnium Ecosystem Assessment, 2005; Stern, 2006). Indeed, the fast pace of depletion of natural resources and its increasingly measurable consequences makes the identification of conditions, institutional arrangements and policy response conducive to sustainable management of ecosystems urgent. Developing countries are of particular importance in this regard as they are home to large but threatened natural areas contributing significantly to climate change mitigation and hosting most of the world's biological diversity.

Conservation interventions and policies tend to move away from regulatory approaches and towards approaches that focus on positive incentive (Tom *et al.*, 2009) and thus recognize the many functions of ecosystems and the importance of local people in the management of these ecosystems. In other words, the notion of environmental services, defined as a subset of ecosystem services - the benefits people obtain from ecosystems - characterized by externalities (FAO, 2007) tends to underlie these approaches. The main impact of this trend is the increasing development of Payment for Environmental Services mechanisms that has become popular as a tool for forest conservation in the developing world (Corbera *et al.*, 2009). Muradian *et al.* (2009) define PES, as an alternative to Wunder's definition (Wunder, 2005), as the transfer of resources between social actors, which aims to create incentives to align individual or collective land use decisions with the social interest in the management of natural resources. Despite the number of studies focusing on the economic aspects of PES and the valuation of ES has increased in the last

decade (Jeanneaux and De Mareschal, 2010) research on the process of emergence of PES in developing countries has only recently started. It shows for example the increasing influence of international NGOs and international institutions in diffusing that concept from the ground to public policies (Monnery, 2010) and gives clues to identify the consequences of the diffusion of these notions, including the intended ones.

The change in national policies and institutions is not only marked by the environmental globalization but also by the integration of developing countries in the global economy, by the access to new information technologies and by the increasing links with the development assistance. Consequently, many scholars show that the foreign influence in the emergence of environmental policies is significant and even a requirement for change. Besides, it appears that this influence is performed through diverse combinations of international relations and agents. International diplomacy and non-governmental advocacy affects the process of policy change not only through conditions on development aid but through complex system of spheres of influence, power relations and micro-mechanisms mobilizing various resources (Monnery, 2010).

This paper analyzes the emergence of approaches using the notions of environmental services (ES) and payments for these ES in policies and interventions for forest conservation in Cambodia and the influence international relations have in this process. Cambodia is taken as a case-study for several reasons. After a long period of civil war that came to an end in 1997, Cambodia has rapidly embraced the globalized world, joining the ASEAN in 1999 and the World Trade Organization in 2004, ratifying the Convention on Biological Diversity in 1995 and the Kyoto protocol in 1999. The exposure of the country to foreign influence is made even more significant as the country has received an increasing amount of foreign aid and assistance, over 100 million USD in Agriculture and Environment sectors, from an increasing number of countries and institutions since that time (CDC, 2010). Moreover, the extent of its forest cover and biodiversity makes Cambodian forest of global conservation importance (Strange *et al.*, 2007; Clements *et al.*, 2009). Initial conservation strategies in Cambodia focused on protected area management and were relying on command-and-control instruments as in the Law on Environmental Protection and Natural Resource Management.

On the other hand, the use of market-based mechanisms such as Payment for

Environmental Services has been limited both in public policies and in practice although they are increasingly considered as a complementary instrument for conservation.

1.2. Theoretical Framework and Empirical methodology

The International Political Economy (IPE) focuses on the effects of economic interactions and power relations on political structures and outcomes, and vice-versa. It further contributes to take into account the historical dimension of phenomena and the analysis of power relations. Chavagneux (2010) describes three main approaches in the IPE, each of them considering a different type of agent, in turn States for Joseph Nye, hegemonic elites for Robert Cox and non-state agents (for Susan Strange as the most influential in power relations. Strange's approach is of particular relevance in the Cambodian context given the variety of stakeholders, besides government institutions, potentially involved in the phenomenon of emergence of the notion of ES. Indeed, Strange focuses on the diffusion of political power in an increasingly globalized world and her main contribution is to switch from a state-centered approach to the idea that states have ceded more and more power to alternating ruling structures, especially to that of the private firms but also non-governmental organizations (Strange, 1996). Further approaches support the paper. The approach by the spheres of influence described by Steinberg (2003) provides a framework to analyze what stakeholder affects the environmental policy and why Kingdon's model of windows of opportunity (Kingdon, 1984) offers a comprehensive way to analyze and explain the complexity of emergence the notion of SE in policies and interventions. The paper is also supported with other considerations from the Policy Transfer Studies, an approach offering a broad analysis framework to understand policy convergence phenomena including the description of the agents involved in policy transfer, the nature of the transfer and the reasons why it occurs (Dolowitz and Marsh, 2000; Delpeuch, 2008).

About 34 semi-structured interviews were carried out with a wide variety of national and international institutions including donors, private companies, administrations, NGOs and academic institutions working on natural resource conservation and rural development in Cambodia (see details in Table 1-1). Interviews were focusing on the description of the institution's level of knowledge on ES and its approach to that notion, the origin of that viewpoint and the way this notion is used in the institution's activities (See detail guideline in Annex B1).

Interviewed Institutions	Number of interviews
Bilateral Donors (AFD, DANIDA, JICA, USAID, SIDA)	5
Multilateral Donors (UNESCAP, FAO, IFAD, EU, UNDP)	5
Private Enterprises (Deveco, Green Ventures, ONFI)	3
Governmental Administration (FA, MoE)	2
Conservation NGOs (EWMI, CI, FFI, WCS, WWF)	5
Development NGOs (AVSF, CEDAC, COrAA, GERES, GRET, LWF, NGO Forum, PACT)	8
Research Bodies (ACIAR, CDRI, CIRAD, RUPP, RUA, World Fish Center)	6
Total	34

Table 1-1: List of interviewed stakeholders

Complementary information was collected from scientific articles, grey literature and government strategies and legislation. The data in this article on the actual conservation projects are reviewed form CDC and accessible on their website http://www.cdc-crdb.gov.kh/.

The paper is organized as follows. First, the results are described in three stages. The paper draws a picture of the extent to which the notion of ES is integrated in practice in environmental policies and interventions. Then, it identifies what stakeholders are involved in the environment sector and affects environmental policies and to what extend do they know, diffuse and use the notions of ES / PES. At last, it analyzes whether there is an opportunity window for the emergence of the notion of ES in Cambodia and what the nature of the emergence is. Finally, the last section summarizes the paper, gives concluding remarks and suggests policy recommendation for better use of ES and PES in the field of conservation in Cambodia.

1.3. Results

1.3.1. Institutional framework and integration of the notion of ES in environmental policies and interventions

The Forestry Administration (FA) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) has the responsibility for managing the forest resources of Cambodia, although there is an overlap with the Ministry of Environment (MoE) for forests in protected area

and related reserves (Strange *et al.*, 2007) and with the Fishery Administration of MAFF for flooded forests. The responsibilities of government authorities and the general directions for the management of forest resources in Cambodia are mainly described in two Laws, namely the Forest Law (2002) and the Law on Environmental Protection and Natural Resource Management (1996) and in their subsequent regulations. The initial strategy for the management and conservation of forest resources is based on command-and-control approaches that mainly focus on protected area management. Totally covering more than 18 percent of the country, 23 protected areas were created through a Royal Decree in 1993 and managed by MoE whereas a growing number of fish sanctuaries and protected forest areas are set up through MAFF (PAD Partnership, 2003). The use and extraction of forest products and game resources are strictly regulated, especially in protected areas, through the delivery of permits and the definition of guidelines for management, prohibited activities and subsequent sanctions. The legal framework acknowledges only to a limited extent ecosystem or environmental services provided respectively by forests and forest users. For example, the role of forests in the protection of soil and water is addressed in the Forest Law and other regulations. Moreover, the use of positive incentives as a policy instrument for conservation is almost absent from the legal framework. However, the Forest Law and later on the sub-decree on community forestry management give local communities a legal recognition of their traditional user rights and the community forestry status a land title for fifteen years and the right to use a forest patch in the production forests if and only if they manage that area in a sustainable way.

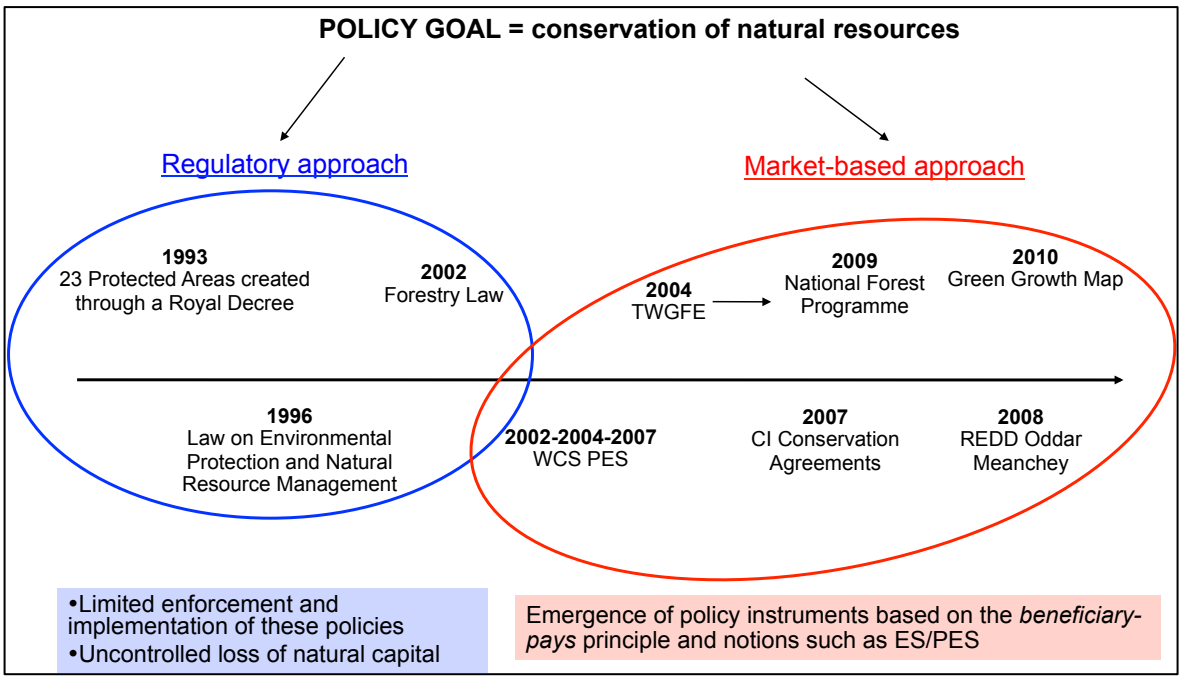


Figure 1.1: Evolution of conservation policy in Cambodia

In the recent years, the notion of ES has been increasingly used both in public policies and in operational projects for forest conservation. The notion of ecosystem services has first been explicitly used from the early 2000's in a number of ecosystem valuation studies focusing on forests and coastal areas in particular. These studies do not only consider the direct use value of ecosystems but also the indirect and non-use use values associated with carbon storage, watershed protection, biodiversity, water quality, tourism and so on. Cambodian research institutes or departments of government ministries such as the Royal University of Phnom Penh (RUPP), the Cambodian Development Research Institute (CDRI), MAFF and MoE carried out these studies with the technical and financial support of international conservation programs such as the UNEP/GEF Project Entitled « Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand », CIFOR's program entitled « Poverty Environment Network », DANIDA's project entitled "natural resources and environment program" or EEPSEA. These overarching programs generally aimed at contributing to improve the management of natural resources in a sustainable and pro-poor manner. In turn, the economic valuation studies support the definition of improved policies by demonstrating the high reliance of local populations on natural resources for their livelihood, the economic importance of indirect use values of ecosystems and thus the benefits of sustainable management of natural resources (Bann,

2003ba; Bann, 2003a; UNEP, 2007)

From 2002 and more intensely from 2007, the notion of environmental services has been used in practice through the implementation of projects aimed at reaching conservation goals and using economic incentives to induce local land-use change. These projects explicitly focus on increasing or maintaining the provision of environmental services including in particular conservation of biodiversity and flagship species, climate change mitigation and forests carbon storage capacity or landscape beauty for ecotourism. However, it is worth noting that PES projects often use some ES such as landscape beauty in ecotourism projects or carbon storage in REDD schemes as proxies to reach results in terms biodiversity conservation. PES mechanisms focusing on biodiversity conservation were pioneers in Cambodia and include for example community-based ecotourism and agri-environmental payments projects implemented by WCS, conservation incentive agreements implemented by CI or an ecotourism project implemented by WildAid in the Cardamoms. More recently, lots of institutions are considering the Reduction of carbon Emissions from Deforestation and forest Degradation (REDD) mechanisms. The project implemented by PACT in Oddar Meanchey was the first one to be implemented and PES is used as a mechanism for the distribution of benefits from the sale of carbon credits on the voluntary market. In these schemes, change, and jointly the provision of ES, is induced by providing communities or individuals with payment, either in-cash or in-kind, transferred if and only if they comply with commonly-agreed conditions stipulated in contracts especially land-use plans, non-hunting and non-logging rules. Monitoring, evaluation and sanctions are the third levy that would eventually ensure the provision of ES. Local populations are considered as service providers and, depending on the mechanism, buyers are either tourists, urban consumers, the NGO itself or, when dealing with carbon finance, firms buying carbon credits on the voluntary market. International conservation NGOs initiate and implement these schemes and play the role of intermediaries in the transaction of ES, making the link between the demand and the supply. It is worth noting that although these schemes are still at the pilot stage, the limited number of experiences implemented so far systematically involves government agencies, the Forestry Administration and the Ministry of Environment in particular. Indeed, they eventually aimed at being replicated at a larger scale and at contributing to the definition of national strategies for forest sustainable management.

From 2009, the concept of ES has emerged in subsidiary public policies and government strategies, but not yet in overarching Laws. ES are systematically associated with the notion of payment and PES schemes are mentioned as such in these documents. It is the case for the Green Growth Roadmap, initiated by UNESCAP and defined with several Government ministries and agencies, for the National Forest Program defined by the Technical Working Group Forest and Environment gathering the Forestry Administration, the Ministry of Environment and all donors working in Cambodia, and for the Cambodia REDD+ roadmap designed by an inter-ministry taskforce supported by some donors. PES and REDD are mainly seen as an alternative and innovative funding sources for the implementation of policies for sustainable management of forests. That is associated with the explicit recognition by the government of the various ecosystem services provided by forests and the potential of these services to be marketed. The Green Growth Map Kingdom of Cambodia (2009) also sees PES mechanisms as a specific investment mechanism that can allow multiple stakeholders with economic objectives to invest in the sustainable management of environmental systems. In the REDD+ roadmap, PES mechanisms are considered for the implementation of REDD+ as mechanisms contributing to forest protection, and for benefit-sharing of REDD money as mechanisms draining benefits down to local communities in particular for results at achieving REDD+.

Within the framework of the two main Laws regulating the management of forest resources in Cambodia and based on command-and-control approaches, the use of approaches based on ES and positive incentives is still limited in scope but progressively emerging in ecosystem valuations, PES pilots and eventually in public policies and strategies. Besides, looking at the way ES and PES are used in practice shows the diversity of institutions currently involved in the conservation sector in Cambodia and suggests the important contribution of international NGOs in the emergence of the notion ES associated with carbon storage and biodiversity conservation in particular.

1.3.2. Perception, position, resources and the influence of various institutions on the emergence and diffusion of the notion of ES

Conservation NGOs (WCS, CI and WWF) and some international donors including bilateral donors having environment in their mandate (USAID, AFD in particular), UN agencies (UNDP, UNESCAP) and philanthropic foundations (MacArthur foundation) are

the most influential stakeholders in the effective introduction and diffusion of the notion of ES in Cambodia. Their perceptions and positions regarding environmental issues and the subsequent solutions integrate the notion of environmental services and positive incentives for conservation. The notion of ecosystem services, rather than environmental services, is known, conceptualized and often underlies their global or regional strategies for conservation and subsequently their local interventions. For example, CI headquarters stress the importance of economic incentives to make conservation attractive to resource owners and developed the conservation incentive agreements, which are also implemented in Cambodia, as a key mechanism to address this need. The use of these concepts is originally motivated by perspectives of results in terms of biodiversity conservation but also, in many cases and especially for agencies with broader mandates, by co-benefits in terms of local development and climate change mitigation. This is associated with the recognition of the multiple and interlinked services of a given ecosystem and, in practice, with the focus on the provision of ES used as proxies to protect habitats and thus reach goals in terms of biodiversity conservation. In this regard, these institutions argue that maintaining ES is important to sustain both human well-being and economic growth. Besides, they explain that the growing pressure on ecosystems is due to the fact that ES are not priced and thus not taken into account in economic decisions. Economic incentives are thus justified as a tool to achieve both conservation objectives by making conservation economically viable and economic goals. These economic arguments are particularly used to raise public decision-makers' interest for conservation.

These proactive institutions hold and deploy relatively important financial, political and scientific resources that positively affect their capacity to influence on environmental policies and interventions. The financial contribution of international donors in the field of conservation is significant compared to the limited budget of the MoE and the FA. In practice, donors are funding operational projects jointly implemented by NGOs and government agencies that contribute both to the enforcement of Laws and to the introduction of innovative interventions for conservation such as PES schemes. Similarly, donors financially support the process of definition of some government strategies, covering costs related to consultation processes and technical assistance in particular. That process is carried out in arenas such as technical working groups or taskforces gathering key development partner, donors and government agencies and generally leads to the

development of innovative policies that in some cases integrate the notion of ES. The most important political resource dispatched by both international NGOs and donors are extended networks and personal connections with individuals in position of influence, mainly high-ranking officials but also key-representatives of other NGOs and donors. These connections are multiple and occur in different venues gathering various representatives of NGOs, donors and government agencies and facilitate the diffusion of information and ideas, including the concept of ES. It comprises in particular the interactions occurring in the definition and the implementation of multi-stakeholders projects such as PES pilots that systematically involve government agencies, one international NGO and often one local NGO. Networking and diffusion of political alternatives for conservation also occur in the various workshops focusing on environmental issues and natural resource management as well as in the working groups where public strategies are being discussed and defined, including those integrating the notion of ES. These connections are rather material-based and thus linked to the financial resources. For instance, the development of network and personal contacts of donors is facilitated by their capacity to deploy financial resources.

Similarly, political resources of international conservation NGOs are enhanced because of the important role they play in the financial intermediation with donors, due to their expertise of local environmental issues and context and their capacity to design sound project proposals and discuss them with donors. Finally, it is worth noting that these conservation stakeholders and donors are also producing a relatively important amount of grey and scientific literature on the local context of natural resources and on their own experience that helps practitioners and policy-makers to manage uncertainties on the value of ES, the state of biodiversity, the impact of policy interventions on natural resources, the link between poverty and conservation, the real management and further issues related to natural resources. The main Government agencies involved in the emergence of the notion of ES have been identified in the previous section as the Forestry Administration and the Ministry of Environment. The concept of ES is not yet conceptualized at the institutional scale and do not underlie these institutions' approaches to conservation although definitions might be known at the individual level. However, PES and REDD mechanisms are considered in their operational form as concrete alternative source of funding for conservation as reflected in the recent strategic plans like the National Forest Program and

by the support of the government to the implementation of PES and REDD pilots. That might be explained by the limited financial resources available in public agencies for sustainable management of natural resources and their strong reliance on external source of funding. Public agencies are rather opportunistic in embracing these new funding sources opportunities and one might thus consider them as followers of these concepts introduced by foreign development partners.

However, despite the limited financial resource they have, these administrations hold significant political resources that give them a central role in the emergence of the notion of ES in Cambodia. A limited number of government officials of these administrations have an advanced knowledge and understanding of these concepts because they often play the role of intermediaries between development partners and government institutions. They are for instance systematically involved in the definition of projects initiated by development partners and that include the concept of ES, they are invited to contribute as keynote speakers or participants in workshops on environmental issues and they are the central stakeholders in the processes of definition of new strategies integrating the notion of ES. Besides their intrinsic academic capacities, the political power of these individuals relies in their extended network within the administrations and connections with the highest spheres combined with a high degree of expertise in functioning of the Cambodian administration. Furthermore, one important source of power of government agencies lies in the fact that they are the official representatives of the sovereign state that, as a matter of fact and according to Paris declaration on the alignment of aid, is to be reckoned with for any aid agency working in Cambodia and is thus inescapable partner for the implementation of any development and conservation project. The Ministry of Economy and Finance, the Supreme National Economic Council and, to some extent, the Council of Ministers have been quoted as having a potential greater and more direct political influence than technical ministries such as MoE and MAFF especially when moving to the definition of more overarching legal framework. Interactions between these institutions and foreign development agencies on environmental issues and subsequently the introduction to the notions of ES and PES are recent. Like technical Ministries, these concepts are so far known and conceptualized on an individual basis and PES is considered as an alternative source of funding for the enforcement of public policies but also a mechanism that would make conservation economically attractive in comparison with other land use.

Recently, various Cambodian public Universities and research institutes such as RUA, RUPP and CDRI have been carrying out research projects focusing on the valuation of ecosystem services, on the institutional and economic analysis of the first PES experiences and on the emergence of these notions in public policies. It is worth noting that this paper is the result of one of these research projects jointly developed by the Royal University of Agriculture and an international research program named SERENA (Environmental Services and Uses of Rural Areas) that focuses on the emergence of the notion of ES in various countries. The perception and knowledge of the concepts of ES and PES are generally based on mainstream definitions underlying the specialized scientific literature i.e. the Millinnium Ecosystem Assessment (2005) and Wunder (2005) and are introduced by the foreign scientific partners that generally initiate these research projects. The use of these notions is motivated by the development of specific knowledge on the local case of ES and PES concepts in order to support the development of appropriate policies and interventions for the sustainable management of natural resources. These public agencies thus contribute in increasing the scientific resources of the government of Cambodia and thus its capacity to influence the definition of interventions and policies in the environment sector. Extension of the research results is done through the publication of policy briefs and reports, the organization of workshops and already contributes to bridge the gap of knowledge on these notions that has been identified amongst public institutions and development partners at the national level.

Indeed, confusion between the notion of ES and the polluter-payer principle is quite common especially amongst stakeholders not primarily concerned by conservation issues and more specifically dealing with pollution issue.

In this section, we show that conservation NGOs and some international donors lead the emergence of the notion of ES because they deploy relatively important financial, scientific and political resources. However, the political resources of government agencies are significant and, as an illustration, conservation NGOs and donors have to demonstrate and highlight the economic goal of ES and PES in order to have their positions compatible with those of government agencies and eventually make conservation work.

1.3.3. Nature of the emergence process and opportunity window for a wider dissemination of the concepts of ES and PES

Interactions amongst the institutions involved in the conservation and natural resource management sectors are organized following two channels, each of them explaining one aspect of the emergence of the notions of ES and PES in the policy agenda and in conservation interventions. The first channel originates in the identification and formulation of problems associated with the unsustainable management of natural resources in Cambodia and its consequences in terms of economic development, poverty alleviation and conservation. These problems are documented in a number of studies that are generally initiated by conservation NGOs and donors and in some cases by academic institutions, at the local level and often carried out in collaboration with public offices. In essence, these reports recognize, quantify and put a value on various ecosystem services provided by Cambodian forests and thus demonstrate the global, national and local importance of their conservation (Bann, 2003b) However, they also show that deforestation and forest degradation are expanding rapidly (FAO, 2005). This problem is further documented by identifying the major underlying causes of deforestation that are often illegal and associated with the weak nature of the Cambodian institutional environment. For example, access to large parts of forest resources are governed by informal institutions, government land-use planning and especially the definition of protected areas has been poorly informed, property rights are unclear and encroachment an easily available secure form of wealth (Clements *et al.*, 2009). Furthermore, neither the Royal Government of Cambodia (RGC) nor the Forest Administration has the necessary capacities or sufficient financial strengths to implement laws and strategies. Finally, this problem is reported to be closely linked with poverty issues as natural forests are estimated to be fundamental asset for nearly four million rural people live within 5 km of the forest and as benefits generated by the use of forest resources are currently unequally shared and captured by those who control the access to the resource and the market chain but who do not have an incentive to manage the resource in a sustainable manner (Ashwell, 2004).

This way to analyze the situation and formulate local problems leads mostly conservation NGOs and donors to consider PES schemes as alternative solutions within the existing set of laws and regulations and more specifically as a complement to protected area management. Indeed, these schemes allow channeling new financial resources for

conservation purposes, to support the enforcement of laws and make conservation economically viable as a land-use system for resource users. In practice, they permit of reaching targets in terms of conservation by inducing changes in individual land-use decisions through the transfer of resources and the enforcement of rules conditioning this transfer.

Besides, these mechanisms generally focus on enhancing the provision of at least one environmental service, allows integrating its value in land-use decisions and thus also contribute to reach a social optimum in resource management that benefits people at various scales, including those who enjoy the public benefits of forests. Furthermore, in practice, implementation of incentives and enforcement of conditions are systematically accompanied with a change in the local institutional arrangement aimed at framing the transaction and which often include the creation of communities managing natural resources, the closer intervention of both the NGOs and partner public agencies. In turn, it leads to results in terms of poverty alleviation because the change in governance induces a modification of the way benefits are shared. Local resource users are systematically recognized as environmental service providers and are in this regard the main beneficiaries of PES schemes, having their land ownership clarified and being the main recipients of payments. In the end, the concepts of ES and PES are transferred toward government agencies in particular to draw the government's interest on conservation and its attention on potential solutions for conservation that could eventually be replicated in other contexts. This is done through the diffusion of the results of the abovementioned studies focusing on local issues and identifying solutions in workshops, reports, policy notes and so on, but also through the joint definition and implementation by international NGOs and government partners of PES pilots as solutions to local problems identified in preliminary studies.

The second channel relies on the formulation of policy-alternatives, REDD and PES mechanisms, in the international sphere. These policy instruments have not necessarily been designed to solve local problems but rather to cope with global environmental issues which effects are increasingly recognized and measured at the global scale and include global warming or the high rate of species extinction. In turn, these global concerns are generally associated with general questions on the economic policy instruments that would contribute to biodiversity conservation or on the way to include greenhouse emissions

from deforestation in a post-Kyoto climate change agreement. REDD and PES mechanisms are being developed as a response to these questions and are more specifically based on contributions from various international spheres. It includes the diplomatic sphere through the negotiations on climate change and the definition of the REDD framework, the scientific sphere that contribute to design and conceptualize these mechanisms and explore their potential and risks as well as the civil society and political spheres that develop and implement concrete cases of these instruments worldwide that then become references in Cambodia. These spheres are in turn linked to institutions working at the national level and constitute the starting point of the diffusion of these policy alternatives in Cambodia.

In practice, the way these policy alternatives diffuse down to the national level suggests that these policy alternatives are systematically linked with financial support. For example, international donors are often involved in the design of these policy alternatives, either because they are part of the international negotiations on biodiversity or climate change or because they initiate and support studies focusing on these mechanisms to design their strategy. Consequently, their interests and in some cases their strategies are influenced by these concepts and they are thus more prone to support programs based on these policy alternatives. That will in turn influence operational stakeholders that are in interaction with them and rely to some extent on their financial or technical support, such as government agencies that benefit from donors' support through programs focusing on capacity-building, policy definition or operational projects implemented in collaboration with international NGOs. Besides, as economic instruments, these tools are also ways to channel funding for conservation from other sources such as private investors, carbon markets, tourists and are thus regarded as opportunities to fund activities in conservation or natural resource management by NGOs and government agencies in particular. In this regard, interest of development partners are focusing more specifically on REDD mechanism because it is considered as being promising in driving larger funds at a larger scale toward conservation and as they are more prominent due to the media coverage on the negotiations on climate change and the quantity of publications on that topic. In the end, these policy alternatives are diffusing as concrete solutions and are eventually integrated in public policies as alternative funding sources, or implemented as REDD projects or pre-designed PES schemes. These two channels are coupled in two points and conservation NGOs, international donors and government agencies play a key role in

connecting the two. First, some conservation NGOs and international donors are instrumental in the respective key and initial stages of each stream, namely the problem identification and the policy-alternative formulation. For example, Conservation International headquarters designed one pattern of PES mechanisms, the *conservation incentives agreements,* which they implement in various settings worldwide. On the other hand, they also contribute to document issues threatening the ecosystems of the Cardamom Mountains in Cambodia and propose solutions that are, for example, specified in the Central Cardamoms Protected Forest Management plan defined by CI. Eventually, CI implemented the conservation incentive agreements in Cambodia as a complement to the protected area management system in the Cardamom Mountains.

Secondly, Cambodian public agencies, the MoE and the FA in particular, are also at the crossroad of the two channels, and more precisely in the final stage of diffusion of both problems and policy-alternatives. For example, REDD as a policy alternative for funding forest-related policies has rapidly diffused in various public strategies and amongst government offices and public servants through various channels, including in particular their participation in COP15 and the implementation of various capacity-building projects on REDD by international donors. On the other hand, the Forestry Administration, if not involved directly in the collection of data, is often the recipient of studies that identify problems in the forest sector such as the Independent National Forest Review commissioned by the TWGFE. This review constitutes the basis for the design of the National Forest Program that in turn includes REDD as an alternative financing mechanisms for the sustainable management of forests. The process of emergence of the notion of ES and more particularly of its operational form as Payment for Environmental Services is allowed by the completion of two key-steps, namely the formulation of local problems and subsequent solutions and the definition of policy alternatives and its diffusion down to the national level. The emergence both in policies and its use in operational interventions is even more facilitated by the coupling of the two channels that links a plausible solution with concrete problems. It also confirms the key role played by the government agencies and international institutions as well as the importance of interactions amongst them. Although the two above key-steps are generally carried out by international NGOs and donors, the diffusion, both bottom-up of local problems or top-down of policy alternatives, occurs through interactions between the international and

domestic spheres with government agencies as final recipients.

1.4. Discussion and Conclusion

The increasing awareness of the importance of ecosystems and their conservation, associated with the current rapid rate of degradation of these resources, challenges policymakers and highlights the need for instrumental change. Policy response is even more urgent in the case of tropical forests, characterized by high rate of deforestation and, on the other hand, by high carbon storage capacity and significant biological diversity. In this regard, the emergence of environmental policy is driving scholars interests as an explanatory variable to understand the outputs of a given policy. The paper focuses on the emergence of approaches based on the notion of environmental services and positive incentives in environmental policies dealing with natural resource conservation and takes Cambodia as a case study. Environmental policies have long been characterized by a strong bias in favor of regulatory approaches based on command-and-control instruments. However, in the recent years and in different settings worldwide, an increasing number of countries tend to move towards approaches that focus on positive incentives and alternative instruments. The analysis of the institutional framework for conservation policies suggests that Cambodia is actually following that trend. The initial strategy of the government defined in two main Laws and the subsidiary decrees and strategic plans was based on command-and-control instruments associated with the management of protected area. However, the recent years have been characterized by a progressive recognition of the various services provided by ecosystems, the importance role played by local population in their management and the increasing prevalence of PES mechanisms in policies and interventions. Indeed, the notion of ES has emerged in turn in various valuation studies of forest and coastal ecosystem services, the implementation of PES and later on REDD schemes and finally the explicit integration of PES as a policy-alternative in various subsidiary strategies. However, the extent of diffusion of these notions in policies and interventions is still limited, at the pilot stage or in “niche” strategies for PES and REDD mechanisms. That situation might be explained by the fact that this process is recent, less than ten years, and the emerging approaches still have to comply with the overarching laws based on regulatory approaches. Thus, rather than a fundamental change in approaches to natural resource conservation, that process might be considered as the first step of emergence of approaches based on environmental services and positive

incentives in Cambodia. The paper highlights several factors as being instrumental in the emergence of the notion of environmental services and economic incentives in Cambodia.

Firstly, as suggested by Kingdon (1984), the identification of local problems and the formulation of policy alternative such as REDD and PES, are the cornerstones of the two channels of emergence of the notion of ES in Cambodia. A number of studies highlight the failure of the State in framing the management of natural resources in Cambodia in an effective, sustainable and equitable manner through the current regulatory approach. It further focus on the failure to produce public goods such as climate change mitigation and biodiversity conservation and to enable a fair distribution of the benefits from the use of natural resources that would benefit the society as a whole. This problem is often formulated by and thus visible amongst international NGOs, donors and to some extent government agencies so that in many cases, its explicit formulation contributes to justify and influences the choice of operational and policy instruments. Indeed, alternative solutions such as PES schemes, as defined by Muradian *et al.* (2009), are specifically designed and implemented to tackle these issues and are based on the recognition of the importance of various environmental services and of the role of local populations in their management. In turn, the formulation of problem also influences the political process as policy-makers are either directly involved in the production of this information or are the final recipients.

Furthermore, PES and REDD have been designed as policy instruments in the international sphere and in response to global environmental concerns on climate change and biodiversity loss in particular. The diffusion of these instruments down to Cambodia is linked with the negotiation on climate change, the diffusion of scientific research and capitalization of pilot experiences but also with financial support. Indeed, these instruments are considered by government agencies and NGOs as complementary tools, besides the regulatory ones, aimed at reaching goals in terms of financing strategies for the sustainable management of natural resources, as they influence donors' strategies and thus the allocation of aid or they are expected to allow raising funds directly from alternative sources.

Secondly, the level of knowledge and the position of various actors regarding the concepts of ES and PES influences their preference for certain approaches to conservation and

policy instruments and in turn the process of emergence in different manners. In Cambodia, three types of actors, including some international donors, conservation NGOs and academic institutions, know and use these concepts. However, they have very diverse positions, levels of knowledge and thus different ways to justify and use these approaches and instruments. For example, some international donors and conservation NGOs are considered as proactive as these notions are known, learning from their own or others' experiences and researches, conceptualized at the institutional scales and in turn underlying some aspects of their intervention strategies. The use of these notions is primarily justified by perspectives in terms of biodiversity conservation but also by further benefits in terms of local development, economic growth and climate change mitigation as they recognize the value of various ecosystem services. Furthermore, government agencies and some NGOs are rather opportunistic. Although they are known by key-individuals usually in contact with aid agencies and the various values of ecosystem services recognized, these notions do not underly the government strategies but are rather considered directly in their operational form as alternative policy-instruments. The motivation and the justification of the use of these instruments lie in their potential to work as alternative fund-raising mechanisms for conservation activities and strategies. In the end, the paper shows that these actors will influence the emergence of the notions of ES in a different manner by implementing PES or REDD schemes or contributing to the diffusion of policy-ideas differently according to their various positions and justifications.

Thirdly, the paper highlights the foreign influence on domestic environmental politics and institutions and especially the importance of non-governmental institutions and donor agencies in the emergence of the notion of ES and PES in Cambodia. Importantly, the research shows that the power of these institutions to influence environmental policies and interventions lies in the relatively important financial, scientific and political resources they deploy and is strongly linked with the national institutional setting as many NGOs and donors work in Cambodia and support the Government of Cambodia. In practice, international donors and NGOs play an important role in the formulation and diffusion of information on the nature of problems, policy alternatives and subsequently the concepts of ES and PES. This is supported by their capacity to implement studies and project and produce related scientific and grey literature, to orient other stakeholders' decisions by funding operational projects and supporting the definition of policies and to influence the

position of policy actors through their extended networks and personal connections with individuals in position of influence.

However, it is worth noting that, unlike in Madagascar Monnery (2010), multinational private firms deploy very limited financial resources in the environment sector. Foreign investment firms, banks or capital risk companies are more prone to invest in environment and especially in projects linked with carbon markets as they are promising in terms of return on investment but this is still very limited. For example, an investment fund supported the implementation costs of the first operating REDD project in northern Cambodia and gets benefit from the sale of carbon credits. Besides, firms managing economic land concessions or operating hydroelectric dams are so far are not investing in the natural capital although they usually strongly rely on ecosystems services. For example, dam companies operating in the Cardamoms are seen as promising buyers of environmental services for watershed protection by various conservation stakeholders but no such schemes have been implemented.

Fourthly, the diffusion of the notions of ES and PES occurs through interactions between the international sphere and the domestic sphere and highlights the importance of government agencies. Although the initial step of the emergence channels are initiated and mostly carried out by international institutions, the diffusion of these concepts is always oriented toward government agencies as final recipients and through interaction between some international donors and NGOs and key-representatives of Government agencies, MoE and FA in particular. Interactions consist of diffusion of information in workshops or through the dissemination of reports and policy-briefs based on studies and experiences generally initiated by international institutions but also of discussions between government and aid agencies for policy or project definition. Government agencies are inevitable stakeholders in the diffusion of these notions because, despite their lack of human, scientific and financial resources, they hold important political power. Indeed, political resources are held by a limited number of government officials and lie in their academic capacities, their good knowledge of Cambodian administration, their extensive network with high-ranking officials, and their position as official representatives of the sovereign state and government agencies which aid agencies have the obligation to work with.

The coupling and interactions among these factors facilitate the emergence of the notions

of ES and PES in the policy agenda, instrumental choices and operational interventions. In Cambodia, although these concepts are, at the current stage, not mainstreaming policies and interventions for natural resource conservation, the analysis of the process of emergence of these concepts suggests that there might be an opportunity window open for a broader diffusion because several key-factors (formulation of the nature of problems, formulation of policy alternatives, position of actors, influence of international sphere and interactions between institutions) are interacting and contribute to draw two channels of emergence where government agencies, MoE and FA in particular, and international donors and conservation NGOs play a key role in connecting the two.

Paper 2

2. Adoption of organic rice on agro-ecosystem with High risk of flood : Insights from an Agrarian System Analysis and Diagnosis

Abstract

Organic agriculture is still a market niche but it is the greatest practices toward a sustainable agriculture. In Cambodia 85% of farmers are rice producers. In addition, organic rice productions are adopted, under NGOs supports and certifications, as the way to improve farmers' revenue headed for sustainable rural development. This study aims in defining economic constraints of organic rice adoption on the agro-ecosystem with high risk of flood by using Agrarian System Diagnosis and Analysis. Our finding shows that organic rice gives high value-added/ha but low value-added/family labor because of the low surface available for it. In addition, based on ecological constraints make it possible to produce only outside the flood pulse effect area. For the reason that the inundation causes chemical contamination engenders organic label loss. Moreover, organic farmers face to social status constraint because organic practice is viewed as tools for the poor. Originally, organic rice farmers was among the poorer chosen by NGOs to help them to get out of poverty. Another constraint is institutional aspect that organic farmers face to late payment from their cooperative because of lack of fund in their association. Our finding reveals that price premium is still not high enough to induce new adoption face to economic, ecological and intuitional constraints. The positive points are organic farmers become (i) trained farmers (ii) producers of quality (iii) model farmers who participate in policy making events of the MAFF and (iv) part of an organization with a unified voice on the issues affecting their livelihood.

2.1. Introduction

Organic agriculture has quickly developed worldwide over the last twenty years. The area of organic agricultural land more than trebled between 1999 and 2010 (Willer and Kilcher, 2012). Even if organic agriculture is often viewed as a market niche (its share of all agricultural land is only about 0.9%), it is considered a powerful lever for the adoption of sustainable agriculture practices, in particular for developing countries. Indeed, 1.3 million producers (80% of all producers) came from developing countries in 2010. A large literature underlined links between Organic agriculture and the Millennium Development Goals or sustainable development (Pugliese, 2001; Rigby and Cáceres, 2001; Setboonsarng, 2006a). Unfortunately, the literature clearly emphasizes the constraints peasants from the South meet when they produce organic fruits and vegetables; i.e., low yields, inputs costs, rules compliance, food security, and farming contracts.

Cambodian organic agriculture offers a good illustration of this issue. Cambodia's 2013 HDI of 0.543 ranks the country among the least developed countries in the world (UNDP, 2014). In spite of a recent economic growth due mostly to the industrial production (construction, garment sector etc), Cambodia still remains an agricultural country. About 80% of Cambodian people live in rural areas and 90% of the poor come from these rural areas (Mund, 2010). Moreover, if economic growth is mainly due to the expansion of the industrial sector in urban areas (primarily in the capital city, Phnom Penh), rural areas provide a safety net for industrial workers when shocks occur (World Bank, 2013). In that case one of the key messages of several economic analyses is that any poverty reduction policy has to target rural households (Timmer, 1992; Harris and Orr, 2014). In this context, it is worth noting that 85% of people living in rural areas are rice producers. The main drivers of rural development are dedicated to the agricultural system of lowland rice production. The Tonle Sap Lake (TSL) Flood plan is the most suitable agro-ecosystem for rice production (see the map in Annex A.1.) as it increases soil fertility through sedimentation and provides abundant water for this crop. But this agro-ecosystem also increases the risk of yield loss caused by flood. So, rice production plays a role in flood control and adaptation (Dan *et al.*, 2005; Tsubo *et al.*, 2007; Masumoto *et al.*, 2008; Someth *et al.*, 2009; Ly *et al.*, 2012). World Bank (2013) highlights the importance of rice production in the Cambodian context. According to its economic analysis, the drivers of poverty reduction between 2004 and 2011 are the increase of rice production (23%) and

rice price (24%), far ahead of other factors (farm wages [16%], non-farm business [19%], urban salaries [4%] and unexplained reasons [14%]) (World Bank, 2013). In this context, organic rice production is viewed as a key driver of rural development in Cambodia; see for instance the National Export Strategy or the Green Growth Roadmap which considers organic agriculture to be one of the main sectors to be prioritized (Green Growth Secretariat, 2009; MAFF and MWRW, 2010; MAFF, 2011). The Organic product labeling is often an NGO action for poverty reduction by using the price premium given by consumers (Rigby and Caceres, 2001; Giovannucci, 2007). In Cambodia this is also implemented and supported (financially, institutionally and technically) by the NGOs in order to improve farmers' livelihood through agricultural value added (Rigby and Caceres, 2001; Cheattho, 2011; COrAA, 2011a). Meanwhile, low yield in organic agriculture compared to conventional one (de Ponti *et al.*, 2012) may lead to its low adoption.

