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Mémoire de fin d'études

What place for an agroecological rice technique in rain fed lowland rice systems?
- Case study of the SRS in Xieng Khuang Province, Laos

Figure 1: Farmer in a paddy field (Bourjac,2017)

BOURJAC, Mathilde
Promotion 103

Stage effectué à Xieng Khuang Laos
du 27/04/17 au 30/09/17
au sein de : GRET

Maître de stage : Ferrand, Pierre

Mémoire de fin d'études soutenu en Novembre 2017

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Abstract

With the growing concern about food security in the northern part of Laos, it is critical to address the issue of sustainable intensification of food production, especially the staple food: rice. In this context, the presented study is designed to evaluate the performance and sustainability of a recent agro-ecological rice cropping technique, named the Sustainable Rice System (SRS). This innovation, introduced in rain-fed lowland systems, is compared to traditional rice growing practices in the study area of Kham District, Xieng Khuang Province. The conduction of the study goes through the understanding of real diversity of practices, which has the result of a distinction between one-seedling practices, named as SRS, and the multiple-seedling practices. Then, the emphasis on the SRS group demonstrates its status in the area as well as the benefits and disadvantages. In order to assess the sustainability of the SRS, the study tries to go beyond only using the "yield" indicator as the "be all and end all", through the three mainstays dimensions of agro ecology; Social, Economic and Environmental. This shows that, even if the yield is not the primary benefit of the technique, farmers are still interested in adopting it as it provides other benefits. Nevertheless, all of the effects are not positive, and the durability of the technique does not seem to be fully guaranteed. This study therefore introduces many key answers to the questions addressed and presents a first overview to pave the way for following studies.

Key Words: *Laos, Xieng Khuang, rain fed lowland rice, Agro ecology, performance evaluation, SRI/SRS, food security*

Résumé

Avec les préoccupations croissantes concernant la sécurité alimentaire dans le Nord Laos, il est essentiel d'étudier la question de l'intensification durable de la production alimentaire, en particulier en ce qui concerne l'aliment principal : le riz. Cette étude vise à évaluer la performance et la durabilité d'une nouvelle technique de riziculture agro-écologique, appelée système de riz durable (SRS). Cette innovation, introduite dans la riziculture pluviale de bas- fond, est ici opposée aux pratiques traditionnelles de culture du riz dans la zone d'étude du district de Kham, dans la province de Xieng Khuang. La conduite de l'étude passe par la compréhension de la diversité présente des pratiques rizicoles, ce qui a pour résultat la distinction entre les pratiques repiquant un seul brin par poquet, correspondant au SRS, et celles en repiquant plusieurs. L'accent est ensuite mis sur le groupe SRS afin d'appréhender sa place dans la région, ainsi que ses performances. Pour être en mesure d'évaluer la durabilité du SRS l'étude tente de dépasser la vision du rendement comme panacée des indicateurs de performance, en s'appuyant sur les trois dimensions du concept de l'Agro écologie ; sociale, économique et environnementale. Cela démontre que, bien que le rendement ne soit pas le principal bénéfice de la technique, les autres avantages apportés intéresse tout de même les agriculteurs pour l'adopter. Néanmoins, tous les résultats ne sont pas positifs et la durabilité de la technique ne semble pas entièrement garantie. Cette étude introduit donc de nombreuses réponses clés à la question soulevée et présente un premier aperçu permettant d'ouvrir la voie à de prochaines études.

Mots clés: Laos, Xieng Khuang, riziculture pluviale de bas-fond, Agro écologie, évaluation de performances, SRI/SRS, sécurité alimentaire

Resumen

Con la creciente preocupación por la seguridad alimentaria en la parte norte de Laos, es fundamental abordar el tema de la intensificación sostenible de la producción de alimentos, especialmente el alimento básico: el arroz. En este contexto, el estudio presentado está diseñado para evaluar el rendimiento y la sostenibilidad de una técnica reciente de cultivo agroecológico de arroz, denominada Sustainable Rice System (SRS). Esta innovación, introducida en los sistemas de tierras bajas secanas, se compara con las prácticas tradicionales de cultivo de arroz en el área de estudio del distrito de Kham, provincia de Xieng Khuang. La conducción del estudio resume la comprensión de la diversidad real de prácticas, cual resultado de una distinción entre las prácticas de una sola plántula, denominada SRS, y las prácticas de plántulas múltiples. Luego, el énfasis en el grupo SRS demuestra la situación en el área y también los beneficios y desventaja. Para evaluar la sostenibilidad del SRS, el estudio excede del único indicador de "rendimiento" como "ser todo y terminar todo", a través de las tres dimensiones principales de la Agroecología; Social, Económico y Ambiental. Esto demuestra que, aunque el rendimiento no es el principal beneficio de la técnica, los agricultores todavía están interesados en adoptarla, ya que proporciona otros beneficios. Sin embargo, todos los resultados no son positivos y la durabilidad de la técnica no parece estar completamente garantizada. Por lo tanto, este estudio introduce muchas respuestas clave de las pregunta y presenta una primera visión general para preparar el camino para los siguientes estudios.

Palabres claves: Laos, Xieng Khuang, cultivo de arroz de tierras bajas secanas, Agroecología, evaluación de resultados, seguridad alimentaria

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Table of acronyms and foreign terms

/: per
%: per cent
ACTAE: Towards an Agro ecological Transition in Mekong Region
ADRA: Adventist Development and Relief Agency.
ADS: Agriculture Development Strategy (ADS)
AE: Agro Ecology/ Agro Ecological
ALiSEA: Agroecology Learning alliance in South East Asia
AV: Added Value
C: Carbon
CCL: Cooperation Centre with Lao
CIIFAD: Cornell International Institute for Food, Agriculture and Development
CIRAD: French Agricultural Research Centre for International Development
cm: centimeters
CO2: Carbon Dioxide
CUSO: Canadian University Services Overseas
DAFO: District Agriculture and Forest Office
DST: Department of Science and Technology
e.g.: Exempli Gratia (for example)
EU: European Union
FAMD: Factor analysis of mixed data
FAO: Food and Agriculture Organization
GP: Gross Produt
GRET: Groupe de Recherche et d'Echange Technologique
ha: hectare
HCPC: Hierarchical Clustering on Principal Components
IFAD: International Fund for Agricultural Development
IRASEC: Research Institute of Contemporary Southeast Asia
IRRI: International Rice Research Institute
K: Potassium
kg: kilogram
km: kilometers
km^2: kilometers square
LAK: Lao Kip
LEAP: Laos Extension for Agriculture Project
MAF: Ministry of Agriculture and Forestry
N: Azote
NABP: National Agricultural Biodiversity Program
NARC: Lao National Agriculture Research Centre
NAFRI: National Agriculture and Forestry Research Institute
NCMI: Northern Community-Managed Irrigation Sector Project
NGO: Non-Governmental Organisation
NGPES: National Growth and Poverty Eradication Strategy
P: Phosphorus
PAFO: Province Agriculture and Forest Office
PC: Production Cost
PCA: Principal Component Analysis
PROFIL: Promoting Organic Farming and marketing In Lao

PRONAE: Lao National Agro Ecology Programme
RL: Return to labour
SAEDA: Sustainable Agriculture and Environment Association
SAMAD: Sustainable Agriculture and market Access Development
SDC: Swiss Agency for Development and Cooperation
SRI: Intensive Rice System
SRS: Sustainable Rice System
TABI: The Agro Biodiversity Intervention
WWF: World Wild Fund

Ban: Village (Lao)
Kha Kib Diao: name of a paddy cropping technique when one seedling is used for transplanting (Lao)
Kha Phong: name of a paddy cropping technique when only a nursery Phong is used (Lao)
Kha Sam: name of a paddy cropping technique when a nursery Sam is used (Lao)
Kin khao: manger
Khumban: Village grouping (Lao)
Lao Loum: Lao people leaving in lowland
Lao Theung: Lao people leaving in the hillsides
Lao Soung: Lao people leaving near the mountain peak
Tai Dam: Black Thaï

To avoid any confusion in reading this text, the choice was made to lay out the exact meaning of words used, which could be easily confused by the reader. Particularly, the word "Laos" will be used to describe the administrative state of the country bound by its borders. The term "Lao" will be used to describe both the inhabitants of the state, as well as the adjective to do with Laos. This term is preferred to "Laotian", as the latter was a term used under the French protectorate, and the former is the term used by the inhabitants themselves. When addressing the question of a population of Lao origin, the term "Lao ethnicity" will be used. Similarly the term "rice system" will refer to a methodology applied for agricultural management related to rice in a given region. Whereas, the terms "rice practice" and "rice technique" describe the actual technique itinerary of growing rice crop. Moreover, the term "paddy" is the name given to the rice grown in the lowlands.
Finally, the terms relating to "intensification" refers to the French approach, in which "Intensification" pertains to the quantity of resources used for acreage used (Touzard and Belarbi, 2009).