The constraints of organic production development are strong. Contrary, there are relatively few papers on organic rice constraints in Cambodia. Due to its high potential for export, most of the grey literature focuses on the value chain constraints. Some of these constraints are common to the conventional rice market (e.g. weak competitiveness due to high freight or electricity costs). Others are specific to the organic market (certification compliance, cooperative governance etc.) but few analyses focus on the process by which organic rice is chosen by farmers compared to conventional rice system. The explanation could be that most experts believe that as chemical pesticides and fertilizers are not being widely used in rice production, conversion to organic farming should be easy and quickly adopted by farmers. But this explanation is insufficient.

To understand the economic constraints on the adoption of organic rice production in Cambodia, it is useful to develop an in-depth analysis based on farmers' practices. Because we believe that organic adoption is firstly a farmer's choice, it seems important to understand the different cropping systems peasants adopt. But also because practices are embedded in a specific natural asset, it is useful to analyze these practices when taking into account the functioning of the ecosystem.

The main objective of this article is to highlight the issue of organic rice adoption by peasants based on a farming system framework. If economic analysis is our guideline, we envelop it in a production systems framework to stress the constraints present during the

organic rice production process. We show through an in-depth fieldwork conducted over 2010 and 2012 in the floodplain of the TSL, several economic analyses that enable us to draw conclusions about opportunities to strengthen organic rice production.

The first part provides the methodological background of the study. In the second part, we focus on the main results, i.e. understanding the agro-ecosystem before analyzing the different rice production systems and suggest a typology of rice production systems. This leads us to explain economic constraints of organic rice production adoption in the third part. We conclude with some key comments in the fourth part.

2.2. Materials and methods

2.2.1. Method

The Agrarian System Analysis and Diagnosis, or shortly called Agrarian System is used for this study. It is an all-encompassing concept, capable of making sense of agricultural activities at a regional scale in a way that accounts for both ecological and socio-economic dimensions. This methodology is used as a holistic approach to understanding agricultural transformations at the regional level. This approach includes all the fundamental factors that influence farmers' decisions and practices with great ability to analyze agricultural transformations. A French speaking agronomist created it during the 1970-1980s at the same time as the English concept about Farming Systems Research (FSR) approaches promoted by the Association for Farming Systems Research and Extension. But FSR is limited to technical and financial analysis of the farm and rarely takes into account the farm environment and historical change. This approach often uses the Rural Rapid Appraisal methodology associated with statistical analysis tools to perform farm typology (Cochet, 2012). The Multivariate Statistic analysis (actor analysis through principal component analysis; and cluster analysis) produces farm typology for the researchers to study in detail by choosing several farmers in each type of farming systems (Carmona *et al.*; Flanigan *et al.*; Daskalopoulou and Petrou, 2002; Senthilkumar *et al.*, 2009; Carmona *et al.*, 2010; Flanigan *et al.*, 2014). The Farming system, like the Agrarian System's production system framework can be used to determine how capable individual farmers are to organize their own farm but neither can be used in isolation to understand the dynamics of farming activity at a regional scale. Agrarian system method takes into account all

social, economic and political aspects, which leads to an understanding of the agricultural evolution of the region (see Figure 2.1). The concept was redefined by Mazoyer as *''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''*, cited by (Cochet, 2012), p. 130. There is also another tool called agricultural system analysis and modeling created within the same period that helps in understanding the biophysical and human processes in relationship with the use of natural resources at different scales (field, farm, region, etc). This method sounds very similar to the agrarian system. It links agro-ecosystem (Biophysical system) and human (Farm management system) and integrates the key inputs and outputs in the simulation or modelling in order to explain farmers' decision to adopt any cropping system or animal husbandry (Belcher *et al.*, 2004; Martin *et al.*, 2012). This method has evolved to become increasingly specific with the integration of informatics system like SAM (Simulation Model using STELLA modelling software)(Belcher *et al.*, 2004) and ASPSIM (Agricultural Production System SIMulator) (Adam *et al.*, 2012), etc.

In this article, we use the methodology of agrarian system diagnosis and analysis. It provides an understanding of "Mode d'exploitation du Milieu" in French terms, which means how farmers use the land (Cochet *et al.*, 2007).

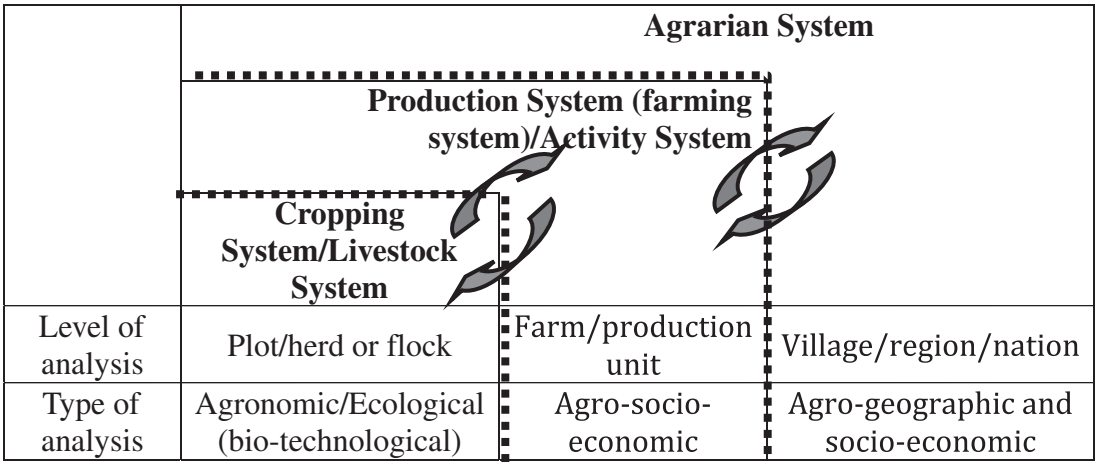


Figure 2-1: Nested scales of analysis
Adopted from (Cochet, 2012), p. 133

The typology of the production system is to create the model type of agricultural exploitation by grouping the farms with the same resources (land, level of mechanization,

labor force) in similar socio-economic contexts, with a similar combination of cropping systems (Cochet and Devienne, 2006b). This work starts from the understanding of cropping system and animal husbandry concepts that are applied to the plot and animal raising on the farm rather than to a crop or animals. It functions as a system, which needs to be analyzed in terms of system of the set of "crops types, techniques, crops sequences and associations, history of the plot" under the specific pedo-climatic conditions. It is why it is necessary to understand the study zone called "agro-ecosystem", which is a factor defining farmers' decisions in the choice of cropping system in order to adapt to all conditions related to agro-ecosystem but also the other socio-economic-political factors (Dufumier, 1993; Cochet, 2004; Cochet and Devienne, 2006b; Dufumier, 2006; Gafsi, 2006) (see Figure 2.1 above).

Thus, Production System modelling or typology is a complex analysis of external factors (agro-ecosystem transformation, Technical change and Socio-eco-political change) and internal factors (Land, labor force, Capital). All these conditions influence the choice of farmers in combining the different rice cropping systems in order to survive in a specific ecosystem or to increase their productivity (Barral *et al.*, 2012).

Landscape reading	This is a stage of understanding the agro-ecosystem and zoning. Started by observation of the agro-ecosystem and vegetations, the question "why" guides us to meet the elderly and local people for a better understanding of land use change in study zone.
Historical study	The current agricultural situation is the fruit of a long or medium term evolution. This study is trying to identify the key factors of change, which create the actual agricultural practices.
Production system modeling and performance economic calculation	This stage leads us straight into economics field. The comparison of performance economic (Value-Added (VA) and Agricultural Revenue per active) of production system will clarify and explain why in the same region farmers practice different production systems.

Table 2-1: Step of agrarian system analysis and diagnosis
Adapted from literature (Cochet and Devienne, 2006a; Dufumier, 2006; Cochet et al., 2007; Cochet, 2012).

The whole study is trying to explain, "Why individual farmers adopt specific rice production systems?" Agrarian System Analysis and Diagnosis could be summed-up into 3

stages as in Table 2-1 above.

Those 3 steps, will lead us to build the relation of Socio-eco-political condition that influence farmers' way of land use. Each change results from different factors influencing farmers' choices.

Evaluating the Economic Results of cropping systems (i) in one unit of land (ha) in one year

Gross Output (GO_i/ha)

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

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

Intermediate Inputs (II_i/ha)

II: monetary value inputs such as seeds, chemical inputs and services used (plouhing, transplanting, weeding, harvest, transport) during one year of production for each cropping system (i) **in one unit of land (ha)**

$II_i /ha = \Sigma$ (quantity of inputs used/ha x price) + Σ (service 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 economic reason for its adoption.

$$\mathbf{GVA_i/ha = GO_i/ha - II_i/ha}$$

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

Evaluating the Economic Results of production systems (j) in one unit family labor (fl) in one year

GR_j/fl = Gross remuneration of family labor in their production system (j=1…21). It aims to show the wealth created by one family labor (fl, equivalent to fulltime work) which combines different cropping systems (i). It explains the economic decision of farmer's combination of different cropping systems (i) in their production system (j). Thus we propose to go through this GRj/fl[1]:

GVA_i= GVAi/ha x S_i

S_i = total surface of cropping system

$GRj/fl = \Sigma (GVAi)/fl_{(i=1…9)}$

Economics Depreciation of Farm Equipment (DEF_j): Showing the wealth created by farmers is not enough to understand the economic reason for adoption because each production system (j) needs different levels of capital to invest in farm equipment. We keep the DEF at least to compare the investment level that each farmer needs to start up the production.

DFE = current purchasing price / number of years of actual use

$DFE_i/FL = DEF_i/$(number of family labor force)

Table 2-2: Economics calculation formula
Adapted from (Barral et al., 2012)

[1] This article won't calculate farm Income because we would like to show up the wealth created from each rice cropping systems, which composes a production system. Consequently, we will be able to show up how the economic value of organic rice contributes to wealth creation that serves also to explain the level of its adoption.

To perform the economic calculations in an agrarian system, we will measure the annual monetary value of the output (sales, household consumption, gift, in kind payment related to labor cost paid etc.). In this article, we will quantify the wealth created by one farm (we use the term of family labor to include all family members who contribute farm activity) called Value-added and Gross Remuneration of family labor. The economic formulars are detailed in Table 2-2 as below.

2.2.2. Delimitation of study zone

The delimitation of the study zone is based on the landscape and land use transformation managed by farmers by combining different cropping systems allocated on the managed agro-ecosystem (Cochet, 2012). The study was conducted on farmers in two districts, Steung Sen (Sroyov Tbong, Roka and Rolous village) and Santuk (Phanhagy, Ompus and Porkhav villages), which use the agro-ecosystem flood plain of TSL. The study zone is under two water regimes. The first is from the great lake flood pulse and the second from some waterways connected with Mekong river from Kampong Cham. According to Keske and Huon (2002)'s study the TSL and its floodplain are divided into 5 zones starting from the lake[2]. We exclude their zone 5 (urban zone) because it is a non – agricultural zone. We studied zones 1, 2, 3 and 4 where agricultural activities take place. In our study, we use the survey based on agro-ecosystem observation to better understand and delineate zones, which can explain clearly the agro-ecosystem and how farmers manage the land to adapt to flood pulse and ecological risks. Based on flood pulse calendar, vegetations and cropping systems we divided our study area into 3 zones starting from national road to the great lake by incorporating the elevation from Keske and Huon (2002). Our zone 3, is the combination of their zones 1 and 2 because farmers practice the same cropping system on the ecosystem of grassland, shrubs and flooded forest.

2.2.3. Sampling

The data collection has to ensure the understanding of agrarian system and the economic calculation in order to explain diverse situations and trajectories of production system. The result is the fruit of different times of field works and of multiple detail case studies by

[2] In their study, Keske and Huon (2002) defined 5 zones: zone 1 (area with the elevation between 0 and 6 meters); zone 2 (area with the elevation between 6 and 8 meters); zone 3 (area with the elevation between 8 and 10 meters); zone 4 (area with the elevation between 10 meters and the National roads and zone 5 (urban zone i.e. six provincial capitals of the study area).

avoiding the theory of all-embracing (Cochet *et al.*, 2007). For this study we carry out in total 208 interviews that can be divided into 2 types:

- 36 farmers for qualitative data, which is the most important for the beginning of the fieldwork for understanding the "milieu" and landscape or technically called "agro-ecosystem" change. This step helps us to do delimitation of the study zone and understanding the history and change in agriculture of the study zone. We carried out individual interviews and one group discussion of 12 elderly farmers (see annex B.2 and B.3).
- 172 farmers for quantitative qualitative data. The sampling size is calculated from Yamane (1967:886) formula (Glenn, 2009), which tends to facilitate the limitation of the sample size and decrease the errors in economic calculation. But sample selection is still based on the reasonable sample choice to ensure the heterogeneity of farmers in the region. 20 organic farmers are fully included inside the 165 persons in order to have all the details from these production systems. We also conducted group discussions within the organic farmers (16 farmers) in order to understand their general situation, market chain, commitment and the reason for adopting organic rice cropping system (see questionnaires in Annex B.4 and B.3).

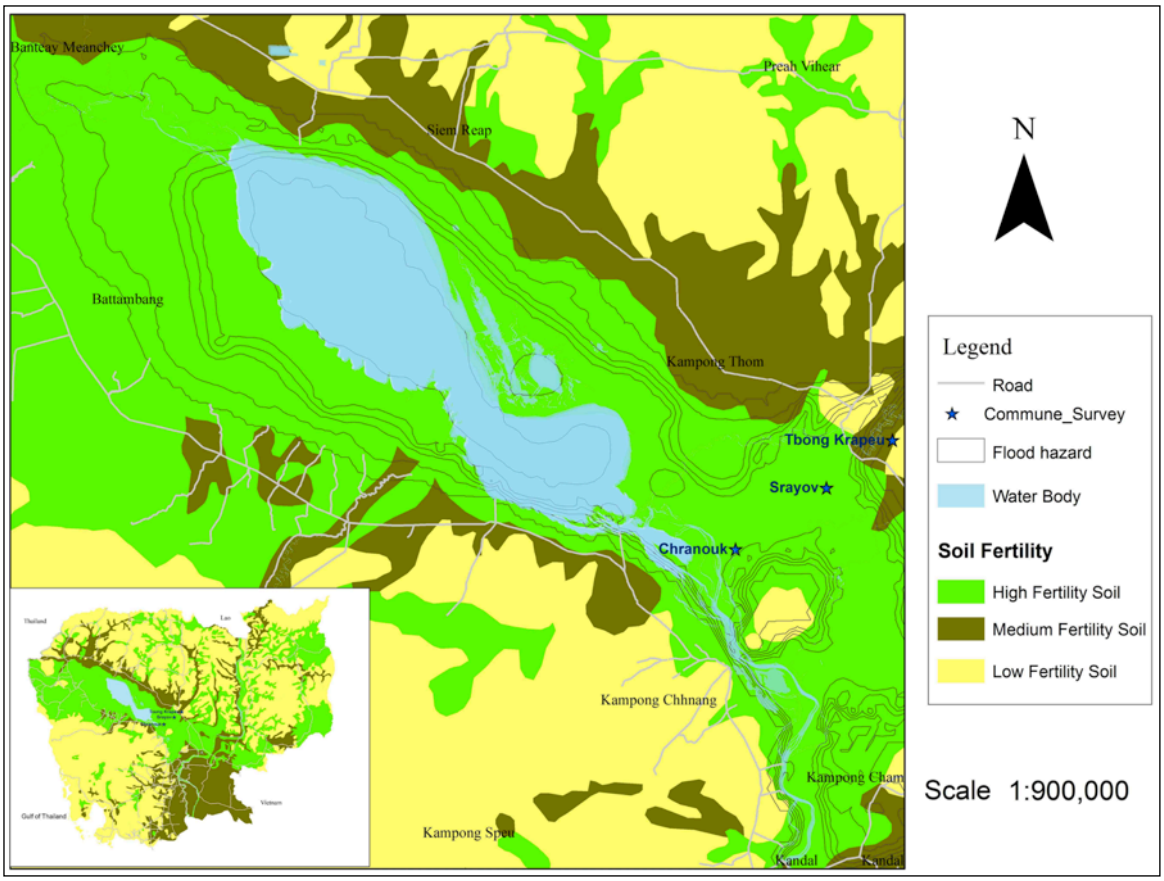
2.3. Results

Agrarian system analysis and diagnosis lead to understand several aspects of agricultural situation such as agro-ecosystem understanding, history and land use evolution, cropping system analysis and understanding of farmers' choices ending with economic analysis of production systems.

2.3.1. Agro-ecosystem understanding

The study zone is located on the floodplain (see Map 2-1) of Tonle Sap Lake (TSL). It is the largest fresh water lake of Southeast Asia and of Mekong River Basin. In 1997, it was recognized as the first Biosphere Reserve in Cambodia (UNESCO, 2012). During the dry season, from November to April, water flows through the Tonle Sap River into the Mekong River. Conversely, during the wet season, from May to October it flows back to TSL. This floodplain extends over 15,000 km^2 and stores 50 to 80 km^3 of water from the

Mekong River in wet monsoon season (Arias *et al.*, 2012). The TSL ecosystem is a flood pulsed ecosystem, where the average suspended sediment flux into the Tonle Sap Lake is 7 million tons while the outflow flux is only 1.6 million tons. Only limited amounts of floodwater sediment reach the middle and upper parts of the floodplain. These areas are often used for floating and recession rice cultivation, which have low productivities (Kummu and Sarkkula, 2008). The flood pulse creates vast areas of seasonal floodplain habitats, which are the main feeding habitats for most fish. The productivity of the lake is among the highest in the world due to a combination of high water temperature, annual flooding, and the supporting role of the inundated forest in stimulating the development of micro-organisms and phyto- and zooplankton (Lamberts, 2006).



Map 2-1: Soil fertility and flood hazard of Tonle Sap Floodplain

The study zone is situated in the Lacustrine floodplains on old alluvial terraces suitable for rice production. Our study zone situates on the high fertile soil type. The fertility level of the TLS floodplain is dependent to the flood pulse carrying the sedimentation.

Consequently, this zone situated in the region with high risk of flood hazard in rainy season (Dan *et al.*, 2005; Nguyen *et al.*, 2011). The soils of the zone are classified as the Toul Samroung type, a soil occurring on the old alluvial terraces or the colluvial-alluvial plains, which has clayey or loamy topsoil. Soil in this group develops moderate to large cracks upon drying. The topsoil has a blocky structure and is very hard when dry. Internal drainage is slow. The CEC and organic matter levels are low to moderate but it has moderate to high potential for rice and yields respond well to improved management. The soil is well suited to irrigation. This soil group is classified by Crocker (1962) in the Brown, Gray, or Cultural Hydromorphic soil units (see maps in Annex A.3 and A.4) or it would be Luvisol or Vertisol using by FAO/UNESCO soil classification system (White *et al.*, 1997; P. *et al.*, 2000; Shimizu *et al.*, 2006). Based on the recommendation given by White, Oberthür *et al.* 1997, the irrigation system is needed to increase its potential for rice production.

During the annual rainy season the study zone is covered by water from the great lake flood pulse as well as the Sen and Chinit streams from the Preah Vihear province. Based on our study of farmer perception, flood pulse calendar, vegetations and cropping systems; the study area could be divided into three zones starting from national road to the great lake.

Zone 1, called Sre leu (upper rice terrace): high lands situated next to village along the national road with elevation of approximately 10 m. This zone is rarely flooded with normal water regime except during a flood disaster. Within this zone, there are a lot of fruit trees and also other leaf trees in rice fields or on dykes. The vegetation is specifically selected by villagers in order to provide food and materials for their requirements for sustenance, house construction and furniture (Ex: Palm tree). On this zone, farmers grow traditionally seasonal rice (rainy season rice). However, they also grow short-term rice when they have the possibility to irrigate (near irrigation system or natural water sources). Here is the only zone where farmers can grow organic rice with no risk of flooding, which can cause label loss. This zone is rarely covered by alluvial materiel except when there is flood disaster.

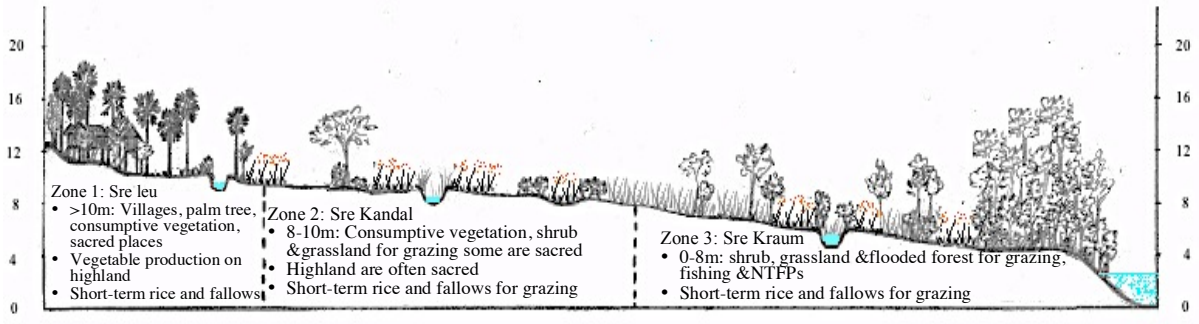


Figure 2-2: Present land use in dry season and early rainy season (Dec-Jun)

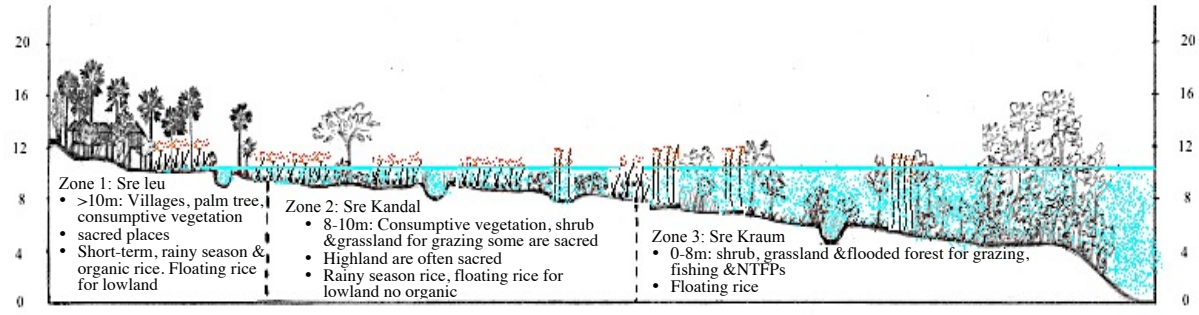
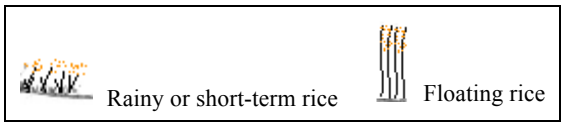


Figure 2-3: Present land use in middle of rainy season (Jul-Nov)



Zone 2, called Sre Kandal (Middle rice terraces): This zone has an elevation of 8 to 10 m and is flooded during the rainy season. It is typically composed of paddy field without vegetation. Flood damage precludes the survival of any provisioning trees. Some places are characterized by shrubs next to a natural pond or small river. This zone is used for hunting, fishing and animal grazing as well as wallows. The soils are sandy on highland because of the run-off when water leave and loamy in hollow because of the deposits.

The main crop is rainy season rice. Sometimes there is also floating rice on hollow land. There is also short-term rice with irrigation system especially with high dike to protect fields from floodwater.

Zone 3, called Sre Kraum (Lower rice terraces) : This zone has an elevation less than 8 m and initially floods during the early rainy season with elevation under 8 meters. Naturally,

this zone is flooded everywhere during the July to November rainy season,, because of the water flowing from the great lake and the rain. The alluvial deposits from the water flow make the soil in this zone more loamy and fertile than that in the other study zones. This zone is still wild and characterized by flooded forest, shrubbery, grassland, and paddy fields. Farmers grown mainly receding and floating rice under the trees in areas that they call "clear flooded forest areas". In the dry season those rice field are left fallow then grass and shrub start growing again. Nowadays, by setting up irrigation system, farmers abandon the cultivation of floating rice and adopt short-term rice, which gives much more yield but necessitates intensive deployment of chemicals (both early season and receding rice). As a consequence, wild vegetation is removed in order to enlarge their cultivated space and facilitate machinery access and function. In this zone, there are also some agricultural companies and concessions investing in short-term rice production. They own at least 150 ha. On those fields, the only vegetation is rice. There is one concession of 2000 ha is investing in road and irrigation system construction. This concession will convert 2000 ha of flooded shrub, flooded grassland and flooded forest to rice field[3]. Consequently, they are harming the ecosystem and endanger species by destroying their habitats (ENS, 2010; UNESCO, 2013; WCS, 2013). Apart from rice, this zone is also used for grazing, fishing, hunting and particularly firewood as well as NTFP (Non Timber Forest Products) such as honey.

The farmers in this region have a strong sense of risks management faced to flood. They own the land dispersing in those 3 zones that we have identified. This fact helps them to minimize the risk from flood and drought by adopting different rice varieties and practices in order to adapt to those three different agro-ecosystems. The normal water regime comes from the lake covers firstly zone 3; secondly zone 2 and the latest zone 1 (see Table 2-3 below).

[3] We don't include in our study the concession or any large scale exploitation more than 100ha because first of all we can't get access to them and secondly, it doesn't represent farmers' situation.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Zone 1												
Zone 2												
Zone 3												

Table 2-3: Water regime in the study zone

Flood under TLS flood pulse Flood period in case of disaster

2.3.2. Evolution of rice production system in study zone

Situated on the floodplain of TSL, the study zone is appropriated for rice but unfortunately, due to a lack of water management, the region never knew a glorious period of rice exportation from 1953 to 1970 but ensured their subsistence. The production system was not much different from nowadays. One production system is a combination of floating rice and rainy season rice in order to adapt to the ecosystem that they own on 3 zones. They start in April with floating rice on zone 3 and some on the lowland of zone 2; following by long term rainy season rice in June on zone 1 and 2; and finish with medium term rainy season rice in September on zone 3 as receding rice (see in the session 2.3.3 below). According to elderly farmers, the soil was very fertile and they produced without chemical amendment. Unfortunately, the combination of rainy season floods and dry season drought resulted in many farmers consistently losing their full yield for multiple years. The qualitative data is based on unstructured interviews with elderly farmers and a literature review (Allen and Long, 1989; Mak, 2001; Neupert and Prum, 2005). The history of the study zone is summarized as follows.

In the period of Republic of Cambodia (1970-1975), agricultural activity was disturbed by war and the hunger started. Over the suffering year of 1972, their production was destroyed by bombardment and the villages were burned. Farmers relocated to the dry forest northern of Kampong Thom province. They got organized to survive in groups of 5 to 10 families by collecting NTFP and cultivating pluvial rice.

During the Khmer rouge regime (1975-1979), they endured the same thing in the whole country. They had to work hard on collective rice fields and agricultural infrastructure

construction. The canal was built across the village to irrigate rice fields. Floating rice fields in zone 3 and 2 were completely abandoned. In some villages, they produced rice crops twice a year in zone 1 and 2 but every meal they were served with liquid porridge and salt. They didn't know how much the yield was, they always harvested heavy panicles though they were granted only about 10 grains in a liquid porridge.

In the period of People's Republic of Kampuchea (1979–1993), they started their new life by producing rice on collective rice fields until 1983 when the government distributed 41 acres of land to each individual farmer. The land was situated in zones 1 and 2. The majority of farmers transplanted because they believed that it gave more yield than direct seedling. The Zone 3 was occupied by Khmer Rouge soldiers but farmers were permitted to collect NTFP, firewood, animal grazing and fishing as well as clearing shrubs and small trees to convert into floating rice field once again. From 1985, floating rice activity in zone 3 was an important source of food security because it was linked to all above activities. There was a consistent risk of floods during the rainy season and drought in the dry season. Otherwise, agricultural infrastructure that was built during the Khmer Rouge Regime was useless because it was built without studying the gravity. In the 90s, High Yield Variety (HYV) was introduced to farmers but it wasn't adopted because farmers possessed insufficient funds to invest in chemical fertilizers and pumping water for irrigation. Moreover, the techniques at that time was transplanting for HYV, it was overload of work for farmers.

From 1993 ("The kingdom of Cambodia" period), the government provided strong support for agriculture by building new and repairing the Khmer Rouge's irrigation system. Farming practices and farming system remained the same with small farmers but there was an increase in the adoption of some HYV and chemical inputs use increased remarkably. From 2002 to 2009, it was a hot period of land tenure. It starts by concession of agricultural land (2000ha) and 4 other private companies invest for HYV rice production in zone 3. A lot of farmers lost their floating rice fields for those who didn't have land title. Anyway, those who had land title had no choice but to sell their land to them because their dams stop water from going into floating rice fields. In 2003, there was a campaign to give land title but because of corruption, some farmers became victims of land loss. Since they got land title, rice fields selling was increased especially floating rice field because of low yield, water regime was disturbed, animal grazing were prohibited by companies for the

land next to companies. It was a real challenge for agriculture in this region. Nevertheless, irrigation system constructed by companies became an opportunity for some farmers to adopt HYV by buying water from them and benefit also for transportation infrastructures. Consequently, the majority of flooded shrub, flood grassland and flooded forest was cleared more and more. Before the widespread adoption of HYV in 2002, farmers produced long term and medium term rainy season rice in zone 1 and 2 then floating rice in zone 3 as well as on some lowland in zone 2. So, in dry season, all rice fields were in fallow thus grass and shrub took place under clear flooded forest. After the adoption, HYV was cultivated mostly in zone 3 and some in zones 1 and 2 if possible to irrigate.

Organic rice production has parallel but separate history. The organic farmers Raksmey Steung Sen Association (RSSA) was created in 2003 but recognized by the Ministry of Agriculture, Forestry and Fishery (MAFF) and the Ministry of Commerce (MoC) in 2006. Financial aid was provided by German International Cooperation (GIZ), German Development Services (DED), International Finance Cooperation (IFC) and the European Commission. This association aimed to improve the productivity of farmers by introducing new technologies and practices as well as increasing the value-added. Organic and SRI techniques are transferred to farmers. The supporters helped farmers to manage their value chain from production through to marketing. The contract was made directly between the association and buyers (organic shops, restaurant and hotel in Siem Riep and Phnom Penh). The recruited farmers are poor with less than 2 hectares of land. Anyway, they can produce organic rice only in zone 1 to avoid flood. Nowadays, they are 20 in association.

In 2007, COrAA (Cambodian Organic Agriculture Association) took reins and guided the association to produce and certify organic rice, COrAA also provided additional important support such as market information sharing and conducting a dialogue on policy. All members of the association have to buy at least one share of 30000 riel (7.5$). These shares bring funds to the association to buy rice from farmers and sell to the buyers. They will also be used to finance micro-credits for members with low interest rates of 3%/month. When rice is sold, the final benefit[4] will be divided as follows:

- 42% is given to the shareholders (i.e. the farmers)
- 25% is devoted to increase funds

[4] Final Benefit = (Total benefit after rice sold) − (Interest of the loan during the year (3%)) − (5 riels/kg for each vice chief) − (5 riels/kg for each chief producer) − (7000 riels for each 300 kg to buy clothes)

- 20% is, allocated to the association emergency fund
- 10% is used for the association staff salaries
- 3% is used for the administration costs (to which must be added the 3000 riel (0.75$) fee)

2.3.3. The actual cropping system

We divide rice cropping into 3 main categories based on the cropping calendar (see Table 2-5*)*, location and practices (see Figure 2.2 and 2.3 p. 58). In each main type Rainy season rice, Short-term rice, Floating rice, based on variety and practices that the farmers use in one parcel, we divide them into different rice cropping systems as is described below:

	Rice cropping system	**Yield (t/ha)**	**Paddy Price ($/kg)**
Rainy Season Rice	Medium term rice with direct-seedling (MTD)	1.30	0.30
	Medium term rice transplanted (MTT)	2.20	0.30
	Long term rice with direct-seedling (LTD)	1.30	0.28
	Long term rice transplanted (LTT)	1.90	0.28
	Organic Rice (OR)	2.20	0.32
Floating Rice	Floating Rice (FR)	1.57	0.21
Short-Term Rice	Early season rice (ESR)	4.57	0.22
	Receding rice (RR)	4.57	0.22
	Early season rice + Receding rice (ESR+RR)	9.14	0.22

Table 2-4: Rice cropping systems typology

We separate the practices of transplanting from direct-seedling because these practices give different yield in rice cropping system. And yield difference will reflect different opportunity costs between systems. Generally, transplanting requires more labor but it increases the yield. Direct-seedling is the most common practice but transplanting is used where lands are not flooded. Farmers choose different varieties and practices in order to adapt to water regime by ensuring that the vegetation stage of rice occurs during the period of deep water. The choice of medium or long-term variety is dependent upon the local water regime and rainfall. When the rain comes early, between April and May, they cultivate long term rice more than medium term because there is enough water to sustain the rice until the completion of the 6-month-long growth cycle.

In most of rice cropping systems, farmers can produce a single cycle per year and per parcel because of the water regime and the photosensitivity of rice varieties. However, early season and receding rice can be grown in combination both on the same rice field when there is possibility to irrigate and to drain.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
MTD		Land preparation		Sowing		Maintaining (Weeding, water adjustment…)		Harvest				
MTT		Land preparation		Sowing	Transplanting		Maintaining Weeding, water adjustment…)	Harvest				
OR		Land preparation		Sowing	Transplanting		Maintaining Weeding, water adjustment…)	Harvest				
LTT	Land preparation		Sowing	Transplanting		Maintaining (Weeding, water adjustment…)		Harvest				
LTD	Land preparation		Sowing	Maintaining (Weeding, water adjustment…)				Harvest				
FR	Land preparation		Sowing	Maintaining (Weeding, water adjustment…)				Harvest				
ESR											Land preparation &Sowing	Maintaining (pesticide & water)
		Harvest										
RR									Land preparation & sowing		Maintaining (pesticide & water)	
	Harvest											
ESR + RR	Land preparation & sowing	Maintaining		Harvest				Land preparation & sowing		Maintaining (pesticide & water)		Harvest

Table 2-5: Rice cropping calendar

2.3.3.1. Rainy season rice cropping systems

Rainy season rice cropping systems are viewed by farmers as their traditional method of rice production. It is based on the selection of natural seed varieties based on the traditional historical practices specific to their family and community. The scientific term for these seasonal is photoperiod sensitive rice varieties (CARDI, 2007). Land preparation always begins between April and May, with 2 cycles of ploughing that commence when the first rains come. The first ploughing, is used to "wake up the land" and the second is to break down all clods. Technically, these practices help them to manage weed efficiently because all weeds are totally incorporated and decomposed well by the soil. Afterwards, farmers will plant direct seedling a week after the second plough. Direct seedlings (MTD and LTD) are used more than transplanting (MTT and LTT) because labor becomes rare in that region. They choose to transplant when planting is running behind schedule and water covering their land that they can't do direct seedling. In this case, they need to prepare also

the nursery, which demands much more attention in weeds control to facilitate the germination. Normally, they need approximately 20 to 30 persons/ha working one day. Contrary to direct seedling that only 1 to 2 fl/ha can finish work for 1day or half of day work. Furthermore transplanting needs to be done no later than the first week of September to give enough time for vegetation stage; if not it will give lower yield.

Medium term rice (MTT and MTD) is traditionally the first choice of farmers in this region in order to produce Ambok (grilled and flattened by crushing) and sell in Phnom Penh during the national event (Water Festival) in November. Its cycle begins in May and ends in November (see Table 2-5). 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 (CARDI, 2007). This rice is mostly cultivated in zone 1 (90%) because it cannot bear immersion in deep water for a long time. This variety can also be grown temporarily in zone 2 when the water is not high.

Long-term rice (LTT and LTD) is cultivated 62% in Zone 2 and 38% in Zone 1. Direct seedling (LTD) is predominantly practiced in Zone 1 and some high land in Zone 2 where there is less water during the early rainy season so that they can sow on muddy land. On the other hand, transplanting (LTT) is adopted for Zone 2 and some low land in zone 1 where they can transplant in 20 to 30 cm of water height. As workers become rare in the region, farmers prefer direct seedling. According to farmers the long term variant can survive very well in deep water until 60 to 70 cm. These varieties have 6 month of life cycle starting in April and ending in December (see Table 2-5).

Meanwhile, long and medium term rice are natural varieties and photo periodically sensitive so that local farmers selected them naturally to adapt to this agro-ecosystem.

In Rainy season rice cropping system, farmers don't use many chemical inputs. We met only a few farmers who use herbicides or/and pesticides when required and fertilizers when they have sufficient funds. For example, pesticides that they often use are Sapen Alpha 1sachet/ha against crab, which cost them 1.2$/ha. For fertilizers they often use DAP for 50 to 100kg/ha, which cost them around 20$/ha to 40$/ha. Beside these farmers, they produce in natural way. Most of them put manure from 3 to 6 ox chart per ha (around 30kg/ox chart). The yield in average is 1.3 t/ha for direct seedling and 2.2t/ha for

transplanting.

Organic rice (OR) is considered by farmers as rainy season rice. They cultivate this rice only in zone 1 particularly on high and not flooded land. It has the same life cycle as the other medium term rice variants. This rice cropping system is transplanted with only one stem when farmers have been trained in SRI (System of Rice Intensification) technique by NGOs. Organic farmers are mostly former SRI farmers. SRI practices are transferred to farmers in order to improve their productivity by increasing organic fertilizer use (Ly *et al.*, 2012). Unfortunately, it was adopted by few farmers because in the study region as it is difficult to manage the water in order to transplant in muddy soil with single young stems. The organic label came later in 2003 to enhance the practices and increase farmers' revenues. Sometimes, farmers confuse SRI with organic or the one stem transplanting practice. Organic farmers understand how to achieve accreditation as an organic producer by adhering to their standard of zero chemical inputs within 3 years. 55% of farmers in the RSSA produce organic rice on 100% of their land with 0.77 ha in average per household. For the others, because of the ecological risk of flood, they use only the appropriated land for organic rice while they use the remainder to produce floating rice associated with long term or medium term rice. Farmers said OR needs from 2 to 3t of compost per ha but they can find only 1 to 2 oxcarts (around 35kg/oxcart) per year. This is the main constraint and factor limiting their yield to 2.2t/ha in average.

2.3.3.2. Floating rice

Floating rice is normally a cropping system of rainy season rice but this study keeps it separate because of its particularity that used to adapt to deep water in zone 3 and this system is replaced by short-term rice. Since 2002, many lots of floating rice fields have been converted to short-term rice in zone 3. It is why only 36% is found in zone 3 and 64% in lowland of zone 2. In rainy season, predominantly in Sept and Oct (see Table 2-5), overflow from the lake inundates the paddy field with up to 4 meters of water, creating the condition that only floating rice can adapt to this deepwater environment. These rice varieties can elongate their stem up to 30 centimeters per day and keep their leaves above the surface of water and escape drowning (Cummings, 1978). In our study zone, farmers argue that these rice can grow up to 50 centimeters per day when there is flood disaster.

This rice cropping system is the most extensive that needs low labor and capital. As soon

as possible when there are the first rains (see Table 2-5), farmers start ploughing the land two times, if needed, in order to incorporate weeds into the soil and let them decompose inside. After harrowing, they sow the seed in April or later in May and harvest in December. Since 2010, some farmers have started to use herbicides instead of ploughing twice. In these practices they use the Roundup to kill all weeds before incorporating them into the soil. This rice cropping system is the most resistant to flood but is also the most risky in yield loss because of rats. When the water is still high in maturity phase, the rats can climb on the tree and eat the rice panicles. They can't use any pesticides or rats poison because of high water. This fact makes this rice become almost chemical free with low yield, 1.57 tons in average but it still more than direct seedling rainy season rice (1.2 to 1.4 t/ha). It is because the lands for rainy season rice get less alluvium from the flood compared to floating rice field. Some farmers of floating rice, in zone 2 try to use some fertilizers, 50kg/ha of Nitrogen (N) but the yield is not enhanced because of the run-off of N by water.

2.3.3.3. Short-term rice

Since 2002, there have been more and more farmers adopting short-term rice in this region because they lost too much floating rice yield flood disasters almost every year. In the case of flood in 2010, 2011 and 2012, short – term rice were out of risk. The factors that accompany them to change production are:

- Market for input and output: The Vietnamese businessmen provide credits with seed and chemical inputs and in addition, they go to buy rice directly from the rice field even if it is far from the village.
- Agricultural Services provider: At the same time, there are private services providers for ploughing, harvesting, pesticide paying etc. Those services are copied from Battambang provinces where rice productions are mostly developed. A lot of combine-harvesters are from that province. Moreover, they come with the examples of intensive rice production systems techniques to share with farmers in Kampong Thom provinces. These kinds of services facilitate farmers to adopt short-term rice easily without any more capital needs. Services providers accept also to be paid at harvest time when farmers sell their rice directly in rice field, so all reimbursements are made at the same time. What farmers said is that everything

takes place on the rice field. However, this model is only realizable transportation and combine-harvester vehicles have access to the rice field. Most short-term rice farmers are converting by tearing out all trees, shrubs from their field to allow access to these machines. So, it is much easier for farmers to produce short-term rice when compared with rainy season and floating rice variants that they need to harvest and dry by themselves. Sometimes, the weather is not favorable so, they risk to lose the quality of rice.

- Irrigation system: There are 3 kinds of irrigation sources. First, is from the companies which produce short-term rice, second is from the government and last one is from the natural sources. We saw that there are few companies which own between 150ha to 200ha of short- term rice. They can produce 2 to 3 crops per year by constructing irrigation system. They build high dams around their land to prevent flooding from the great lake and divert waters to their reservoir and canals. Although, this fact is a chance for farmers who have fields around to take advantage of irrigation system and infrastructure to develop short-term rice productions by buying the water from companies. In zone 3, there are also some farmers constructing and integrating mini irrigation systems directly into their rice field.

Short-term rice becomes farmers' strategy to adapt and mitigate to flood disaster by cultivating rice out of flood calendar *(see* Table 2-3 *pages 60 and* Table 2-5 *pages 64)*.

The first cropping system of short-term rice is Early Season Rice (ESR). It is cultivated in all study zones but the majority is in zone 3 for 45%, 34% are in zone 2 and 21% are in zone 1. The second is Receding rice (RR), in majority, is produced in zone 3 (47%), 36% in zone 2, rest 17% are in zone 1. They can produce in zone 1 and 2 thanks to the irrigation system constructed by the government as well as natural pond and waterways. In zone 3, they buy water from the company. The last one is a combination of early season rice and receding rice (ESR+RR) on one parcel. This is the most productive system because of the double harvest. Although, it is also a system that uses the most water and chemical inputs. 36% of this cropping system is in zone 3; 40% in zone 2 and 24 % is in zone 1. The yield of short-term rice is 4.5t/ha to 5t/ha. So if they can produce 2 cycles (ESR+RR) it means that they can get almost 10t/ha.

Short-term rice cropping system uses a lot of chemical inputs with techniques provided by Vietnamese businessmen who sell a package for inputs, which has seeds and chemical inputs. Problems occur when farmers adopt bad techniques when deploying the cocktails of pesticides, which means they mix at least 3 different pesticides in one to spray for one time. The agricultural department (MAFF) and other agricultural development projects led by NGOs such as CEDAC[5] and HARVEST[6] provide training in good techniques of chemical use but there is a tendency among farmers not to put them into practice effectively.

2.3.4. Towards a typology of production system

The term of production system as known as farming system indicates, means the understanding at once the structure and the diversity of farm organizations. It is necessary to understand what the farmers do; how and why they combine a number of cropping systems on one farm; and to evaluate their economic return. Understanding the rice cropping sub-systems, and their relationships *are* definitely the most important starting point when attempting to understand the farmers' choice. The typology of production takes into account 3 main factors (Land Capital and Labor) and incorporates them with how association of cropping system on their lands (see Figure 2.4) by managing agro-ecosystem (Cochet and Devienne, 2006a). Farmers combine these different cropping systems on a given agro-ecosystem in order to maximize their revenue and minimize the vulnerability faced to risks of flood. In general, one farmer owns the land all over the 3 zones in order to minimize those risks.

Land: Based on the data, we can divide the size of exploitation into 3 sizes:

- Large exploitation: from 5 to 11 ha
- Medium Exploitation: from 2 to 5 ha

[5] Centre d'Etude et du Développement Agricole du Cambodgien. It focuses on building the capacity and knowledge of rural farmers in ecologically-sound agriculture and is especially recognized for its farmer-led extension services, agricultural innovation trainings, support for farmer organizations and publications.

[6] Cambodia HARVEST is a five-year integrated food security and climate change program supported by the American people through the United States Feed the Future and Global Climate Change initiatives. The program seeks to reduce poverty and malnutrition by diversifying and increasing food production and income for up to 85,000 rural Cambodian households. It focuses on four provinces around the Tonle Sap Lake: Battambang, Pursat, Siem Reap, and Kampong Thom, where there is a high percentage of poor and food insecure families.

- Small Exploitation: from 0.12 to 2 ha

Capital: If we look at the level of capital investment on farms, we could see 3 levels of mechanization as follows:

- Mechanized: for those who possess mechanical mule and motor pump.
- Medium mechanized: for those who have only a motor pump.
- Non-mechanized: for those who have neither a mechanical mule nor a motor pump.

Labor: In this region, farmers don't use permanent employees. All permanent labor forces are family members. When they need more labor, they exchange help between family relatives, friends and neighbors. If, they can't find enough labor they will engage daily workers. The family labor (fl) force is calculated based on the data gathered on the proportion of their time that they spent on their production activities. It is not a total family member or number of active persons in production but it is about the percentage of each family member's time contribution in the production.

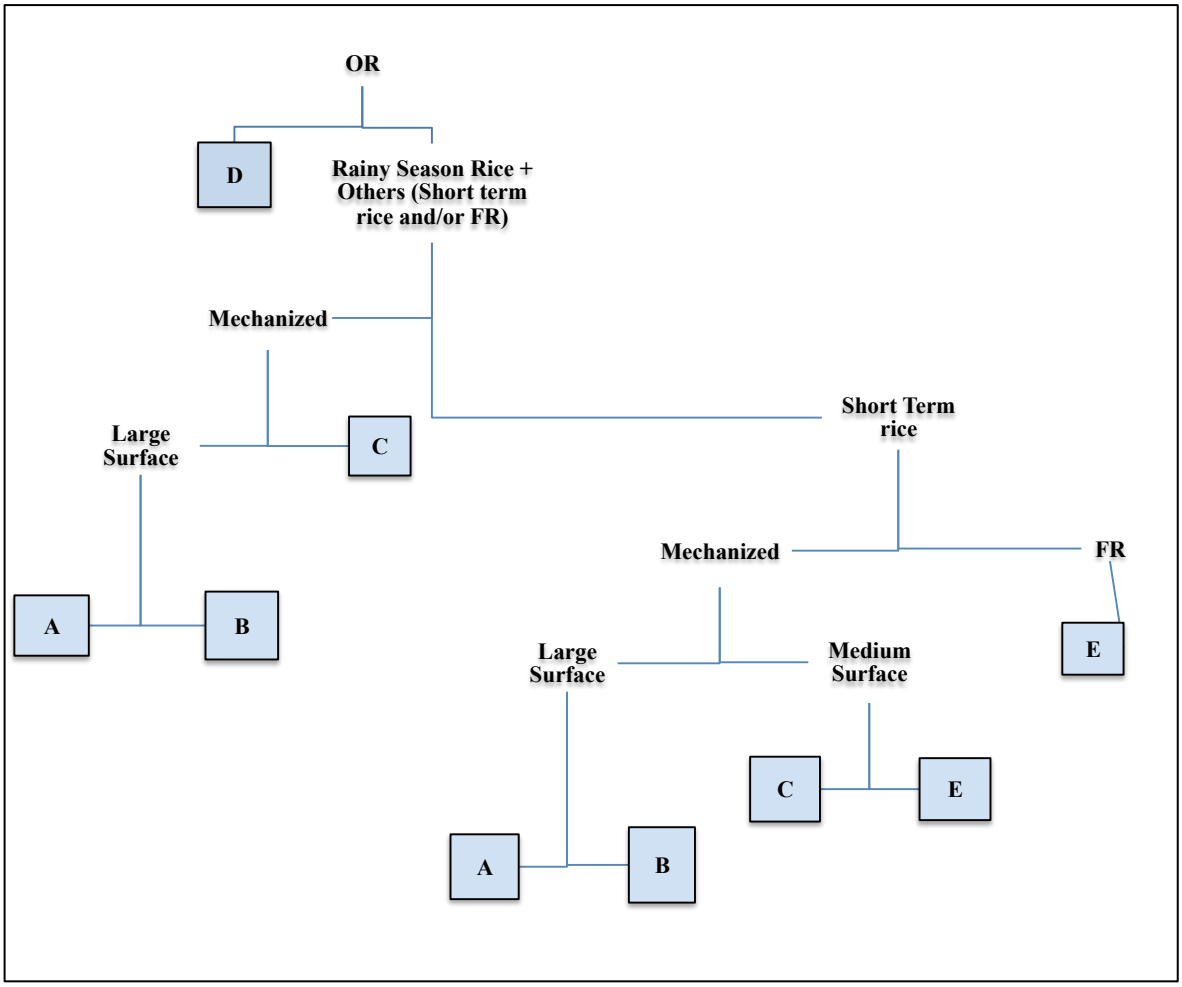


Figure 2-4: Production systems typology chart

There are 5 main types (see Table 2-6) of production systems that farmers practice in the region in order to better manage agro-ecosystem and maximize their productivity.

2.3.5. Medium to large exploitation mechanized (Group A)

This group is characterized by comfortable farmers in the region. They have made investments focused on the conversion of most of their rice field into short-term rice fields. These investments include building canals, reservoirs and dykes to ensure the irrigation as well as clearing out the trees and shrubs of flooded area in zone 3. The additional variable costs of buying water and chemical inputs for short-term rice production are also very high. Poorer farmers cannot afford this level of investment. In this production system, they often associate short-term rice with other rainy season rice and sometimes with floating rice. The local farmers consider the group A as the pioneers who ensure the economic

growth for the country.

The A2, A5 and A6 types have adopted the monoculture of short-term rice growth even when they own the land in 3 different zones. This group of farmers have enough capital to convert their entire rice field into a form compatible with short-term rice production.

Number of farmer (165)	Rice production system (j)	Surface in average (ha)	Labor	Mechanization	
				Mechanical mule	Pump
22	**A. Medium to large exploitation mechanized**				
4	A1. RR + MTT + LTD	8.93	3.5	yes	yes
2	A2. (ESR+RR) + RR +FR	7.85	3.5	yes	yes
3	A3. ESR + RR + LTT	8.27	3.7	yes	yes
3	A4. (ESR+RR) + RR	5.30	3.7	yes	yes
3	A5. (ESR+RR)	5.00	3.7	yes	yes
5	A6. RR	5.00	3.4	yes	no
2	A7. (ESR+RR) + MTD + FR	2.65	3.0	yes	yes
28	**B. Small to medium exploitation with medium mechanized**				
5	B1. RR + MTD + FR	3.53	2.5	no	yes
5	B2. (ESR+ RR) +MTD	1.58	2.7	no	yes
11	B3. RR+FR	2.99	3.0	no	yes
7	B4. ESR + FR	2.06	3.4	no	yes
48	**C. Small to medium exploitation non-mechanized**				
11	C1. (ESR+RR)	0.97	2.6	no	no
14	C2. MTD + FR	2.39	3.8	no	no
11	C3. MTT + MTD	1.16	2.8	no	no
6	C4. LTD	1.16	2.5	no	no
6	C5. LTD +FR	0.94	2.9	no	no
22	**D. Small exploitation Organic non mechanized**				
6	D1. OR + LTD	1.50	2.0	no	no
11	D2. OR	0.77	2.7	no	no
5	D3. OR + FR	1.29	2.7	no	no
45	**D. Pluri-activities exploitation non-mechanized**				
42	E1. FR	1.25	1.6	no	no
3	E2. ESR	0.30	2.0	no	no

Table 2-6: Rice production systems typology

The type of A1, A3, A4 and A7, combine short-term rice with rainy season rice. The fundamental reason is their rainy season rice fields have insufficient irrigation and drainage for short-term rice. Those A3 and A7, produce MTD and MTT in areas where they cannot produce short-term rice. Adopting short-term rice help farmers to minimize

risk from flooding and combining that with MTT and MTD production is the way to minimize the impact of falls in short-term rice. However, if they could they still want to convert all rice fields into short-term rice because the risk of flood is higher than risk of price drop.

2.3.5.1. Small to medium exploitation with medium level of mechanized (Group B)

This category of production system is composed of medium farmers who use services of the available agricultural services provider to increase their productivity in the short-term. Therefore, their expenses in intermediate inputs per hectare is a little bit higher. Based on the possibility of irrigation and their capital, they can convert a part of land situated in zone 3 and zone 2 into short-term rice field. In the other lands, they still continue to produce rainy season rice. The trend of this group is they will convert more and more rice field into short-term rice by using their annual benefit.

2.3.5.2. Small to medium exploitation non-mechanized (Group C)

Majority of farmers in this category combines the rainy season rice cropping system with including floating rice cropping. These systems (C2, C3, C4 and C5) are common practice and they are considered as traditional practices by farmers. MTT and MTD cropping system are the most chosen because of their high value-added compared to other rice cropping system. They are appropriate to combine with FR because FR doesn't need much labor or maintenance during the growth stage. Therefore farmers can have time to focus on transplantation and the weeding and water management of the medium term crop (see Table 2-5 *)*. Contrary, MTD or MTT have high risk of yield loss face to flood disaster in late rainy season in October. Moreover, if the weather is still wet and raining within the harvest period (November), the quality of paddy will be low and not suitable to make Ambok (grilled and flattened by crushing) for water festival. Consequently, they will sell for lower price. These farmers of group C, consider themselves as poor and not courageous to invest for short-term rice because they are afraid of their inability to repay any incurred.

The system C1 produces monoculture of short-term rice as the large exploitation in group A and B with their technical supports. The system C1 is in zone 3, where farmers converted from floating rice field into short-term rice fields. This group of farmers expose themselves to debt (inputs seller or private micro credit) because they need to purchase all

inputs. For them, the debt is a challenge because they see that short-term rice is the way to adapt to flood and bring them out of poverty.

2.3.5.3. Organic non-mechanized (Group D)

Organic farmers are often pluriactive combining with non-farm activities such as moto taxi, home groceries, motorbike and bicycle reparation and carpenter, etc. They cannot rely on their production to ensure their livelihood. Organic rice production helps them to increase their income but not sufficiently to create wealth. Their typical situation before 2003 was that of a poor farmers who owns approximately 2 hectares of land. They were selected by the NGOs at that time in order to help them to generate the income with the value-added through organic rice production. As their land is limited to 2ha and organic rice can only be produced in zone 1, they cannot markedly increase their income. Anyway, this is still the best solution for them because no additional funding is required in order to produce organic rice by using available inputs. Only in some rare time do they need to pump the water for irrigation. As members of the association, they are in a stronger position for negotiation and lobbying activities. Organic rice accreditation is relatively straightforward because their poor economic position means they had to money to adopt any other model. The result from group discussion shows that these farmers considered themselves as "poor and illiterate farmers" who don't have a sense of wealth creation. Thus their actual status makes them proud because they become:

- Trained farmers, the farmers who participate in the meeting and seminar
- Producers of quality: good for environment and human health
- Model farmers who participate in policy making event of MAFF

These farmers have a strong commitment not to adopt short rice in their production because of the fact that this cropping system is the source of chemical pollution. In their practices of other rainy season and FR are also organic but they can't get the label because those lands are covered by water every year. Furthermore, COrAA doesn't have the label for medium quality of rice (non-fragrant rice, which Khmer people class as the normal rice of rainy season). The organic label is given to the organic practices of Jasmine or Romdoul varieties, which are first quality (fragrant rice).

2.3.5.4. Pluri-activities exploitation non-mechanized

These production systems (E1 and E2) are characterized by poor farmers working as agricultural laborers for third parties during the rainy season. During the dry season they work as construction worker or soil transporters at Phnom Penh or as rubber workers. Other family members may work in textile factories in Phnom Penh. They have in average 1.19 ha/family and possess no machinery and use no third-party agricultural services. They aim to produce a crop with the minimum of financial outlay. The causes of the farmers only having small amounts of farmland vary:

- Some families possessed no children or were unmarried at the time of land redistribution in 1983. So they don't have much land to transfer to the children. So the young farmers have only the possibility to clear out the flooded land in zone 3 for FR.
- Some families sold their land in zone 1 and 2 because of debt and illness. They keep only land in zone 3 where is too cheap to sell and nobody wants it.
- Some families needed to send their family members (daughters and/or wife) to find work in Phnom Penh predominantly in the textile industry, so they have to sell small piece of valuable land in zones 1 and 2 to finance their urban living expenses until they begin to generate a revenue stream after finding employment.

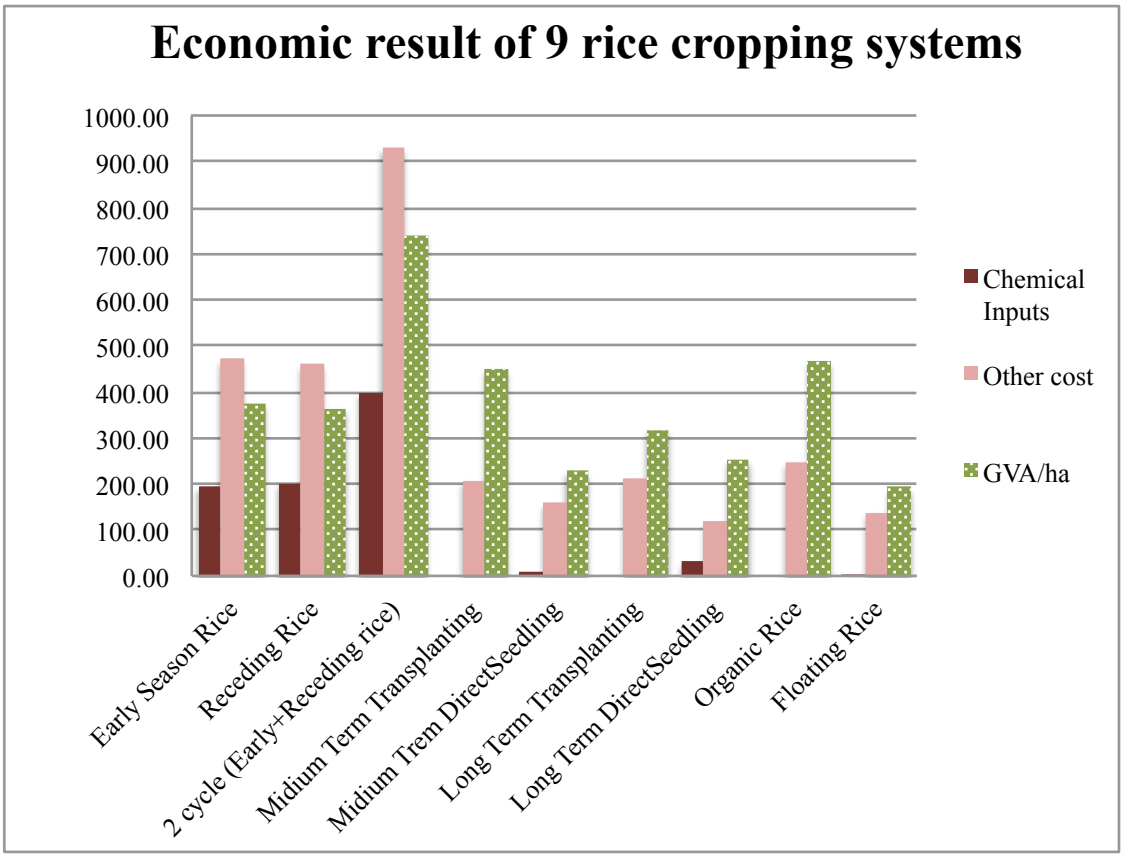
The system E2, farmers convert from FR to ESR hoping to increase their land productivity. Anyways their rice field surface is too small to be able to produce the same value-added as the systems in group A.

2.3.6. Economic results

The economic result is the way to show the efficiency or productivity of the system that is dependent on the agro-ecological condition of their parcel (Dufumier, 2006; Aubron *et al.*, 2009; Barral *et al.*, 2012; Charroin *et al.*, 2012). The typology of production system (see Table 2-6) illustrates that large and medium exploitation focuses on short-term rice to the greatest extent. It is because they have the most capital to expend on more expensive systems compared to the other groups. By comparing their economic performance, we will be able find out clearly the factor limiting the adoption of OR.

2.3.6.1. Gross Value-Added/ha (GVA_i/ha) of cropping system (i)

In Graphic 2-1 is the comparison of GVA_i/ha and intermediate costs of 9 rice cropping systems. The 2 cycles of (ESR + RR) is the most productive because of the double harvest in a year but it has also the highest cost of production. Anyway, MTT and Organic are the most productive as a part of one cycle rice cropping system. While, FR is still the least productive one because of low yield and low price. The comparison shows that if short-term rice can be more productive than MTT and OR, they need to double the harvest. MTT and OR have low production cost same as the other rainy season rice and FR but they have high price that increases the GVA/ha.



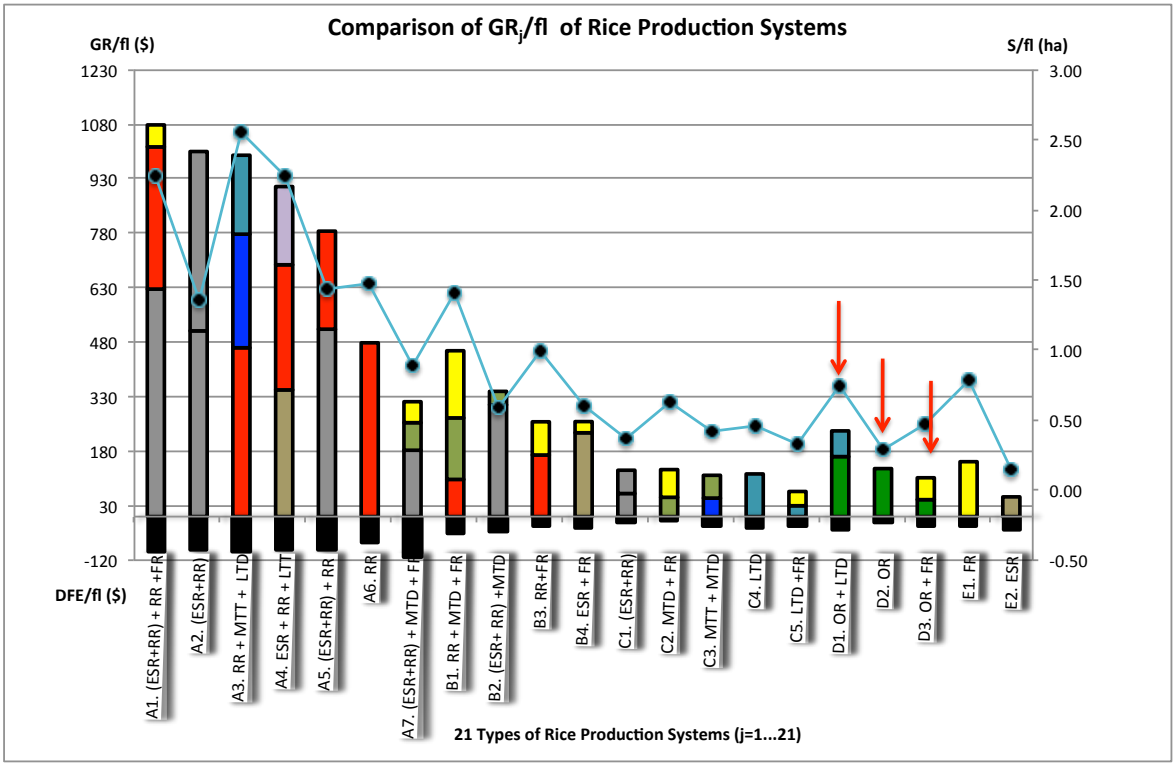
Graphic 2-1: Economic results of 9 rice cropping systems

The GVA/ha can show the land productivity but still does not explain the low level of adoption of OR. In the region there are only 20 organic farmers and that crop is not always on 100% of their land. If OR has high land productivity, why they are still poor? And why is the trend in the region to adopt short-term rice?

To respond to those questions, we need to deal with the value-added per family labor in the

production. Because, one production system is the combination of cropping system that farmers try to maximize their benefit and increase their work productivity.

2.3.6.2. Gross Remuneration per family labor (GR/fl)



Graphic 2-2: Comparison of GVA/FL of 21 production systems

From the Graphic 2-1 and Graphic 2-2, we switch from land productivity (GVA$_i$/ha) to labor productivity (GR$_j$/fl) in order to understand better the farmers' decision to maximize their profits.

The positive part of principal vertical axis is GVA/fl per year. It shows the wealth that farmer can make within a year based on their production. The negative part is the investment cost corresponding to farm equipment (DFE/fl) that one farmer needs in order to ensure his production system.

The economic result shows that the group A is the most profitable even if their investment in farm equipment per family labor (DEF/fl) is high. Within this group, the production system A2 has high-performance. With the smallest surface per family labor (1.35ha/fl), it creates the same level of wealth. So the possibility of doubling the cycle of short-term rice (ESR+RR) on total land, is the best opportunity for farmers to increase the profit they

make from agriculture. This fact shows very clearly, in the system A1, A5 and A7, that farmers can do (ESR+RR) on only 38% of their land. On the other part of their land, they can only cultivate a single –cycle of RR and FR. So that, these farmers need more land than in the system A2 to create the same level of wealth. Moreover, if they can do only one cycle of short-term rice combining or not with other rainy season rice, they really get less benefit with more S/fl as we can see in the case of A3, A4 and A6.

The result shows the same for the group B, C and F, short-term rice uses less land and is the most remunerated for farmers. The combination of short-term rice and rainy season rice is the way to maximize their profit and to use all the land that they own on different ecosystems (zone 1, 2 and 3).

The group D is organic rice production system (pointed by the arrows). In the Graphic 2-1 and Graphic 2-2 of GVA/ha shows that OR has high-performance per hectare but the truth is that farmers do not earn much money with this crop because one farmer can produce on average 0.28ha/fl of OR only. For this reason, they own small surface and limited non-floodable land as well as lack of inputs for compost; they can't increase the GR/fl by enlarging OR surface. If they can have more land to enlarge their OR system, they will also have high remuneration per family labor because OR can create high wealth on small surface (see system D2 in Table 2-6) compared to the other rainy season rice and FR (C2, C3, C4, C5 and E1).

2.4. Discussions and Conclusion

The adoption of organic rice by farmers in developing countries, such as Cambodia, is a complex issue. If the organization of value chain is a key component of this adoption, we believe that agrarian system analysis can also provide a good explanation of the farmer decision-making. Our analysis points to several constraints: economic, ecological, social and institutional.

Producing organic rice crops offers few revenues to peasants despite a huge GVA/ha (2nd / 9 rice cropping systems – see Graphic 2-1 page 76). The main problem is the lack of inputs for compost and using a high level of work. The possibility to get more revenue from other cropping systems leads peasants to choose, if they can, non-organic rice.

This economic argument is reinforced by ecological constraints. One of the key drivers of rice cropping systems is water management. Natural flooding is controlled and provides free ecosystem services (sedimentation, water provision). But the uncontrolled flooding (i.e. natural disaster) can destroy all production. This is more problematic for organic rice farmers because flooded production leads to the loss of their organic label. The strategy to cover this risk should be to produce rice in zone 1. But because zone 1 is the furthest from the TSL, water can reach the production fields later than in the other zones and provide delay with the rice cycle. Water risk management is the main challenge of most farmers. Adopting organic farming makes this risk management more complex.

The Social dimension of the agrarian system analysis is maybe the most accurate. In farmers' mind, organic rice targets the poorest farmers. It is worth noting that in that place, the promotion of organic rice was provided by NGOs, which targeted poor farmers. The main idea was that before being certified, poor farmers were organic farmers "by default". Because of their poverty level they did not possess sufficient funds to invest in intermediate inputs. Adopting organic rice cropping system was not problematic for them. Their actual status makes them proud because they become: (i) trained farmers (participating in meeting and seminar with foreign people), (ii) producer of quality (good for environment and human health), (iii) model farmers who participate in policy making event of the MAFF and (iv) part of an organization with a unified voice on the issues affecting their livelihood.

Despite all these advantages, organic farming is always viewed by local people as a tool for poor people and not an option for all farmers. Using chemical products reflects technical and professional skills. It enables farmers to adopt short-term rice cropping system, getting large fields and high productivity.

This feeling of freedom and modernity, far from organic label constraints, is strengthened by institutional constraints directly created by the organic value-chain. Even if organic

farmers get a better price (premium) with organic rice, they face up to long payment delays. Farmers will only be paid once their rice is sold by the association. The association can pre-pay farmers only if it possesses sufficient cash flow which stems from the farmers' adhesion to the association. Some farmers disagree with this system because most of the time they need cash as soon as possible after the harvest for family needs. In this case, they won't sell to the association and they will sell to normal local buyers with the reduced price of normal rice. Moreover, the price defined by the organic rice association is based on price of the previous year. Sometimes, the current normal market price is higher and organic producers prefer selling their rice to the normal market than to the organic one in order to maximize profits. All these behaviors are locally viewed as institutional constraints and block new organic adoption decisions.

To conclude, the promotion of organic rice production is a key challenge for most developing countries. It is not enough to define new national strategies and to show the potential of premium as a tool of sustainable development for poor farmers. Identifying local constraints seems to be a promising tool to understand opportunities and pitfalls of organic adoption. Combining economic, ecological, social and institutional constraints, as the agrarian system analysis does, is an interesting approach for researchers and policy makers.

Paper 3

3. Trade-offs between ecosystem services and opportunity costs in the Tonle Sap Lake agro-ecosystem (Cambodia)

Abstract

The usefulness of Ecosystem Services Framework (ESF) to emphasize relationships between agriculture and ecosystems has received much less attention. In addition, studies applying ESF to understand links between ecosystem services and rice production systems are still missing. The objective of this paper is to try to fill this gap by adopting the ES and EDS (ecosystem dis-services) approach suggested by Zhang *et al.* (2007), and combine with Agrarian System Analysis and Diagnosis methodology (Cochet and Devienne, 2006a; Dufumier, 2006; Cochet *et al.*, 2007; Cochet, 2012) in order to identify ES and EDS provided by rice production systems adopted by peasants on the agro-ecosystem of Tonle Sap Lake flood plain. Our finding show that organic rice production system is not economically and ecologically performant in ES provision. Contrary, rainy season rice, floating in particular, is the most performance for ES provision. We propose 3 choice to reconcile economic and ecologic performance as following (1) Promote production system with medium performance for ES but low opportunity cost is to promote adoption of rainy season rice excluding floating rice in combination with short-term rice. (2) Promote production system with medium performance for ES with medium opportunity cost is to promote adoption of rainy season rice including floating rice in combination with short-term rice. And (3) Promote production system with high performance for ES with high opportunity cost is to promote adoption of floating rice alone in production system.

3.1. Introduction

The Millennium Ecosystem Assessment (2005) has provided a new framework based on the ecosystem services concept in order to stress the need for ecosystem conservation. In tropical literature, this Ecosystem Services Framework (ESF) has been used mainly to provide economic and ecological arguments for protected areas, mainly in forest ecosystems (e.g. regulation services through hydrological function or carbon sequestration).

However, as explained by some authors (Zhang *et al.*, 2007), the usefulness of ESF to emphasize relationships between agriculture and ecosystems has received much less attention, except for specific value chains such as coffee or cocoa (Rapidel *et al.*, 2011). Yet, in tropical developing countries, this issue is particularly relevant. Agriculture is the main form of land management in these countries, in which food security and food sovereignty are key matters for farmers and policymakers. Several recent publications have shown the importance of agro-ecosystems in terms of sustainable development in rural areas. Most of these papers discuss the links between ecosystem services and agricultural activities, and as a feedback loop the links between these activities and ecosystem services (Swinton *et al.*, 2006; Dale and Polasky, 2007; Swinton *et al.*, 2007; Zhang *et al.*, 2007; Power, 2010). Based on a study case of rice production close to the Tonle Sap Lake in Cambodia, this paper tries to look further into that issue.

Cambodia provides a good illustration of this topic for several reasons. This country, which is ranked in the medium human development UNDP category in 2014 (137th among 187 countries), is mainly a poor and rural country. According to Mund (2010), about 80% of Cambodian people are living in rural areas and 90% of the country's poor are coming from these rural areas. The main drivers of rural development are dedicated to the agricultural system of lowland rice production. 85% of people living in rural areas are rice producers (Mund, 2010). According to the World Bank, the drivers of poverty reduction between 2004 and 2011 are the increase of rice production (23%) and rice price (24%), far ahead of other factors (farm wages [16%], non-farm business [19%], urban salaries [4%] and unexplained reasons [14%]) (World Bank 2013, p.50). In this context, the government tries to increase rice productivity through different way such as machinery and agricultural technology (new varieties, fertilizer, cultivation techniques). Whatever the policy

promoted, the key point of the adoption of rice production systems by these small farmers is the availability and controllability of water. That is why the main rice production area is located around the Tonle Sap Lake (TSL) flood plain. The TSL is the most suitable agro-ecosystem for rice production thanks to increased soil fertility through sedimentation and abundant water for this crop (see below for more details). But the agro-ecosystem also increases the risk of yield loss caused by flood. Besides, rice production terraces also serve as a flood control solution through dykes built between rice fields (Dan *et al.*, 2005; Tsubo *et al.*, 2007; Masumoto *et al.*, 2008; Someth *et al.*, 2009; Ly *et al.*, 2012). Thus, farmers face both positive and negative interactions with the TSL ecosystem. The implementation of rural development policies based on rice productivity in this critical ecosystem provides a good illustration of trade-offs between provisioning services and regulation services.

Little research has been conducted on this issue. On the one hand, literature related to the rice sector is abundant and the functioning of the TSL is well known. On the other hand, the ESF is mainly used in the forest sector in order to justify conservation activities (protected areas, payments for ecosystem services...). Studies applying ESF to understand links between ecosystem services and rice production systems are still missing. The objective of this paper is to try to fill this gap.

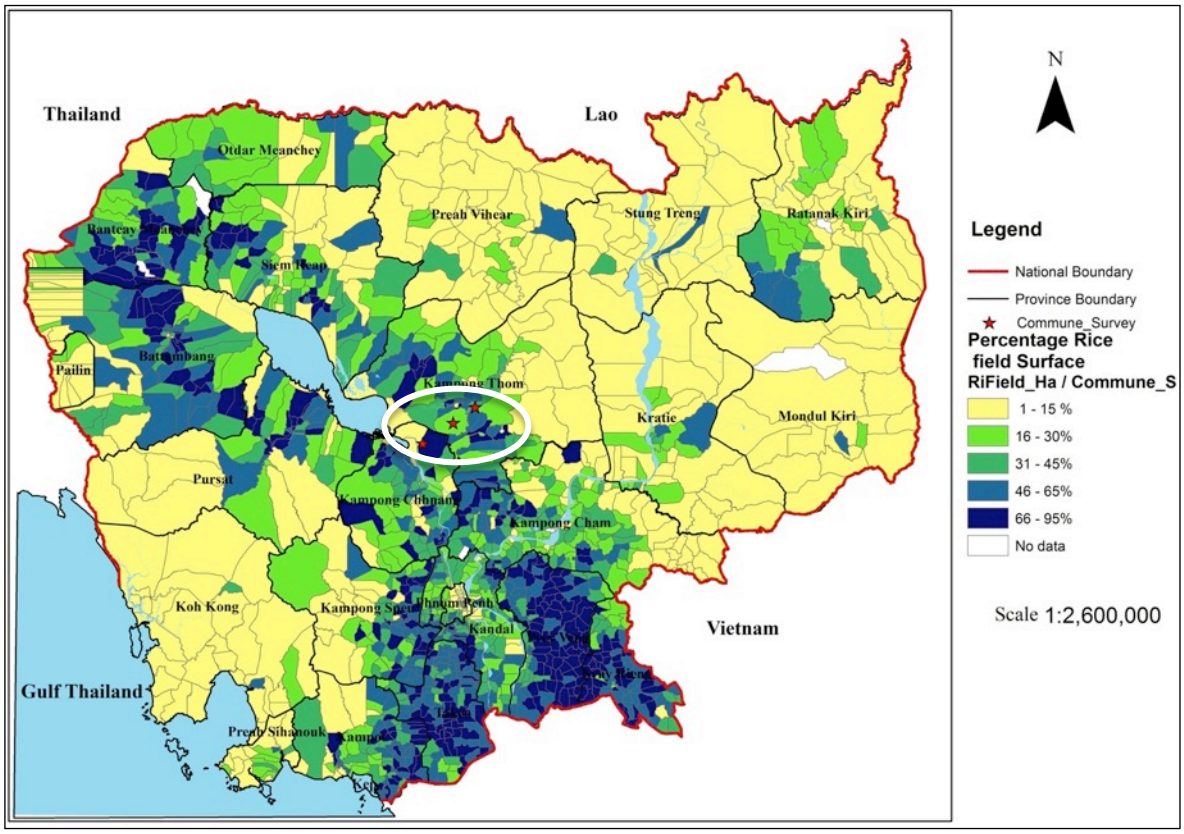
To do so, the first section describes the study case and the functioning of the TSL ecosystem. We present our methodology, based on the general structure of ES (Ecosystem Services) and EDS (ecosystem dis-services) suggested by Zhang *et al.* (2007). To study interrelations between agricultural activities and the ecosystem, we adopt the Agrarian System Analysis and Diagnosis. In the second section, we present our results, focused on ES and EDS provided by the agro-ecosystem in the different rice cropping systems and rice production systems adopted by farmers. In doing so, we are able to show the different trade-offs and opportunity costs between rice production systems. A general discussion about the usefulness of ESF based on this work is conducted in the last section.

3.2. Material and methods

3.2.1. Study site

The Tonle Sap Lake (TSL) is the largest fresh water lake in Southeast Asia and of the Mekong River Basin. In rainy season (May to October), this great lake receives and stores

the water flowing back from the Mekong river, rainfall, as well as its tributaries and expands until it covers up to 15,000 km^2. Contrarily in dry season (November to April), from late October/November water reverses into the Mekong river downstream and the lake shrinks down to 2,500 km^2 (Varis and Keskinen, 2006; Brooks *et al.*, 2007; Arias *et al.*, 2012). This natural mechanism ensures the flow of the Mekong river, protects the agricultural land of the Mekong delta in Vietnam from saltwater (Pham *et al.*, 2008) and ensures water availability for dry season and receding rice irrigation in Cambodia and Vietnam (Dan *et al.*, 2005).



Map 3-1: Rice field in Cambodia
Source: Open development Cambodia

Being the first Biosphere Reserve of Cambodia, this lake is also classified as one of the world's most productive wetland ecosystems (Varis *et al.*, 2006; UNESCO, 2012). Different researches confirm a high productivity of fish catch in the TSL. Van Zalinge *et al.* (2000) mentioned 289,000t to 431,000t per year but (TKK *et al.*, 2008) mention only between 179,500t and 246,000t. The lake is the fourth most productive captive fishery in the world, representing 16% of the Mekong river fish capture. It provides 60% of the

protein intake of the entire Cambodian population, who consumes 20kg to 60kg of fresh water fish per capita per year (Van Zalinge *et al.*, 2000; TKK *et al.*, 2008).

The flood pulse creates vast areas of seasonal floodplain habitats for birds and fishes as well as a rich plain for agriculture, which ensures local livelihood with rice (see Map 3-1 p.81), fish and non-fish aquatic products, timber and non-timber products (Lamberts, 2006; MacAlister and Mahaxay, 2006). Thus, this is the world's highest biodiversity and the most productive ecosystem for inland fish in Southeast Asia (Brooks *et al.*, 2007; Yen *et al.*, 2007). The whole ecosystem of the lake, floodplain and riparian flooded forest and shrublands provide an ideal wetland habitat for the Mekong fish species (feeding, breeding and rearing their young) (Kummu *et al.*, 2006). Varis and Keskinen (2006) show that the Tonle Sap Lake ecosystem plays an important role of flood regulation by preventing and mitigating floods in the lower floodplains. This floodplain provides a large seasonal reproductive grassland habitat to two-thirds of the world's bird populations, particularly the threatened Bengal Florican (Houbaropsis Bengalensis).

On the other hand, this grassland, integrated farming and biodiversity area supports since more than 1,000 years the livelihood of the local population, with grazing and traditional land use of wet season rice growing and dry season fallowing. These ecosystems are in many places used for floating and flood recession rice cultivation, which has low productivities. These paddies play an important role in regulating floods and fostering groundwater. Their dike systems use water harmoniously by storing it for irrigation and help to reduce the risk of flooding for the local cities as well as Phnom Penh. The excess water is stored and discharged slowly into the lake then down the Mekong (Masumoto *et al.*, 2008; Pham *et al.*, 2008). Every year, 1.6 million tons of sediment are stored in the lake and floodplain, making the soil naturally fertile with young alluvial deposits (Gray *et al.*, 2007; Kummu and Sarkkula, 2008) with long term sedimentation rate of $0.75mm/a^{-1}$ (Dan *et al.*, 2005).

In summary, this ecosystem provides huge ES for local peoples such as Supporting Services, Provisioning Services, Regulating Services and Cultural Services (Millennium Ecosystem Assessment, 2005, 2007). Before going into the details, we present basically the different components of ES provided by TSL through the ESF proposed by Millennium Ecosystem Assessment (see Table 3-1).

Supporting Services - Soil formation and fertility (Sedimentation, Biomass from forest) - Nutrient cycling - Primary production	**Provisioning Services** - Fish and other aquatic species, including plants - Non timber forest products (wild foods, honey) - Rice - Grass for grazing - Timber for firewood, house construction, equipment for agriculture and fisheries
	Regulating Services - Carbon sequestration by flooded forests - Regional and local water regulation - Natural habitat/biodiversity - Nursery - Waterways for transportation
	Cultural Services - Ecotourism (floating villages, birds, Tonle Sap trips) - Cultural heritage (floating villages) - Sense of place in cultural practices (Water festival) - Spiritual services (Arak Teuk "Water Guardian") - Cambodian culture

Table 3-1: Ecosystem services provided by Tonle Sap Lake ecosystem
Adapted from (Millennium Ecosystem Assessment, 2005)

3.2.2. Methodology

Following Zhang *et al.* (2007), we adopt the following framework: ecosystems and agriculture are embedded in a complex relationship based on positive and negative interrelations and feedback loops. Ecosystems provide supporting services (soil structure and fertility, nutrient cycling, water provision…), regulating services (soil retention, pollination…) and also dis-services (pest damage, flood disaster etc). But the ecosystem is not the only provider of ES (or EDS). Provisioning services and non-marketed services are the two main outputs of agro-ecosystems (see Figure 3.1).