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Introduction

South-East Asia is one of the cradles of rice, appearing around 7,000 years ago in India and China, and 4,000 years ago in Siam[1]. Nowadays rice is second most consumed cereal in the world. Asia consumes more rice than the global average, and produces 90%[2] of the global stock. This makes Asia the first producer and consumer of rice. The production of this crop therefore seems primordial to insure a food supply proportional to the population of the region, and by extension essential to its political stability. Fluctuations in the price of rice can therefore have serious impacts on society and can drive social movements.

Laos is no exception to this Asian trend. As a Lao proverb says, “The true Lao is one who eats sticky rice”. This small country at the heart of South-East Asia has a rich culture focusing around rice. Their myth of creation is even centered on this cereal. According to ancient beliefs, the separation of the god of rice into two parts is the origin of the duality between mountain and lowland rice cropping, and the divide in population between these two regions. The later introduction of Buddhism did not attenuate this belief. Indeed, the unity of rice is found once more through the Buddha. However these beliefs are slowly disappearing as a result of modernization. Other than the spiritual foundations for Lao culture, the country is to this day the second consumer of rice in Asia, rice being the nation’s staple food. Although Laos is today auto sufficient in rice, there are still disparities among the different provinces composing the state. In this sense, the majority of rice production comes from the rich plains central to the country, whereas the northern mountainous regions do not yet have an assured self-sustaining production. Besides, family farms in this area are restricted by a limited workforce due to a low population density, and are always competing against the allotment of land to foreign investors for mining projects or leasing. The constant increase in production needs, as well as financial pressure paint a picture in which intensification of rice production in the area seems necessary.

The production of rice is very polluting, namely because of the large amounts of methane released into the atmosphere contributing to global warming. However, the repercussions of this phenomenon are strongly felt in the region. The increase in global temperature has led to a less predictable rainfall, as well as a sharper and more variable disparity between wet and dry seasons. Since managing the water level is one of the keystones of rice cropping, these changes pose a threat to the agriculture in regions with limited irrigation infrastructure. It is beginning to look like a real challenge for Laos. In the future, Lao farming will have to adapt to new conditions using a finely tuned long-term intensification of agriculture, all the while respecting the environment. To quote Pierre Rabhi, Agro ecology is “... much more than a simple agronomic alternative. It is linked to a deeper notion of respect of all life forms, and must allow the establishment of a different vision of life by reconciling vital necessities and the preservation of life, both today and in future generation” and seems to be a key in future development of rice cropping. It is, at the very least, the direction in which agricultural policies are tending within the Lao government. They are notably striving for intensification of farming using new agro ecological techniques, rather than pushing towards a previously favored “Green Revolution”.

[1] Siam is now known as Thailand

[2] % stands for per cent

In this sense, the Sustainable Agriculture and Environment Association (SAEDA), a Lao NGO[3], have developed an innovative technique called "Sustainable Rice System". This technique, first introduced in 2009, in the region of Xieng Khuang, is intended to intensify lowland rice cultures. The Northern Province is one of the poorest in the country. More specifically it is located at the Vietnamese border and was heavily bombarded during the first Indochina war. Besides, farming in the region is characterized by an intense use of chemical fertilizers. However, the arrival of this new technique has a raised some questions as to its integration due to the traditional system already in place since millennia, as well as the use of chemicals and finally the scarcity of labor force and capital of farmers in the region. Considerations, which can be expressed in a more global question: What place for an agro ecological rice technique in rain fed lowland rice system?

This line of questioning will be the theme of this dissertation, and subsequent answers its body. What is this Sustainable Rice System (SRS) exactly? Why would farmers take the risk of trying this new technique? What are the motivations and barriers to its adoptions? How has the technique fared since its first introduction in 2009? How far has it come? And finally, is it indeed more advantageous for households than an as eco-friendly as advertised? The technique will therefore be assessed in the region through its diffusion and performance relative to traditional methods in order to answer some questions as to SRS's place and future.

This thesis is divided into four parts. Firstly, an in-depth description of the context of the case study will be given, delving into the importance of rice in Laos, but also current alternative farming initiatives in the lowland regions. Secondly the actual methodology of the system will be presented. This will be followed by a detailed analysis of collected data, as well as subsequent results. In conclusion, a discussion will be led to finally answer some of the questions laid out, namely the place and future of SRS in Lao farming.

Part I. Context of the study

I.1. The role of rice farming in Laos

I.1.a. A rice civilization

Laos is a country of 236.800 square kilometers (km²) situated in South East Asia in the middle of its giant neighbors; China, Thailand, Vietnam and Cambodia. With the aim of growing out of being the "Least Developed Country" by 2020, it has one of the highest economic growth rates in the region. This economy still relies heavily on agriculture, and rice is the staple food.
We cannot say that rice created the Asian civilization because it already existed, but it organized the old social cultures of the area (Swaminathan, 1984). Most of the core beliefs and social patterns are related to rice. For instance, in Laos, but also in other Asian languages, the word "eat: *kin khao*" could be literally translated as "eating rice".
In another way, the economic and calendar organization of the villages is often based on the cultivation of rice and the work to be carried out in the fields; setting up a system of mutual assistance between the various villagers.

[3] NGO stands for Non-Governmental Organization

The link made with rice is deep, since it occupies a preponderant place in local and traditional beliefs. Indeed, the old main god is the “god of rice”; also called “the soul of rice” or “god of field” (Taryo, 1984).
In Laos, rice cultivation has a predominant role in the functioning of society, politics and religion (Stringler, 2011). During the daily ceremonies and religious festivals of greater importance, rice is always the main offering. For example, every morning the monks go to the streets to collect the rice offerings from the local inhabitants in order to obtain food for the day, as well as enough to make gifts to the most in-need. This daily ceremony still rhythms the life of almost every Lao family. Even despite that with modernization, changes in lifestyle and the evolution of agricultural techniques, the place of legends and beliefs gradually disappear (Taryo, 1984). The place that rice has taken in these beliefs for thousands of years can explain the importance it has today from the nutritional and economic point of view.

Moreover to be historically and spiritually a rice country, Laos is known to be a place “where people listen the rice growing” (Lelarge, 2015). This expression presupposes the importance of this cereal grain in the country. That is confirmed by the fact that the average of Lao milled rice consumption was around 162.6 kg per inhabitant per year (Eliste and Santos, 2012). This makes Laos the 2nd rice consumers in Asia and one of the biggest consumers in the world (Eliste and Santos, 2012). One Laos’ specificity is the consumption of glutinous rice. When other countries consume this type of rice in cake or in alcohol, Lao people make it their main dish. They are considered to be the people with the highest per capita consumption of glutinous rice (Schiller and al, 2006). They have more than 4,000 different rice varieties, most of them glutinous. There is thus a huge diversity in rice cultivation, geographically, but also historically.

I.1.b. Towards the second green revolution for the rain fed lowlands?

Lao government has always supported agriculture to enable to assure food security (Gentil and Boumard, 2005). Consequently, several agrarian changes were implemented through the years.