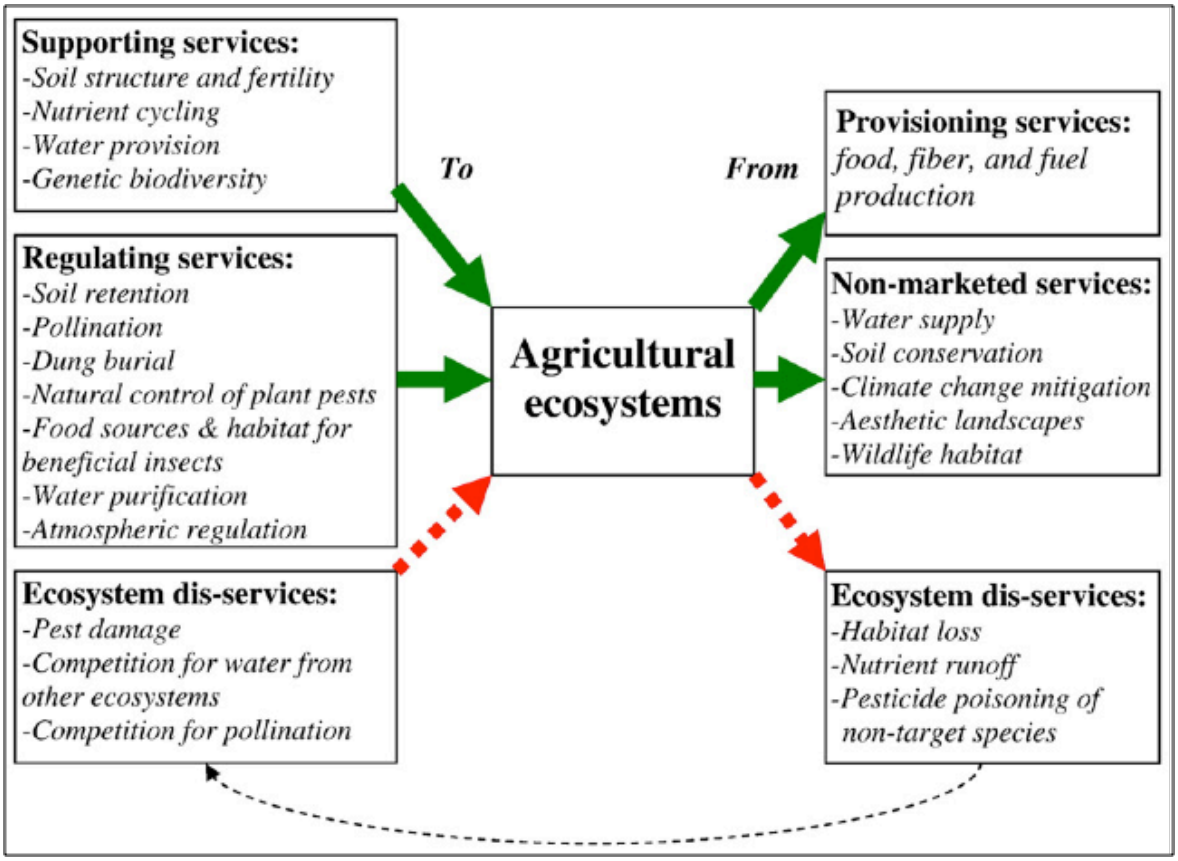


Figure 3.1: ES and EDS framework suggested by (Zhang et al., 2007)

In order to analysis these different flows of (dis)services, we adopt field methodology from Agrarian System Analysis and Diagnosis (Cochet and Devienne, 2006a; Dufumier, 2006; Cochet *et al.*, 2007; Cochet, 2012). The survey has been conducted in 3 stages in order to understand farmers' choices under socio-econo-political conditions: *(1) Landscape reading:* understanding the agro-ecosystem and zoning. Started by observation the agro-ecosystem and vegetations, the question "why" guide us to meet the elder and local people for better understanding of land use change in study zone. *(2) Historical study:* The current agricultural situation is the fruit of a long or medium term evolution. This study is trying to identify the key factors of change, which create the actual agricultural practices. *(3) Production system modeling and performance economic calculation:* This stage leads us straight into economics field. The comparison of performance economic (Value-Added "VA") and Agricultural Revenue per active) of production system will clarify and explain why in the same region farmers practices different production system (Neang *et al.*, 2014).

Evaluating the Economic Results of cropping systems (i) in one unit of land (ha) in one year
Gross Output (GOi/ha)

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

Qi: rice production (auto consumption + sold production); Pi: average selling price on the local market
Intermediate Inputs (IIi/ha)
II: monetary value inputs such as seeds, chemical inputs and services used (plouhing, transplanting, weeding, harvest, transport) during one year of production for each cropping system (i) in one unit of land (ha)

$$II_i/ha = \Sigma \text{ (quantity of inputs used/ha x price)} + \Sigma \text{ (service used /ha x price)}$$

Gross Value-Added (GVAi/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 economic reason for its adoption.

$$GVA_i/ha = GO_i/ha - II_i/ha$$

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

Evaluating the Economic Results of production systems (j) in one unit family labor (fl) in one year

GRj/fl = Gross remuneration of family labor in their production system (j=1…21). It aims to show the wealth created by one family labor (fl, equivalent to fulltime work) which combines different cropping systems (i). It explains the economic decision of farmer's combination of different cropping systems (i) in their production system (j). Thus we propose to go through this GRj/fl7:

GVAi= GVAi/ha x Si
Si = total surface of cropping system

$$GRj/fl = \Sigma\ (GVAi)/fl_{(i=1\ldots9)}$$

Economics Depreciation of Farm Equipment (DEFj): Showing the wealth created by farmers is not enough to understand the economic reason for adoption because each production system (j) needs different levels of capital to invest in farm equipment. We keep the DEF at least to compare the investment level that each farmer needs to start up the production.
DFE = current purchasing price / number of years of actual use

$$DFE_j/FL = DEF_j/(\text{number of family labor force})$$

Table 3-2: Economics calculation formula (Neang et al., 2014)

In summary, agrarian system analysis and diagnosis allow us get specific field data on agro-ecosystem management and agricultural practices. Our approach can be divided into 4 steps as following see Figure 3.2 as below.

[7] This article won't calculate farm Income because we would like to show up the wealth created from each rice cropping systems, which composes a production system. Consequently, we will be able to show up how the economic value of organic rice contributes to wealth creation that serves also to explain the level of its adoption.

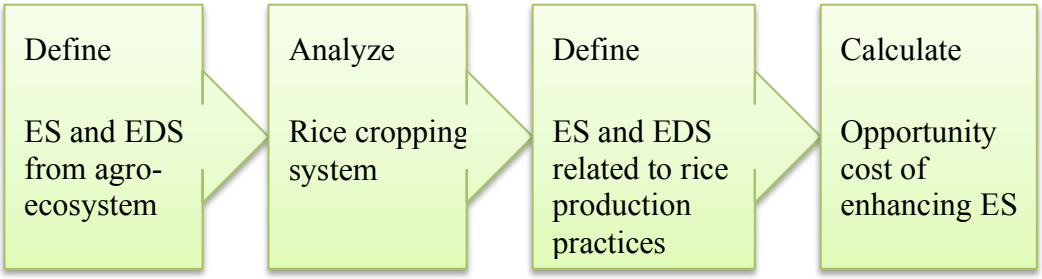


Figure 3-2: ES and ED's identification step

Combining Agrarian Systems Analysis and Diagnosis with the ES and EDS framework allows to link the economic performance of production systems contribute to farmers livelihood on one hand, and the ecological efficiency of ES provision for sustainable agro-ecosystem use, on the other hand. The comparison of Value-added and ES provided across different production systems typology will show the trade-offs between them. Our purpose is to identify production systems that are most effective and efficient, while being operational, productive and feasible for farmers. In others word, we are looking for production systems that allow to maintain ES with low opportunity costs.

We interviewed 208 farmers living in 2 districts, Steung Sen (Srayove commune: Srayov Tbong, Roka and Rolous villages) and Santuk (TbPhanhagy, Ompus and Porkhav villages). We chose our samples randomly in those different villages along the floodplain of the TSL (flooded grassland, flooded shrub land and clear flooded forest).

The data collection has to ensure the ability to understand agrarian systems and to carry out economic calculations in order to explain diverse situations and trajectories of production systems, in particular the opportunity cost attributed to each production system. The result is the outcome of different field work sessions and of multiple detailed case studies in order to avoid the theory of all-embracing (Cochet *et al.*, 2007). The data collection was between 2012-2013; we collected a total sample of 208 farmers who can be divided into 2 types:

- 36 farmers for qualitative data, which is the most important for the beginning of the fieldwork, to understand the agro-ecosystem and landscape or technically called "agro-ecosystem" change. This step helped us to do the delimitation of the study zone and understand the history and change in agriculture of the study

zone. We conducted a group discussion focusing on agro-ecosystem and practices changes and impact on their livelihood system (e.g sources of food from rice fields). (see Annex B.2 and B.3)

- 172 farmers for quantitative data. The sampling size is calculated from Yamane (1967:886) formula (Glenn, 2009), which tends to facilitate the limitation of the sample size and decrease the errors in economic calculations. But farmers selection is still based on the reasonable sample choice method to ensure heterogeneity of farmers in the region. Because of time constraints, we decided to choose 50% of them (87 farmers) for deep interviews on their thinking about impact of agricultural inputs and agro-ecosystem change on their health, rice field ecosystem and on the fishery sector. (see Annex B.4 and B.5)

3.3. Results

3.3.1. Services and dis-services provided by the TSL Ecosystem to agriculture

This lacustrine active floodplain has brown or gray clayey or loamy topsoil, which is classified in the Toul Somroung soil type by CARDI. It is characterized by slow drainage and cracks into hard blocks when dry. The soil is well suited to irrigation. This soil is classified by Crocker (1962) in the Brown, Gray, or Cultural Hydromorphic soil units. It would be Luvisol or Vertisol using the FAO/UNESCO soil classification system (White *et al.*, 1997; P. *et al.*, 2000; Shimizu *et al.*, 2006). Based on the recommendation made by White, Oberthür *et al.* 1997, irrigation systems are needed to increase its potentiality for rice production. In order to maintain the field, this soil needs 62 to 100 kg of N and 40 to 52 kg of P_2O_5 per hectare.

Even though this soil is naturally fertile thanks to alluvial deposits, the sedimentation doesn't reach the middle and upper terraces due to low current speeds caused by vegetation (flooded forest, flooded shrub and flooded grassland) (Dan *et al.*, 2005; Kummu *et al.*, 2008). Rice yield is still low because of poor soil as well as floods and droughts without proper water management systems (Fujisaka, 1991; Nguyen *et al.*, 2011; Mitchell *et al.*, 2013). Local farmers call their agricultural situation "Tveu Sre Rompeung Mak", which means "Producing rice by counting on the sky". This local saying illustrates their vulnerability to floods and droughts during production season. Their harvest is hazardous.

The TSL floodplain is an ideal ecosystem of flood pulse by bringing water for rice irrigation but it can also increase vulnerability to natural disasters, especially floods.

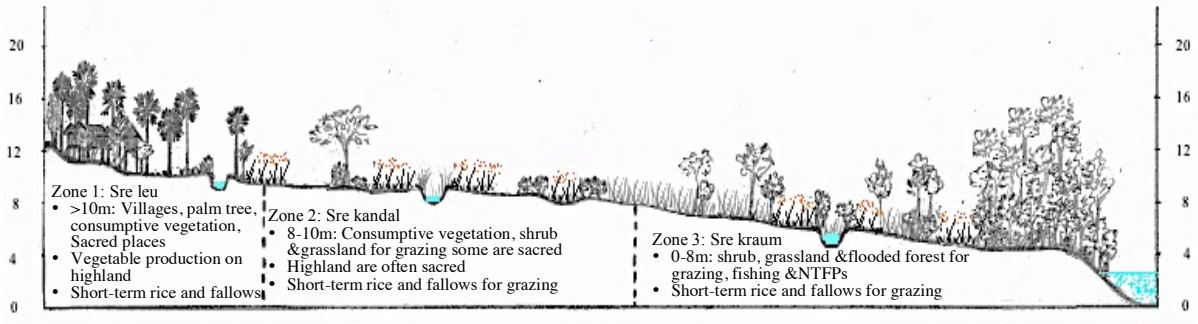


Figure 3.3 : Current land use in dry season and early rainy season (Dec-Jun)

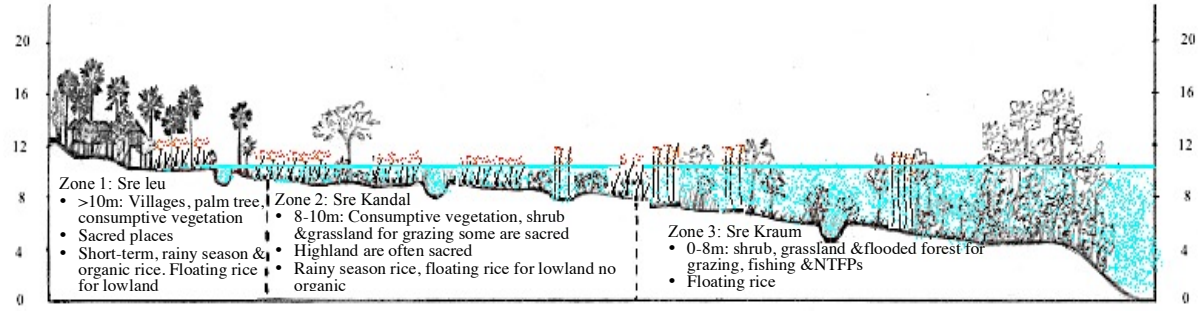


Figure 3-4: Current land use in middle of rainy season (Jul-Nov)

Following Keske and Huon Keske and Huon (2002), this agro-ecosystem landscape can be divided into 3 different zones based on different elevations which receive different effects of the flood pulse. ES and EDS from each zone are different (see Figure 3.5). We use the local term to refer to those zones, corresponding to the elevation measures by Keske and Huon Keske and Huon (2002).

Zone 1 "Sre Leu", which means "Upper rice terraces" (approximately 10 m of elevation (Keske and Huon, 2002)). This agro-ecosystem, including the villages, often has ring dikes up to 30 cm high in order to keep water as long as possible after the rain. This zone is flooded last by the flood pulse with 10 to 30 cm of water during August and September. This zone provides several provisioning services. Firstly, water provision enables rice production in rainy season (rainy season rice and floating rice on lowland as well as short-term rice - only one cycle). Secondly, the flood plain absorbs water in rainy season, which prevents floods in the villages. Thirdly, the ecosystem is a source of food (fish and other

aquatic species, both animals and plants) in the rice fields. Palm trees (Borassus Flabellofer) and other trees (fruits, leaf, wood) on ring dikes complete the provisioning services. The particularities of palm trees make them important in Khmer society by ensuring different ES. They provide habitat for bats that generate the most fertile excrement to the soil, ensuring a supporting service, as well as regulating services because bats eat insects. These trees represent Khmer identity in Khmer people's minds, ensuring cultural services. They also provide sweet juice for producing sugar. There are also a lot of termite nests that local people believe to host guardian spirits. In terms of EDS, the risk of lack of water for rainy season rice and floating rice in the beginning of rainy season is a real problem for farmers. Conversely, flood pulses of the TSL can cause label loss for organic rice and decrease the possibility to produce short-term rice from August to October because of high risks of floods. Lastly, this agro-ecosystem is sometimes faced with floods and droughts in the same year.

Zone 2 "Sre Kandal", which means "Middle rice terraces" (8 to 10 m of elevation (Keske and Huon, 2002)), the agro-ecosystem is characterized by rice fields with low ring dikes are around 10 cm high. There is no perennial tree because of long and high inundation from the natural flood pulse. Farmers graze their animals in dry season and fish in natural ponds as well as waterways surrounded by flooded shrub. This zone is flooded before zone 1, with 15 to 40 cm of water from mid-July until end of November. Water provision is the main ES. It enables rice production, except organic rice due to impossible water management. Floating rice on lowland is more important than in Zone 1. In contrast, this zone also provides different sources of aquatic food in rice fields and natural ponds or small rivers, and firewood from flooded shrub. This zone provides ideal conditions for animal grazing, particularly buffaloes who like ponds, with highly nutrientious grass. In some places, there are highlands with big trees, which local people believe to host the guardian spirits that protect them from floods. They usually graze their animals on those places in rainy season. In case of flood disaster, those highlands become the safe places to keep their animals. On the other hand, rat hunting during dry season, at the beginning and at the end of rainy season, is an important source of income for farmers by selling them to Vietnam. In terms of EDS, flooding from natural flood pulse of the TSL causes impossibility to produce organic rice. And every year, farmers face a low risk of yield loss because of rats, for rice fields close to flooded shrub areas.

Zone 3 "Sre Kraum", which means "Lower rice terraces" (0 to 8 m of elevation (Keske and Huon, 2002)): In this agro-ecosystem, rice fields are associated with clear flooded forest, which is called "Prey Kraum". This ecosystem is the richest one, made up of flooded forest, scrubland and grassland. It is permanently flooded in rainy season, starting in June until end of November, with more than 1.5 m of water, and the ring dikes are important to keep water for rice's maturity stage. This ecosystem provides enormous ES to agriculture and farmers livelihood. Despite the high fertility of the soil thanks to alluvial sedimentation, the high flood led farmers to adopt floating rice. Nowadays majority of farmers converted those floating rice fields into short-term rice field and majority of them producing two cycles of short-term rice. This zone is also an important source of firewood, some strong wood usable for agricultural tools as well as for house construction, NTFP (honey and medicinal plants), fishing for family consumption and sale, and animal grazing during the dry season with nutritious grass. Farmers have traditional practices of grazing associated with fishing by organizing work sharing between farmers to graze their animals in that zone (2 persons in charge of 15 to 30 animals for 1 month). That zone lies 20 to 40 km from their village. The persons in charge fish and collect NTFP. These activities give them financial revenues for their family. Rat hunting is also an important occupation during dry season, at the beginning and at the end of rainy season, for sale to Vietnam. These rats are called rice rats and are the most demanded because consumers believe that they are healthy and clean by eating only rice. High flooding from flood pulses prevents rice production except floating rice. Anyways, risks of flood and rat damage are still high for floating rice because it is grown during a period of high water level. As a consequence there is no possibility to use rodenticide. Rats climb on trees and eat rice panicle. And it is impossible to travel by foot or vehicle in rainy season because of flooding.

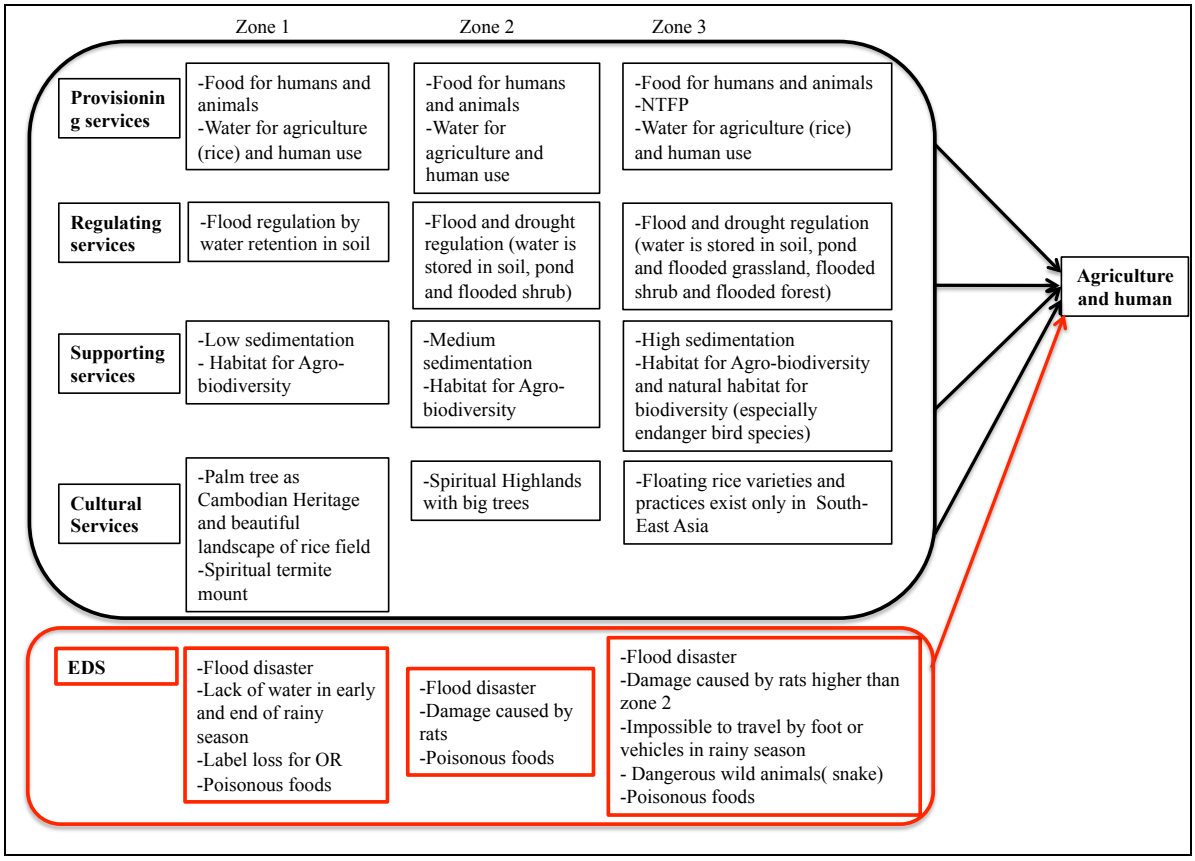


Figure 3-5: ES and DES related to the three zones of TLS flood plain agro-ecosystem, Adapted from Zhang et al. (2007)

3.3.2. Services and Dis-services provided by rice cropping system

In our study case, we classify rice cropping systems into 3 main categories composed by 9 cropping systems based on varieties and practices that farmers use in one plot located on different agro-ecosystem of flood pulse of the TSL (Neang *et al.*, 2014).

The first main cropping system is called "short-term rice". These systems have been recently adopted (2000-2002) in order to better adapt to flood disasters during the rainy season. Short-term rice cropping systems are called dry season rice by farmers. These non-seasonal and non-photosensitive varieties enable farmers to produce outside of the flood period by adopting 3 different cropping calendars. (1) **Early season rice (ESR),** which they can start end of Feb and harvest in May with a productivity around 4.9t/ha. (2) **receding rice (RR)**, for which they wait until the water recedes to start at end of December and harvest in early January for 4.57 t/ha. They get lower yield for RR because of drainage from flood is difficult. (3) Some farmers combine ESR and RR on the same rice field,

which enable them to double their productivity to almost 10t/ha. Water management is important for all of these calendars, with ESR needing most importantly irrigation while RR needs the possibility of drainage most importantly. All kinds of short-term rice require agro-chemical inputs such as fertilizer and pesticides. Our short-term rice respondents assert that, based on sellers' advices, they use chemical pesticides preventively and mix 2 to 3 pesticides together as a cocktail in case of pest attacks. In addition, herbicide use is becoming common practice for short-term rice to reduce plowing. Anyways, farmers' perception is that technical practices of these rice cropping systems could lead to agro-ecosystem and agro-biodiversity degradation, as well as poisonous food for local farmers. 75% of respondents believe that fish and other aquatic species from their rice fields are poisonous because of chemicals used and they don't consume them anymore for fear of chemical residues. Regrettably, poorest farmers still continue to eat this food for lack of an alternative. The relation between rice techniques practices, and EDS are detailed in Table 3-3.

The second main cropping system is Rainy season rice cropping systems are farmers' traditional practices, with seeds selected naturally and locally by them and their ancestors. Medium term rice, with 120 to 150 days to maturity, starts in May. It can be transplanted **(MTT)** if water is too high or direct seeded **(MTD)** if they start early enough, when water isn't there yet. It is often fragrant rice, with which farmers produce Ambok (rice grilled and flattened by crushing) to sell to Phnom Penh at a national event (Water Festival) in November. This rice is called medium duration of maturity and its flowering time is between 10th and 15th October (CARDI, 2007). This rice is mostly cultivated in zone 1 (90%) because it cannot survive deep and long floods. Sometimes, this rice can also be found in zone 2 where land is not flooded and unsuitable for long-term rice. Long term rice direct seedling **(LTD)** is predominantly practiced in zone 1 and in some high lands in zone 2, where there is less water in early rainy season, enabling farmers to sow on muddy land. On the other hand, transplanting **(LTT)** is adopted in zone 2 and some low lands in zone 1 where they can transplant in 20 to 30 cm high water. Because workers have become rare in the region, farmers prefer direct seedling. According to farmers, long term rice can survive very well in floodwater until 60 to 70 cm. These varieties have 6 months of life cycle, starting in April and ending in December. For rainy season rice, farmers who have money will use pesticides against crabs and rats, and some low amounts of fertilizer (50 to 100 kg

of DAP per hectare). On average they get from 1.3t/ha for direct seedling to 2.2t/ha for transplanting. **Organic rice (OR)** is cultivated only in zone 1, particularly on high land, to avoid floods even from the natural flood pulse. It has the same life cycle as other medium term rice systems. This rice is transplanted with only one stem at a time, because farmers received trainings from some NGOs about SRI practices (System of Rice Intensification). Organic farmers are mostly former SRI farmers. SRI practices are transferred to farmers in order to improve their productivity by increasing organic fertilizer use (Ly *et al.*, 2012). Unfortunately, it was adopted by a small number of farmers because in that region, it is very hard to manage water in order to transplant in muddy soil with single young stems. The organic label came later, in 2003, to improve farmers' practices and increase their revenues. Sometimes farmers are confused about whether SRI is organic or is transplanting one stem at a time. But organic farmers understand very well how to get the organic label by respecting their standard of zero chemical inputs within 3 years. 55% of farmers in Raksmey Steung Sen Association (RSSA) produce organic rice on 100% of their land, with an average of 0.77 ha per household. Because of the ecological risk of flood, others use only the suitable part of their land for Organic Rice and still continue to produce floating rice associated with long term or medium term rice on the rest of their land. Farmers said OR needs from 2 to 3t of compost per ha but they can find only 1 to 2 oxcarts (around 35kg/oxcart) per year. This is the main constraint and factor limiting their yield, to 2.2t/ha on average.

The third cropping system is Floating rice (FL) is normally a cropping system of rainy season rice but this study keeps it separate because of its particularity that it can grow very tall in case of flood, and thus represents a good protection against the risk of flooding. Since 2002, many floating rice fields were converted to short-term rice in zone 3. This is why only 36% is found in zone 3 and 64% in low lands of zone 2. In rainy season, predominantly in September and October, overflow from the lake floods the paddy fields, with up to 4 meters of water, creating conditions that only floating rice can survive to. These rice varieties can elongate their stem up to 30 centimeters per day, keep their leaves above the surface of the water and escape drowning (Cummings, 1978). In our study zone, farmers argue that these rice varieties can grow up to 50 centimeters per day in case of flood disaster. This rice cropping system is the most extensive, requiring few labor and capital. As soon as the first rains appear, farmers start ploughing the land twice, if needed,

in order to incorporate weeds into the soil and get them to decompose inside. After harrowing, they sow in April or May and wait until December to harvest. Since 2010, some farmers start using herbicide instead of ploughing twice. In this case they use Roundup to kill all weeds before incorporating them into the soil. This rice cropping system is the most resistant to flood but it is also the most risky, because when the water is still high at maturity stage, rats can climb on trees and eat rice panicle. The pesticides or rat poisons are ineffective in that case, because of the high water. This rice system is thus chemical free. It has a low yield, 1.57 tons on average but still more than direct seedling of rainy season rice, which yields 1.2 to 1.4t/ha. This is because lands used for rainy season rice receive less alluvium from the floods compared to floating rice fields. Some farmers growing floating rice in zone 2 tried to use some fertilizer, 50kg/ha of Urea, but the yield was not different because of the run-off of N by water. The ES and EDS provided by this rice cropping system are well define in Table 3-3 .

Rice cropping systems (i)			Practices and Land Use	Ecosystem services (non-marketed) FROM Agro-ecosystem	Ecosystem dis-services FROM Agro-ecosystem
Early Season Rice (ESR)	Z1: 21% Z2: 34% Z3: 45%	Short-term rice	Using the existent rice field in zone 1	Cultural Services: Preserve spiritual practices and beauty of agricultural landscape, such as rice fields with palm trees. Provisioning Services: leaves, trunks, fruit and juice from palm trees for farmers' basic needs	
Receding Rice (RR)	Z1: 17% Z2: 36% Z3: 47%		Ring dike, canal and reservoir construction for irrigation and drainage or for preventing water from flowing into rice fields	Ensure flood regulation for short-term rice	Disturb water regime, alluvial deposits and flood regulation capacity of ecosystem
			Chemical use (cocktails of pesticides and fertilizer) in all zones with the same practices		Degrade soil and agro-biodiversity and pollute water
Early + Receding Rice (ESR+RR)	Z1: 24% Z2: 40% Z3: 36%		New hybrid variety « High Yield Variety »	Reduce the genetic resources in daily food consumption	
			Deforestation of flooded clear forest, shrub and grassland in zone 3		Degrade habitat, biodiversity and flood regulation capacity of this ecosystem
Medium Term rice Direct-seedling (MTD)	Z1: 90% Z2: 10%	Rainy season rice	Dependence on water regime from flood pulse of TSL with less than 30cm height of ring dikes	Regulating Services: Respect water regime and alluvial deposit	
Medium Term rice Transplanted (MTT)			Maintenance of existing high lands, spiritual places and palm trees. Furthermore palm trees are replanted every year in zone 1.	Cultural Services: Preserve spiritual practices and beauty of agricultural landscape, such as rice fields with palm trees. Provisioning Services: Leaves, trunks, fruit and juice from palm trees for farmers' basic needs.	
Long Term rice Direct-seedling (LTD)	Z1: 38% Z2: 62%		Absence of chemical use or small amounts of fertilizer and pesticides used if needed	Regulating Services: Preserve Agro-biodiversity fauna, flora and amphibians of rice fields. and Water quality	
Long Term rice Transplanted (LTT)			Use of natural and local varieties (Fragrant and Non-Fragrant rice)	Regulating Services: Preserve natural varieties for the genetic bank	
			Use of hybrid Medium Term rice fragrant varieties in case of flood or drought.		Degrade natural varieties in genetic bank

Organic Rice (OR)	Z1: 100%		Use of only existing rice fields, thus absence of new deforestation of flooded forest, shrub or grassland	Regulating Services: preserve indirectly flooded clear forest for Habitat and Biodiversity	
			High land and spiritual place, Palm tree are kept. Palm tree are replanted every year in zone 1.	Cultural Services: Preserve spiritual practices and beauty of agricultural landscape (Rice field with palm tree). Provisioning Services: leaf, trunk, fruits and juice for farmers' basic need.	
			Restrain from use of chemicals	Regulating Services: Preserve Agro-biodiversity (fauna, flora and amphibians of rice fields) and Water quality	
			Use new hybrid varieties « Fragrant Rice »	Reduce the genetic resources in daily food consumption	
			Rice field are protected from flood by ring dikes around 40cm high to avoid chemical contamination for preserving label		Degrade regulating services: soil formation from deposit*
Floating Rice (FR)	Z2: 64% Z3: 36%	Floating rice	Use of only existing rice fields with many trees (flooded clear forest in zone 3) on it	Conserve directly flooded clear forest Regulating service: Flood regulation, Habitat and Biodiversity Provisioning services : firewood, NTFPs and inland fish	
			Dependence on water regime from flood pulse of TSL	Respect water regime and alluvial deposit. Regulating services: soil formation from deposit*	
			Existed High land for spiritual place and Palm tree are kept	Cultural Services: Preserve indirectly spiritual places and beauty of agricultural landscape (Rice field with palm tree). Provisioning services: leaves, trunk, fruits and juice for farmers' basic need. Provisioning services: Materiel and food from palm trees	
			Absence of chemical use or use of small amount of fertilizer and pesticide if needed	Preserve fauna, flora and amphibians of rice fields. No chemical residue leaching into water. Regulating service: soil biodiversity and water quality	
			Use natural and local varieties	Preserve natural varieties for genetic bank Regulating Service: Natural variety conservation	

Table 3-3: ES and EDS from rice cropping systems

* *Soil deposit (sedimentation) on flood plain is very low because of the low speed of water flow from flood pulse (Dan et al., 2005; Kummu et al., 2008)*

3.3.3. Trade-offs and opportunity cost analysis

3.3.3.1. Trade-offs between provisioning services and other ES in each production system

The key interest of ESF is to focus on trade-offs. For farmers and policy makers, the main output of ES is rice provisioning. As we quoted, the TSL ecosystem is the main zone of rice production in Cambodia, due to the flood pulse process. The previous analysis showed the opportunities and risks to produce in the different area. Our fieldwork led us to identify different strategies developed by peasants to manage these opportunities and risks. These strategies are combinations of different cropping systems (*i*) into a specific production system (*j*). Based on several criteria (surface, labor, capital), we distinguish 21 different combinations of rice production systems and calculate the value-added for each (Table 3-4). The value-added/fl corresponds to the capacity of one family labor to produce on their land. It is then possible to gather these different groups into 7 main categories as **production system models** taken into account relations with regulating and cultural services. Because it is not possible to evaluate a monetary value for all these ES or EDS in this study for each category, we adopt a qualitative valuation (+ for positive effect "ES"; - for negative effects "EDS") based on our expertise in the field and interviews with peasants. Only the provisioning services, which we are able to calculate in monetary terms, are represented as value-added/fl per year.

Production system model A is a combination of different types of short-term rice systems, some of them being double cycle systems (ESR+RR). In this production system, farmers can double their yearly revenue. Model A only provides a low level of cultural services, by maintaining the existing spiritual places. Farmers in model A try as much as possible to convert all their rice fields to adopt short-term rice and they buy water from private rice companies[8]. This model provides only low level of cultural services related to the fact that they maintain the existing spiritual places. On the contrary in term of EDS it degrades a lot of regulating services as detail in (Table 3-4). System A is a clear trade-off between maintaining others ES and provisioning services correspond to productivity of land and labor (Value-add/fl). To bring the value-added from of 478.28$/fl to 1004.67$/fl, farmers get the score of -9 for EDS.

[8] There are a few private companies producing short-term rice in zone 3 (Sre kraum). They own 150 to 200 ha of rice field. They invest in irrigation systems by making high dikes around them, with reservoirs inside, to prevent floods and drought.

Model B is a combination of short-term rice systems (double or single cycle) with other rainy season rice cropping systems. Farmers manage their system to convert their land to an agro-ecosystem of short-term rice as much as possible. On the rice fields where they cannot produce short-term rice, they continue to cultivate rainy season rice, including floating rice. Because of its high price, Medium term rice (MTD or MTT) is their best way to get high land productivity and value-added per family labor because of its high price. Model B shows a possibility to increase land and labor productivity while still staying in harmony with the ecosystem of the TSL flood plain. In model B, provisioning services from different groups vary significantly (from 260.92$/fl to 1077.81$/fl) but with regards to other ES, they have almost the same score of about +3 on average.

Production model C represents organic production systems, with some being in combination with rainy season rice cropping systems in order to also produce on land where flood cannot be controlled. Organic rice production model is not the most effective in terms of ES because it degrades natural varieties and increases flood risks for other fields. This is due to organic rice cropping system needing to avoid any contamination by flood. During the seasonal flood period, farmers generally drain water from their rice field by letting water flow through neighboring rice fields by gravity. Organic rice fields forbidding this, they increase flood risks for other fields. They also disrupt alluvial deposit for nutrient renewal. In model C, one farmer can make a value-added between $106.87 and $235.86 by generating a +6 score of ES on average.

Model D represents the short-term rice production system of farmers with small production areas. Farmers in this model did not have capital to invest in converting their rice field to short-term rice. Thus they only take advantage of the opportunity to get water from private companies and pay back after harvest. They cannot get high labor productivity because of their small area, less than 1 ha per farmer. This system offers small value-added for farmers and comes with a high cost for society and the environment, like production model A. In this model, one farmer can only make 54.30$ to 127.63$ by generating EDS of -9 on average.

Number of farmers	Rice production system (j)	Provisioning Services		Regulating Services				Cultural Services
		Surface (ha/fl)	Value-added ($/fl)	Agro-biodiversity	Natural Variety	Habitat/ biodiversity/ water quality	Flood regulation	Spiritual/ Scenic
11	**A. System intensive providing high provisioning services and high EDS (-9 in average)**							
3	A1. (ESR+RR)	1.35	1004.67	---	---	---	--	+
3	A2. (ESR+RR)+RR	1.43	785.54	---	---	---	--	+
5	A3. RR	1.47	478.28	--	---	--	--	+
38	**B. System intensive providing medium to high provisioning services and low regulating + cultural ES (+3 in average)**							
5	B1. (ESR+RR)+RR+FR	2.24	1077.81	+	-	-	-	++
5	B2. RR+MTT+LTD	2.55	994.43	+	+	+	-	++
3	B3. ESR+RR+LTT	2.24	908.2	+	+	+	-	++
3	B4. RR+MTD+FR	1.41	456.41	+	++	++	-	++
2	B5. (ESR+RR)+MTD	0.59	344.61	+	---	-	-	++
2	B6.(ESR+RR)+MTD+FR	0.88	316.19	+	-	-	-	++
7	B7. ESR+ FR	0.61	261.45	+	+	++		++
11	B8. RR+FR	1.00	260.92	+	+	++	-	++
22	**C. System organic rice providing medium provisioning services and medium regulating + cultural ES (+6 in average)**							
6	C1. OR + LTD	0.75	235.86	++	-	++	-	+++
11	C2. OR	0.29	132.1	+++	---	++	-	+++
5	C3. OR + FR	0.48	106.87	+++	-	++	+	+++
6	**D. System intensive providing low provisioning services and high EDS (-9 in average)**							
3	D1. (ESR+RR)	0.37	127.63	---	---	---	--	+
3	D2. ESR	0.15	54.3	--	---	--	--	+
37	**E. System traditional providing low provisioning services and high regulating + cultural ES (+11 in average)**							
14	E1. MTD + FR	0.63	129.37	++	+++	+++	+	+++
6	E2. LTD	0.46	117.4	++	+++	++	-	+++
11	E3. MTT + MTD	0.41	113.64	++	+++	++	-	+++
6	E4. LTD +FR	0.32	69.13	++	+++	+++	+	+++
42	**F. Floating rice system providing low provisioning services and high regulating + cultural ES (+15 in average)**							
42	F1. FR	0.78	151.08	+++	+++	+++	+++	+++

Table 3-4: Rice production system typology with ES (+) and EDS score (-)

Model E, called "traditional system" by farmers, refers to combinations of different rainy season rice cropping systems. This model represents the way farmers try to adapt to the flood plain ecosystem by creating rice field terraces, which let them adopt rainy season rice cropping systems in all 3 zones of Sre Leu, Sre Kandal and Sre Kraum (details in section 3.2.1 page 83). It symbolizes a complex manmade agro-ecosystem in harmony with an ecosystem of high risk of seasonal flood. Floating rice is a perfect component of harmony

between man and the flooded forest ecosystem because instead of changing this ecosystem, farmers cultivate rice varieties that can adapt to flood. Farmers can get from 69.13$/fl to 129.63$/fl and accumulate a high score of ES of +11 on average.

The last production model, F, corresponds to poor farmers who own around 1 ha per labor, only in the low land area called Sre Kraum (details in section 3.2.1 page 83), on grassland, in the flooded forest ecosystem or along the waterway, with high risks of flood. These farmers do not have enough financial capital to invest in conversion to short-term rice. Therefore they continue to produce floating rice, which provides low provisioning services but very high regulating and cultural services. Farmers in this model produce on average 151$/fl while they provide the highest score of ES, +15 on average.

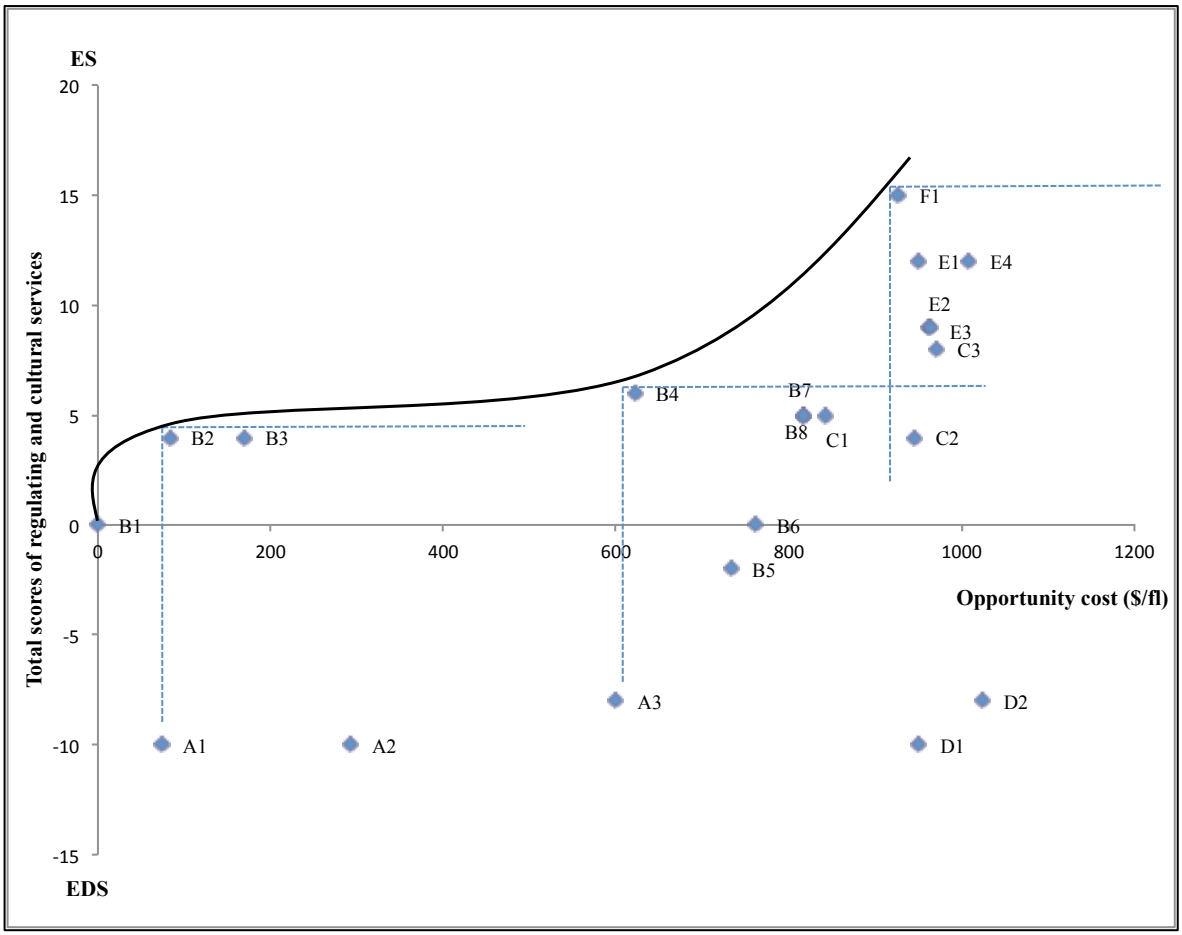
3.3.3.2. The most efficient production system model

The Table 3-4 clearly shows the impossibility to promote a specific production system that would be able to conserve all ES provided by the agro-ecosystem. The more we promote rice provision, the more we destroy regulating and cultural services. Moreover, for political decisions it would be useful to calculate the opportunity cost that farmers would have to face if policymakers would decide to promote pro-ES production systems. To pursuit this argument, we calculated the opportunity cost of each production systems compared to the adoption of the most productive rice production system, B1 ((ESR+RR) + RR +FR). This system provides high productivity per one family labor along with a balance between ES and EDS provided. In other words B1 provides high provisioning services at zero cost for the ecosystem. The Graphic 3-1 presents a spatial distribution (cloud of points). Each production system is located on the graph with its opportunity cost (in US$) on the horizontal axis, and on the vertical axis the sum of its regulating and cultural services scores (1 plus increase the total score by 1, 1 minus decreases the total score by 1). As we can see, some of the production systems provide the same (regulating and cultural) ES score but with more or less opportunity cost compares to B1. Thus, it is then possible to define an optimal frontier of ES production systems (black curve), composed by the different efficient production system.

- Systems with low opportunity cost, less than 300$/fl: B1, B2, B3, A1 and A2. The system B1 is a control system, with zero opportunity cost and zero balance

of ES and EDS. At the same opportunity cost, systems A1 and A2 have negative scores for ES, as opposed to B2 and B3 which have positive scores for ES. In this group, **B2** is efficient in terms of opportunity cost to preserve ES.

- Systems with medium opportunity cost, between 600$/fl and 850$/fl: B4, B7, B8, C1, B5, B6 and A3. At almost the same opportunity cost, A3 and B5 have negative scores for ES, while B4, B7, B8, C1 and B5 have positive scores for ES. Thus, among these production systems, only **B4** is efficient in ES preservation.
- Systems with high opportunity cost, more than 900$/fl: F1, E4, E3, E2, C2, D1, D2. With equal opportunity cost, model D (D1 and D2) has negative scores for ES. On the contrary, others have very positive scores for ES. Among them, **F1** is the most efficient for ES preservation.



Graphic 3-1: Comparison of opportunity cost with the score of ES provided

When comparing production models A, B, C, D, E and F, model A and model D appear to be the most dangerous for ES. Both systems have -9 as score of EDS. However model D has a much higher opportunity cost, of 986$/fl on average, than model A, with only 321.65$/fl on average. All production systems in model B are reasonable for ES and can also provide high provisioning services. They are thus able to ensure ES with low opportunity cost. Interestingly, models A and D are not productive compared to model B. Another way to say it, is that producing only short-term rice with high chemical pollution and ecosystem conversion is less productive than combining short-term rice with rainy season rice as well as floating rice. The latter also helps to increase positive externalities on the environment, with low chemical pollution and low ecosystem conversion, which are good for ES preservation. Models E and F are the most effective and efficient for ES preservation but they represent the highest opportunity cost for farmers. Organic rice systems (C1, C2 and C3) are not efficient for ES provision, while still coming with a high opportunity cost for farmers, around 919$/fl, despite a price premium for organic label.

3.4. Discussion and Conclusion

In most of these production systems, farmers achieve economic efficiency thanks to short-term rice, with this performance being even better if they can adopt a double cycle schedule, to have two harvests per year on the same land. On the other hand, rainy season rice and floating rice enable farmers to achieve ecological performance by ES provision. Thus production systems that are most efficient economically for famers and also ecological in terms of ES provision, are systems in which farmers combine short-term rice cropping systems with rainy season rice cropping systems, especially floating rice.

More precisely, compared to B1, which is the most profitable production system, only 3 production systems provide an efficient trade-off between provisioning services on one hand and regulation or cultural services on the other hand: B2 (Receding Rice + Mid-Term Transplanting + Long-Term Direct seedling); B4 (Receding Rice + Mid-Term Direct seedling + Floating Rice); and F1 (Floating Rice). In terms of number of farmers in these production systems, F1 includes the majority of farmers (B1 = 5 farmers, B2 = 5 farmers, B4 = 3 farmers and F1 = 42 farmers). In spite of this, Floating Rice production systems are practiced by the poorest farmers in the region and are on a path to disappear. This is due to their low productivity, together with the high risk of yield loss caused by climate

uncertainty and rats. The trend in the region is to convert floating rice field into short-term rice, which requires irrigation and drainage as well as chemical inputs in order to provide high yield.

Consequently, for public policies aiming at promoting pro-ES production models, we recommend to encourage the re-adoption of rainy season rice, especially Floating Rice, or increase its surface in production in order to be both economically efficient for farmers and operationally effective for the agro-ecosystem. Producing only Floating Rice generates the highest ES with very high opportunity cost for farmers. However this cost could be reduced by diversifying towards high value-added rice cropping (Short-term rice, Mid-Term Rice, or Organic rice). Conversely, producing only short-term rice engenders high value-added for farmers with the highest DES. However, DES could be reduced by diversifying towards rice cropping systems providing high ES, such as Floating Rice. Hence promoting this production will contribute to poverty reduction in Cambodia. Despite high ES provision, this production system also generates high opportunity cost, which will make it expensive for public policies to maintain.

Based on our results, organic rice production systems are not economically and ecologically efficient in ES provision. Thus, we propose 3 different choices (1) In order to promote production systems with medium efficiency for ES but low opportunity cost, promote adoption of rainy season rice, excluding floating rice, in combination with short-term rice. (2) To promote production systems with medium performance for ES and medium opportunity cost, promote adoption of rainy season rice, including floating rice, in combination with short-term rice. And (3) To promote production systems with high performance for ES and high opportunity cost, promote adoption of floating rice alone in a production system.

Paper 4

4. Investigating consumers' motivations to buy organic food on the urban Cambodian domestic market

Abstract:

In developing countries such as Cambodia, chemical fertilizer and pesticides are still identified as necessary for economic and rural poverty reduction, but farmers' knowledge related to their uses is limited. Organic and eco-labeled products are defined as luxury products and they target fair trade from developing countries toward developed countries. Even in the research sphere, questions are often focused on international markets despite the progressive emergence of local demand for green lifestyle. This research focused on domestic markets in Cambodia, more specifically in Phnom Penh, intended to fill this gap and to look for the possibility to compensate ES from agriculture. The study tends (i) to identify organic consumers, (ii) to explore the market preferences for organic food and (iii) to explore the perception and awareness of organic consumers related to ES and EDS provided by agriculture. The main reasons that motivate organic consumption are (1) health preservation, (2) quality of products (3) local foods, (4) improving farmers' revenue, (5) tasty foods and (6) environmental preservation. Organic consumers are mostly in the group of young people under 24 years old and elders more than 60 years old, with high level of education starting from bachelor. They mostly earn more than 300$/month. The surveyed population has good knowledge about ES and EDS. As one of organic consumption reason was to consume local products, we note significant consumers' preferences not only for organic label, but also for eco-label and GI label.

4.1. Introduction

Organic agriculture is known as practices, which can preserve ecosystem, ensuring good condition for biodiversity and provides ecosystem services (ES) (McLaughlin and Mineau, 1995; Sandhu *et al.*, 2007; Sandhu *et al.*, 2010a). In the World, organic producers (164 countries in 2012 and 170 in 2013) and lands (37 million hectares in 2012 and 43.1 million in 2013) increase every year. The global markets show also demand side increasing 59 billion US dollars in 2010 and 72 billion US dollar in 2013. Organic and eco-labeled products focus on fair trade from developing countries toward developed countries and the biggest market demand is Germany, the United States of America and France (Willer and Kilcher, 2012; Willer and Lernoud, 2015). Those products are seen as luxury environmental goods that gain consumers' confidence toward a green lifestyle good for both health and environment (Kempen *et al.*, 2009).

On the contrary, in developing countries chemical fertilizer and pesticides are still identified as essential for economic development and rural poverty reduction by increasing productivities and managing post harvest (Ecobichon, 2001; Popp *et al.*, 2013). Unfortunately, most of farmers of those countries have still limited awareness and knowledge related to new agricultural technologies, that they are adopting. That causes high damage to farmers' health and environment (Dasgupta *et al.*, 2007). The proof from Cambodia, some farmers believe in cocktail of pesticides as the most effective pest management, but the truth is they are facing to great danger of health and environmental degradation (EJF, 2002). Agro-chemical residues threat food security and food safety in southeast Asian countries such as Cambodia, Vietnam and Thailand because a large part of the (rural) people relies on agro-biodiversity as important sources of proteins and sometime those species are serving as snacks (Balzer and Pon, 2002; Halwart, 2008; Neang *et al.*, 2015). Cambodia exports rice field rats and snails to Vietnam; then frogs, snakes and a lot of more inland aquatic species as well as insects to Thailand (Hortle K.G. *et al.*, 2004). Thai and Vietnamese consumers expect for low chemical residue in agro-biodiversities and agricultural products from Cambodia (Toan *et al.*, 2013). This is the proof that there is demand for food from low input agricultural products or even organic products despite the poverty. Consumers are afraid of health degradation. This strong environmental connection lifestyle could be a way to encourage organic agriculture for local consumption in Cambodia as well as in other developing countries.

The study of Figuié *et al.* (2004) revealed consumers expectation for safe vegetables in Vietnam. Moreover some literature reviews also show that demand from domestic consumers for organic products such as in Thailand, Malaysia and Vietnam is increasing (Figuié, 2003; Mergenthaler *et al.*, 2009; Ibitoye *et al.*, 2014a; Ibitoye *et al.*, 2014b).

As it has been recently stressed by Ibitoye *et al.* (2014a) *p.612*, "*A number of organic food consumption studies concentrated on consumers in the United States of America and the European continents*. *Thus far, we have no sufficient information about the consumption trend of organic food in Asia as compared to those industrialized countries (U.S.A, Europe, Australia)*". There are only few research studies available about the purchase of organic food in South East Asia as a local market need. The research questions are often focused on fair trade, market competition for developing countries to satisfy western quality requirements (taste, food quality and phytosanitary standards) (Raynolds, 2004; Parvathi and Waibel, 2013). The approached concerning organic rice in Cambodia studied by Thavat (2011) is related to products flows, especially into international markets promising high price premium, but facing to high competition with neighborhood countries. Then, when we look at Royal Government of Cambodia policy organic agriculture, rice production is oriented toward exportation by increasing productivity in order to export 1 million tons of milled rice in 2015 (MAFF, 2011). The productivity of rice field has slightly increased from 3.15t/ ha in 2014 to 3.18t/ha in 2015. Furthermore, Cambodia rice granted the phyto-standard inspection and exported 205,717 tons of milled rice to 57 countries in 2012 (RGC, 2014).

Our research intends to fill this gap carrying out a survey on the domestic market in Cambodia, more specifically in Phnom Penh, the capital of the country welcoming different classes of life standards, jobs and education levels. There are also the potential consumers for organic food from agricultural since more and more organic food shops are open. Seeing this increase in domestic consumers' confidence of Cambodian agriculture as more environmental friendly, this proposed study was to confirm the advantage of producing organic products for highly potential domestic consumers. This study encircled only Phnom Penh consumers because in Cambodian rural area, the agricultural products, particularly rice. Our agriculture is for auto-consumption at rural area and surplus are for destination to the capital city consumers. The organic food shops are found only in the capital (Chhim, 2009; Cottin, 2010; Mund, 2010; ADB, 2014; RGC, 2014).

Objective of the paper is to investigate on potential local market for organic foods and others agricultural products respecting environment. This study looks for distinguish organic from non-organic consumers in distinctive socio-economic categories and understand their behavior in food products consumption. Finally, this study tends to discover consumers awareness related to Ecosystem Services (ES) and Ecosystem Dis-Services (EDS). There are 3 objectives in this study as following (i) to identify organic consumers, (ii) to explore the Cambodian domestic market preference for organic foods and (iii) to explore the perception and awareness of organic consumers related to ES and EDS provided by agriculture.

4.2. Research question and theoretical framework

4.2.1. Research questions and hypothesis

The survey was conducted from May to June 2012. The study sought to understand the recent development of the market preferences for organic foods in Cambodian urban by identifying consumers' socio-economic characteristics, motivation in consuming organic food and their awareness related to roles of agriculture in ecosystems conservation. This study tried to verify few following hypothesis (i) we were likely to see an emergence of significant part of the Cambodian urban population willing to consume organic food and most of them are rich and educated peoples. (ii) People consume organic because they want to preserve the environment and their health and (ii) There is a strong connection between organic agriculture and ES provision in consumers' perception and they are more likely to know that agricultural systems provide ES and Dis-ES than non-organic consumers. Thus we tried to respond to the following questions:

1- What are the socio-economic characteristics of the urban organic consumers?

2- What are their motivations to buy and consume organic food?

3- What are their ES and EDS perceptions linked to food production?

4.2.2. Theoretical Framework

As developed by Lancaster (1966 p.3), the consumer theory explains the consumers choices. Consumers' preferences are not always rational because their choices combine *all instrinsic motivations* to consume some goods and not others. Likewise, some *characteristics* of goods cannot satisfy the owner but their beauties can. Goods are not

common in consumers' preferences, which create particular characteristics that can satisfy the consumers. As a result, *consumption is an activity in which goods, singly or in combination, are inputs and in which the output is a collection of characteristics.* For example, an owner of a car can find satisfaction not in the car itself, but in the attributes that come along with the car, such as services included with that model of car (comfort, prestige, speed, etc).. In another word, consumers classified goods across their characteristics and then they choose to consume the good satisfying them the most by incorporating multiple characteristics of its intrinsic qualities.

The notion of quality is subjective and difficult to define. Quality is what makes one thing more credible and desirable by consumers. Quality is a critical element in competition. A high quality good or service for consumers is a product containing certain attributes which are relevant for the majority of the consumers (Bowbrick, 2014). The traditional model of "perfect competition" considers that the **products are heterogeneous,** that they are perfect substitutes each other and that buyers perceive no actual or real differences between the products offered by different firms. So, consumers will make choice between identical products or completely different products. That model was careless about **differentiation**: products or services are distinctive from others by different characteristics (such as feature, benefit or quality) so that consumers obtain different levels of satisfaction. The characteristic of the products could be divided into vertical differentiation when one product is universally considered as superior to the others; and horizontal differentiation when some consumers prefer one product and others prefer another products. All dimensions related to esthetic value and location are horizontal characteristic; at equal price consumers will choose one or another products based on their taste or their subjectivity. By the way, vertical differentiation relates to quality of the products. And at equal price, it exists only one demand for the best quality one because its price judges its quality. Practically, it is difficult to distinguish vertical and horizontal differentiation because consumers combine all those characteristics to make their choices. Consuming some types of goods and services is also a signal showing social class on which they belong to, called conspicuous consumption. Thus the goods and its quality are not valued for themselves but for social status. In this case, the more products' price is high, the more they got high utility for social reputation. There is the same principle for environmental quality characteristic that some environmental consumers value goods and services for their characteristics dedicated to environmental preservation (Beath and Katsoulacos,

1991; Coestier and Marette, 2004).

The model of food consumption proposed by Coestier and Marette (2004) and MacFie (2007) seems relevant for this study by having two emphasis together "consumers and properties of the products (including sensory properties)". These two emphasis are developed in the six factors model of food preferences as following:

- **Personal factors**: level of expectation, priority-familiarity, influence of other persons, Individual personality, appetites, moods and emotions and meaning attach to foods.
- **Socio-economic factors**: family income, food cost, symbolic meanings, social status.
- **Educational factors**: Educational status of individual-family and nutritional education.
- **Cultural, religious and regional factors**: Cultural origins, religious background, believes and traditions, culture-race and geographical regions.
- **Intrinsic factors**: food appearance, odor, temperature, flavor, texture, quality, quantity, preparation and presentation.
- **Extrinsic factors**: environment-situational, advertisement and merchandising, time and seasonal variations.

Moreover this study looks forward to defining consumers' preferences related to another utility: this one is not direct but it creates the value-added to products and services. That utility is ecosystem services dimension while consuming one product increases the environmental preservation and social benefits. This perception is relevant in rich and developed countries (Point, 1998; Coestier and Marette, 2004; Kempen *et al.*, 2009).

In the same argument, food consumption choice is a combination of attributes fulfilling consumers' satisfaction. Food itself has nutritional characteristics but it comes along with other characteristics such as price, taste related to biological aspect (variety) or territory (local product identity), impact on health or environment, and more general impacts on society (increase farmers' revenue and preserve local culture). All these attributes are combined together and enable to categorize "organic and non-organic consumers" as well as "environmental and non-environmental consumers; distinguish different goods distribution systems (organic, non-organic, quality goods and low price goods) which are in competition to target the consumers (Cropper and Oates, 1992; Portney, 1994; Point,

1998; Rambonilaza, 2010; Lusk *et al.*, 2013). The consumers' perception of environment and ecosystem conservation has recently become a new argument used on the domestic market to sell goods and especially food as well as compensate the costs of the ecosystem services provision by farmers. The environmental aspect of foodstuffs are interpreted in the eco label, organic as well as fair trade label. Some labels are more specifically focused on endangers species conservation like birds (Jason *et al.*, 1999; Dachary-Bernard, 2004; Gómez Tovar *et al.*, 2005; Gibbon and Bolwig, 2007; Clements *et al.*, 2010).

Thus, the notions of **provisioning services, regulating services and cultural services** are included in our study in order to test the environmental motivations of Cambodian consumers. This article seeks to associate the ecosystem services notion and the economics of food demand in order to determine product-based ES consumers' preferences.

4.3. Empirical research method

4.3.1. Preliminary research and observation

Our first objective was to collect information related to the food distribution system in Cambodia and especially in Phnom Penh. We met different types of consumers in order to prepare the questionnaires for the survey as well as elaborate an appropriate sampling strategy. We observed and used open discussion with few key questions with sellers in traditional markets as well as the sell assistants in organic shops and supermarkets. This preliminary research (see guidelines in Annex C.1) aims at:

- Getting information related to organic and non-organic food distribution system
- Getting sellers' point of view on organic and non-organic consumers and their supposed main socio-economics characteristics such as their level of wealth, education and age.

This preliminary study was used to determine the survey's locations, the type of food distributions systems as well as the survey strategy in order to build a sample as representative of the population of Phnom Penh as possible.

4.3.2. Construction of questionnaire

The first part of the questionnaire seeks to characterize consumers' socio-economic profile with a range of questions about age, jobs, level of education, age of family members, nationality and family revenue. The information related to the family revenue corresponds

to the last question of the questionnaire to avoid bothering respondents (see question 2 and 3 in Annex C.2).

The second part of the questionnaire is about the awareness and perception on relation between agriculture and ecosystem as a whole. In this part, we design a range of multiple-choice answers. In question 4, we try to get consumers' perception on positive and negative impacts of agriculture on environment and human health. Regarding positive impacts, the respondent may select the following choices: providing food supply and basic needs for economic growth; preserving biodiversity, forest and water quality or in more simple term "preserving environment"; mitigating climate change; preserving some aspects of the Khmer culture. Regarding the negative impacts, the respondent may select the following choices: chemical pollution; forest and biodiversity degradation; accelerating climate change; natural varieties degradation; farmers' health and human health degradation by chemicals (see detail in Annex C.2).

Then the question 5 seeks to know consumers' awareness about the types of agriculture that provide positive impacts. In question 6, the given answers related to ES definition are related to this field, we didn't give any un-related answers. The question 7 aims at understanding respondent's consumption situation related to organic foods including rice, as well as their reasons for consuming organic or non-organic products. We end up with the question 8 asking consumers if they know the label existing in Cambodia or not. This question is used in conclusion of our analysis to indicate the possibility in the future to certify (or not) product-based ES (see detail in Annex C.2).

4.3.3. Targeted markets for the consumers survey

This preliminary research and our observations confirm a personal opinion related to the fact that city dwellers have with different life styles. To be able to get a representative sample of the different standards of living, life style as well as jobs, we use three criteria (1) location of survey and (2) type of markets as mentioned in the Table 4-1 and Map 4-1 then we add (3) survey strategy.

Related to the different locations where we interviewed the consumers, we consider Boeung Keng Kang 1 commune (Sangkat) as the center of the city where the upper and middle classes live. Most of organic shops are situated within this part of the city. then we go south-west toward Stung Mean Chey commune where the lower class people live. Only

few organic shops are situated within this commune.

At a distance of Boeng Keg Kang 1, we also include all the three types of food distribution system such as **traditional markets, supermarkets and organic shops**. Housewives buy food every morning while office workers; students buy their food during the evening and weekend. Taking into account this fact, our survey strategy tends to cover a wide range of consumer's types by carrying out interviews three times a day: in the morning, in late afternoon and during the weekend from 7:00 am to 9:00am, noon from 11:00am to 1:30pm, evening time from 4:00pm to 8:00pm.

We target the survey population according to our preliminary research stating that the sellers reveal a strong connection between consumers' standard of living, the location where they buy their food and the kind of food they buy. The table 4-1 and the Map 4.1 give details about the different survey locations that have been chosen. Among the traditional markets, we chose the Olympic and O'Russey markets located within a radius of 2 km from the center of the city where rich and middle classes of people live. Then, traditional markets are located in a radius of 2 to 4 km and we chose Deum Kor, Doem Kor and Stung Mean Chey markets where middle and lower classes live. Finally, supermarkets and modern shopping malls correspond to a new life style imported mainly from western countries and rapidly adopted by the Cambodian upper class. But middle and lower classes also go there to enjoy new activities of the modern life. We selected 3 supermarkets: the Lucky Supermarket on Sihanouk Boulevard, the Lucky Soriya in the center of the city and another Lucky Sovanna Supermarket which is around 3.7 km from the center. The Lucky Supermarket on Sihanouk Boulevard is mainly frequented by foreigners and upper class customers compared to the Lucky supermarket located in the Sovanna shopping mall is mainly frequented by the Cambodian middle class. For the Organic shops, we selected 3 brand names: Happy Farm, Natural Garden in city center and DEDAC shops within from 1 to 4 km from the center. In Happy farm and Natural garden shops, most of the clients are foreigners. In DEDAC shops (CEDAC enterprise), there is a mix of Khmer clients and foreigners.

Type of markets targeted	Distance from Independence monument	Population targeted	Type of Food sold
Traditional Markets (Psar)			
Olympic	2 km	Upper and middle class	All kind goods and food but no organic
O'Russey	1.5 km		
Dorm Kor	2.8 km	Middle and lower class	
Stung Mean Chey	4 km		
Supermarkets			
Lucky Sihanouk Blv	0.7 km	Upper and middle class	All kind of goods especially imported goods
Lucky Soriya	1.5 km		
Luctky Sovanna	3.7 km	Middle and lower class	
Organic Shops			
Happy Farm	0.7 km	Upper and middle class	Mainly organic and local food
Natural Garden	0.8 km		
CEDAC at street 63	0.9 km		
CEDAC at street 360	2 km	Upper, middle and lower class	
CEDAC at Kampuchea Krom boulevard	3.8 km		

Table 4-1: list of the survey locations

Map 4-1: Map of survey places in Phnom Penh

4.4. Socio-economic characteristics of the population surveyed

The socio-economic characteristics that we use in questionnaires are based on common situation as well as the response that we got from the survey. Their response permits to get representative characteristic of Phnom Penh population. We target scope our respondent for adults only because we surround those who can take decision in buying foods. In total, we got 300 individuals for our survey. The survey was conducted by using face-to-face interviews directly in the traditional markets, supermarkets and organic shops. After data clearing, only 295 questionnaires are retained because of missing data related to revenues (see detail Table 4-2).

Survey Places	**Frequency (n=295)**	**Percentage**
Traditional Market (Psa)	**120**	**41%**
Olympic	29	10%
O'Russey	30	10%
Dorm Kor	31	11%
Stung Mean Chey	30	10%
Supermarket	**29**	**10%**
Lucky Supermarket	29	10%
Organic Shop	**146**	**49%**
Happy Farm	27	9%
Natural Garden	30	10%
CEDAC at street 63	29	10%
CEDAC at street 360	30	10%
CEDAC at Kampuchea Krom boulevard	30	10%
Total	295	100%

Table 4-2: Sample distribution in each survey's places

We divided respondents into 5 categories of ages that represent different class of people from schooling age to professional age and then retired. Our hypothesis related to job is that NGOs employees and Private Sector Company (bank, companies) employees are better paid than civil servants. The personal business is also another category of job that people can make benefit in Cambodia. People who invest their own money and create their own business particularly in selling clothes, restaurant, food and beverage wholesaler are considered in our survey as personal Business. The other categories are students, garment factory workers, guardians, moto taxi and taxi drivers. Garment factory workers and Guardians are in the category of the lowest salary in Cambodia. For education, we just considerer the main categories of education in Cambodia system.

The Table 4-3 illustrates that majority of respondents (47%) have 25 to 35 years old then 27% have more or less 18 to 24 years old. This means that the majority of our sample is made of young and active people.

In the categories of jobs, 22% are working as employees in the private sector which is representing the first sector of our sample. In addition, other respondents are doing their personal business (15%). 14% of our respondents are students.

Socio-economic Demographic		Frequency (n=295)	Percentage
Age			
	Age 17-24	82	28%
	Age 25-35	138	47%
	Age 36-45	39	13%
	Age 46-60	29	10%
	Age>61	7	2%
Job			
	House wife (No job)	32	11%
	NGO employee	37	13%
	Private Sector employee	64	22%
	Government employee	26	9%
	Personal Business	45	15%
	Student	41	14%
	Others	50	17%
Education level			
	Primary school	36	12%
	Secondary school	46	16%
	High School	48	16%
	bachelor (Bac+4)	131	44%
	Master & More	34	12%
Nationality			
	Khmer	268	91%
	Others	27	9%

Table 4-3: Sample characteristics

The greatest part of the sample is not working related to agriculture, nor environment nor conservation, which represents 80% of respondents.

Related to their education level, 44% of people have a bachelor degree. Then, if we look at the primary school, this level of education corresponds to only 12% of the sample. Globally, this signifies that our respondents are well educated people.

The result shows that the majority of head of household and respondent (90%) are Khmer and around 10% are foreigners: from a Western country, Chinese **or other country.**

4.5. Results

4.5.1. Organic certification in Cambodia

The organic certification in Cambodia is a bit confused between private brand name and official label because before the emergence of the common label certification, different NGOs and institutions working in agricultural and rural development had developed already their organic productions. Then they are selling their products by using their own brand name and often with NGOs' name on the packaging.

In 2006, several NGOs, entrepreneurs, development programs conducted by international donors and individuals in government ministries established the Cambodian Organic Agriculture Association (COrAA) as a Cambodian certification's body that plays an important role in labeling the organic and chemical free products. COrAA works closely to existing farmers associations to establish an internal control procedure under their restrict agriculture techniques for organic products and chemical free. For organic production certification, they follow IFOAM standard guideline. On the other hand, they have COrAA's standards for chemical free agriculture, which does not allow the use of fertilizers and pesticides during the cropping cycle. The controls are divided into 2 steps (1) an internal control ensuring by farmers association themselves, and (2) an external inspection offering by COrAA. In COrAA standard, in 2007, (COrAA, 2007a, 2007b) it took 12 months after following the standards to get the certification "conversion to organic". And it took 24 months for annual crops and 36 months for perennial crops to get the "full" organic label. However, in chemical free certification, no conversion length is required and the standard is less convenient. COrAA revised Chemical free standard in COrAA (2011b) and made it more strict. Then, Organic standard was revised in COrAA (2013) with a remarkable integration of three dimensions of sustainable agriculture as Ecological, Social and Economic sustainability. Anyway, the length of conversion is more suitable than the last version in 2011. It needs 12 months of organic management for annuals crops and only 18 months for perennials crops. Anyway, these labels have not been totally adopted by their founders and partners yet because farmers still can't meet COrAA standards. One remarkable thing is that in all organic shops, local foods

supplementary are very promoted such as Moringa based, Spirulina based, turmeric based so on. COrAA certifies all those organic products.

4.5.2. Food distribution system in Phnom Penh

In Cambodia, the main structures distributing food are traditional markets. Food sellers own their small shops to sell different categories of food. Supermarkets and organic shops are new and they exist only in the Capital, Phnom Penh. Presently, some people understand about advantage of organic food for their health, but organic food is more expensive than non-organic food. Most of organic shops' customers are foreigners as well as Cambodian medium and rich class people. Our preliminary survey in traditional markets, supermarkets and organic shops bear out our hypothesis. The potential consumers are not only foreigners (mainly expats) but also Cambodian people who frequent more and more organic shops. Organic shops are often a small shopping place selling mainly organic food products but sometimes, promoting local food products as well even if they are non-organic. Most of organic shops are often selling their own products from their own farm or from contracted farming of farmer associations that they helped to establish.

4.5.2.1. The Organic shops

There are three types of organic shops in Cambodia.

a. <u>CEDAC organic shops</u>

Created in 1997, CEDAC (Centre d'Etude et de Développement Agricole Cambodgien) is a Cambodian NGO playing an important role in agricultural and rural development. In 2003, CEDAC started its program of organic rice certification. CEDAC has created a business partnership model called "CEDAC enterprise" in which anyone can invest to create an organic shop under this brand name, in order to sell organic products produced by its farmers network. Then, CEDAC encourages farmers to be in cooperatives called "National Federation of Organic Rice Producers Groups" (Cheattho, 2011). People from CEDAC have done marketing for their products under their own label of CEDAC's Natural Agriculture Products and have opened the first organic shop in Phnom Penh in 2004. From 2008, this firm has played main role selling organic food in Phnom Penh and has got high confidence from their customers with its own label. There are now 10 CEDAC shops in Phnom Penh that retails organic product (fresh and processed) bought from their producers

and farmers - 93 organic rice producers associations representing 756 households - as well as others products certified by COrAA. Their supply can't still meet customers' demand. CEDAC enterprise exports also organic rice to United States (114 tons in 2013)[9], with BCS certified quality to the United States under the brand name Organic Brown Mekong Flower Rice and Organic Mekong Flower Rice (COrAA, 2013).

b. Happy Farm organic shop

Happy Farm organic shops were created in 2010. They sell mostly their organic food produced in their integrated farm (fish, animals and crops). They produce both western and local vegetables. And then, they import non-organic food products including vegetables in order to respond to their foreign clients as well as Cambodian with western lifestyle. A lot of their organic products are not certified. Moreover, an employee of Happy Farm market explained to us that their customers increase from day to day and they don't have any difficulties to sell organic foods without certification. The certified products that they sell are food supplementary[10].

c. Natural Garden Shop

The first Natural Garden shop was created in 2008 starting to sell its own products from integrated farming (fish, animals and crop) and then enlarge collaboration with farmers next to its farm. This shop buy as well organic products from others producers and vegetable firms in Cambodia. Most of Natural Garden shop products got "chemical free and organic" certification from COrAA except the imported processed food from Europe for their western clients. Natural Garden targets modern lifestyle peoples and western clients by supplying western vegetable from its own farmers such as romaine, oak leaf, Lolo Rosa, batavia, frisée, roquette and spinach[11].

4.5.2.2. The traditional markets

The traditional markets are the places with open-air building and where individual sellers can have their small store under the roof or just under the big sunshade. They sell all kind

[9] CEDAC. (2015). "CEDAC accomplishement." Retrieved 10 juin 2015, from http://www.cedac.org.kh/?page=detail&ctype=article&id=403&lg=en#sthash.7PV9437r.dpuf.
[10] Happy Farm (2015). Retrieved 29 Jun 2015, from http://www.happyfarm.com.kh/index.php?option=com_content&view=article&id=2&Itemid=9&lang=en.
[11] Natural Garden. (2015). Retrieved 29 Jun 2015, 2015, from http://www.ngkhmer.com/suply-chain

of stuffs for household everyday needs. Whatever, the buyers and the sellers can bargain the price to get an acceptable one. In every traditional market, there are several rice stores inside. Unlike other food stores, rice sellers do home delivery for every client who buy 50kg form. As Rice is main staple, people often buy in big quantity. There are more and more clients order by phone call for home delivery.

There is no certified organic food sold in traditional, but some exceptional sellers gain confidence from their clients to sell non-certified agricultural products with following characteristic "products in Cambodia, small size with spot bitten by insects". In the seller and buyer perception, Cambodian products mean direct link to almost chemical free or organic. Otherwise, sellers confirm that in general they sell quickly Cambodian products. Particularly they will sell out very fast vegetables and fruits because those two products are the most concerned by consumers that believe that vegetable coming from Vietnam and Fruits coming from Thailand contain more chemical residues than Cambodian products. Sellers also validate that beauty as well as size of fruits and vegetable are important criteria to recognize "Cambodian products". They are often small and have insect spots that's the sign of low chemical inputs use. Every seller takes opportunity of confidence from their clients, to sell Cambodian products with a high price. Even though, rice sellers always introduce to consumers their connection to get organic rice from farmers and provincial rice millers. They can sell their "called organic rice" to their confidential clients without difficulty and no need the official label.

4.5.2.3. The Supermarkets

The Supermarkets are often located inside shopping center and the most famous brain is Lucky supermarket. This is a very recent trend in Cambodia and mainly located in PP; there is a huge development of shopping/commercial centers over the past ten years. Lucky supermarkets are a popular one in Phnom Penh and they have 15 locations for supermarkets and fast-foods. In term of size, supermarkets are much bigger compared to organic shops but still smaller than traditional markets. Lucky market group sells very few local products, even rice are mostly imported despite the fact that Cambodia is auto-sufficient in rice. They import from Thailand, Japan and the USA in order to meet client demands from multi-nationalities.

In conclusion for the analyze of food distribution, understanding the market chain of food

distributions in Phnom Penh gives the basic information to get clear point of view of different organic and non-organic market channels . The differentiation of organic and non-organic foods is not simply based on the label but on the whole value chain from crop to consumers' table. The confidence between "organic farmers - organic shops - organic consumers" seems more important than the label itself, according to our in-deep interviews with employees of organic shops and supermarkets. Organic producers associations are regularly associated to organic shops even if they got the label from different institutions, in order to ensure the products flows and avoid label counterfeiting. Moreover, organic consumers see the product differentiation by the shops brand name and shops location more than the label.

4.5.3. Organic food consumption in Phnom Penh

The survey reveals that 67% of population declare consuming certified organic products including rice that they buy from organic shops. Even if it is not 100% of their consumption, they all integrate organic products into their consumption. Come along with only 33% declare never consume any certified organic products.

4.5.3.1. Reasons for consuming organic products

The principal motivation to consume organic products is related to "Preserve health" which represents 95% of the motivations quoted by the people interviewed. Far behind, 70% consume organic product because its quality is related to safety and packaging. Then 66% of people consume organic products because they are also considered as "local products". There are also 57% who consume organic products because they want to improve farmers' revenue. Afterward 53% declare consuming organic products because this kind of food is tastier than non-organic food. Finally only 48% want to preserve the environment by consuming organic products. Apparently, the reason related to their wealth is chosen by 8% (see Table 4-4 below).

Reasons for consuming organic	**Frequency** (n=197)	**Percentage**
Preserve health	187	95%
Quality (safety)	137	70%
Local	131	66%
Improve farmer revenue	113	57%
Tasty	106	54%
Preserve environment	94	48%
Wealth	16	8%
Others (Cheap, help economy, no chemical)	3	2%

Table 4-4: Reasons for consuming organic products

4.5.3.2. Reasons for not consuming organic products

Among non-organic consumers, 54% answer that they don't consume organic products because they don't know where to buy them. Along with it, 24% do not consume organic products because they prefer to buy food in traditional markets as the ambience is familiar with a strong relation between sellers and buyers. 22% find that organic products are expensive, 19% say that organic shops are often located far from their house and 14% do not have enough confidence on the label. The study also reveals that the beauty of the products is not important for consumers (only 14%). This takes out the main difficulty in organic production because without pesticides, farmers can hardly preserve a good fruits or vegetables appearance (see Table 4-5).

Reason	**Frequency (n=98)**	**Percentage**
Don't know where to buy	53	54%
Prefer Food Market ambience	24	24%
Expensive	22	22%
Far	19	19%
No confident on label	14	14%
Not beautiful	2	2%
Others	21	21%

Table 4-5: Reasons for not consuming organic products

4.5.3.3. Places to buy certified organic products

The organic consumers buy frequently their organic products in the different branches of CEDAC shops (70%). Lucky supermarket identified by 21.36% as the place where they buy organic products, which is contrary to our preliminary study that Lucky market doesn't sell organic products except Ibis rice. Happy farm and Natural Garden are both at 17% chosen by organic consumers as their place to buy organic products too (see this Table 4-6)

Places to buy organic food	**Frequency** (n=197)	**Percentage**
CEDAC shop	138	70%
Lucky supermarket	59	30%
Happy Farm	47	24%
Natural Garden	47	24%

Table 4-6: Places to buy organic products

4.5.4. Knowing the organic label

Among all the respondents, 44% declare not to know any organic label. Among people who know the label, 51% declare knowing the CEDAC certification and only 2% declare knowing COrAA label (see Table 4-7).

Type de label	**Frequency (n=295)**	**Percentage**
CEDAC	151	51%
COrAA	15	5%
Ecocert	5	2%
Don't know any label	131	44%

Table 4-7: Awareness of people on organic labels in Cambodia

In contrast, COrAA which is the local certification body is not well-known by Cambodian organic consumers despite it also certifies the organic products sold in CEDAC enterprise shops (COrAA, 2011a).

About Ecocert which is an international certification body, it is known by only 2% of consumers. This result also shows clearly the potentiality of local market for organic products.

4.5.5. Profile of organic consumers

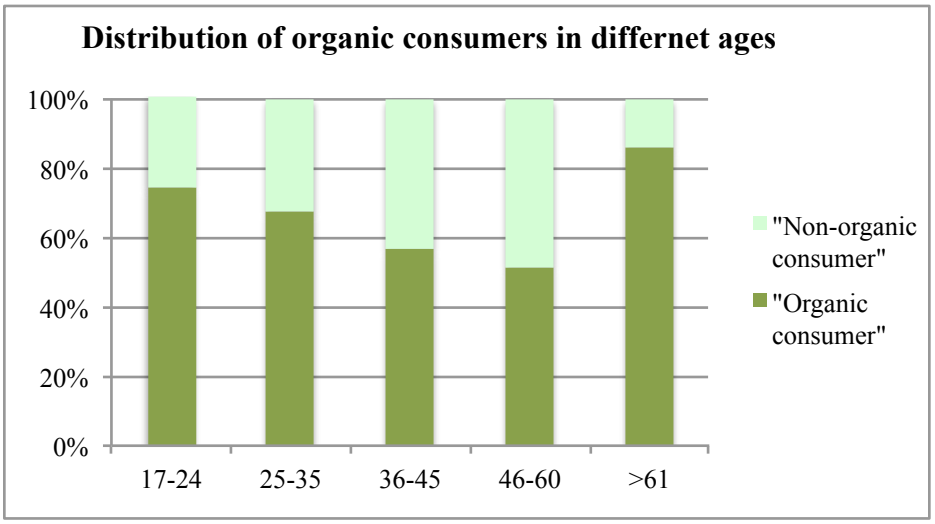
This table below compares the socio-economic characteristics of organic and non-organic consumers in Phnom Penh. This table allows to see the main characteristics and helps to understand the factors determining the consumers group as shown in the Graphic 4-1, Graphic 4-2 and Graphic 4-3 below.

Profile of organic consumers				**(n=295)**
	Organic consumer		Non-organic consumer	
	Frequent	Percentage	Frequent	Percentage
Age of respondent				
17-24	61	73%	21	27%
25-35	93	67%	45	33%
36-45	22	56%	17	44%
46-60	15	52%	14	48%
>61	6	86%	1	14%
Family member (age)				
<13	81	62%	50	38%
13-18	68	67%	34	33%
19-50	190	67%	95	33%
>50	77	68%	37	32%
Family size				
1 to 3	56	67%	27	33%
4 to 6	99	65%	53	35%
More than 6	32	70%	14	30%
Education				
Primary	19	53%	17	47%
Secondary	21	46%	25	54%
High school	22	46%	26	54%
Bachelor	106	64%	25	15%
Master and more	29	85%	5	15%
Job description				
Related to agriculture	35	83%	7	17%
Related to environmental conservation	23	82%	5	18%
Not related to agriculture and environmental conservation	148	63%	87	37%
Family Revenue				
Less than 300$	38	46%	44	53.7%
300-500	53	66%	27	33.8%
500-700	25	81%	6	19.4%
700-1000$	31	79%	8	20.5%
> 1000$	50	79%	13	20.6%

Table 4-8: Organic consumers' characteristics

4.5.5.1. Age

The survey show that consumers of all ages buy organic products. Among them, the elders (more than 60 years old) consume the more. But the youngest part of the population (between 17 to 24 years old) seems also very sensitive to organic consumption as 74% of them declare consuming organic products. We find also that 67% of middle-age consumers (between 25 to 35 years old) declare consuming organic products (see details in Table 4-8 and Graphic 4-1).