The first major change, which took place during the late 1970s, was an attempt of collectivization following the power establishment of the Laos (Gentil and Boumard, 2005). This was linked with the closure of borders with Thailand from 1978 to 1980, to favour the Lao rice production (Sacklokham, 2014). But, due the farmers’ rejection of this “cooperative campaign” (Evans, in Dufumier, 2000), these practices collapsed in 1979. The private land property was therefore re implemented once again (Gentil and Boumard, 2005). Another major modification took place in the mountainous area of Laos. It consisted of the substitution of the slash-and-burn rice cultivation by commercial crop due to government wheal (Ducourtieux, 2006) and is still in place. As we will focus on the lowland systems we will not detail this change. Indeed, at the same times lowlands had to face other changes. Following the collectivization attempt the Lao government tried to intensify the paddy productivity. This was done notably from the year 1995 (Schiller, 2006). Some authors wrote that Lao did not experience the “green revolution” as other Asian countries (Aubertin, 2016). This can be explained by the absence of excessive population density, thus there was no justification for the green revolution (Dufumier, 2000). Nevertheless, other authors qualify this intensification of lowland paddy changes as inspired by the “green revolution” (Gentil and Boumard, 2005).

This intensification included intensification of the labor and the use of chemical and mechanical inputs, e.g.[4] fertilizers and tractors. This was coupled with the development of irrigation capacity and the introduction of improved rice cultivars. This improvement of the irrigation system mostly took place in the central and southern Laos where now 90% of the irrigated lowlands are (Schiller, 2006). The evolution from 1995 to 2001 multiplied by eight the acreage of irrigated lands during dry season (Schiller, 2006).

The objective was to conduct two rice campaigns per year to raise the production and feed the population. This led the country to reach self-sufficiency in rice in 2000 (Sacklokham, 2014). Nevertheless, the share of irrigated lowland during dry season is only 240,000 hectares out of the total of 600,000 hectares of lowlands with rice cultivation. Furthermore, only 70,000 hectares are irrigated during the dry season (Shimazaki, 2011).

The lowland area of Laos represents 20% of the territory, but is habituated by two thirds of the population, which causes land pressure. This is linked with the politic change of an interdiction to keep a fallow more than 3 years since 1994. This leads to fertility issues. Despite the fact that reforms have not always worked, rice production has on average steadily increased over the last sixty years, as can be seen in the following figure.

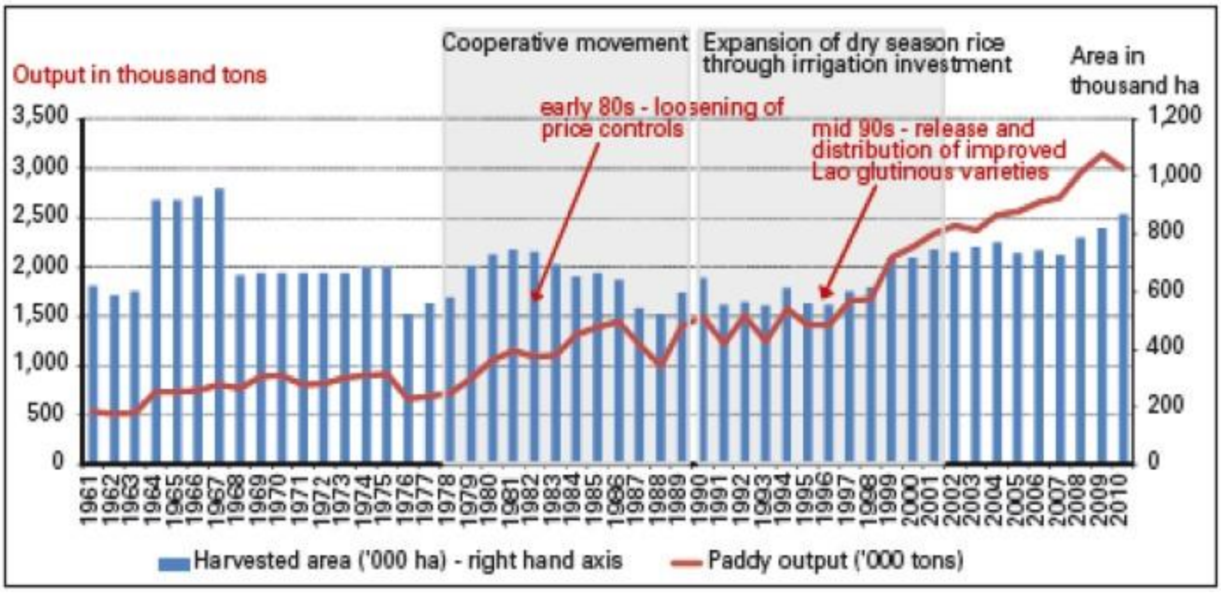

Figure 2: Rice production and total rice cultivation acreage from 1961 to 2010 (Sinsamphanh, 2014)

Since the beginning of the 2000s the government politics regarding agriculture have progressed in the sense of the second green revolution. If the green revolution was defined by the goal to reach the food autonomy, the second green revolution aims to reach food security through a sustainable agriculture. Since 2004, the main objective of agriculture supported by the government is the use of sustainable resources and land use (Manivong, 2016). This is part of the National Growth and Poverty Eradication Strategy (NGPES) with the objective outlined previously to grow beyond the placement of "Least Developed Country" by 2020. This program involved food security, the conservation of the forest, endangered environment and species and the eradication of poppy and slash-and-burn cultivation.

[4] e.g.: Exempli Gratia

Likewise, the National Agricultural Biodiversity Program (NABP) has a long-term strategy for environment conservation and development of biodiversity. In addition, the most recent program, the Agriculture Development Strategy (ADS), has the goal of reaching the food security. This would be accomplished through the increase of rice production up to five tons per hectare in 2025. The programs referred to previously are completed with tools (Manivong, 2016). These tools include the implementation of Organic agriculture standards since 2005, and regulation on the control of pesticides in 2010. They are supposed to support the development of a sustainable agriculture and the biodiversity conservation. As those changes are quite new, there is still progress to make for Lao agriculture and that lead to current challenges to face.

I.1.c. Current challenges for rice in Laos

There is presently a change in consumption in Laos. Indeed, it seems to have become fashionable to consume other kinds of food. For example, since the early 2000s, in restaurants for tourists, they now prefer to serve white non-glutinous rice as it is seen as good to show that you can afford something other than glutinous-rice, especially in big cities (Eliste and Santos, 2012). But still, glutinous rice is the main crop produced in Lao. According to Research Institute of Contemporary Southeast Asia (IRASEC), 80% of the 4% of arable land of the country were used for rice cultivation in 2014.

In 2016, the total rice production of Laos was four million tons, which set it in the 15th place of the Asian countries in terms of rice production. The other main crops are the maize, peanut, coffee and bananas. But the perennial crops only count for 0.5% of the arable lands.

Although Laos has achieved rice-sufficiency for more than a decade, rice production is heterogeneous across the country and food security is not assured for all. Indeed, there are disparities of rice production in the different area of the country. In the map below, we can see the share of the main production areas in Laos in 2012, according to Ministry of Agriculture and Forestry statistics.

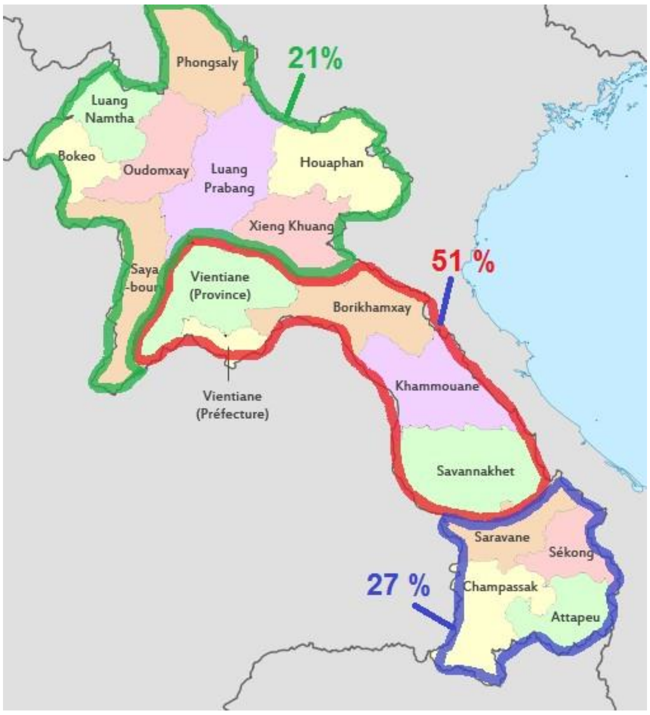

Figure 3: Share of main Lao paddy production area in the national production (Bourjac, 2017)

The main productive provinces in each of these areas are Savannakhet and Vientiane Capital in the Centre, then Champasak, Saravanh in the South, and finally Sayaboury in the North. These differentiations can be explained by the diversity of landscapes, e.g. the northern part Laos is more mountainous, or the soil quality and the investment in infrastructure. In Northern Lao, the lowland cultivation is in valley area confined between mountains, whereas in Central and South Laos, the lowland cultivation takes place in the valleys adjacent of the Mekong River. In addition to the inequality of production, there is a lack of efficiency in food distribution management, according to the Ministry of Agriculture and Forestry. This can lead to a shortage of food in remote areas. Indeed Laos is mostly made of hills and mountains, which explains the various rice ecosystems that can be found. The average size of those multi-production farms was, in 2000, about 1.62 ha per family (Gentil and Boumard, 2005).
Even in if upland rice systems provide lower yields than the lowland systems, they are more adapted to the mountainous areas and have an important place as it fits to the main type of Lao land.

Despite the fact that rice production is the main one in the country, it is still meant to be for subsistence. This subsistence farming was, in 2014, standing to 45% of the PIB, and hiring 80% of the population, according to IRASEC. Rice cultivation in Laos is less competitive that its neighbors (Sacklokham, 2014) with few exportation. This can be explained by the low efficiency of the system following the harvest. For example the long-term storage capacities and the transformation (rice flour or rice noodle) are not good enough to allow a good exportation system. This can also be explained by the lack of efficiency of the irrigation systems in comparison with Vietnam (Sinsamphanh, 2014).

The market agreements with South East Asian and European countries should allow Laos to have development opportunities (Vongsakid, 2007). But there are still high export barriers and low investment, which leads to the development of parallel systems. On another hand, regarding the political policies, as we saw previously, the Lao government has a global strategy with the aim of supporting agro ecology. However, in parallel they also support foreign investments and land redistribution (Manivong, 2016). This impacts the agricultural sector, by implementing industrial crops e.g. bananas or rubber, and threatens the farming agriculture. The balance between those two systems will be an important challenge to address. Another factor that rice has to face is climate change. Indeed, this negatively impacted the crop productivity in Asia countries (Cruz and al in Sinsamphanh, 2014). According to the crop projection made by Sinsamphanh (2014) about rice, in the future the climate change will impact the rice cultivation by modifying the rain falls timing and increase climate diseases such as drought or pest. It already induces 10% losses of the national production (Sacklokham, 2014).

There are therefore present challenges for rice in Laos to face inequalities, be competitive with its neighbors, and preserve the environment. In order to take on this challenge, a diversification of rice cropping practices has appeared.

I.2. Agroecology practices in lowland rice cropping systems

I.2.a. A diversity of interventions on the improvement of paddy systems

The traditional Lao lowland rice production is based on a permanent flooded rice field, traditional varieties, organic fertilizers and draught animal power. But with the increase of constraints, the lowland rice system has been evolving in the last decades and the traditional system has been replaced by intensive rice systems following the green revolution. In spite of these changes, the lowland rice production still has a lot of challenges to face including environmental factors and objectives in terms of production intensification. Nevertheless, to increase the production following the ideas of the second green revolution, some agro ecological improvements have been implemented in Laos. While most of the agro ecological initiatives refer to upland area, some still exist for lowlands.

- The "Rice-Beef" system: Direct seeding mulch based cropping

The main actor working on this subject in Laos is the CIRAD, through the Lao National Agro Ecology Program (PRONAE), since 2004. This system goes further than only improving rice, as this crop is included in a 5-year rotational system with livestock. In fact, the purpose is to improve pastureland regeneration by using rice as a cash crop. The principle of this system is to improve the pastureland during the first year through initial mineral fertilization and forage growing, then 3 years of livestock pastoral fattening and then 1 year cropping rice. This is beneficial for the rice as the years of fattening increased the fertility of the soil, helping to get good rice production for the purpose of selling it. This management of pastureland is coupled with non-tillage; therefore the soil is no longer distributed by mechanical action anymore (DSC source) and its physicochemical structure is improved. That further enables to reduction of the use of chemical fertilizers as the fertilization is provided through plants and livestock.

- No burning of rice straws

Before, the rice straws of a harvest were just burned and thus useless. Furthermore, burning the straws is responsible of CO_2 release (Mendoza and Samson in Triplet, 2015). Now there are two potential uses to reuse of the biomass of the rice straws. As it contains 40% of C, 0.6% of N, 0.15% of P and 1.83% of K[6] (Tanaka in Triplet, 2015), it has the potential to be used as compost. The first one, for breeder-farmers, is the use of rice straw to feed their livestock. This can be done in two different ways. For the first one, farmers provide the rice straws directly in troughs. The second one is that they leave the straws in the rice field and the livestock graze there directly. Similar to the "Rice-Beef" system, this enables an increased fertility through the nutrients of the animal faeces. The way to reuse the biomass when farmers do not own livestock is simply to leave the rice straws in the rice field. The straws rot and enable a nutrient transfer to increase the fertility.

- Integrated Pest Management

The Food and Agriculture Organization (FAO) introduced this program in Lao since 1996. The aim of this program is to reduce the environmental and health risks due to the use of pesticides by the improvement of the decision process for farmers. Three steps are followed by farmers; the identification, the oversight and the action. The purpose is to help farmers refine their needs in term of pest management and adjust the type and quantity of product needed. It can lead to reducing the use of chemical pesticides, the implementation of bio-pesticides, but also the integration of fishes or ducks in the paddy field. In fact, the introduction of fish can enable the control of pests and the faeces increase the nutrient recycling by fixing the N and the P up to 15.6% and 38.5% respectively (Triplet, 2015). Moreover, introducing ducks can assist in pest management. Duck are common predators of snails or crabs for example The presence of ducks in a paddy field furthermore enables, with the moving of their feet, to release the nutrients to facilitate their appropriation by plants and to avoid the weed growth. Furthermore, their faeces can increase the soil fertility.

[5]CIRAD stands for French Agricultural Research Centre for International Development

❖ The organic rice production

The Santhong organic rice farmer group conducts this alternative. They are located in Vientiane Capital province, in the district of Santhong and cover 10 villages. The Swiss organization Helvetas helped to create this group, through a project, which aims at Promoting Organic Farming and marketing In Lao (PROFIL). What is meant by the term organic is the use, and furthermore the production of compost and bio-extracted liquid fertilizers and also the acquisition of an organic certification. In 2015, a total of 284 households owned 369.6 hectares of organic rice for a production of 1,108 tons (Manivong, 2016).

❖ The “beautiful rice growing technique

This system was created in Vientiane province, in Tholakhom district. The objective of this technique is to remove women from the rice field. Commonly the work of women in the paddy field is the transplanting and the harvesting. In this system, there is no nursery or transplanting because the seeds are spread in the paddy field (60kg/ha[6]). Another distinction is that there is no weeding or herbicide used, but two months after the spreading, each plant in the paddy field is cut down, including rice plant and weeds. The waste is left on the soil for mulching. This technique was invented following the observation that buffalos eating the rice made it grow faster afterwards. The Lao Farmer Network implemented this technique.

These outlined systems are not completely distinctive from the traditional system (Newby and al, 2013) but have the will of trying to optimize the agro-ecosystems while respecting it. The more developed improvement in lowland rice system is the System of Rice Intensification (SRI), which will be examined in the following paragraph.