Graphic 4-1: Distribution of organic consumers in different classes of age

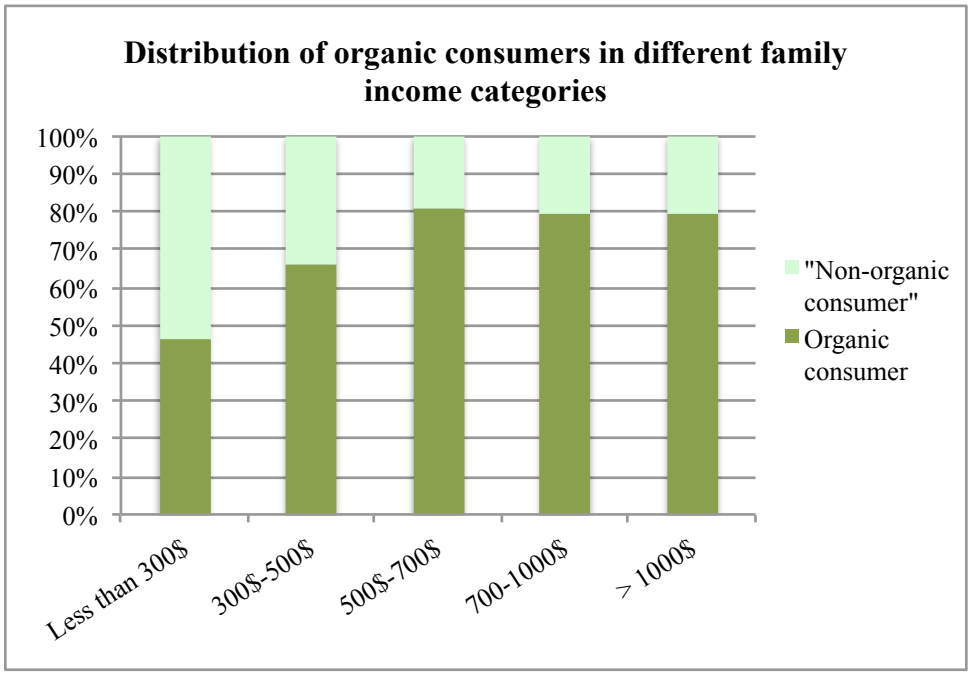
4.5.5.2. Age of family members

Health preservation is the strongest argument quoted by organic consumers. The organic consumers represent more than 60% of all family categories with different ages of theirs members (see detail in Table 4-8).

4.5.5.3. Family income

The wealthier the consumers are, the more they seems to consume organic products. Indeed, the number of organic consumers increases when the level of family income increases. Among those who earn less than 300$/month per family, only 46% of them are organic consumers. In contrast, among those who earn more than 1000$/month per family, 79% are organic consumers. It is also remarkable that with an income from 300$ to 500$/month per family, 66% are organic consumers. And then from 700-1000/month and more, 80% are organic consumers. In conclusion, both middle class (300$-

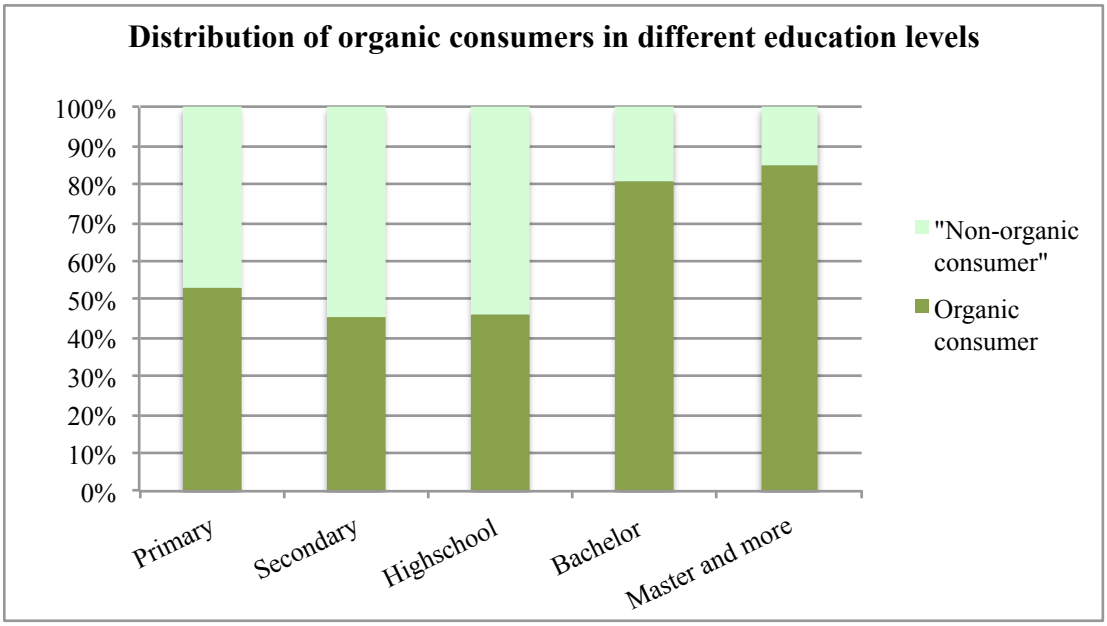
500$/month) and the rich class are potential consumers for organic products (see detail in Table 4-8 and Graphic 4-2).



Graphic 4-2: Distribution of organic consumers in different family income categories

4.5.5.4. Education level

The number of organic consumers in different levels of education from primary school (53%) to high school and associate bachelor (46%) are not significantly different. Nevertheless, from Bachelor (64%) to Master or more (82%), the numbers of organic consumers increase remarkably (see detail in Table 4-8 and Graphic 4-3).



Graphic 4-3: Distribution of organic consumers in different education levels

4.5.5.5. Job description

The result in Table 4-8 shows that more than 80% of people working in relation with agriculture and conservation sectors declare consuming organic products. Nevertheless, there are 63% working in other sectors without any link to neither agriculture nor conservation sector who can also be considered as organic consumers.

4.5.6. Consumer Perception on ES et EDS

For the survey the concept of ES and EDS provided by agriculture was simplified after questionnaires testing by using the term positive and negative impact of agriculture. Each definition proposed in the question number 7 (see Annex C.2) is based on different ES categories of ES identified in Neang *et al.* (2015), adapted from Millinnium Ecosystem Assessment (2005).

The analysis shows that 98% respondents have awareness related to impact of agriculture on ecosystem both positive and negative. And only 2% don't know any impact.

4.5.6.1. Positive impact of agriculture "ES"

The most chosen options in positive impacts are "Food Supply" (93%) and "Serve as basic for economic growth (79%)", which means that people surveyed have a strong awareness that agriculture is provisioning services provider. Anyways, the awareness related to

regulating services and cultural services are well known by 30 to 45% of our respondents (see detail in Table 4-9).

ES	Positive Impact	Frequency (n=295)	Percentage
Provisioning Services	Food Supply	274	93%
	Serve as basic for economic growth	233	79%
Regulating Services	Preserve plant natural variety	133	45%
	Preserve biodiversity, forest and water quality	136	46%
	Preserve environment	130	44%
	Mitigate climate change	91	31%
	Other (Create work, health in general, quality of village's products)	9	3%
Cultural services	Preserve some Khmer culture	91	31%

Table 4-9: Awareness of peoples on ES related to agriculture

4.5.6.2. Negative Impact of agriculture "EDS"

On the other hand, seeing agricultural sector as polluter is strongly representative in their choice, which is 81%; so chemical pollution is their first concern. Related to this choice, the "Human health degradation by chemical inputs" is also chosen by 77% of respondents as their second concern. Contrary only 58% think about farmers' health degradation. The options related to forest and biodiversity degradation as well as climate change acceleration is their fourth concern. Natural variety degradation is the last one, and only 24% of respondents are concerned about it (see detail in Table 4-10).

EDS	Impact Negative	Frequency (n=295)	Percentage
Degrade Regulating services	Chemical pollution	239	81%
	Human health degradation by chemical inputs	227	77%
	Farmers health degradation	171	58%
	Forest degradation	142	48%
	Biodiversity degradation	112	38%
	Accelerate Climate change	91	31%
	Natural varieties degradation	71	24%
Others (Degrade natural condition for agriculture, lose the quality of nature, degrade people's health, use natural resources)		3	1%

Table 4-10: Awareness of peoples on EDS related to agriculture

4.5.6.3. Type of agriculture providing ES

Within those who know the impacts of agriculture on ecosystem, only 2% of them don't

know the type of agricultures that provides positive impacts. We use the term positive impact to represent the ecosystem services; so a type of agriculture that provide a positive impact is a type of agriculture providing ecosystem services. In Table 4-11, 83% of respondent identified organic agriculture as ES provider. "Agriculture who uses the natural variety" is at the second position of ES provider (64%). On the other hand, "Agriculture without amendment" and "Conventional agriculture by respecting the standard of chemical inputs use" are at their last choices as ES provider (see detail in Table 4-11).

Type of agriculture providing impact positive (ES)	Frequency (n=295)	Percentage
Certified Organic agriculture	245	83%
Agriculture who use the natural variety	188	64%
Agriculture without amendments (organic or inorganic)	109	37%
Conventional agriculture respecting standard of chemical use	98	33%
Others (agriculture that produce naturally or based on farmers knowledge)	3	1%
don't know	8	3%

Table 4-11: Awareness of people on types of agriculture providing ES

4.5.7. Relation between ES awareness and organic consumption

In the multiple choice questions, respondents can choose both knowing positive impact and negative impact of agriculture on ecosystem and human health vs. they don't know any impacts. Then the question related to types of agriculture providing positive impacts (ES) is also multiple choice of different agricultural practices vs. they don't know any type.

Profile related to Awareness				**(n=295)**
	Organic consumer		Non-organic consumer	
	Frequent	Percentage	Frequent	Percentage
Consumers perception on ES and EDS				
Knowing Impact Positive (ES)	105	77%	31	23%
Knowing Impact negative (EDS)	91	73%	34	27%
Don't know impact	4	57%	3	43%
Perception on types agriculture providing positive impacts (ES)				
Organic agriculture	177	72%	68	28%
Conventional agriculture respecting inputs (fertilizer	72	73%	26	27%
No amendment	76	70%	33	30%
Use natural varieties	120	64%	68	36%
Don't know any type of agriculture	2	25%	6	75%

Table 4-12: Organic consumer profile related to their perception and awareness

Among those who know positive and negative impacts of agriculture on ecosystem and human health, as we can see in Table 4-12, 77% of those who know positive impacts and 72% of those who know negative impacts are organic consumers. And still 57% of those who don't know any impacts are also organic consumers.

Among those who believe that the conventional agriculture respecting the rate of each chemical inputs provides a positive impact on ecosystem and human health, 73% are organic consumers. This result shows that even if they believe that there is alternative technique to provide positive impact, they still consume organic.

Then, among those who identify organic agriculture as practices providing positive impacts (ES provider), 72% are organic consumers. In a similar way, among those who identify no amendment agriculture as ES provider, 70% declare consuming organic. And finally, 64% of organic consumers chose "agriculture using natural variety" as type of agriculture providing ES (see detail in Table 4-12).

4.6. Discussion and Conclusion

Organic and non-organic food products are not sold in the same food distribution system. Organic food is mainly sold in organic shops, few are sold in supermarkets but they are absolutely not sold in traditional markets. Organic shops often sell their own farm products where they can guarantee the quality of the product and the certification process. Sellers in traditional markets still can get consumers' confidence to sell non-certified organic food products.

The main reasons that motivate organic consumption are (1) health preservation, (2) quality of products (3) local products, (4) improving farmers' revenue, (5) tasty products and (6) environmental preservation. This result gets in line with the results obtained from international literature such as Loureiro *et al.* (2001); Figuié (2003); Mergenthaler *et al.* (2009); Ibitoye *et al.* (2014b). This literature demonstrates that consumers put their health and products quality at main reasons for organic products consumption. Those studies find that environmental benefit is also at the first priority of choice. In contrast, our study shows that environmental preservation is at 6th range in consumers' choices concerning organic food (for our sample of people living in Phnom Penh). An explanation could be that for Cambodian citizens, development is a priority, comparing to environmental preservation, because Cambodia is a developing country. .

Organic consumers disperse in all different socio-economic categories. However, most of them are young under 24 years old and elders more than 60 years old. In categories of family size and ages of family, around 60% in each categories are organic consumers. On the other hand, organic consumers in the category of job related to agriculture and conservation are more in than other jobs, without relation to agriculture and conservation. Furthermore, there are more organic consumers in high levels of education starting from bachelor than in lower levels.

Our study shows that there is less organic consumers (46%) in the category of family income lower than 300$/month but it start increasing (66%) in the category of 300$ to 500$/month. In addition from 500$/month to more than 1000$/month per family there is no different level of organic consumers per category (79% to 80%). This result raises question about the study done by Kempen *et al.* (2009) proving that consumers in developing countries are too poor to pay the price premium for certified products.

Nevertheless, our findings reveal another connection between three reasons for consuming organic products: "local product", "improve farmers revenue" and "environmental preservation". This means that Cambodian consumers have willingness to consume local organic products in order to reduce rural poverty. For sure, fair trade is one choice for developing countries to alleviate poverty but sometimes it focuses too much on international market both in research studies and policy, such as approaching by Setboonsarng (2006b); Thavat (2011); RGC (2014). Our finding demonstrates that there is local demand for organic products, which may lead to possibility for domestic markets development. Developing shorter value chain could probably reduce transaction costs. Or

else, the Protected Geographical Indications (GI) sound realistic because of the consumers expectations for quality of products related to territory as mentioned in GI policy brief of MoC and MAFF (2010) about Battambang oranges, Battambang rice, Kampot durian and Kampot pepper. The connection of those three reasons for organic consumption combining with consumers' perceptions on type of agriculture using natural varieties as ES provider could be translated as a significant consumers' behavior for eco-label as well as product-based ES. It could be linked with propositions of Sandhu *et al.* (2007), Bennett and Franzel (2009) and Sandhu *et al.* (2010a) to use agriculture as fundamental for ecosystem conservation by enhancing ES provided by agriculture. In addition, the population of the survey has a good knowledge about positive impacts (ES) and negative impacts (EDS). Our study shows also the common result based on consumers' perception of ES provided by agriculture, they focus on provisioning services much more than other services. As well as their perception on EDS, agriculture is well known as a chemical polluter and for natural resources degradation, which is also clearly mentioned in FAO (2007).

This exploratory research should be pursued toward willingness to pay for product-based ES to evaluate local farmers' goods practices guaranteeing ES provision from agriculture. A rural country such as Cambodia, needs a strong agricultural policy to preserve its own traditional practices as well as its reach genetic bank face to global competitive market and ignorance concerning own local market. Seeing high expectations of local urban consumers for environmental products, Cambodia should enhance its comparative advantage for an agriculture respecting ecosystem services more than jump into highly productive agriculture for exportation. Cambodian consumers are willing to preserve their health, farmers' health, natural ecosystems and also to increase farmers' revenue through their consumption. This opens a big gate toward product-based PES as mentioned in Muradian *et al.* (2009). This product-based PES could be obtained by a resource transfer between different social actors in order to get a social benefit. This way out sounds as a perfect starting point to reduces rural poverty. By the way, it needs also a strong policy related to label and certification link with a strong institutional and legal framework for label protection. Besides, human resources with knowledge and awareness related to ES and PES are important to make it happen. Subsequently, this is also an open door for scholars and researchers in the related domains.

General conclusion

Farmers manage their ecosystem and transform it into an agro-ecosystem producing food and fiber for humans and animals as well as inputs for other economic sectors. Through this role as source of provisioning services, agriculture is often considered as a polluter and as an activity that degrades forests and natural resources. But agriculture also plays an important role of provider of other ES (regulating services, cultural services) thanks to its positive practices and appropriate agro-ecosystem management. Unfortunately, those ES are generally consumed by the whole society without any financial compensation for farmers (FAO, 2007; Swinton *et al.*, 2007; Zhang *et al.*, 2012). Moreover, the opportunity cost for those farmers appears to be high, leading them to adopt more labor-intensive agricultural systems with a better economic return. This situation leads to a trade-off between provisioning services and other ES. PES is a market-based mechanism used to incentivize farmers to maintain agricultural land uses providing ES, even if it often cannot cover all of the opportunity cost (Wunder, 2006; Pham *et al.*, 2013). The main question of this dissertation is: How do the ES notion and PES schemes emerge in Cambodia? Are they implemented in the agricultural sector? Then, following the results related to this emergence, this dissertation aims at exploring ES provisions from agriculture: Do rice production systems provide ES? Are there possibilities to find a local market for these ES?

This thesis is made up of four articles. The first one is related to the emergence of the ES notion and PES schemes in Cambodia. The second one presents the TSL flood pulse agro-ecosystem for rice production systems and the understanding of the conditions of farmers' adoption of different rice cropping systems. The third article aims at identifying ES and EDS related to those rice production systems and then calculates farmers' opportunity cost to maintain those ES. The last article tries to identify socio-economic characteristics of organic consumers and their awareness of ES and EDS provided by agriculture.

Through this conclusion, we intend to summarize our main findings, recapitulate our analytical, theoretical and methodological contributions. We then propose a price premium product-based PES related to organic rice and others rice providing ES. We finish with policy recommendations and perspectives for future research.

Main results

Our first research focuses on understanding the emergence of the ES and PES concepts using the International Policy Economy framework (Strange, 1996). This framework enables to explain why some issues and problems become prominent in the policy agenda and are eventually translated into concrete policies. The study then provides an analysis of the sphere of influence (Steinberg, 2003) and the window opportunity (Kingdon, 1984) of the ES and PES concepts in Cambodia. Our study tries to identify PES forms that are currently implemented in Cambodia. About thirty semi-structured interviews were carried out during 2009-2010 with a wide variety of national and international institutions including donors, private companies, administrations, NGOs and academic institutions working on natural resource conservation and rural development in Cambodia. Our findings illustrate that ES and PES have not been used in the agricultural sector yet. ES and PES concepts flow from an international level into Cambodia through conservation stakeholders and funds with the will of donors to support conservation NGOs in their activities. The notion of ES is much more understood as Environmental Services than as Ecosystem Services and is often associated with carbon sequestration and biodiversity conservation for flagship species. The most influential donors are USAID, AFD, UN (UNDP, UNESCAP) and philanthropic foundations. Conservation NGOs (CI, FFI, WWF, WCS, Wildlife alliance, WildAid, PACT) work in cooperation with the Ministry of Environment in the context of protected areas, with the Forestry Administration (MAFF) in the context of protected forests and with the Fishery Administration (FiA) in the context of flooded forests and coastal zones. These administrations often find themselves in overlapping activities. Forest and Natural Resource Management is mainly based on command-and-control tools under the Forest Law (2002) and the Law on Environmental Protection and Natural Resource Management (1996) focusing on protected forests and protected areas creation. Only from the early 2000's has the notion of ES been increasingly used, both in public policies and operational projects related to Forest and Natural Resources conservation as well as pro-poor development. Forestry Communities and Protected Area Communities were created in order to apply Community-Based Natural Resources Management (CBNRM). The incentives take two forms: direct and indirect payments. Conservation NGOs incentivize the local communities with direct payments to adopt conservative land use practices in agriculture and NTFP collection. Indirect

payments come in the form of an eco-label (Ibis rice) for agricultural and NTFPs products. Additionally, ecotourism acts as a source of rural revenue which incentivizes farmers to stay in the conservation program. All of these projects are still at the pilot stage and at small scale. Since 2010, REDD+ and climate change mitigation mechanisms are well integrated in national policies and strategic plans. But ES and PES are still not well known and are still missing in policies. Development NGOs working on rural and agricultural development are not working with ES and PES yet. All of their projects are Integrated Conservation and Development projects, following the idea of sustainable development. For lack of public policy with economic incentives to preserve ES, PES schemes turn to the markets and international aid. This first paper confirms our **hypothesis 1** stating that ES and PES have not emerged in agro-ecosystem conservation yet.

The second paper seeks to understand the agro-ecosystem of the Tonle Sap Lake (TSL) flood pulse and its farmers' practices. We apply the Agrarian System Diagnosis and Analysis approach (Cochet and Devienne, 2006b; Cochet *et al.*, 2007; Cochet, 2012) which enables to understand how the ecosystem determines farmers' practices and how they manage the agro-ecosystem to adopt different rice cropping systems, organic rice in particular. In 2012-2013, we carried out a survey in Kampong Thom province on the agro-ecosystem of the TLS flood pulse. The survey included 36 farmers for qualitative data related to history and understanding of the agro-ecosystem's management. We then conducted in-depth interviews with 172 farmers, collecting quantitative data in order to calculate value-added. The area has propitious soil for agriculture and rice is the most adapted cultivar for this floodable agro-ecosystem. Rainy season rice cropping systems, floating rice in particular, are well adapted to the flood pulse. However, short-term rice varieties are being adopted in order to better respond to floods by cultivating outside of flood periods occurring during rainy season. Organic rice cropping system is adopted to cultivate next to the villages in areas that are not floodable outside of flood disasters. This cropping system increases risks for farmers in case of flood. Farmers' strategies to reduce risks are to combine different rice cropping systems into one production system in order to use the flood plain agro-ecosystem. To adopt short-term rice in their production systems, they have to invest in small-scale irrigation systems or to buy chemical inputs. For those who do not have enough financial means, some service providers and chemical input sellers accept to give everything in advance with obligation to reimburse at harvesting time. So farmers do their best to convert their rice fields, year by year, to adopt short-term

rice. They keep their other rice fields, where it is impossible or too expensive to convert, for producing floating rice and rainy season rice. Some farmers can do two short-term rice cycles, which allows them to double their revenues. Organic rice is not widely adopted because of economic, ecological, social and institutional constraints. Despite its value-added per hectare being higher than other rice cropping systems (except double cycle of short-term rice), organic rice provides very low value-added per one family labor (fl). This is because farmers lack inputs for compost, need a high quantity of work for this system, and have no possibility to increase the surface/fl because of the limited surface per family and the risk of flood. This result supports the **hypothesis 2** stating that the price premium is not high enough to promote the adoption of organic rice production. Actually, the reasons for low adoption are much more complicated and the price premium cannot be the only explanation.

In our third paper, we combine the Agrarian System Analysis and Diagnosis approach with the ES and EDS framework proposed by Zhang *et al.* (2007). We use the same sample and data, collected from the 172 farmers during 2012 and 2013, as our paper 2. This combined approach allows to detail ES and EDS in the interactions between agro-ecosystems and rice production systems. Our approach enables to analyze the trade-off between provisioning services and other ecosystem services. Agricultural techniques and land management practices allow us to identify ES and EDS from agriculture. Our findings reveal the possibility to reduce trade-offs between ES provided by agriculture. This corresponds to reconciling economic growth and conservation by promoting rice production systems that provide a high level of provisioning services and that are harmless for other ES. In our findings, double cycle short-term rice cropping systems provide the highest land and labor productivities but increase pollution, degrade agro-biodiversity, natural varieties and habitat and disturb natural flood regulation. On the contrary, rainy season rice cropping systems, especially floating rice, provide low land and labor productivities but enable farmers to produce rice in harmony with the natural flood pulse ecosystem. Thus integrating these 2 systems into one production system reduces the trade-off between provisioning services and other ES. Meanwhile, enlarging rainy season rice surface enhances ES provision increasing social benefit. Our analysis shows that organic rice cropping system is less ecologically efficient than rainy season rice, and that the price premium for organic label is not high enough to reach an economic efficiency similar to short-term rice. Our study confirms the **hypothesis 3** stating that organic rice is not the

only ES providing system. All rice production systems providing ES lead to high opportunity costs for farmers, as their value-added per family labor is low.

Finally, our fourth paper aims at identifying socio-economic characteristics of local organic consumers and to determine their environmental awareness related to ES and EDS. In this article, we use the Consumers' Preferences theoretical framework of Lancaster (1966) and the model of food consumption proposed by Coestier and Marette (2004) and MacFie (2007).

For this study, we carried out a survey with 295 consumers in 10 different traditional markets, supermarkets and organic shops in Cambodia. This study provides an understanding of the demand for organic agricultural products, including rice, from Cambodian consumers in Phnom Penh. In organic shops, organic products are separated from non-organic ordinary products that are sold in traditional markets. In supermarkets, only a few brands of organic rice are sold. Cambodian organic products are mainly certified by COrAA, the local certification body. Some organic shops possess their own label. Organic consumers value the shops' brand names more than the label itself. Besides, Ibis Rice is the only wildlife friendly organic eco-label, created by WCS to incentivize farmers to preserve birds (Ibis and Giant ibis). The international label Ecocert is not well known in the Cambodian market. Our survey reveals that 67% of consumers claim to consume organic products. The reasons are for (1) health preservation, (2) quality of products (3) local origin of products, (4) improving farmers' revenue, (5) tasty products and (6) environmental preservation. The willingness to consume organic products in order to improve farmers' revenue, encourage local products and preserve the environment is an open window for implementing GI label and Eco-label products. The surveyed population identifies well the ES (positive impacts) and EDS (negative impacts) from agriculture. They identify "Organic agriculture", "Conventional agriculture respecting input (fertilizer and pesticide) rates", "No amendment agriculture" and "Agriculture that uses natural varieties" as ES providing practices. For lack of public policy to preserve ES provided by agriculture, the ES based-product label appears to be a good way to preserve ES and reduce rural poverty by increasing farmers (ES providers) revenue. In this regard, strong policy on labels and certifications is needed, together with a strong institutional and legal framework for label protection. The findings of our study do not support the initial **hypothesis 4** stating that organic consumers have specific characteristics compared to

others. Firstly, organic consumers are not only educated and wealthy people; secondly, they do not work specifically in either agriculture, environment protection or conservation. And finally, all the surveyed consumers are aware of ES and EDS related to agriculture and are able to identify the types of agriculture providing ES and EDS.

Contribution of this dissertation

Theoretical contribution: combining approach "Apply Agrarian System Analysis and Diagnosis in ES identification

The adoption of rice production systems that guarantee food security, economic development and biodiversity conservation is a challenge for farmers. We have built a specific approach based on the framework developed by Zhang *et al.* (2007) on ES and EDS in agriculture in combination with the methodology of Agrarian System Analysis and Diagnosis developed in (Cochet *et al.*, 2007; Cochet, 2012). Thanks to this approach, we have reached, in particular, the **Objectives 2 and 3** of the thesis. This combined approach also enables to understand numerous factors of the following issues.

Firstly, it shows the ecosystem's role in the adoption of agricultural practices. Each farmer, according to his capital (land, labor, financial capital), his knowledge and his risk aversion, combines different cropping systems in his production. The analysis enables to understand the importance of the ecosystem for small household farming. All modifications in the natural functioning of this ecosystem imply serious changes. In this precise case, the hydraulic construction project in the Mekong region is likely to harm this fragile balance. The measurement of the ecosystem's importance for rice production and its impact on the social organization should be taken into account, in particular when the country engages in green growth.

Secondly, agricultural practices, such as chemical input application, conversely modify the ecosystem's functioning and reduce just as much the quality of ecosystem services. Farmers are aware of the impact of their techniques on services that they derive from this flood pulse ecosystem, such as water, fish and many kinds of rice field aquatic species.

Thirdly, this analysis enables to show that maintaining all ES is impossible. There exist huge constraints to provide all ES at the same time as increasing provisioning services.

This supports the results of the study by TEEB, for example. The trade-off analysis leads to opportunity cost calculation, which is rare in the literature. Agrarian System Analysis and Diagnosis is very useful to carry out this calculation. It enables to demonstrate the economic cost of adopting agricultural practices that improve regulating and cultural services. In this study we propose to identify the efficient production systems, leading us to imagine a Pareto efficient frontier. The limits of this calculation are clear. It is difficult to compare precise economic data with scores stemming from the judgement of experts and of local farmers. Nevertheless, there is potentially a benefit for policy making in obtaining a cardinal measure of cost-efficiency by estimating a monetary value of regulating and cultural services. This estimation is partly random due to the methodological biases and to the cost of collecting the data. The benefit of this measure is thus uncertain. This represents a potential research orientation for the future. Similarly, it seems important to emphasize the importance of spatial dynamics (landscape analysis). The TSL flood pulse ecosystem is also important for fishing activities. An additional assessment of this sector could provide important information to the TSL area planning decision makers. Finally, it could be useful to insist on how the good functioning of the TSL ecosystem provides a natural insurance to populations. A livelihood analysis could shed light on the strategies adopted by farmers under political, economic and natural shocks. For example, the World Bank mentions that during the economic crisis in 2009, almost 20% of the urban population went back to live with their family in rural areas (World Bank, 2013).

Empirical contribution: well-defined ES and market perspective for price premium

This dissertation offers a good understanding of relationships between humans and agro-ecosystems. Cambodian farmers use the ecosystem of the TSL flood pulse to produce rice, ensuring a supply of the main staple for the population. Along with rice, they also provide various ES but still without PES. In theory, the basic idea behind PES schemes is that the users or beneficiaries of a service compensate the providers. These findings may provide inputs to a potential PES framework to remunerate farmers. The PES will benefit both service providers and service beneficiaries, as well as result in continued or improved ecosystem services, beyond what would have been provided without the payment (Engel *et al.*, 2008; Wunder, 2008; Wünscher *et al.*, 2008). Nevertheless, in our study zone, the direct ES users are farmers themselves and people living on the TSL (see Table 1-Conclusion).

		Benefits and Beneficiaries		Price	Potential Market and payment
		Farmers and local population	General population including farmers		
Regulating Services	Agro-biodiversity / water quality	Sources of additional revenue Sources of food Drinking water for humans and animals	Food Drinking water	Market price for food and drinking water	
		Consumptive and Non consumptive Fauna and Flora to regulate soil fertility and diseases, for humans as well as rice production itself Water quality and ecological balance ensuring biodiversity	Consumptive and Non consumptive Fauna and Flora for disease regulation for humans Water quality and ecological balance ensuring biodiversity	Market Price for consumptive species No price for others	Price premium for water-based ES Price premium for food (consumptive species) from rice field Price premium for rice-based ES Rural Eco-Tourism
	Natural Variety Existence	Preservation of genetic bank Enhanced resilience	Preservation of genetic bank Enhanced resilience	Market price for rice as food No price for genetic bank preservation	Price premium for rice-based ES
	Habitat / biodiversity	Sources of additional revenue Sources of food and basic need supplies (firewood, NTFPs)	Food and basic need supplies (firewood, NTFPs)	Market price for food	
		Enhanced resilience Climate change adaptation or mitigation	Enhanced resilience Climate change adaptation or mitigation	No price	Price premium for rice-based ES Rural Eco-Tourism
	Flood regulation	Enhanced resilience Climate change adaptation or mitigation	Enhanced resilience Climate change adaptation or mitigation	No price	Price premium for rice-based ES
Cultural Services	Spiritual / Scenic services	Maintain Social relationship in sharing labor (floating rice-grazing-NTFPs collecting-fishing) Beauty of landscape Preservation of social identity by palm tree as Khmer identity Preservation of social identity by traditional cropping systems of rainy season rice and floating rice Preservation of social identity by Khmer rice variety (natural varieties)	Beauty of landscape Preservation of social identity by palm tree as Khmer identity Preservation of social identity by traditional cropping systems of rainy season rice and floating rice Preservation of social identity by Khmer rice variety	No price	Price premium for rice-based ES Rural Eco-Tourism

Table 1-Conclusion: Potential markets and price premiums associated with ES provided by rice production system of the TSL area

Most of them are poor (Heinonen, 2006; Matsui *et al.*, 2006) and they may not be able to pay. As a consequence, in this case asking ES users to pay may lead to social conflict caused by poverty. Moreover, the lack of Public Policy for PES schemes, and of Agricultural Policy on ES makes a user-payer mechanism sound hard to implement.

As it is, a market-based instrument PES sounds relevant to bring the non-market value ES into monetary form and incentivize conservation. This mechanism could cover part of the opportunity cost of ecosystem users to preserve the ecosystem in a way that it continues to provide the ES. It can take different forms, such as subsidies to farmers for adopting alternative land uses providing ES or as a fee charged in eco-tourism, etc. Yet another form can be a **product-based ES eco-labeling** with a **price premium** (Engel *et al.*, 2008). In this perspective, we propose a framework to identify ES that can be taken into account in a price premium in Table 1-Conclusion above.

Empirical contribution: An initiative towards a product-based PES scheme to compensate farmers' opportunity costs

In paper 1, we found that the notion of ES has not been used in Cambodian agricultural sector yet. Moreover, 80% of Cambodians are farmers living in rural areas and 70% of agricultural land is used to produce rice. Additionally, 90% of Cambodian poor rely on rice production and need productivity improvements and price increases in order to escape poverty (World Bank, 2013). Our idea is to identify rice production systems providing ES in order to target farmers providing ES. Then, by analyzing value-added per family labor, we would be able to identify the poor among them. The rice-based PES scheme could then target those poor as a priority.

Our findings show that organic rice cropping system provides less ES than some rainy season rice cropping systems, especially floating rice. These systems take place on a flooded agro-ecosystem where they could not be certified organic because of the natural flood pulse flooding that agro-ecosystem every year. Thus, farmers are only remunerated for provisioning services by market prices of rice, reflected as Value-added per one family labor (VA/fl) (see Figure 1-Conclusion). Short-term rice provides high VA/fl but degrades other ES. On the contrary, rainy season rice cropping systems, especially organic rice and floating rice, provide low VA/fl but high value of non-price ES. By maintaining those systems, farmers apply practices that are helpful for ES provision but they incur very high

opportunity costs. These ES are produced at the same time as rice but only rice is remunerated by the market price paid by consumers. We thus ask ourselves the question: how could we compensate farmers' opportunity costs?

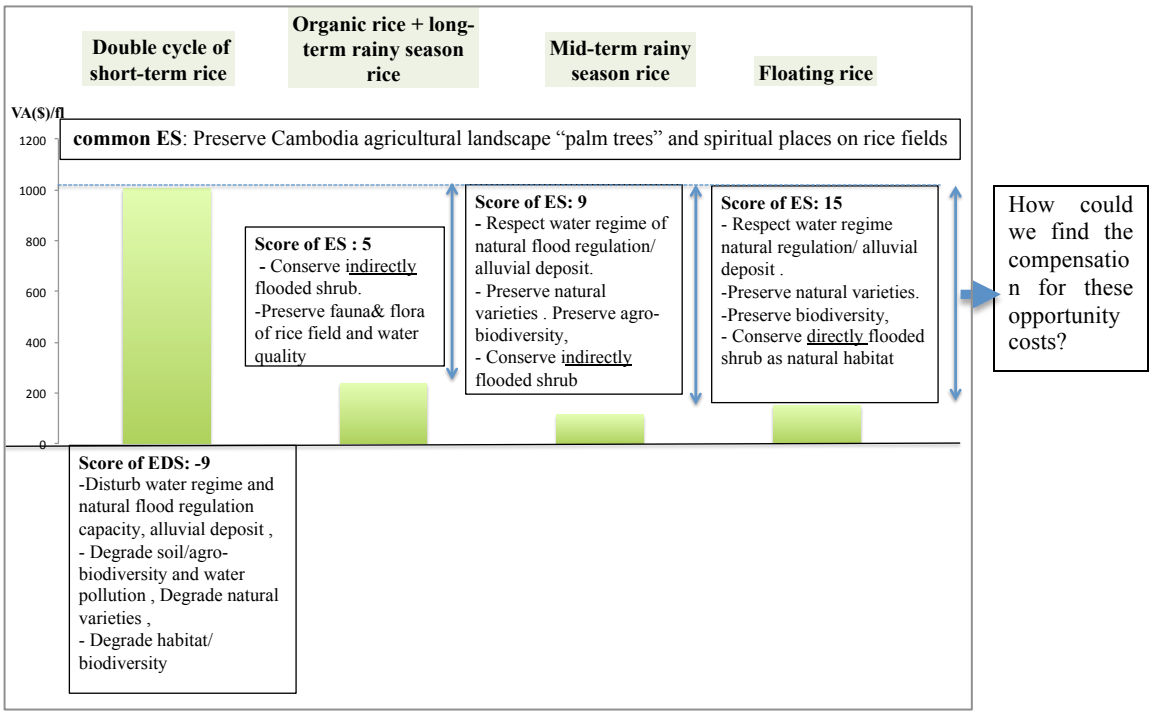


Figure 1-Conclusion: Farmers' opportunity costs and ES provision

In theory, product-based PES is used for poverty reduction. It's a resource transfer between ES beneficiaries (Consumers) and ES providers (Farmers) to maximize social benefit from ES. The process of product-based PES needs a strong management of farmers associations. Moreover contract farming could be used to secure ES provision in the same way that it is commonly used to secure supplies. (Gómez Tovar *et al.*, 2005; Gibbon and Bolwig, 2007; Wunder, 2008; Zilberman *et al.*, 2008; Muradian *et al.*, 2009; Clements *et al.*, 2010).

Even if farmers never intentionally decided to provide these services, they are integrated in their way of producing rice and they benefit the whole society. As our fourth paper revealed a local demand from consumers for organic and ecological agricultural products, we could confirm the possibility to find a market for some of them with a rice-based ES price premium. They could be bought by rice consumers and the price premium would be used to compensate farmers' efforts for the opportunity costs of ES provision.

Perspective

Theoretical perspective: Payment for Ecosystem Services provided by rice producers

As revealed in several studies, the absence of a price for natural resources generates overuse of both renewable and non-renewable natural resources. The theory of ES and Natural Resources Commodification started between the 1950s and the 1960s. It then moved progressively from the concept of Nature's benefits as "Use Value" in Classical Economics to the concept of "Exchange Value" in Neoclassical Economics, by integrating ecosystem functions as "services" and looking to define the monetary value of ecosystem goods and services. Then in the late 1970s, the concept of Ecosystem Services (ES) and the environmental issue were spread widely at the global scale with the aim of inducing public interest for conservation. Natural capital is identified as a stock that needs to be preserved to ensure non-market ES provision. In the late 1990s, ES commodification and monetary valuation methods become the center of economics study, and help economic decision making for biodiversity conservation (Gómez-Baggethun *et al.*, 2010). The concept of ES was broadly defined by Millennium Ecosystem Assessment (MEA), since 2003 and again in 2005, as benefits that humans derive from the ecosystem and use to achieve human well-being. Apart from provisioning services, all types of other ES are declining together with natural capital depletion. In total, two thirds of other ES are declining (Millinnium Ecosystem Assessment, 2005). Then in the 2000s, ES and their value being well defined, they could start to influence policy decision making. At the same time, market-based mechanisms started to be used in conversation, called Payment for Ecosystem Services or Payment for Environmental Services, to guarantee these ES provisions (FAO, 2007; Méral, 2012). In developed countries, organic agriculture and ES became an important subject of research and literature with the goal of showing the ability of agriculture, organic agriculture in particular, to sustain ES (Sandhu *et al.*, 2010a; G. Philip Robertson *et al.*, 2014). The emphasis is often put on agriculture as this sector shows very clearly the trade-off between provisioning services and regulating services (Sandhu *et al.*, 2010b). Agriculture is central for food security. However it is also at the heart of sustainable landscape management for biodiversity conservation. Biodiversity in turn guarantees the vitality of the ecosystem which sustains ES provision. A particular objective of this research area is to give an important role to economic incentives to ensure good practices in agriculture. Eco-labeling is well adapted in practice to increase price premiums for organic products-based ES for biodiversity conservation (Goulart *et al.*; Meichtry-Stier *et*

al.; Tscharntke *et al.*; Bengtsson *et al.*, 2005; Smith, 2006; FAO, 2007; Wunder, 2008). Within these good practices, organic rice takes an important part in the literature because of its high potential in biodiversity conservation, particularly agro-biodiversity (Berg *et al.*; Setboonsarng *et al.*, 2006; Clements *et al.*, 2010; Thavat, 2011; Clements *et al.*, 2013). Identifying ES provided by rice production systems is addressed by this dissertation, but bringing these ES into the market is still missing from this dissertation. Provided ES still do not have precise calculated prices and the beneficiaries are still not identified.

Policy recommendations

In Cambodia, agricultural policies focus mainly on intensification through adoption of new agricultural technologies and machinery to improve productivity for export. In this case, agriculture may become a source of pollution and degradation of forest and natural resources. The agro-ecosystem located around the Tonle Sap great lake plays an important role as one of Southeast Asia and the world's biosphere reserves. However the country lacks of a policy in agriculture for natural resources conservation for a sustainable agricultural development. Rice production intensification may lead to a faster deforestation of flooded forests and degradation of grassland, which should cause a reduction of habitat for agro-biodiversity, birds and fish. Being a country where food security in rural areas relies on rice field species and where the urban population loves consuming these species, agricultural intensification directly threatens human well-being. Moreover, the great lake is an important productive ecosystem providing a habitat to fish, aquatic plants, animals and birds of Southeast Asia. Conservation and development are seen in developing countries as two parts of a trade-off where only one part can be achieved. In particular, in countries where the agricultural sector is seen as the main way to ensure economic growth, conservation is often ignored. In Europe, the Common Agricultural Policy (CAP) and Agro-Environmental Measures define agricultural techniques providing ES for a sustainable rural landscape management. Organic agriculture is a holistic approach that yields both environmental and economic benefits. Organic agricultural practices are well defined for ES provision and enhancement. Similarly, the framework of product-based ES could be developed in Cambodian policy to support ES providers in order to foster sustainable economic growth. At the same time, in the context of weak institutions and without either a legal framework or governmental budget to subsidize agricultural practices, Cambodia may turn to the market and find green consumers willing to pay for

rice-based ES provision. Based on our findings, our policy recommendations are as follows:

Rice Organic Label should be enhanced and should integrate the notion of ES in order to increase price premium for certified organic farmers.

Rice Eco-label should be developed to represent the benefits of "natural variety, flood regulation, resilience, natural habitat for inland fish and bird species". For example, the Wildlife Friendly Label could be used specifically for rice produced in zone 3 to preserve the habitat of the threatened bird species Bengal Florican (Houbaropsis Bengalensis).

GI certification could also be developed for local products. Recently, the government has released a "One village, one product" regulation that makes GI certification easier.

The agricultural and rural eco-tourism activities should be enhanced and implemented more widely to encourage and incentivize some cultural services related to rice field landscapes.

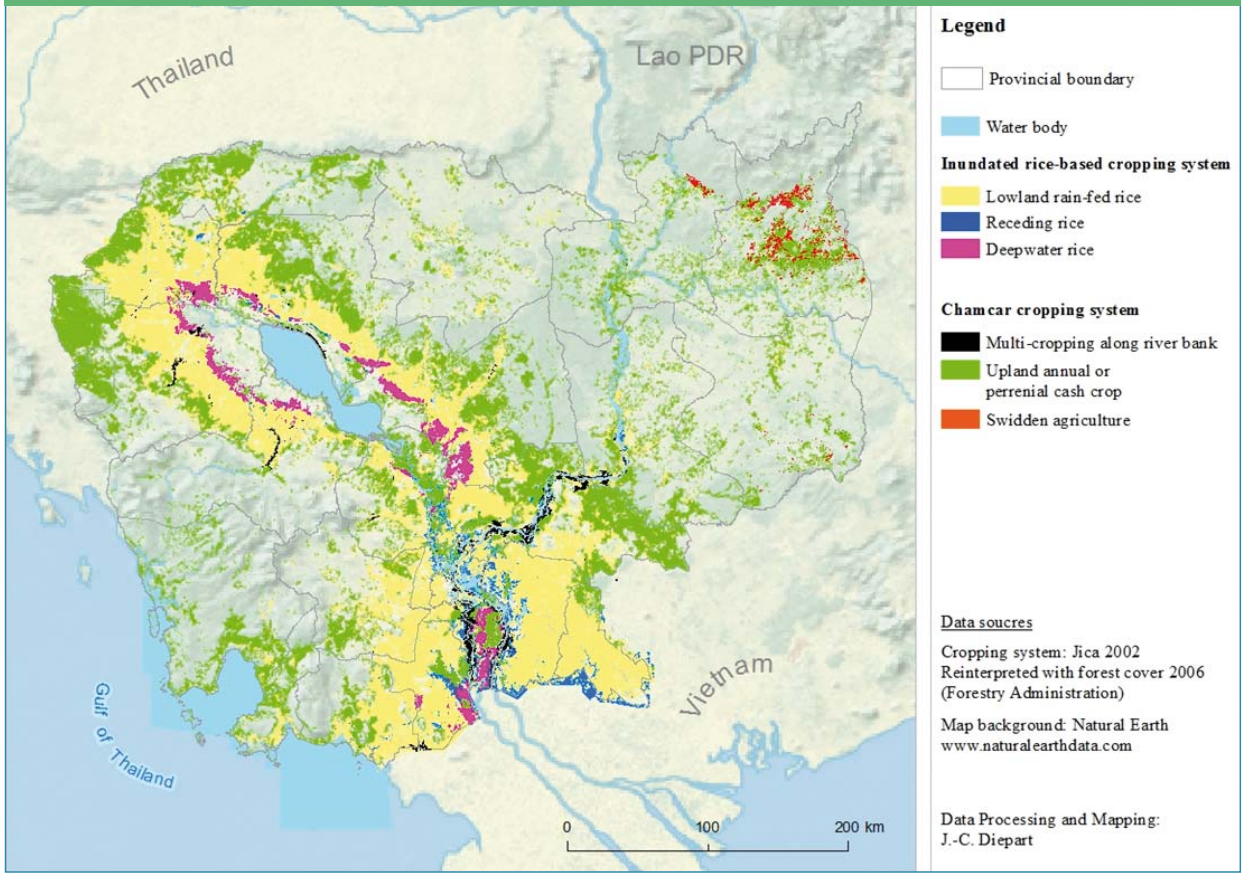
Future researches should explore the Willingness to Pay for Rice-based ES to compensate the opportunity costs of farmers' goods practices guaranteeing ES provisions that benefit the whole society.

Annexes

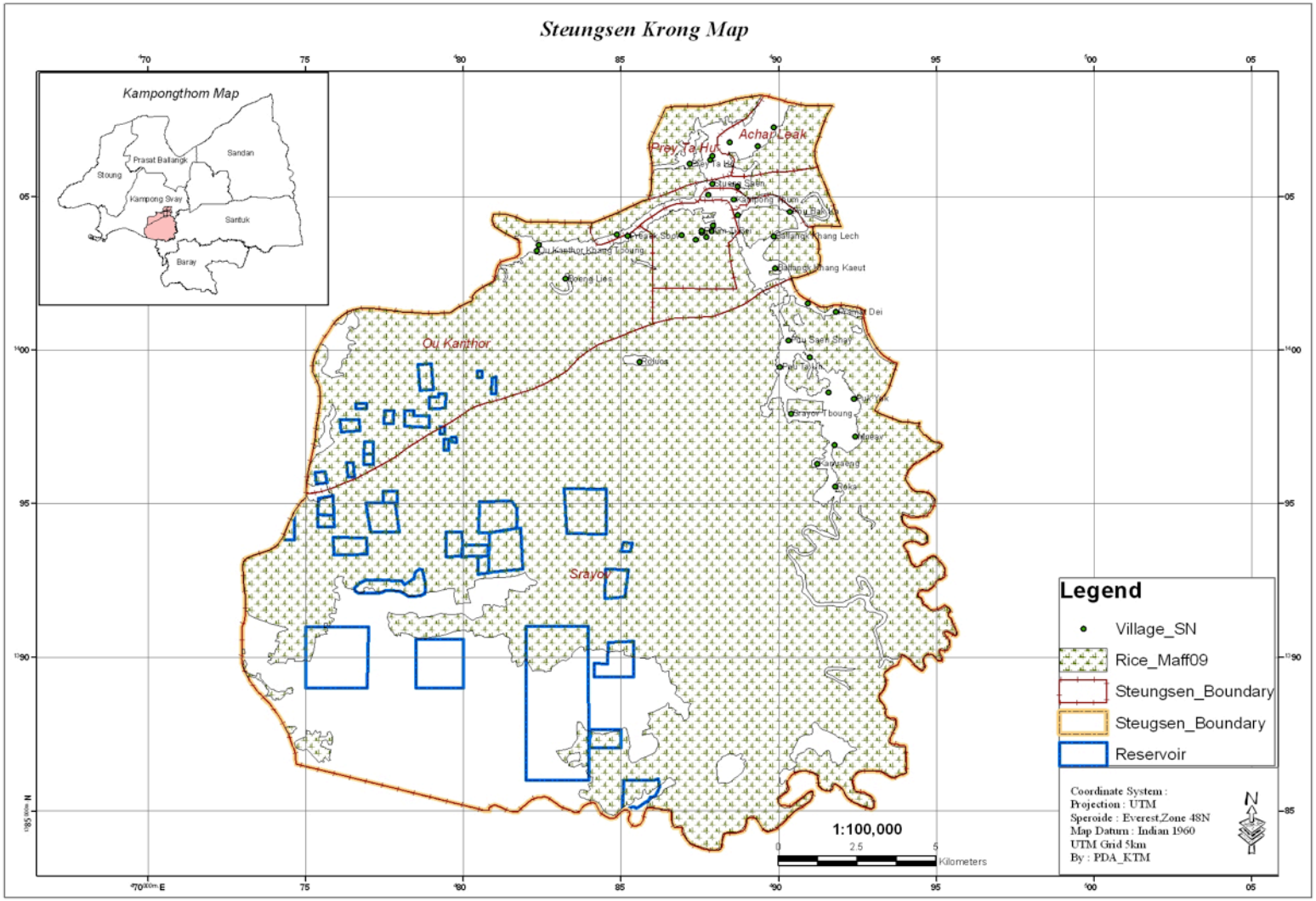
A. Maps

A.1. Cambodian Land use

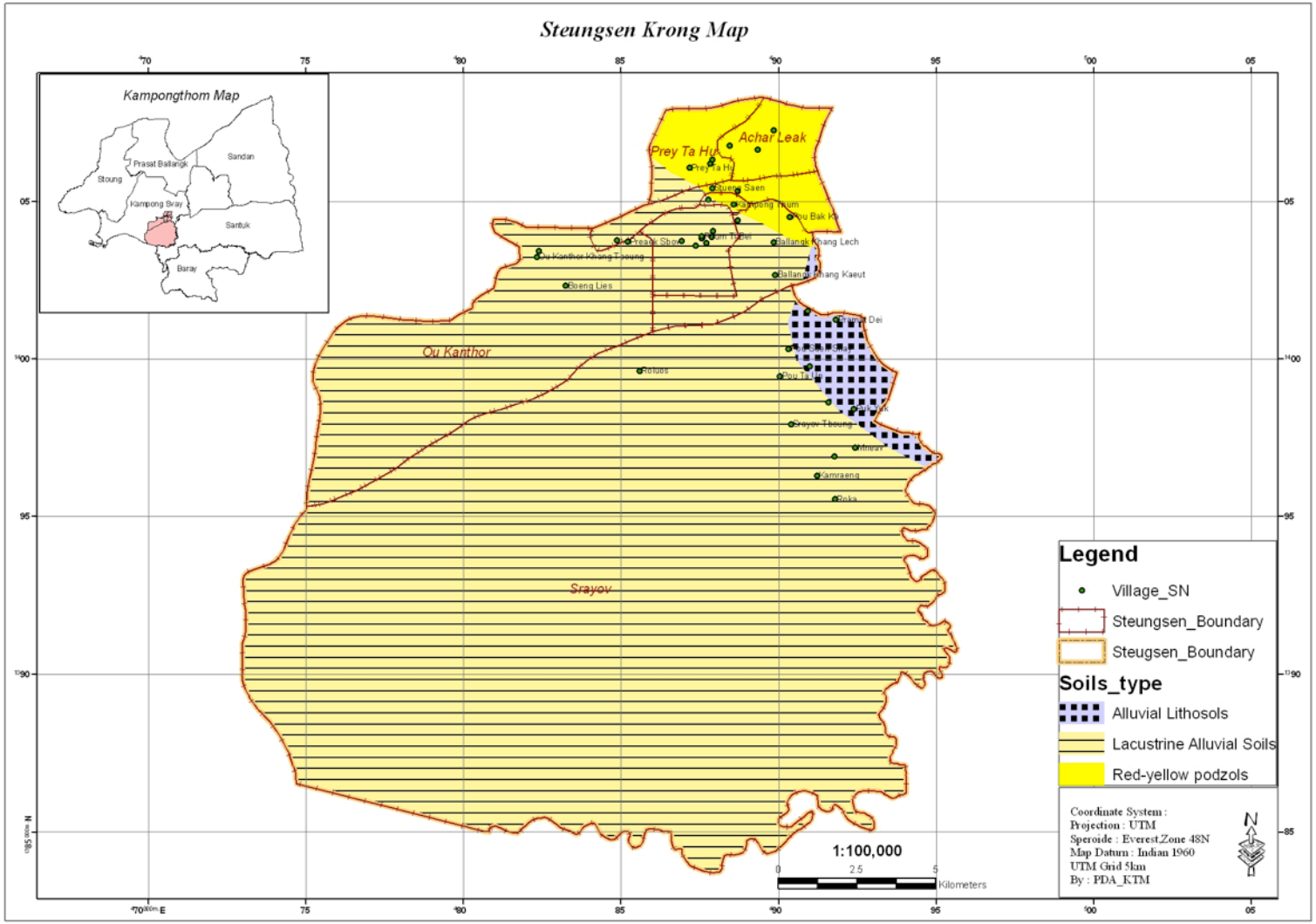
MAP 2: **Distribution of main cropping systems in Cambodia**



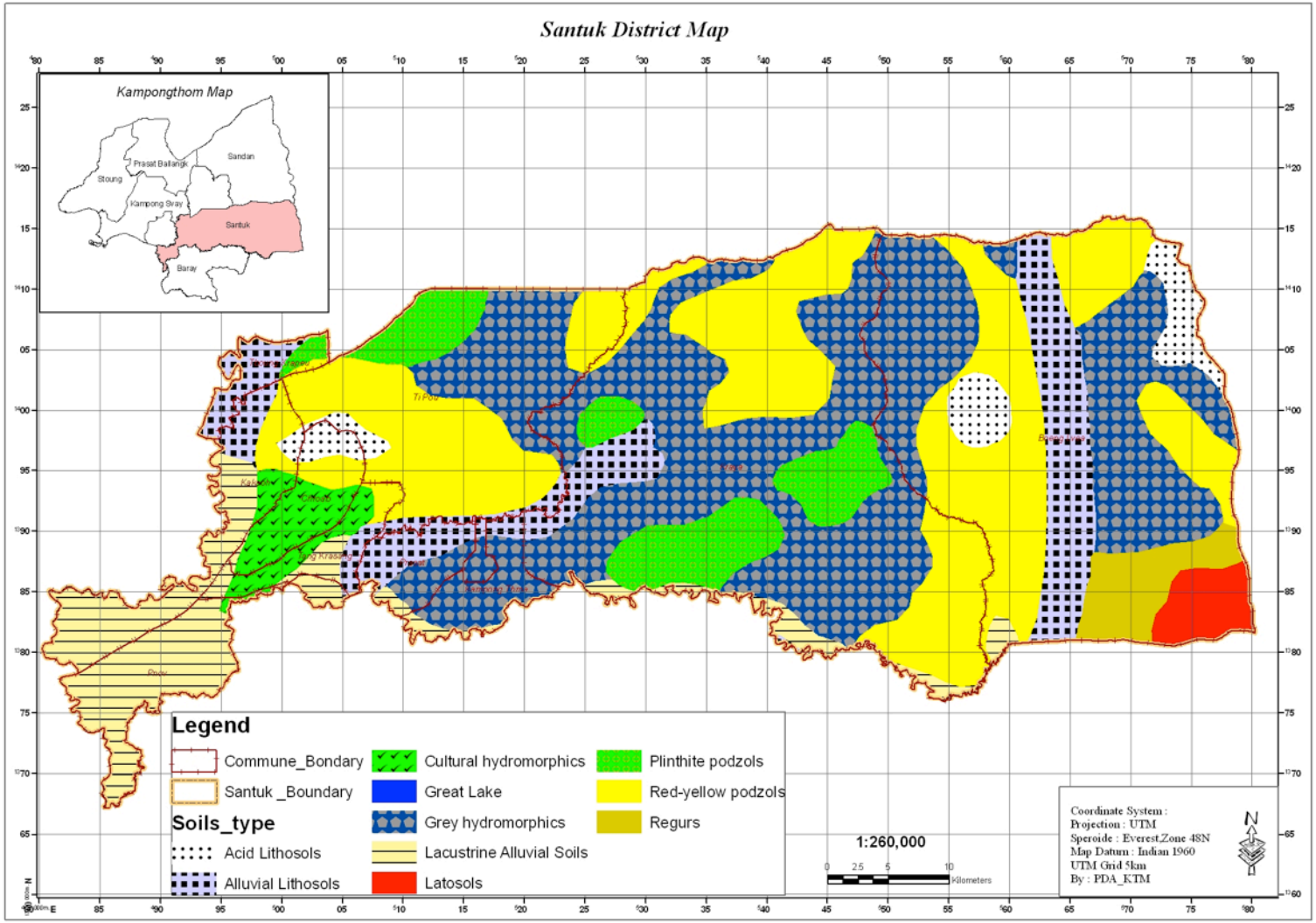
A.2. Individuals and Companies reservoirs for Short-term rice



A.3. Soil types of Steung Sen District



A.4. Soil types of Santuk District



B. Questionnaires for agrarian systems Field Research

B.1. Guidelines for National Survey 2010

Introduction

The team of the Faculty of Agricultural Economics and Rural Development of RUA continues its research project on the Payments for Environmental Services (PES) in Cambodia. This research successfully received funding from both AUF and the Technical Assistance project to RUA, funded by the French Embassy.

During the preliminary phase of the project, we identified some key-environmental issues and related experiences of PES that are currently being implemented in Cambodia. PES is indubitably an emerging concept in Cambodia but so far, its development usually remains at the pilot phase. Moreover, approaches regarding these mechanisms may be quite different from one stakeholder to another and lead to various use and characteristics of PES schemes.

As a result, the current work aimed at understanding the process of emergence and diffusion of this notion in Cambodia and the way these mechanisms are used by different types of stakeholders.

Interviews will be conducted with key-persons involved in the PES issue and representing various institutions including government bodies, NGOs, donors, research and education institutions, international organizations and private companies.

The results of the research will be presented during the steering committee of the project that will take place early July in Bangkok, Thailand and will gather various experts from different universities in Southeast Asia.

Guidelines for interviews

Présentation de la structure, description de la fonction, position dans la structure

Pourriez-vous me présenter votre institution/structure ?

Pourriez-vous m'expliquer en quoi consiste votre emploi/fonction ? Pourriez-vous me décrire votre travail ?

Quelle est votre trajectoire personnelle ?

La notion de service environnemental

Quand avez-vous entendu parler pour la première fois de la notion de SE, dans quel cadre, est-ce au sein de votre structure ? A partir de quand la notion a-t-elle été mobilisée dans votre structure ?

Comment définissez-vous les services environnementaux ? Comment percevez-vous les différentes définitions (services rendus / services écosystémiques / service contre compensation...)

Quelle est l'évolution du sens de la notion de SE dans le temps ? Si des changements ont eu lieu, à quoi/qui peut-on les imputer ?

Dans votre domaine, cette notion a-t-elle des implications, est-elle pertinente ? (opportunités, nouveaux cadrages...)

Quels sont les applications dans votre domaine? Quels services environnementaux et quels écosystèmes sont concernés?

Quelles sont les controverses autour de cette notion selon vous (résistances/opportunités) ?

Ces controverses sont-elles justifiées ?

Quelle est la position de votre structure vis-à-vis des services environnementaux ? Comment vous positionnez-vous ?

Arrivée de la notion de service environnemental au Cambodge et au sein de la structure

Comment a émergé cette notion au Cambodge ? Quels acteurs ont fait émerger la notion au Cambodge ?

Quelles institutions ? La notion a-t-elle été importée ? Si oui d'où ? Quels acteurs l'ont importée ? Si, au contraire, elle a été construite au Cambodge, par qui ?

Quel lien votre structure a-t-elle avec l'institution qui a fait émerger la notion ? Comment cette notion est-elle arrivée ou a-t-elle émergée au sein de votre structure? Par quel réseau?

Position des différents acteurs

Quels acteurs/institutions se sont emparés de la notion ? Quels acteurs/institutions s'y sont opposés ?

Quel acteur central porte la notion ?

Cela a-t-il fait évoluer les rapports entres acteurs ? De nouveaux acteurs ont-ils émergé ?

Y a t il des phénomènes de concurrence/de coopération entre acteurs autour de cette notion ?

Dans quel cadre (institutionnel ou informel) ces tensions ou ces coopérations existent-t-elles ?

Quelles controverses ? -quelles opportunités ? Pour qui ?

Quel rôle joue votre organisation dans les services environnementaux au niveau national ?

Quels sont les liens autour des SE entre votre structure et les autres acteurs ?

La mise en œuvre des SE au Cambodge et dans la structure

Existe-il des dispositifs qui mettent en œuvre les SE ? Au Cambodge ? Au niveau international, au niveau national, au niveau régional/local ?

Existe-t-il des cadres institutionnels favorisant le développement des PES?

Ces dispositifs s'appuient-ils explicitement sur la notion de SE ?

Sinon, pourquoi ? Si oui, dans quel cadre ? Par quels acteurs ? Votre structure est-elle impliquée ? A quel titre ?

Les SE donnent-il lieu à des incitations, des compensations, des réglementations ?

Pourriez-vous citer une action exemplaire/innovante qui relève des SE ?

Avez-vous des activités/projets relatif aux PES ou qui mettraient en place des PES? Si oui, pourriez-vous les décrire brièvement et expliquer leur origine et leur justification?

Question de synthèse

Que pensez-vous de la notion de SE ? Pour vous, la notion de SE est-elle intéressante, justifiée,

contraignante dans votre travail ? Quelles difficultés ? Quelles opportunités ?

Expertise et documents importants

Pourriez-vous m'indiquer les experts de cette notion au Cambodge ?

Quelles sont les institutions qui produisent de la connaissance sur cette notion ?

Quels sont les documents clés sur les services environnementaux au Cambodge ?

B.2. Guidelines for qualitative data in Agrarian System Diagnosis and Analysis

Guidelines for historical study (June 2012)

Start with Research project presentation

1. Production systems before the changes / events or years
2. Landscape description before changes
3. Socio-Political Changes /Impact
4. Impacts on people life

Guidelines for a first understanding of the study zone (July 2012)

1. **History of the farm**

When did it start ? What surface ? What crop ? What changes ? When ?

2. **Farm income**

different farm activities – which activities provide the biggest income ? – other activities apart from farming ?

3. **Household**

how many members ? – age, education and activities – workforce for the farm – do the children plan to stay in the farm ?

4. **Social network**

is he member of a farmers cooperative ? – who does he ask help with his farm when he need ? – how does he interfere with his neighbors ?

5. **Rice cropping systems**

kind of cropping systems – evolution during farm history – surface – chemicals use – material used/ material own – do they have loan ? information about loan access – why did he choose this cropping system – what would he like to do if it was possible ?

6. **Dry season rice**

do all the fields next to an irrigation system grow floating rice ? Is it possible keep growing floating rice ?

how does he see dry season rice ? – how does he see chemical use ? – how does the dry season rice taste ?

7. **Organic rice**

what does he know about organic rice ? – does he know the members of cooperative ? – how does he see organic rice ?

8. **Floating rice**

how does he see floating rice ? – how does floating rice taste ? – what would he think

about a selling price increase ? – what would they think about a label ?

9. Traditional rice

what do they think about transplanting ?

10. Chemical use

environment awareness – change about practice (drinking water, livestock grazing on the fields) – change in the environment : fishing in the rice fields – how do they see chemical use ?

11. Climate change

do they perceive changes concerning flood level frequency ? – do they perceive changes about rain frequency ?

12. Changes in agriculture

How does he perceive the changes in agriculture ? – does he feel confident about the future?

does he feel he can impact on the changes or does he feel this is the way it is ?

How does he think agriculture in the region/ in Cambodia will evolve ?

B.3. Guidelines for Stakeholders

Guideline for COrAA (certification body for organic rice of the study zone)

(June 2012)

Presentation of COrAA

What is COrAA activity in Kampong Thom province ?

Does COrAA provide organic certificate to the farmers when the flood reaches their fields ? Is the rice still considered as organic even though the water can carry chemicals from the conventional fields ?

What varieties are the farmers growing ? Do they have the specification to grow a specific variety or are they free to choose ?

And then, how do the farmers sell their rice ?

Is the demand for organic rice growing on the national market ?

What are the specifications that farmers should follow to get the organic label ?

Are farmers allowed to irrigate their fields if they have access to an irrigation system ?

How can the farmers become members of COrAA ?

Beside the certification, what are the other services provided by COrAA to its members ?

How can the farmers attend a training from COrAA ?

Does COrAA charge a membership fee ?

Guideline for Organic farmers association

July 2012

For how long have you been doing organic rice here ?

What is your role as a chief of cooperative ?

Does he think that the control system is efficient ?

How do the farmers sell their rice labeled ”organic” ?

What is the price that the cooperative offers for the organic paddy ?

Do a lot of farmers sell their rice as a regular rice to the middleman ?

And then, who does the cooperative sell the rice to ?

What are the varieties of rice that the farmers from the village grow ?

In general, what type of tools are the farmers using ?

What lands are suitable to grow organic rice ?

What kind of cropping system do the farmers beside the organic rice ?

In general, do the farmers transplant their rice ?

How the cooperative get the organic seeds ?

B.4. Questionnaires For in-deep interviews on rice production systems

Target Area	*Date*	*Farmer's In Formation*
District:.....Commune.....Village.....		Farmer's Name:.....
Questionaire's code.....	Name's D.C.....	Tel: .....

- Farmer's Status

Gender			□Male □Female
Age			.....
Education Level	□Primary □Secondary □High □University □Others.		
Number in Family		Total.....	Women.....
Main Income In Family	□Agriculture □Staff □Business Man □Worker □Service Provider □Others..		
Rang of age of Member in Family	1. Less than 18 year old.....People 2. From 18 to 30 year old.....People 3. From 31 to 45 year old.....People 4. More than 45 year old.....People		
Do you have enough labor in family?	□Enough □Not enough		
If you have no enough labor, where do you take it from?	□Rent □Farmer help eaothers □Others		

- General Situation in Farmer's Rice Production

Which type of rice production that you grow? (Multiple Choises)

□Early Season	□Recession	□Medium Duration Marturity	□Long Duration Muturity	□Floating	□Organic
How many time you grow it per year?					
.....Time	.....Time	.....Time	.....Time	.....Time	.....Time
Where do you grow it?					
□High land next to village □ Medium land □Low land	□High land next to village □ Medium land □Low land	□High land next to village □ Medium land □Low land	□High land next to village □ Medium land □Low land	□High land next to village □ Medium land □Low land	□High land next to village □ Medium land □Low land

- Why do you choose these rice production?

.....
.....
.....
.....

- When did you start to grow it?.....
- Before, which rice production do you grow?.....
- Why did you change it?

.....
.....
.....
.....

I. Land size in rice production

N^0	Size of land				
	Type of rice production	Period	Own	Rent	Price rent
1					
2					
3					
4					
5					

- When did you start to rent? .....
- Why did you rent?

.....
.....

- Why didn't you rent?

.....
....

II. *Situation of using machine*

Do you use machine?		□ Yes			□ No
N^0	Type of machine	Number of Machine			
		Own	Rent	Borrow	
1	Mechanical Mules				
2	Tractor				
3	Water pump				
	Others				

- When did you use it? .....
- Why did you use it?

.....
.....
.....
.....

- Why didn't you use it?

.....
.....
. .....

III. *Situation of using cattle?*

Do you use cattle in rice prodution?			□ Yes	□ No
N^0	Type of Cattle	Number of Cattle		
		Own	Rent	Borrow
1	Cow			
2	Baffalo			

3	Hourse			
	Others			

- Why do you cattle?

  .....
  .....
  .....
  .....

- Why don't you use it?

  .....
  .....
  ....

What sourses of water do you use in rice production?	□Pond □Well □Lake □Canal □Company's channel □Others.....	
Sourse of money in rice production	□Own money □Bank or Micro-finance □Relative □Others.....	
How do you borrow?	Num. of money .....Riel	Interest.....%
	Period.....Month	Institue's Name.....

- Why do you use these sourses of water?

  .....
  .....
  .....
  .....

- Why do you borrow money?

  .....
  .....
  .....
  .....

- **Situation in Each Rice Productions**
  - *Rice Production 01 ..... (ha)*
  - ***Seasonal Calendar of Rice Production (Draw cross column)***

Type of action : 1. Prepare land, 2. growing, 3. Take care, 4. Havest, 5. Transportation

Activities	May	June	July	August	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	**Apr.**
1												
2												
3												
4												
5												

- Why do you start these action in that time?
  - Prepare Land

    .....
    .....
    ....

- Growing.....
  .....
  .....
  .....
- Maintaining
  .....
  .....
  ....
- Harvest.....
  .....
  ...
- Transportation.....
  .....
  .....
  .....

- ***Economics Efficiency Analysis in Rice Production***
  - ***Variable Cost***

Type of cost	Quantities	Produced Quantities	Price/Unit (if you buy)
Seed			
Natural Fertilizer			
Natural Pesticide			
Chemical Fertilizer			
Pesticide			
Gasoline			
Water			
Others.....			

If you produce yourself, how do you produce?

- Seed.....
  .....
- Natural Fertilizer.....
  .....
- Natural Pesticide.....
- .....
- Others.....
  .....

  - ***Labor Cost***

Type of actions	Number of labor				P/Unit	Num. of day	Price if they do it all
	Family		Outside				
	M	F	M	F			
1.Prepare land							
Plow							
Build dike							
2.Growing							
Sow							
Transplant							

3.Take Care							
Weed							
Through fertilizer							
Spray pesticide							
Irrigate							
4.Harvest							
5.Transport							
6. Others							
Total							

- ***Fixed Cost***

Type of Cost	Q	P/unit	Used Period	Period use in future	Num. day
Tractor					
Mechanical Mules					
Water pump machine					
Pipe					
Water pump					
Sprayer					
Ox Chart					
Cow					
Buffalo					
Plow					
Ronous					
Kandav					
Hoe					
Cleaver					
Basket					
Well					
Bé					
Tang					
Others					
Total					

- ***Gross Income From Rice Production***

Type of Income	Total Quantities	Price/Unit	Total Income
Rice			
Others			
Total			

- ***Selling Rice***

Where did you sell rice?	□At home □Middleman □Local market □Others

- *Rice Production 02* .....
- ***Seasonal Calendar of Rice Production (Draw cross column)***

Type of action : 1. Prepare land, 2. growing, 3. Take care, 4. Havest, 5. Transportation

Activities	May	June	July	August	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1												
2												
3												
4												
5												

- Why do you start these action in that time?
  - Prepare Land
    .....
    .....
  - Growing.....
    .....
    .....
  - Maintaining
    .....
    .....
  - Harvest.....
    .....
    .....
    Transportation.....
    .....
    .....

- ***Economics Efficiency Analysis in Rice Production***
  - ***Variable Cost***

Type of cost	Quantities	Produced Quantities	Price/Unit (if you buy)
Seed			
Natural Fertilizer			
Natural Pesticide			
Chemical Fertilizer			
Pesticide			
Gasoline			
Water			
Others.....			

If you produce yourself, how do you produce?

- Seed.....
.....

- Natural Fertilizer.....
.....
- Natural Pesticide.....
.....
- Others.....
.....

- ***Labor Cost***

Type of actions	Number of labor				P/Unit	Num. of day	Price if they do it all
	Family		Outside				
	M	F	M	F			
1.Prepare land							
Plow							
Build dike							
2.Growing							
Sow							
Transplant							
3.Take Care							
Weed							
Through fertilizer							
Spray pesticide							
Irrigate							
4.Harvest							
5.Transport							
Others							
Total							

- ***Fixed Cost***

Type of Cost	Q	P/unit	Used Period	Period use in future	Num. day
Tractor					
Mechanical Mules					
Water pump machine					
Pipe					
Water pump					
Sprayer					
Ox Chart					
Cow					
Buffalo					
Plow					
Ronous					
Kandav					
Hoe					
Cleaver					
Basket					

Well					
Bé					
Tang					
Others					
Total					

- ***Gross Income From Rice Production***

Type of Income	Total Quantities	Price/Unit	Total Income
Rice			
Others			
Total			

- ***Selling Rice***

Where did you sell rice?	□At home □Middleman □Local market □Others

- *Rice Production 03* .....
- ***Seasonal Calendar of Rice Production (Draw cross column)***

Type of action : 1. Prepare land, 2. growing, 3. Take care, 4. Havest, 5. Transportation

Activities	May	June	July	August	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1												
2												
3												
4												
5												

- Why do you start these action in that time?
  - Prepare Land
    .....
    .....
    ....
  - Growing.....
    .....
    .....
    .....
  - Take Care
    .....
    .....
    ....
  - Harvest.....
    .....
    ...
  - Transportation.....
    .....

- ***Economics Efficiency Analysis in Rice Production***
  - ***Variable Cost***

Type of cost	Quantities	Produced Quantities	Price/Unit (if you buy)
Seed			
Natural Fertilizer			
Natural Pesticide			
Chemical Fertilizer			
Pesticide			
Gasoline			
Water			
Others.....			

If you produce yourself, how do you produce?

- Seed.....
.....
- Natural Fertilizer.....
.....
- Natural Pesticide.....
.....
- Others.....
.....

  - ***Labor Cost***

Type of actions	Number of labor				P/Unit	Num. of day	Price if they do it all
	Family		Outside				
	M	F	M	F			
1.Prepare land							
Plow							
Build dike							
2.Growing							
Sow							
Transplant							
3.Take Care							
Weed							
Through fertilizer							
Spray pesticide							
Irrigate							
4.Harvest							
5.Transport							
Others							

Total							

- ***Fixed Cost***

Type of Cost	Q	P/unit	Used Period	Period use in future	Num. day
Tractor					
Mechanical Mules					
Water pump machine					
Pipe					
Water pump					
Sprayer					
Ox Chart					
Cow					
Buffalo					
Plow					
Ronous					
Kandav					
Hoe					
Cleaver					
Basket					
Well					
Bé					
Tang					
Others					
Total					

- ***Gross Income From Rice Production***

Type of Income	Total Quantities	Price/Unit	Total Income
Rice			
Others			
Total			

- ***Selling Rice***

Where did you sell rice?	□At home □Middleman □Local market □Others

- *Rice Production 04* .....
- ***Seasonal Calendar of Rice Production (Draw cross column)***

Type of action : 1. Prepare land, 2. growing, 3. Take care, 4. Havest, 5. Transportation

Activities	May	June	July	August	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1												
2												
3												
4												
5												

- Why do you start these action in that time?
  - Prepare Land
    .....
    .....
    ....
  - Growing.....
    .....
    .....
    .....
  - Take Care
    .....
    .....
    ....
  - Harvest.....
    .....
    ...
  - Transportation.....
    .....
    .....
    .....

- ***Economics Efficiency Analysis in Rice Production***
  - ***Variable Cost***

Type of cost	Quantities	Produced Quantities	Price/Unit (if you buy)
Seed			
Natural Fertilizer			
Natural Pesticide			
Chemical Fertilizer			

Pesticide			
Gasoline			
Water			
Others.....			

If you produce yourself, how do you produce?

- Seed.....
.....
- Natural Fertilizer.....
.....
- Natural Pesticide.....
.....
- Others.....
.....

- ***Labor Cost***

Type of actions	Number of labor				P/Unit	Num. of day	Price if they do it all
	Family		Outside				
	M	F	M	F			
1.Prepare land							
Plow							
Build dike							
2.Growing							
Sow							
Transplant							
3.Take Care							
Weed							
Through fertilizer							
Spray pesticide							
Irrigate							
4.Harvest							
5.Transport							
Others							
Total							

- ***Fixed Cost***

Type of Cost	Q	P/unit	Used Period	Period use in future	Num. day
Tractor					
Mechanical Mules					
Water pump machine					
Pipe					
Water pump					
Sprayer					
Ox Chart					
Cow					
Buffalo					
Plow					
Ronous					

Kandav					
Hoe					
Cleaver					
Basket					
Well					
Bé					
Tang					
Others					
Total					

- ***Gross Income From Rice Production***

Type of Income	Total Quantities	Price/Unit	Total Income
Rice			
Others			
Total			

- ***Selling Rice***

Where did you sell rice?	□At home □Middleman □Local market □Others

- **Farmers' knowledge and perception in riceproduction**
  - **Where do you know the technique in rice production from?**
    .....
    .....
  - **Have you ever got the technique to grow rice? □Yes □No**
- If yes, which is institution?.....
- What type of training do you get?
  .....
  .....
  .....
  - **Did you have any problem in rice production?**
    .....
    .....
  - **How did you sole it?**
    .....
    .....
    .....
  - **Do you get success?**
    □Success □Get some □Not success □Others.....
  - **Do you happy for income from rice prodution?**
- □Very happy □Happy □Not happy □Others.....
  - **Beside rice, do you have any plant in your rice field? (Where and type of rice production)**
    .....
    .....
    Is it importance?

.....
.....
- Why do you keep it? Beside you, who use it?

.....
.....

- Beside plant, Does it has mound, spririt and anything?

.....
.....

- What is importance of these thing?

.....

Impact of changing in rice production on environment and human health

Impact on environment

- Does rice production change in this area?
  □change □not change □don't know
- How does it change?
- □very change □change □less change
  How does it change?

.....
.....

- Do you think these change have impact on environment?
  □impact □not impact □don't know
- Which products have strong impact? why?.....
  .....
  . .....
- If it has impact, what does it impact on?.....

.....
.....

- How does it impact?.....

.....
.....
..

Impact on human health

- Does changing in rice production have impact on rice production?
  □impact □not impcat □don't know
- If is has impact, why?.....

.....
.....

- How does it impact?.....

.....
.....

- If it has no impact, why?.....

.....
.....

Impact on fisheries

□impact □not impact □don't know

- If is hasimpact, why?.....
.....
.....
- How does it impact?.....
.....
.....
- If it has no impact, why?.....
.....
.....
.....
.....
.....

Do you consume any species in your rice field?

.....
.....
.....
- If yes, what do you consume?

.....
.....
.....

Why?.....
.....

- Are there the species that you consume before (give years or events) and then sto consuming? Why?

.....
.....
.....
.....
.....

- If no, why?

.....
.....
.....
.....
.....

Is there any change related to those consumptive species? Yes □ ; No □

- If yes, what is the change? Why?

.....
.....
.....
.....
.....

Thank You

B.5. Guidelines for verification Rice techniques – Chemical inputs of 9 rice cropping systems

1. Early Rice					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

2. Receding Rice					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

3. Double cycle (Early Season + Receding Rice)					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

4. Long term-trasplanting					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

5. Long Term Direct seedling					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

6. Midium Term direct seedling					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

7. Midium Term Transplanting					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

8. Floating Rice					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

9. Organic rice					
Name of chemical fertilizer *please mark quantity of NPK	**Q/ha**	**Calendar of use (month)**	**Calendar of use (in production cycle: before plowing, transplanting…)**	**Purpose**	**price/can or /bottle or package (please note quantity inside)**
Name of Chemical inputs (pesticide, herbicide, fungicide…)					
Special Cocktail of pesticide (when they mix)					

C. Questionnaire for Consumers Survey

C.1. Guidelines for rice markets exploring (May 2012)

To observe about rice market in Phnom Penh, three kinds of market were defined: traditional market, supermarket and organic shops in Phnom Penh City. By the ways, the objectives of this research are study on rice market and make pre-typology of rice consumers. To respond to these objectives the questions will ask about packaging, brand name, crop, and price per Kilogram by liking with the life standard of customer. Therefore, we also study on origin of rice sold on the market.

For traditional market we selected Oresy, Olympic, Dermkor, Thom Thmey and Steng Meanchey market. We adjust our choice of market based on the location, which retaled to the life standard of the customer. By the way, Tom Tmey market is full of foreigner and and hight class people. Oresy market and Olympic market are for middle class customer because most of goods are not too expensive. Steng Mangay and Dermkor market are small markets for middle and poor peoples. On the other hand, for the supermarket we selected 3 supermarkets: Lucky supermarket on Norodom Boulvard because, this market is full of foreigner and high-class customers. The second is Lucky supermarket in Sovanna shopping center, it is for the middle class. The last one is Lucky supermarket in Soriya shopping center, it is full of rich customers. The supermarket, we choose only Lucky because the others don't really sell fresh foods.

For the Organic market we also Selected 3 markets: Happy Farm, Natural Garden and DEDAC Market. The Happy farm and Natural garden, most of their clients are foreigners. Otherwise, DEDAC shops (CEDAC enterprise) are for Khmer and foreigner clients. We chose 5 branches of CEDAC. There are CEDAC at Road 360 (the first one), CEDAC at Road 271 (Place for middle class and poor) and another branch we will ask the information about location from the CEDAC manager.

Guideline

1. How many kind of rice you sell? (Organic and Non-organic rice)

   Organic rice

   - What kind of variety of organic rice?
   - Ask (brand name, who give certificate for them, packing, price per kg, supplier and where?)
   - Why does seller call organic rice?
   - Do the customer have confidence on your organic rice and why?
   - What kind of customer who buy organic rice?
   - Price (for retailer and direct consumer)
   - Observation (take a photos and brand mane)

   Common rice

   1. Ask (packing, variety, supplier and where it come from?), location (battambang rice or somewhere else)
   2. Do the customer confident on your rice?
   3. What kind of customers?
   4. Price (for retailer and direct consumer)
   5. Observation (take a photos and brand name)

C.2. Questionnaires for consumers survey (June 2012)

Code: .....Date: ..... Name of Respondent: ….....Area/Market.....

Introduce yourself: I'm a student of Royal University of Agriculture. I would like to have your contribution in a marketing research. This research will contribute to PhD of my lecturer, Ms NEANG Malyne. The interview will take time for may be 40mns. May you spend your time for this interview, please?