I.2.b. The case of the System of Rice Intensification

The Intensive Rice System is a management strategy for crop improvement (Stoop and al, 2002). It was created in Madagascar by a French agronomist priest Father Henry Delaunié (Ramnoelina, 2009). It was developed after 34 years of work in the field with farmers and observation. The main principles of this technique are to transplant young seedlings, use wider spacing between plants, stop continuously flooding soil, mechanical weeder, and enhance the soil quality (Uphoff, 2015). By doing that the SRI influences the soil structure, aerobe and nutrition, the diversity of soil organisms, and the available room for roots and tillering. All of this, if done in order to increase the soil quality to enable the rice plant to express its potential and to get the highest production.
Technically, the details of these principles (Uphoff, 2015) are:
- Transplant a single seedling per hole
- Use seedling aged 8 to 15 days
- Transplant by square of 25 centimeters (cm) with using a string to make square, and no deep transplant
- The seedbed must be dry
- Use a seed rate of maximum 20 kg/ha
- Use as much organic fertilizer as possible
- Manage the weed with a mechanical tool

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[6] kg/ha: kilogram per hectare

Initially the SRS was thought to use chemicals but in the end, it was found to be more organic as Father Laulanié noticed that farmers in the area where he created the technique could not afford chemicals anymore (Uphoff, 2015). Moreover, the concept of Intensive Rice System (SRI) is to propose a set of optimal principles and the more farmers adopt them, the more they can expect good results. Regarding the history of the technique, it was invented in the year 1984. Then, in 1994, the association created by Father Delaunié (Tefy Saina Association) started working together with the Cornell International Institute for Food, Agriculture and Development (CIIFAD), in Madagascar.
Then, the CIIFAD spread the technique in other countries, approximately at the following dates:

"- 1999-2000 - China, Indonesia
- 2000-2001 - Bangladesh, Cambodia, Cuba, Laos, Gambia, India, Myanmar, Nepal, Philippines, Sierra Leone, Sri Lanka, Thailand
- 2002- 2003 - Benin, Guinea, Mozambique, Peru
- 2004-2005 - Senegal, Pakistan, Vietnam
- 2006-2007 - Bhutan, Burkina Faso, Iran, Iraq, Zambia; Afghanistan, Brazil, Mali
- 2008 - Costa Rica, Ecuador, Egypt, Ghana, Japan, Rwanda
- 2009 – 2010 - Malaysia, Timor Leste, DPRK; Haiti, Kenya, Panama
- 2011- 2012 - Colombia, Korea, Taiwan, Tanzania; Burundi, Dominican Republic, Niger, Nigeria, Togo
- 2013 – 2014 - Cameroon, Liberia, Malawi; Congo DR, Ivory Coast, US" (Uphoff, 2015).

These countries did not all appropriate the SRI with the same intensity, as the following map shows. The darker the green color is, the more the SRI is present in the country.

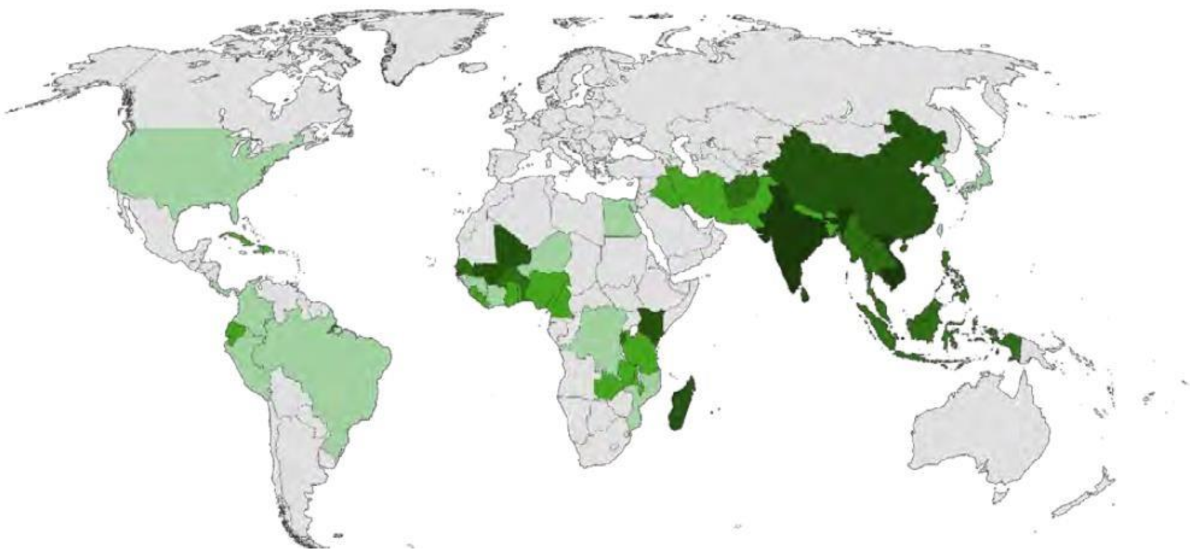

Figure 4: Spread of SRI use in the world (Uphoff, 2015)

The propagation of SRS was not only geographical, but it was also applied to other crops, such as maize (Mc Donald and al, 2008).

To focus the SRI question in regards to Laos, it was introduced in the country in 2001 by Oxfam Australia (Vongsakid, 2007) and in the same year, the Lao National Agriculture Research Centre[7] (Shimazaki, 2011). The latter organization concluded, "the likelihood of disseminating SRI throughout Laos is extremely slim". Then, the implementation of SRI was thus abandoned for years, until a project conducted by the Japan NGO Pronet 21. The reasons for this rejection of SRI were the need of very fertile soil or a huge amount of fertilizer and the impossibility to manage intermittent irrigation during wet season or even individual management.

In 2008, the Ministry of Agriculture and Forestry (MAF) issued a decree to encourage the extension of SRI and begin a politic of SRI development in irrigated areas. This decree really started the spread of the technique in Laos (Shimazaki, 2011). Moreover, a number of important organizations were involved in the propagation. The main ones are namely SAEDA[8], WWF[9], CUSO[10] International and ADRA[11] Japan (Shimazaki, 2011). We can thus see the implication of both local (SAEDA) and international (the others) organizations. The MAF then instructed the provincial and district level to extend the technique to the whole country. But, due to the low labor force availability in dry season, the adoption in Northern part of the country was weaker (Castella and al, 2015). Nevertheless, here is a report of the total expansion of the SRI technique in Laos from 2001 to 2010.

Table 1: Expansion of SRI area and households from 2001 to 2010 (Shimazaki, 2011)

Organization (Finance)	Unit	2001	2005	2006/07	2007	2007/08	2008	2008/09	2009	2009/10
		Wet	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Oxfam Australia	ha	0.005	19.0	1.2	31.0					
	nos	2	77	2	100					
Japan International Volunteer Center	ha			0.8	14.0	3.8	19.0			
	nos			2	22	18	55			
Pro-net 21 (Nippon Koei) & NCMI (ADB)	ha			0.6	1.0					
	nos			3	10					
Pro-net 21 (JICA's Grass-Roots TA)	ha					3.7	8.0	28	72	141
	nos					22	56	94	212	420
NCMI Project (ADB)	ha					5.3	106	303	445	332
	nos					30	677	891	1,308	976
DOI-MAF & PAFOs (Gov. of Laos)	ha							1,142	2,033	3,152
	nos							3,358	5,979	9,270
Grand Total (Whole Laos)	ha	0.005	19.0	2.6	46.0	12.8	133	1,473	2,550	3,625
	nos	2	77	7	132	70	788	4,343	7,499	10,666

Remarks: Wet = Wet season paddy, Dry = Dry season paddy

It seems that there was a general increase of the SRI presence in both terms of acreage or number of households through the years. Nevertheless in the last year we can see that spread is slowing down. In the wet season campaign for 2009, the technique use increase of 73.1% compared to the dry season campaign for 2008-2009. But from the wet season campaign for 2009 to the dry season campaign for 2009-2010 it only increases of 42.2 %. This can potentially be explained by the irrigation capacities during dry season. SRI has a good potential in Laos to help Lao families to get out of poverty. Implementing SRI would cost only 7.50 dollars per family, thus 63,700 kips (Asian Bank of Development). Nevertheless, the SRI technique is "too constraining" according to farmers and organization such as SAEDA, thus it still has limits for complete adoption throughout Laos

[7] NARC: Lao National Agriculture Research Cent

[8] SAEDA Sustainable Agriculture and Environment Association

[9] WWF: World Wilde Fund

[10] CUSO: Canadian University Services Overseas

[11] ADRA: Adventist Development and Relief Agency

It seems that there was a general increase of the SRI presence in both terms of acreage or number of households through the years. Nevertheless in the last year we can see that spread is slowing down. In the wet season campaign for 2009, the technique use increase of 73.1% compared to the dry season campaign for 2008-2009. But from the wet season campaign for 2009 to the dry season campaign for 2009-2010 it only increases of 42.2 %. This can potentially be explained by the irrigation capacities during dry season. SRI has a good potential in Laos to help Lao families to get out of poverty. Implementing SRI would cost only 7.50 dollars per family, thus 63,700 kips (Asian Bank of Development). Nevertheless, the SRI technique is "too constraining" according to farmers and organization such as SAEDA, thus it still has limits for complete adoption throughout Laos.

I.2.c. Recent introduction of an alternative to SRI: the Sustainable Rice System

The Sustainable Agriculture & Environment Development Association (SAEDA) is a Lao organization created in March 1991. Their mission is to promote sustainable agriculture and environment conservation with the diffusion of agro ecological good practices. To that purpose, after observing the SRI technique described before, they implemented their own rice system, called the Sustainable Rice System (SRS). According to them, the SRI entailed too many requirements that were too constraining for farmers in regards to of their context. The eight reasons to change the SRI technique presented by SAEDA are:

- Farmers cannot manage the water in their paddy fields
- Farmer has a lack of labor
- There is land slopping in the area
- The seedlings are too young, thus they can be destroyed easily
- Farmers do not want to transplant by using tools to create squares
- Farmers have too large land area to manage the technique in their whole area
- The technique needs too much time to work on the nursery
- There is too many weed issues

They thus decided to create a technique, which would enable to fight those constraints. The principles of this technique presented by the association are:

- To use traditional rice seeds
- To use seedlings aged of 12 to 25 days
- Transplant by using square of 20 to 30 cm, but without tool
- Do seed selection using salty water
- Put a maximum depth of water up to 10cm
- The use of organic fertilizer solely
- The use of organic pesticide and organic weeder

The SRS was promoted in the frame of the Sustainable Agriculture and Market Access Development (SAMAD) project. The two main objectives of this project were to strengthen an organic producer organization and to improve farmers' incomes and food security. This project was mainly based on organic vegetable production, bio pesticides and organic fertilizers. But an aspect was also the development of SRS. This project was only in one district of Xieng Khuang Province; Pek. In 2009, 5 villages were targeted for the project and a total of 27 households decided to try the SRS in their rice fields. The promotion of the technique in the villages went through different trainings. An initial theoretical training about crop management practices, then a practical training on rice seed selection, preparation of compost and bio extracts.

The final training was practical transplanting of the seedlings in one farm field to show to others.
Then, since 2015, the project has been implemented in the other districts. This was possible through a new phase of the project. The SRS was implemented in Kham district, through the common action of SAEDA and CCL [12]. Their partnership worked by combining the project management of CCL, and the field expertise of SAEDA. Moreover, CCL is the organization in charge of promoting SRS in Oudomxay province and now Phongsaly province. Besides these two organizations, the government provides a lot of support to the SRS, because it fits with the government policies (SAEDA, 2016). This support includes advises, providing access to office and allotment of government officers from DAFO[13]. Indeed, CCL, SAEDA and DAFO work side by side.

The first results obtained in Kham regarding the SRS are increases in the obtained yield when compared to other techniques. In 2013, they observed that the average rice production was about 5.5 tons per hectare, in comparison with the 3.5 ton/ha provincial production average (SAEDA, 2016). In a parallel CCL evaluation report, they observed an individual increase of production of 30 to 50% for farmers who implemented SRS in Kham (Chitavong and Valakone, 2015). The methodology used to get these results is the plot methodology. They conducted in-field statements in different areas for CCL by comparing SRS and other technic for a same farmer. Another early result that was observed is the satisfaction of farmers who can reduce the quantity of rice seed used.
These first findings and observations about the SRS enable some departure hypotheses regarding the SRS performances:
- SRS does not need an excessive amount of labor force
- SRS does not imply too much work on the nursery
- SRS does not induce weed management issues
- SRS enable farmers to use reduced seed quantities

Nevertheless, the low hindsight regarding this technique still opens the door to a lot of questions to understand better this alternative and its performances and sustainability. Indeed, except this yield indicator there is no scientific evidence of the interest of the technique. Moreover, even those who implement the technique, namely CCL team, question the long-term impact of the technique, e.g. the impact on the soil fertility.
This is why the co-director of SAEDA suggested that an assessment would be conducted to be able to present and evaluate better evaluate the SRS.

The proposition of this evaluation was suggested in November 2016 during a workshop organized by the French organization GRET[14]. This workshop was organized in the framework of ALiSEA[15] project component. ALiSEA stands for The Agroecology Learning alliance in South East Asia.

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[12] CCL: Cooperation Centre with Lao
[13] DAFO: District Agriculture and Forest Office
[14] GRET: *Groupe de Recherche et d'Echange Technologique*
[15] ALiSEA "Agroecology Learning alliance in South East Asia"

ALiSEA is a component of a vast project carried by CIRAD named Towards an Agro ecological Transition in Mekong Region (ACTAE). To carry out this project GRET is thus scaling-up the synergies between different actors such as farmers, researchers, development agencies, the private sector, etc.
In this objective of synergy the evaluation of the SRS was a co-evaluation including different actors:
- GRET and Nabong University who would provide a working pair composed of a French and a Lao researcher
- SAEDA who would provide logistical support and information
- CIRAD and CCL who would provide scientific support

The working pair was included with the purpose of combining different knowledge and methodology but also to facilitate the work with the farmers. Indeed, in non-touristic areas (e.g. Vientiane or Luang Prabang) and remote areas, people do not speak French or English. Therefore the assistance of a translator is needed.
This present study was thus designed for a 5-months fieldwork in three provinces of Laos which are Savannakhet, Oudomxay and Xieng Khuang (cf Figure 3), the provinces where SRS is supposed to be implemented. The initial objectives of the study were:
"- To better understand what SRS is and the diversity of practices in SRS
- To Pilot test a multi stakeholder research framework for assessing the impact of an Agro Ecological (AE) practice in terms of social, ecological and economical parameters that could be replicated later on
- To understand the farmers' reasons underpinning the adoption of an Agro Ecological innovation, such as SRS, and how its dissemination can be improved
- To document the performances and the sustainability of the SRS and generate evidences to engage policy dialogue and promote Agro Ecology" (Ferrand, 2016)

Part II. Methodological framework

II.1.Mobilised concepts

II.1.a. Agro ecology

The term *Agro ecology*, appeared for the first time in 1928 in the words by Basil Bensin, an agronomist. This word does not refer to an easy defined-concept but has several definitions and regroups a large variety terms, scales and principles.
Bensin, defined it as an "approach of agronomy inspired by the achievements of the scientific ecology which developed the approach of living as a system of interacting and dynamic communities" (Calame, 2016).
This technical definition was then extended with the additional ecologic and societal concerns? Notably thanks to Altieri who was the first who linked the agro ecology science with the aim of producing food through alternative means in comparison with conventional agricultural productions (Altieri and al, 1998).

In one hand agro ecology is a global concept in purpose of improving conjointly the society and the environment through a well use of resources. These three main spheres are correlated and not commutable (Calame, 2016) and it is their common improvement, which will make the success of it implemented using agro ecology approach.