1. Name of Respondent:..... Phone Number: .....

2. General Information

Position in Family	Age	Job*	Education	Nationality
1. Head of Household 2. Spouse of head of household 3. Other, please precise	**.....** Year	1. Housewife 4. Work/Guardia **2.** NGO Staff 5. Government Staff 3. Private Company Staff 6. Personal Business 99. Other, Please precise……	1. Primary school 2. Secondary school 3. High School 4. bachelor 5. Master & More	1. Khmer 2. Western 3. Other, Please **.....**

Is it related to: Agriculture Environment Conservation Not any of These ***(possible to choose more than 1 choice)***

3. How many people (children and adults) live in your household on a regular basis?

- Children: (<15 years old) - Teenager: (13-18)
- Adults: (19-50) - Olden: (>50)

4. What are impacts of agriculture? (Possible choose both with more than 1 choice in each)

Positive	Negative	I Don't know
o Food Supply o Serve as basic for economic growth o Preserve plant natural variety o Preserve biodiversity, forest and water quality o Preserve environment o Preserve some Khmer culture o Mitigate climate change o Others:……..	o Chemical pollution o Forest degradation o Biodiversity degradation o Accelerate Climate change o Natural variety degradation o Farmers health degradation o Human health degradation by chemical inputs o Others…… ……	

5. Which kind of agriculture that provides positive impact? (Possible to choose more than 1 choice)

- Organic agriculture (Label)
- Conventional agriculture by respecting the standard of chemical use (fertilizer & pesticide)
- Agriculture without amendments (organic or inorganic)
- Agriculture who use the natural variety
- Others…… …….
- I don't know

6. Do you have heard about environmental Ecosystem services (ES)?

Yes, please give a short definition: (Possible to choose more than 1 choice)	No
o Keep environment clean by collecting waste o Reduce climate change o Separate waste at home o Preservation of environment o Preservation some Khmer culture o Preservation of biodiversity, forest and water quality o Preservation of plant natural variety o Benefit from the nature o Good activities which can preserve the environment o Others:……..…… …	

7. Do you consume any organic foods (with and without label)?

- Yes, why? (Possible to choose more than 1 choice)	- No, why? (Possible to choose more than 1 choice)
o To preserve our health o To preserve environment o To contribute in improving farmers' revenue o Organic products are tasty o Organic product are first quality o To show wealthy o To consume local products o Others……	o Too expensive o Don't know where to buy o Organic shops are far o No confidence on label o Not beautiful form and small o Prefer buy food in market because of ambience. o Others……

If yes, where do you buy organic foods? (Possible to choose more than 1 choice)

- CEDAC shop
- Happy farm
- PUAC
- Natural Garden
- Lucky Supermarket
- Others ……

8. What are the organic labels that you know? (Possible to choose more than 1 choice)

- CEDAC
- COrAA
- Ecocert
- Other……
- I don't know

Reference

Adam, M., M. Corbeels, P. A. Leffelaar, H. Van Keulen, J. Wery and F. Ewert (2012). "Building crop models within different crop modelling frameworks." Agricultural Systems 113(0): 57-63.

ADB (2000). Country Operational Strategy, Cambodia: Enabling a Socioeconomic Renaissance. Manila: ADB. ADB, ADB.

ADB (2004) "CAMBODIA: COUNTRY ENVIRONMENTAL ANALYSIS."

ADB (2014). Cambodia: Country poverty analysis 2014. Mandaluyong City, Philippines, Asian Development Bank.

Allen, D. and N. V. Long (1989). "Cambodia (Kampuchea): history, tragedy, and uncertain future." Bulletin of Concerned Asian Scholars 21(2-4): 35-58.

Antle, J. M. and J. J. Stoorvogel (2006). "Predicting the supply of ecosystem services from agriculture." American Journal of Agricultural Economics 88(5): 1174-1180.

Arias, M. E., T. A. Cochrane, T. Piman, M. Kummu, B. S. Caruso and T. J. Killeen (2012). "Quantifying changes in flooding and habitats in the Tonle Sap Lake (Cambodia) caused by water infrastructure development and climate change in the Mekong Basin." Journal of Environmental Management 112: 53-66.

Ashwell, D. A., Miller, F. R. & Dümmer, I. (2004). Ecology, forest cover and quality. Independent Forest Sector Review. The Forest Sector in Cambodia.

Aubron, C., H. Cochet, G. Brunschwig and C. H. Moulin (2009). "Labor and its productivity in andean dairy farming systems: A comparative approach." Human Ecology 37(4): 407-419.

Balzer, T. P. and S. Pon (2002). Traditional use and availability of aquatic biodiversity in rice-based ecosystems: I. Kampong Thom Province, Kingdom of Cambodia. Awareness of Agricultural Biodiversity. M. Halwart, D. Bertley and H. Guttman, FAO, MRC: 17.

Bann, C. (2003). An Economic Analysis of Alternative Mangrove Management Strategies in Koh Kong Province, Cambodia. , EEPSEA.

Bann, C. (2003). An economic analysis of tropical forest land use options, Ratanakiri Province, Cambodia, Economy and Environment Program for Southeast Asia.

Barral, S., I. Touzard, N. Ferraton, E. Rasse-Mercat and D. Pillot (2012). Assessing Smallholder Farming: Diagnostic Analysis of Family-Based Agricultural Systems in a Small Region Illustrated with the Case Study of the Giham Pioneer Front, Sumatra, Indonesia. Philippines, SEARCA.

Beath, J. and Y. Katsoulacos (1991). The Economic Theory of Product Differentiation, Cambridge University Press.

Belcher, K. W., M. M. Boehm and M. E. Fulton (2004). "Agroecosystem sustainability: a system simulation model approach." Agricultural Systems 79(2): 225-241.

Bengtsson, J., J. Ahnstrom and A. C. Weibull (2005). "The effects of organic agriculture on biodiversity and abundance: A meta-analysis." Journal of Applied Ecology 42(2): 261-269.

Bennett, M. and S. Franzel (2009). "Can organic and resource-conserving agriculture improve livelihoods? A synthesis." International Journal of Agricultural Sustainability 11(3): 193-215.

Berg, H., C. Berg and T. T. Nguyen "Integrated Rice-Fish Farming: Safeguarding Biodiversity and Ecosystem Services for Sustainable Food Production in the Mekong Delta." Journal of Sustainable Agriculture 36(8): 859-872.

Billet, J. (1995). "France, a partner in the development of the countries of the IndoChina peninsula: Laos, Cambodia, Vietnam." La France, partenaire du developpement des pays de la peninsule indochinoise: Laos, Cambodge, Vietnam 103: 10-19.

Bonin, M. and L. Eloy (2013). Services Ecosystémiques et agriculture. SERENA, SERENA: 8.

Bowbrick, P. (2014). The Economics of Quality, Grades and Brands (Routledge Revivals), Taylor & Francis.

Brooks, S. E., E. H. Allison and J. D. Reynolds (2007). "Vulnerability of Cambodian water snakes: Initial assessment of the impact of hunting at Tonle Sap Lake." Biological Conservation 139(3-4): 401-414.

CARDI (2007). Rice crop in Cambodia. Phnom Penh, CARDI.

Carmona, A., L. Nahuelhual, C. Echeverra and A. Bez "Linking farming systems to landscape change: An empirical and spatially explicit study in southern Chile." Agriculture, Ecosystems and Environment 139(1-2): 40-50.

CDC (2010). The Cambodia aid effectiveness report 2010. R. G. o. Cambodia, Council for the Development of Cambodia: 51.

Charroin, T., P. Veysset, S. Devienne, J. L. Fromont, R. Palazon and M. Ferrand (2012). "Labour productivity and economy in herbivore rearing: Concepts, analysis and stakes." Productivité du travail et économie en élevages d'herbivores définition des concepts, analyse et enjeux 25(2): 193-210.

Chavagneux, C. (2010). Economie politique internationale. Paris., la Découverte, Collection "Repères".

Cheattho, P. (2011). Organic agriculture in Cmabodia. Phnom Penh, MAFF, AFACI.

Chhim, P. (2009). Customer Network Building in the neighborhoods of CEDAC Shops in Phnom Penh. CEDAC entreprise for social development. CEDAC entreprise for social development, .

Clements, T., J. Ashish, K. Nielsen, D. An, S. Tan and J. Milner-Gulland (2009). "Payments for biodiversity conservation in the context of weak institutions: Comparison of three programs from Cambodia." Ecological Economics.

Clements, T., A. John, K. Nielsen, D. An, S. Tan and E. J. Milner-Gulland (2010). "Payments for biodiversity conservation in the context of weak institutions: Comparison of three programs from Cambodia." Ecological Economics 69(6): 1283-1291.

Clements, T., H. Rainey, D. An, V. Rours, S. Tan, S. Thong, W. J. Sutherland and E. J. Milner-Gulland (2013). "An evaluation of the effectiveness of a direct payment for biodiversity conservation: The Bird Nest Protection Program in the Northern Plains of Cambodia." Biological Conservation 157(0): 50-59.

Cochet, H. (2004). "Agrarian dynamics, population growth and resource management: The case of Burundi." GeoJournal 60(2): 111-120.

Cochet, H. (2012). "The systeme agraire concept in francophone peasant studies." Geoforum 43(1): 128-136.

Cochet, H. and S. Devienne (2006). "Fonctionnement et performances économiques des systèmes de production agricole : une démarche à l'échelle régionale." Cahiers Agricultures, 15(n°6, nov-dem 2006): 5

Cochet, H. and S. Devienne (2006). "Operation and economic performance of farming systems: A regional approach." Cahiers Agricultures, 15(6): 578-583.

Cochet, H., S. Devienne and M. Dufumier (2007). "L'agriculture comparée, une discipline de synthèse ?" Economie Rural(297-298 (janvier-avril 2007)): 15.

Coestier, B. and S. Marette (2004). Economie de la qualité. La Découverte Paris, "Repères": 128.

Colby, L., B. M. Michael, M. Andy, H. Keavuth, D. Kong, C. Nareth, L. Barney, C. Nick and S. Teak (2009). Wildlife decline in Cambodia, 1953–2005: exploring the legacy of armed conflict, Wiley Periodical. 2: 11.

COrAA (2007a). Standards for chemical-free crop production in Cambodia. Phnom Penh, Cambodia, COrAA: 11.

COrAA (2007b). Standards for organic crop production in Cambodia. Phnom Penh, Cambodia, COrAA.

COrAA (2011). Organic Agriculture and Food Processing in Cambodia Status and Potentials, COrAA.

COrAA (2011a). Organic Agriculture and Food Processing in Cambodia Status and Potentials, COrAA.

COrAA (2011b). Standards for chemical-free crop production in Cambodia. Phnom Penh, COrAA: 12.

COrAA (2013). Organic Agriculture and Food Processing in Cambodia Status and Potentials. Phnom Penh, Cambodia, COrAA: 37.

Corbera, E., C. G. Soberanis and K. Brown (2009). "Institutional dimensions of Payments for Ecosystem Services: An analysis of Mexico's carbon forestry programme." Ecological Economics 68(3): 743-761.

Costanza, R., R. d'Arge, R. d. Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Suttonkk and M. v. d. Belt (1997). "The value of the worlds ecosystem services and natural capital." Nature 387: 8.

Costanza, R. and H. E. Daly (1987). "Toward an ecologial economics." Ecological Modeling Elsevier Science Publisher B.V. Netherlands 38: 7.

Cottin, F. (2010). Analysis of Organic Rice Production in Cambodia with an Approach in terms of Payment for Environmental Services: An example of effective PES for development facing contextual issues. Master, VertAgro Sup.

Cropper, M. L. and W. E. Oates (1992). "Environmental Economics: A survey." Journal of Economics Literature XXX: 675-740.

Cummings, R. C. (1978). "Agricultural change in vietnam floating rice region." CNRS, INIST, 37(3): 10.

Dachary-Bernard, J. (2004). "Une évaluation économiqu du paysage, Une application de la méthode des choix multi-attributs aux Mont d'Arrée " ECONOMIE ET STATISTIQUE 373.

Dale, V. H. and S. Polasky (2007). "Measures of the effects of agricultural practices on ecosystem services." Ecological Economics 64(2): 286-296.

Dan, P., C. Gordon and S. I. Sok (2005). "Long-term rates of sediment accumulation in the Tonle Sap, Cambodia: A threat to ecosystem health?" Journal of Paleolimnology 33(1): 95-103.

Dasgupta, S., C. Meisner, D. Wheeler, K. Xuyen and N. Thi Lam (2007). "Pesticide poisoning of farm workers–implications of blood test results from Vietnam." International Journal of Hygiene and Environmental Health 210(2): 121-132.

Daskalopoulou, I. and A. Petrou (2002). "Utilising a farm typology to identify potential adopters of alternative farming activities in Greek agriculture." Journal of Rural Studies 18(1): 95-103.

de Ponti, T., B. Rijk and M. K. van Ittersum (2012). "The crop yield gap between organic and conventional agriculture." Agricultural Systems 108(0): 1-9.

Delpeuch, T. (2008). L'analyse des transferts internationaux de politiques publiques: Un état de l'art. Paris: Science Po. Question de recherche n°27.

Diepart, J. C. (2010). "Cambodian peasant's contribution to rural development: a perspective from Kampong Thom Province." Biotechnologie Agronomie Societe Et Environnement 14(2): 321-340.

Diepart, J. C. (2011). La voie étroite du développement rural paysan au Cambodge, agricultures, modernisation des régimes fonciers et luttes d'acteurs. Etudes et document du GREASE. GREASE, Centre d'Etudes du Développement, UCL, Louvain la Neuve Unité d'Economie et Développement rural, Gembloux Agro-Bio Tech, ULG Centre for Interdisciplinary Research on Rural Development (CIRRD), Hanoi University of Agriculture (HUA): 61.

Diepart, J. C. (2015). The fragmentation of land tenure systems in Cambodia: peasants ans the formalization of land rights. Contry profile n°6, Cambodia, GRET, AgroParisTech, aGter. June 2015.

Dolowitz, D. P. and D. Marsh (2000). "Learning from abroad: the role of policy transfer in comtemporary policy-making " Governance 13: 18.

Douglas, I. (2006). "The local drivers of land degradation in South-Est Asia." Geographical Research 44(2): 12.

Dufumier, M. (1993). "Drugs, agricultural policy and crisis in developing countries." 8(1-2): 51-56.

Dufumier, M. (2006). Etude des systèmes agraires et typologie des systèmes de production agricole dans la région cotonnière du Mali. Programme d'amélioration des systèmes d'exploitation en zone cotonnière (PASE) Projet « caractérisation des systèmes agraires ». INAPG. Paris, INAPG.

Ear, S. (1997). Cambodia: Negociating the peace accords. s. t. Les Cahiers du Ceria.

Ear, S. (2006). The Political Economy of Aid, Governance, and Policy-Making: Cambodia in Global, National, and Sectoral Perspectives. Doctor of Philosophy, University of California, Berkeley.

Ecobichon, D. J. (2001). "Pesticide use in developing countries." Toxicology 160(1–3): 27-33.

Ehrlich, P. R. and H. A. Mooney (1997). "Ecosystem services: A fragmentary history." Nature's Services: Societal Dependence on Natural Ecosystems, Washington (DC) in Daily, G. (Ed.): 8.

EJF (2002). Death in Small Doses: Cambodia's Pesticides Problems and Solutions. Environmental Justice Foundation. London, UK.

Engel, S., S. Pagiola and S. Wunder (2008). "Designing payments for environmental services in theory and practice: An overview of the issues." Ecological Economics 65: 12.

ENS. (2010). "Cambodia Protects Floodplain Grasslands Sheltering Rare Birds." Achievinf Eco-innovation of SMEs through Asia-Europe Cooperation Retrieved 24 oct, 2013, from http://ens-newswire.com/2010/03/18/cambodia-protects-floodplain-grasslands-sheltering-rare-birds/.

FAO (2005). Cambodian. Global forest ressources assessment. Country reports.

FAO (2007). Paying fermers for environmental services. The state food and Agriculture. Rome, Italy. FAO Agriculture Series No. 38: 240.

Figuié, M. (2003). Vegetable consumption behaviour in Vietnam. Sustainable Development of Peri-urban Agriculture in South-east Asia (Susper) CIRAD. Hanoi, Vietnam, CIRAD.

Figuié, M., N. Briscas, V. P. N. Thanh and N. D. Truyen (2004). Hanoi consumers' point of view regarding food safety risks: an approach in term of sociel representation. XI World Congress of Rural Sociology. CIRAD/SEA, IOS/VASS and MALICA. Trondheim, Norway.

Fisher, B., I. Bateman and R. K. Turner (2011). Valuing Ecosystem Services: Benefits, Values, Space and Time. UNEP: 14.

Fisher, B., R. K. Turner and P. Morling (2009). "Defining and classifying ecosystem services for decision making." Ecological Economics 68 (2009): 10.

Flanigan, S., K. Blackstock and C. Hunter "Agritourism from the perspective of providers and visitors: A typology-based study." Tourism Management 40: 394-405.

Flanigan, S., K. Blackstock and C. Hunter (2014). "Agritourism from the perspective of providers and visitors: A typology-based study." Tourism Management 40: 394-405.

Fujisaka, S. (1991). "A set of farmer-based diagnostic methods for setting post 'green revolution' rice research priorities." Agricultural Systems 36(2): 191-206.

Fukase, E. and W. Martin (2001). "Economic and fiscal implications of Cambodia's accession to the ASEAN Free Trade Area." Asian Economic Journal 15(2): 139-172.

G. Philip Robertson, Katerine L. Gross, Stepen K. Hamilton, Douglas A. Landis, Thomas M. Schmidt, Sieglinde S. Snapp and S. M. Swimton (2014). "Farming for Ecosystem Services: An Ecological Approach to Production Agriculture." BioScience 64(No. 5): 12.

Gafsi, M. (2006). "Exploitation agricole et agriculture durable." Cahiers Agricultures, 15(n°6): 7.

Gibbon, P. and S. Bolwig (2007). The economics of certified organic farming in tropical Africa: A preliminary assessment, DIIS working paper.

Giovannucci, D. (2007). Organic Farming as a tool for Productivity and Poverty Reduction in Asia. International Fund for Agricultural Development NACF. Seoul, NACF: 11.

Glenn, D. I. (2009). Determining Sample Size. IFAS Extension, university of florida: 5.

Gómez Tovar, L., L. Martin, M. A. Gómez Cruz and T. Mutersbaugh (2005). "Certified organic agriculture in Mexico: Market connections and certification practices in large and small producers." Journal of Rural Studies 21(4): 461-474.

Gómez-Baggethun, E., R. d. Groot, P. L. Lomas and C. Montes (2010). "The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes." Ecological Economics 69(6): 1209-1218.

Goulart, F. F., P. Salles, C. H. Saito and R. B. Machado "How do different agricultural management strategies affect bird communities inhabiting a savanna-forest mosaic? A qualitative reasoning approach." Agriculture, Ecosystems & Environment 164(0): 114-130.

Gray, T. N. E., H. Chamnan, R. Borey, N. J. Collar and P. M. Dolman (2007). "Habitat preferences of a globally threatened bustard provide support for community-based conservation in Cambodia." Biological Conservation 138(3–4): 341-350.

Green Growth Secretariat (2009). The national green growth roamap. Green Growth Secretariat. Phnom Penh, Ministry of Environment.

Halwart, M. (2006). "Biodiversity and nutrition in rice-based aquatic ecosystems." Journal of Food Composition and Analysis 19(6–7): 747-751.

Halwart, M. (2008). "Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems." Biodiversity 9(1-2): 36-40.

Harris, D. and A. Orr (2014). "Is rainfed agriculture really a pathway from poverty?" Agricultural Systems 123(0): 84-96.

Heinonen, U. (2006). "Environmental impact on migration in Cambodia: Water-related migration from the Tonle Sap Lake Region." International Journal of Water Resources Development 22(3): 449-462.

Hortle K.G., S. Lieng and J. Valbo-jorgensen (2004). An introduction to Cambodia's inland fisheries. Mekong Development Series No.4. Phnom Penh, Cambodia, Mekong River Commission.

Huan, N. H., L. V. Thiet, H. V. Chien and K. L. Heong (2005). "Farmers' participatory evaluation of reducing pesticides, fertilizers and seed rates in rice farming in the Mekong Delta, Vietnam." Crop Protection 24(5): 457-464.

Ibitoye, O. O., N. M. Nawi, N. H. Kamarulzaman and N. Man (2014). "Consumers' awareness towards organic rice in Malaysia." International Food Research Journal 21(5): 8.

Ibitoye, O. O., N. M. Nawi, N. Man and N. H. Kamarulzaman (2014). "Factors influencing consumers' purchasing beheviour towaords organic rice in Malaysia." World Applied Sciences Journal 32(4).

Illukpitiya, P. and J. F. Yanagida (2010). "Farming vs forests: Trade-off between agriculture and the extraction of non-timber forest products." Ecological Economics 69(10): 1952-1963.

Izquierdoa, A. E. and H. R. Graua (2009). "Agriculture adjustment, land-use transition and protected areas in Northwestern Argentina." Journal of Environmental Management 90(2): 858-865.

Jackson, L. E., U. Pascual and T. Hodgkin (2007). "Utilizing and conserving agrobiodiversity in agricultural landscapes." Agriculture, Ecosystems & Environment 121(3): 196-210.

Jaqumin, C. and E. Penot (2007). "Pression foncière et differentciation sociale au nord-ouest de la province de Kompong Cham." Cahiers Agricultures 176: 10.

Jason, F. S., J. Tschirhart, T. Anderson, A. W. Ando, S. R. Beissinger, D. Brookshire, G. M. B. Jr, C. Don, R. Innes, S. M. Meyer and S. Polasky (1999). "Why Economics Matters for Endangered Species Protection." Conservation Biology 13(6): 1257-1261.

Jeanneaux, P. and S. De Mareschal (2010). Analyse bibliométrques de la nption de Services Environemental, SERENA.

Kempen, L. v., R. Muradian, C. s. Sandóval and J.-P. Castañeda (2009). "Too poor to be green consumers? A field experiment on revealed perferences for firewood in rural Guatemala." Ecological Economics ELSEVIER 68: 2160-2167.

Keske, M. and R. Huon (2002). Data bases and topographic zoning, Using GIS for zoning of the villages. WUP-FIN SOCIO-ECONOMIC STUDIES ON TONLE SAP 7. MRC. and WUP-FIN. Phnom Penh, WUP-FIN.

Kingdom of Cambodia (2009). The national green growth map. Ministry of Environment and UNESCAP.

Kingdon, J. W. (1984). Agends, alternatives, and public policies. Little Brown, Boston.

Kummu, M., P. Dan, S. J and J. Koponen (2008). "Sediment: Surse or Blessing for Tonle Sap Lake." Ambio 31(No.3): 6.

Kummu, M. and J. Sarkkula (2008). "Impact of the Mekong River flow alteration on the Tonle Sap flood pulse." Ambio 37(3): 185-192.

Kummu, M., J. Sarkkula, J. Koponen and J. Nikula (2006). "Ecosystem management of the Tonle Sap Lake: An integrated modelling approach." International Journal of Water Resources Development 22(3): 497-519.

Lamberts, D. (2006). "The Tonle Sap Lake as a productive ecosystem." International Journal of Water Resources Development 22(3): 481-495.

Lancaster, K. J. (1966). "A New Approach to Consumer Theory." The Journal of Political Economy 74(No.2.): 27.

Le Billon, P. (2000). "The political ecology of transition in Cambodia 1989-1999: War, peace and forest exploitation." Development and Change 31(4): 785-805.

Liu, Y., M. Duan and Z. Yu (2013). "Agricultural landscapes and biodiversity in China." Agriculture, Ecosystems & Environment 166(0): 46-54.

Loureiro, M. L., J. J. McCluskey and R. C. Mittelhammer (2001). "Assessing consumer preferences for organic, eco-labeld, and regular apples." Journal of Agricultural and Resource Economics 26(2): 13.

Lusk, J. L., J. Roosen and J. Shogren (2013). The Oxford Handbook of the Economics of Food Consumption and Policy, OUP Oxford.

Ly, P., L. S. Jensen, T. B. Bruun, D. Rutz and A. de Neergaard (2012). "The System of Rice Intensification: Adapted practices, reported outcomes and their relevance in Cambodia." Agricultural Systems 113(0): 16-27.

MacAlister, C. and M. Mahaxay (2006). Mapping wetlands in the lower mekong basin using landsat ETM images and field survey data. European Space Agency, (Special Publication) ESA SP, Frascati, Rome.

MacFie, H. (2007). Consumer-Led Food Product Development, Elsevier Science.

MAFF (2006). Agricultural Sector Strategic Development Plan, 2006-2010, Ministry of Agriculture Forestry and Fisheries, .

MAFF (2011). Action plan for rice production improvement and rice exportation. Phnom Penh, Ministry of Agriculture Forestry and Fisheries.

MAFF (2013). Annual Report 2013 (Khmer languge). MAFF. Phnom Penh, MAFF.

MAFF (2015a). report of quantity of rice exportation during 7months early 2015. MAFF, MAFF, Cambodia.

MAFF (2015b). Agricultural extension policy in Cambodia. Agricultural extension. Phnom Penh, MAFF.

MAFF and MWRW (2010). Strategy for agriculture and water 2010-2013. Ministry of Agriculture Forestry and Fisheries and Ministry of Water Ressources and Meteorology. Phnom Penh.

Mak, S. (2001). "Continued innovation in a Cambodian rice-based farming system: Farmer testing and recombination of new elements." Agricultural Systems 69(1-2): 137-149.

Martin, G., M. Duru, J. Schellberg and F. Ewert (2012). "Simulations of plant productivity are affected by modelling approaches of farm management." Agricultural Systems 109(0): 25-34.

Masumoto, T., P. T. Hai and K. Shimizu (2008). "Impact of paddy irrigation levels on floods and water use in the Mekong River basin." Hydrological Processes 22(9): 1321-1328.

Matsui, S., M. Keskinen, P. Sokhem and M. Nakamura (2006). Tonle Sap, Experience and Lessons Learn Brief. Phnom Penh, World lakes.

McLaughlin, A. and P. Mineau (1995). "The impact of agricultural practices on biodiversity." Agriculture, Ecosystems & Environment 55(3): 201-212.

Meichtry-Stier, K. S., M. Jenny, J. Zellweger-Fischer and S. Birrer "Impact of landscape improvement by agri-environment scheme options on densities of characteristic farmland bird species and brown hare (Lepus europaeus)." Agriculture, Ecosystems & Environment 189(0): 101-109.

Méral, P. (2012). "Le concept de services ecosystémique en économie: origin et tendances résentes." Natures Sciences Sociétés 20: 13.

Méral, P. (2013). L'histoire du concept de services écosystemiques. SERENA, SERENA: 8.

Méral, P. and D. Pesche (2013). La notion de service écosystémiques, origine, enjeux et usages dans les politiques. SERENA, SERENA: 6.

Mergenthaler, M., K. Weinberger and M. Qaim (2009). "The food system transformation in developing countries: A disaggregate demand analysis for fruits and vegetables in Vietnam." Food Policy 34: 11.

Miles, G. and N. Thomas (2007). "'Don't grind an egg against a stone'-children's rights and violence in cambodian history and culture." Child Abuse Review 16(6): 383-400.

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-Being: Synthesi. I. Press. Washington, DC.

Millennium Ecosystem Assessment (2007). Millennium Ecosystem Assessment. A Toolkit for Understanding and Action Millennium Ecosystem Assessment, Millinium Ecosystem Assessment.

Millinnium Ecosystem Assessment (2005). Ecosystems and Human Well-Being: Synthesi. I. Press. Washington, DC.

Milne, S. and W. M. Adams (2012). "Market Masquerades: Uncovering the Politics of Community-level Payments for Environmental Services in Cambodia (vol 43, pg 133, 2012)." Development and Change 43(2): 622-622.

Ministry of Planning (2014). Poverty alleviation an approach to an action plan for CMDG-1. M. o. Planning. Phnom Penh, Ministry of planning. April 2014.

Mitchell, J., K. Cheth, V. Seng, B. Lor, M. Ouk and S. Fukai (2013). "Wet cultivation in lowland rice causing excess water problems for the subsequent non-rice crops in the Mekong region." Field Crops Research.

MoC and MAFF (2010). Protected Geographical Indications in Cambodia. Phnom Penh.

Monnery, J. (2010). La place du secteur privé dans l'introduction et l'adoption du concept des Services Environementaux et la mise en place des Paiements pour Services Environnementaux à Madagascar. SERENA.

Mund, J.-P. (2010). The Agricultural Sector in Cambodia: Trends, Processes and Disparities. Pacific News.

Muradian, R., E. Corbera, U. Pascual, N. s. Kosoy and P. H. May (2009). "Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services." Ecological Economics 69(6): 1202-1208.

National Institute of Statistic (2008). Statistical yearbook of Cambodia. National Institute of Statistic. Phnom Penh, Ministry of Planning: 374.

Neang, M., P. Meral, O. Aznar and C. Déprés (2014). Adoption of organic rice on agro-ecosystem with a high risk of flood: Insights from an agrarian System Analysis.

Neang, M., P. Méral, O. Aznar and C. Déprés (2015). Trade-offs within ecosystem services and opportunity costs of rice production systems to maintain ES provision, the case Tonle Sap Lake rice agro-ecosystem, Cambodia.

Neupert, R. F. and V. Prum (2005). "Cambodia: Reconstructing the demographic stab of the past and forecasting the demographic scar of the future." European Journal of Population 21(2-3): 217-246.

Nguyen, Y. T. B., A. Kamoshita, Y. Araki and M. Ouk (2011). "Farmers' management practices and grain yield of rice in response to different water environments in kamping puoy irrigation rehabilitation area in northwest cambodia." Plant Production Science 14(4): 377-390.

P., W., D. A., O. r. T. and R. C. (2000). "The rice soils of Cambodia. I. Soil classification for agronomists using the Cambodian Agronomic Soil Classification system." Soil Use and Management 16(1): 12-19.

PAD Partnership (2003). Cambodia: National Report on Protected Areas and Development, International Centre for Environmental Management.

Pagiola, S., E. Ramírez, J. Gobbi, C. de Haan, M. Ibrahim, E. Murgueitio and J. P. Ruíz (2007). "Paying for the environmental services of silvopastoral practices in Nicaragua." Ecological Economics 64(2): 374-385.

Parvathi, P. and H. Waibel (2013). "Fair Trade and Organic Agriculture in Developing Countries: A Review." Journal of International Food & Agribusiness Marketing 25(4): 311-323.

Pham, T. H., M. Takao and S. Katsuyuki (2008). "Development of a two-dimensional finite element model for inundation processes in the Tonle Sap and its environs." Hydrological Processes 22(9): 1329-1336.

Pham, T. T., K. Bennett, T. P. Vu, J. Brunner, N. D. Le and D. T. Nguyen (2013). Payments for forest environmental services in Vietnam : from policy to practice. Bogor, Indonesia, Center for International Forestry Research (CIFOR).

Pillot, D. (2008). Jardins et rizières du Cambodge: les enjeux du développement agricole, Karthala.

Point, P. (1998). "La place de l'évaluation des biens environnemantaux dans la décision publique." économie publique 1.

Popp, J., K. Peto and J. Nagy (2013). "Pesticide productivity and food security. A review." Agronomy for Sustainable Development 33(1): 243-255.

Portney, P. R. (1994). "The contingent valuation debate: Why economists should care." Journal of Economic Perspectives 8(4): 3-17.

Power, A. G. (2010). "Ecosystem services and agriculture: tradeoffs and synergies." Philosophical Transactions of the Royal Society 365(1554): 2959-2971.

Pugliese, P. (2001). "Organic Farming and Sustainable Rural Development: A Multifaceted and Promising Convergence." Sociologia Ruralis 41(1): 112-130.

Rambonilaza, T. (2010). La composante éthique de la consommation par le consentement à payer. R. f. d. l. gestion. Paris, Lavoisier.

Rapidel, B., F. A. J. DeClerck, J. F. Le Coq and J. Beer (2011). Ecosystem services from agriculture and agroforestry: measurement and payment. London, Washington DC., Earthscan.

Raynolds, L. T. (2004). "The Globalization of Organic Agro-Food Networks." World Development 32(5): 725-743.

RGC (2008). Rectangular Strategy for Growth, Employment, Equity and Efficiency Phase II. Concil of Minister. Phnom Penh, Royal Government of Cambodia.

RGC (2014). National Strategic Development Plan 2014-2018. Phnom Penh, Cambodia, RGC.

Rigby, D. and D. Caceres (2001). "Organic farming and the sustainability of agricultural systems." Agricultural Systems 68(1): 21-40.

Rigby, D. and D. Cáceres (2001). "Organic farming and the sustainability of agricultural systems." Agricultural Systems 68(1): 21-40.

Rives, F. and P. Méral (2013). Terminologies et classifications autour du concept de service écosystemique. SERENA, SERENA: 8.

Sandhu, H. S., S. D. Wratten and R. Cullen (2010). "Organic agriculture and ecosystem services." Environmental Science & Policy 13(1): 1-7.

Sandhu, H. S., S. D. Wratten and R. Cullen (2010). "The role of supporting ecosystem services in conventional and organic arable farmland." Ecological Complexity 7(3): 302-310.

Sandhu, H. S., S. D. Wratten, R. Cullenb and B. Case (2007). "The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach." ELSEVIER 84 (2008)

SCEP (1970). "Man's Impact on the Global Environment: Assessment and Recommendations for Action." The MIT press.

Senthilkumar, K., P. S. Bindraban, W. de Boer, N. de Ridder, T. M. Thiyagarajan and K. E. Giller (2009). "Characterising rice-based farming systems to identify opportunities for adopting water efficient cultivation methods in Tamil Nadu, India." Agricultural Water Management 96(12): 1851-1860.

Setboonsarng, S. (2006). Organic Agriculture, Poverty Reduction and the Millennium Development Goals. International Workshop on Sufficiency Economy, Poverty Reduction, and the MDGs Organized under the umbrella of the Exposition of Sufficiency Economy for Sustainable Development). Available: http://www. adbi. org/files/2006.09. dp54. organic. agriculture. mdgs. pdf.

Setboonsarng, S. (2006). Organic Agriculture, Poverty Reduction and the Millennium Development Goals. International Workshop on Sufficiency Economy, Poverty Reduction, and the MDGs Organized under the umbrella of the Exposition of Sufficiency Economy for Sustainable Development). Available: https://openaccess.adb.org/bitstream/handle/11540/3642/2006.09.dp54.organic.agriculture.mdgs.pdf?sequence=1

Setboonsarng, S., P. Leung and J. Cai (2006). Contract farming and poverty reduction: the case of organic rice contract farming in Thailand. Poverty Strategies in Asia. J. Weiss and H. A. Khan. Cheltenham, UK, Edward Elgar - ADB Institute: 266.

Shimizu, K., T. Masumoto and T. H. Pham (2006). "Factors impacting yields in rain-fed paddies of the lower Mekong River Basin." Paddy and Water Environment 4(3): 145-151.

Smith, K. R. (2006). "Public payments for environmental services from agriculture: Precedents and possibilities." American Journal of Agricultural Economics 88(5): 1167-1173.

Someth, P., N. Kubo, H. Tanji and S. Ly (2009). "Ring dike system to harness floodwater from the Mekong River for paddy rice cultivation in the Tonle Sap Lake floodplain in Cambodia." Agricultural Water Management 96(1): 100-110.

Steinberg, P. F. (2003). "Understanding Policy Change in Developing Countries: The Spheres of Influence Framework." Global Environmental Politics 3: 11-32.

Stern, N. (2006). Stern Review Report on the Economics of Climate Change. HMG, London.

Strange, N., I. Theilade, S. Thea, A. Sloth and F. Helles (2007). "Integration of species persistence, costs and conflicts: An evaluation of tree conservation strategies in Cambodia." Biological Conservation 137(2): 223-236.

Strange, S. (1996). The Retreat of the State. The Diffusion of Power in the World Economy., Cambridge University Press.

Swinton, S. M., F. Lupi, G. P. Robertson and S. K. Hamilton (2007). "Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits." Ecological Economics 64(2): 245-252.

Swinton, S. M., F. Lupi, G. P. Robertson and D. A. Landis (2006). "Ecosystem services from agriculture: looking beyond the usual suspects." American Journal of Agricultural Economics 88(5): 1160-1166.

Thavat, M. (2011). "The tyranny of taste: The case of organic rice in Cambodia." Asia Pacific Viewpoint 52(3): 285-298.

Timmer, C. P. (1992). "Agriculture and economic development revisited." Agricultural Systems 40(1–3): 21-58.

TKK, E. Baran and C. Myschowoda (2008). Have fish cathes been declining in the mekong river basin? Modern Myths of the Mekong. M. Kummu, M. Keskinen and O. Varis, Water & Development Publication-Helsinki University of Technology: 55-64.

Toan, P. V., Z. Sebesvari, M. Bläsing, I. Rosendahl and F. G. Renaud (2013). "Pesticide management and their residues in sediments and surface and drinking water in the Mekong Delta, Vietnam." Science of The Total Environment 452–453(0): 28-39.

Tom, C., J. Ashish, N. Karen, A. Dara, T. Setha and M.-G. E.J. (2009). "Payments for biodiversity conservation in the context of weak institutions: Comparison of three programs from Cambodia." Ecological Economics 69 (2010).

Tscharntke, T., Y. Clough, T. C. Wanger, L. Jackson, I. Motzke, I. Perfecto, J. Vandermeer and A. Whitbread "Global food security, biodiversity conservation and the future of agricultural intensification." Biological Conservation 151(1): 53-59.

Tsubo, M., S. Fukai, T. P. Tuong and M. Ouk (2007). "A water balance model for rainfed lowland rice fields emphasising lateral water movement within a toposequence." Ecological Modelling 204(3-4): 503-515.

Turton, C. (2000). The sustainable livelihoods approach and programme development in Cambodia. O. D. Institute. London, Chameleon Press. Working paper 130: 27.

UNDP. (2012, 02 March 2012). "Poverty reduction." What we do Retrieved 15 april, 2013, from http://www.un.org.kh/undp/what-we-do/poverty-reduction/poverty-reduction.

UNDP (2014). Sustainign Human Progress: Reducing vulnerabilities and Building Resilience. Human Development Report 2014. UNDP. New York, UNDP: 28.

UNEP (2007). Economic Values for Ecotone Goods and Services and Total Economic Values of Coastal Habitats in the context of the UNEP/GEF Project Entitled: "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand", South China Sea Knowledge Document No. 3. UNEP/GEF/SCS/Inf.3.

UNESCO. (2012). "Tonle Sap Biosphere Reserve." Biosphere Reserves Retrieved 05 August, 2013, from http://www.unesco.org/new/en/phnompenh/natural-sciences/biosphere-reserves/tonle-sap-biosphere-reserve/.

UNESCO. (2013). "Biosphere Reserve Information." UNESCO - MAB Biosphere Reserves Directory Retrieved 24 oct, 2013, from http://www.unesco.org/mabdb/br/brdir/directory/biores.asp?code=CAM+01&mode=all.

Van Zalinge, N., T. Nao, S. T. Touch and L. Deap (2000). Where there is water, there is fish? Cambodian fisheries issues in a Mekong River Basin perspective. In M. Ahmed & P. Hirsch (eds.) Common property in the Mekong: issues of sustainability and subsistence. I. S. a. Reviews.

Varis, O. and M. Keskinen (2006). "Policy analysis for the Tonle Sap Lake, Cambodia: A Bayesian network model approach." International Journal of Water Resources Development 22(3): 417-431.

Varis, O., M. Kummu, M. Keskinen, J. Sarkkula, J. Koponen, U. Heinonen and K. Makkonen (2006). Integrated water resources management on the Tonle Sap Lake, Cambodia. Water Science and Technology: Water Supply. G. Amy, A. Annachhatre, E. Arvin, J. Chen and J. Cho. 6: 51-58.

WCS. (2013). "A Wildlife Friendly village in Kompong Thom." Retrieved 24 oct, 2013, from http://programs.wcs.org/cambodia/AboutUs/LatestNews/tabid/8496/articleType/ArticleView/articleId/693/A-Wildlife-Friendly-village-in-Kompong-Thom.aspx

White, P., T. Oberthür and P. Sovuthy, Eds. (1997). The soil used for rice production in Cambodia. A manual for their identification and management. . Phnom Penh, MAFF, IRRI, AusAID.

Willer, H. and L. Kilcher (2012). The world of organic agriculture-statistics and emerging trends 2012. Frick - Bonn, Research Institute of Organic Agriculture (FiFL) and International Federation of Organic Agriculture Movements (IFOAM).

Willer, H. and J. Lernoud (2015). The World of Organic Agriculture. Statistics and Emerging Trends 2015. F.-I. Report, Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM – Organics International, Bonn.

World Bank (2013). Where have all the poor gone? Cambodia Poverty Assessment 2013. A world bank country study. T. W. Bank. Washington,D.C, World Bank: 144.

Wright, H. L., D. L. Buckingham and P. M. Dolman (2010). "Dry season habitat use by critically endangered white-shouldered ibis in northern Cambodia." Animal Conservation 13(1): 71-79.

Wunder, S. (2005). Payments for Environmental Services: Some Nuts and Bolts. , CIFOR, Bogor. Occasional Paper No. 42.

Wunder, S. (2006). "The efficiency of payment for Environmental Services in tropical conservation." Conservation Biology 21: No. 1, 48-58.

Wunder, S. (2008). Payment for environmental services and the poor: concept and preliminary evidence. Environment and Development Economics. United Kingdom, Cambridge University Press 13: 1-19.

Wünscher, T., S. Engel and S. Wunder (2008). "Spatial targeting of payment for environmental services: A tool for boosting conservation benefits." Ecological Economics 65: 12.

Yen, N. T. H., K. Sunda, S. Oishi and K. Ikejima (2007). Tonle Sap ecosystem water quality index development and fish production. WIT Transactions on Ecology and the Environment, Algarve.

Zhang, D., Q. W. Min, M. C. Liu and S. K. Cheng (2012). "Ecosystem service tradeoff between traditional and modern agriculture: A case study in Congjiang County, Guizhou Province, China." Frontiers of Environmental Science and Engineering in China 6(5): 743-752.

Zhang, W., T. H. Ricketts, C. Kremen, K. Carney and S. M. Swinton (2007). "Ecosystem services and dis-services to agriculture." Ecological Economics 64(2): 253-260.

Zilberman, D., L. Lipper and N. McCarthy (2008). "When could payments for environmental services benefit the poor?" Environment and Development Economics 13(3): 255-278.