This concept has the objective to combine social, economic and society improvements and can be found at several levels of analysis as represented on the following figure.

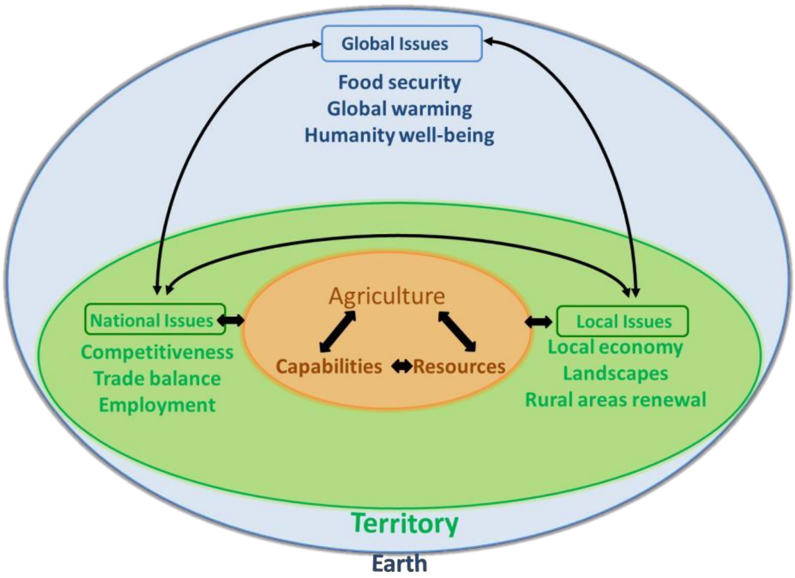

Figure 5: Global approach of Agro ecology (Lairezy, 2016)

Before being this global approach agro ecology was defined as an agronomic science with the basis objective of exploiting ecosystem potentialities in order to grow qualitative products (Levard and Apollin, 2013). Even limited at agronomic level, agro ecology involved the same three dimensions. Indeed, the technique is expected to be economically performing respectful to the environment and carrier of human development. The following figure represents the interrelation of these three objectives, respectively represented in red, green and blue.

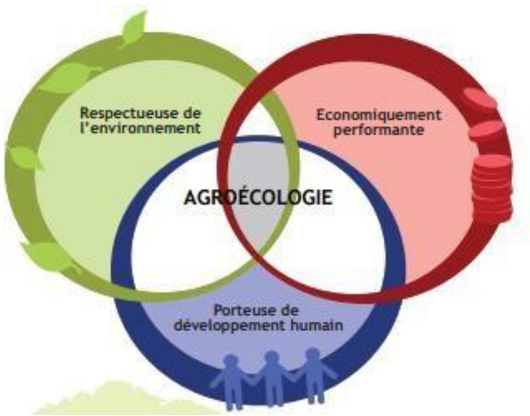

Figure 6: Representation of the Agro ecology retained in the study (Lairez, 2016)

As just discussed there are variable concepts of agro ecology. Added to this variability of concepts, it also exist variability of representation. In Asia, agro ecology is mostly represented within techniques applied to rice cropping (Allaverdian and al, 2013).

Our study will use this representation to focus on a specific cropping technique. Thus, when in the study we speak about agro ecology, we speak about environmental sustainability, e.g. low chemical inputs.

But it also includes economical sustainability, e.g. increasing the household incomes. And finally it includes social sustainability, e.g. women and men labor or alimentation.

II.1.b. Lowland rice system

To have a better understanding of lowland system it is briefly described four different rice ecosystems existing in South East Asia (Trebuil, 2001). This classification is mainly base on the water supplied but also on land characteristics and adaptation of the main types of rice. The International Rice Research Institute (IRRI) currently uses it, and Khush (Trebuil, 2001) created it in 1984. The four ecosystems are the irrigation system, the rain fed lowland, the deep-water system submersion and tidal wetland system and finally the upland system. Added to the Kush classification, information from Sacklokham typology, specifically about Laos' rice ecosystems, is added.

❖ Irrigation system

The rice field is flattened and water management is ensured by an irrigation system based on the use of elevation dams and with a technicality that depends on the infrastructure put in place. Consequently, this system can be found in wet season in addition to available rainwater when the infrastructure is quite simple. It can also be found in the dry season thanks to pumping of the water table. It is even possible in some area to find 3 cycles per year due to the irrigation installation and the use of a semi-dwarf variety. This system is made possible, by the technicity put in place, to alleviate the classic climatic variations. This allows a yield average of 4 to 5 ton per hectare per cycle, with a maximum of 10 ton per hectare per cycle. However, this system requires an expensive initial investment, which is not accessible to all farmers. In Laos, is mostly located in Central and Southern Lao. It corresponds to the main productive system of the country, even if it represents only 13% of the total rice acreages (Eliste and Santos, 2012).

❖ Rain fed lowland

As its name suggests it, is mostly located in lowland area. It is characterized by a lack of comprehensive water management. Indeed, the amount of water in the paddy field is fully dependent on the rainfall. This ecosystem only allows one cycle of rice in the wet season and is highly dependent on climatic variations. This could lead, for example, to periods of drought or heavy submergence, which can limit the yield up to 4 tons per hectare per cycle. This system therefore seems to be less productive than the one involving irrigation as it is more subject to the climatic risks. This is the system corresponding to the context of the study, which is a basin, thus lowland, but with no irrigation system. It is especially important in Laos, where it accounts for 70% of the total rice area, than compared to any other country in South East Asia (Eliste and Santos, 2012). From this point, the term "lowland" will refers to the "rainfed lowland".

❖ Upland system

This system is mainly found on slope area but can still be located on flat surface. The main factor of this system is that it is entirely dependent on monsoon rains. However, nothing is done to dam this water. There is therefore no flooding of the crop, thus the plants stay mostly without water.

This system is often part of a slash-and-burn management and can be found in mountainous and remote areas. In Laos it includes a fallow period from 2 to 7 years, leguminous and cash crops, such as maize, (Sacklokham, 2014) and is situated mostly in Northern Lao.

❖ Tidal wetland system

It is a system mainly based on alluvial plain or coastal zone. There is no management of the water slide in the sense that it is the flooding of the rivers or the rise of the sea that flood the rice field up to more than 50 cm for a given period. There is thus only one cycle of the type of rice cropping and the yield goes from 1 ton per hectare in deep-water system submersion up to 5 ton per hectare while on coastal zone. This system is rare in South East Asia and does not exist at all in Laos (Sacklokham, 2014).

❖ Plateau system

An additional specific system which does not appears in Khush classification is the plateau system (Sacklokham, 2014). This system is only located in the Boloven plateau, Southern Lao, area where there is mostly coffee production. The purpose of this system is to clean the area for cash crop production. As the rice cropped in this system is rain fed, it can be included in the lowland rain fed system of Khush classification.

This is important to focus a study on the intensification of the rain fed lowland in Laos, as we saw that only 12% of the total paddy cultivation area is irrigated (Shimazaki, 2011), the remaining 88% are rain fed.

II.1.c. Innovation

First of all we questioned if the SRS can really be considered as an innovation as it does not fully accord with a radical change by introducing something that did not exist before. Firstly, SRS seems to suggest a change in society, from a conventional agriculture, to a sustainable one. Secondly, it is not only a technique provided vertically to farmers, but it is adapted by them. Finally, in farmer perceptions the SRS is felt as something new that induces changes for them. This combination of novelty and appropriation make us make the postulate that SRS is an innovation. It will therefore be considered and question following this assumption. Moreover strictly speaking about the technical aspect, it is also an innovation, with introduction of the one-seedling transplanting, and the use of organic inputs.

In the literature, we observed that the innovation could be taken as a gateway to understand the agrarian dynamic. It would thus only a comprehension key, but not the main subject of analysis. This is what Chauveau and al implemented in 1999. In our present study, the choice was made to considerer the innovation as study subject. This was done regarding the initial objective of the study; to assess the performances of the SRS. But this could be limiting, as only taking in account the innovation at a t-moment. We therefore decided to add the study of the innovation's kinetic (Lavigne Delville in Chauveau, 1999). Studying the innovation's kinetic mean considering the innovation as a process and questioning the dynamics around the innovation. In the present study this will goes through the questioning of what led to the implementation of the innovation, what is its spread and what could be its sustainability. If an innovation can have an impact on social dynamics, the choice of innovation is individual (Chauveau and al, 1999). We therefore decided to study the individual farmers' adoption process. Bases on the results obtained, by using a synthetic analysis, we will try to emphasize main trends, appropriated to the study area (Chauveau and al, 1999), about innovation dynamic and performances.

II.2. Materials and methods

II.2.a.The overall approach design

The methodology used was designed and adjusted all along the internship period regarding the expectations, and the constraints faced. This methodology aims to be a combination of different methods and tools adjusted regarding the required data to collect. The global approach used has divided the study subject in different levels of analysis following an iterative approach; from the general to the more specific. Starting with the general context of the study and leading to a focusing on the SRS technique. Moreover, it was decided that the methodology conducted would be only qualitative. This choice was made because the study is a sort of case study (Gagnon, 2012) of SRS in Xieng Khuang Province.

Furthermore, it seemed that the qualitative approach was more complete than the quantitative one regarding the study topic. Indeed, our research refers to a process of an innovation installation in an area and includes the understanding of decisional process. At the different steps, tools of the agrarian diagnosis were used but adapted to the means of the study. The path followed is schematized in the following graph.

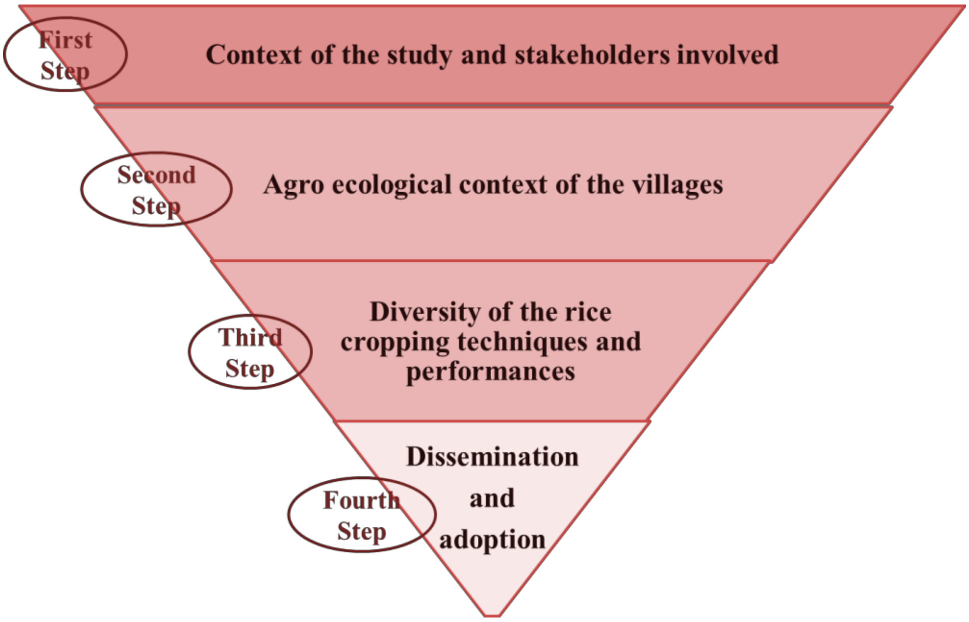

Figure 7: Overall approach design (Bourjac, 2017)

The following steps of the study described refer to the ones of the previous figure.

- First step: Context of the study and stakeholders involved

The first level of analysis is a comprehensive overview of the organizational context of the present study. This part lasted during 3 weeks in Vientiane capital and 1 week in Xieng Khuang province. This was executed through key informant interviews and literature review. The key desired results of this phase were to precisely determine the delimitation of the study area, to organize the co-evaluation with the partner actors and improve the methodology.

❖ Second step: Agro ecological context of the village

Once the study area was determined, it was possible to follow the methodology to the second step. This step corresponds to the geographical characterization of the villages. This had the objective of understanding the agro ecological context in which the innovation enters, and create a farm typology. This step lasted 5 days in Xieng Khuang province. The farm typology tool from the agrarian diagnosis is used but modified, as it is really not the central component of the study.

❖ Third step: Diversity of the paddy techniques and performances

This level of analysis focused at cropping level and had two objectives. The first one was describing the different paddy cropping systems in the area. The second one was comparing their performances. Technic-economic analysis tool from the agrarian diagnosis is used there but restricted as focused on cropping system level.

❖ Fourth step: Dissemination and adoption

The last level of analysis concerned the farmers' perceptions and decisions. This was supposed to lead to understand the reasons of appropriation or not by farmers of the SRS.
At this step it seemed relevant to be inspired by the historical approach of the agrarian diagnosis. Therefore, we adjusted it to be used for understanding the process of SRS adoption.

These different steps are not disconnected from one another. On the contrary, following the iterative approach, the methodology was thought to go back and forth between the different results obtained in order to fine-tune them. In the following document these different part of the global approach can be referred as Step 1, Step 2, Step 3, and Step 4.

II.2.b. Method dimensioning

This part has the purpose to explain precisions about choices made for the methodology and why changes had to be made regarding the initial demand. The entry point of the study was supposedly the key performance indicators and the evaluation of a practice. But it appeared during the first step that some revisions were needed regarding the way the study had been planned. Indeed, it was not easy to obtain a proper definition of SRS and it appeared that the differences with SRI were small. From this observation it seemed that before the evaluation several steps needed to be observed. These different steps were identified as the understanding of paddy cropping systems diversity in the area, the characterization of the SRS and the paths and means for its dissemination.
Furthermore, as the SRS was supposedly implemented in three provinces (Xieng Khuang, Oudomxay and Savannakhet), thus the study was planned to include them all. Finally, it was decided to focus only on Xieng Khuang province. This was because during the Step 1 it was highlighted that Xieng Khuang is the historical birthplace of the SRS, but also that there was no SRS implemented in Savannakhet and no time to study two different provinces. In that continuity we were supposed to work in the districts of Pek and Kham. This choice was made because Pek is the first place where the SRS appeared, and Kham included recently implemented areas. Therefore it seemed interesting to compare farmers' behaviors and SRS performances in both areas. Finally, because of organizational issues with the local partner, and due to farmers' schedules the study had to focus on Kham district only.

II.2.c. Limits of the study

Through the design and the implementation of the study, biases were encountered. This part aims at informing the reader about the limits encountered in the study framework, and its design.

❖ Limits due to institutional constraints are:

- That the study was designed initially be a co-evaluation between different organizations. The study was supposed to be conducted through the cooperation with a researcher from University in Vientiane University and the author of this writing. Nevertheless, the potential partner did not wanted to have a field activity and was not kind of going to the province more than a few days. Two unsuccessful tries with 2 researchers from Vientiane Universities induced important delay in the study schedule and the field part initiation. This, combined with the bureaucracy needed to renew visa, induced short temporal window to spend in the villages for the study.

- That the Laos is a communist country, which brings to some political limit and freedom restrictions to operate. It is important to take in account that Laos government keep an eye of what happens in the country through vertical management and a large importance given to district and province authority. They are thus always paying attention, when not controlling, who go to study which topic in province. To limit this constraint it was decided to present the purpose of the work to the districts governors at the beginning of the study. Nevertheless, this vertical authority transposed to the presence of a young woman foreign researcher, might explain complexity to access complete and transparent information from some farmers or local project team. Indeed, it was difficult to be heard and to have direct interaction with people. Despite discussions and several tentative with local organization, head of villages and government members, it was never possible to conduct the interviews in the paddy field or to spend a sufficient time in the villages or to always have the reasons of denials. In addition, not going to the paddy field, explained by the head of villages for the sake of facilitating the work regarding the few amount of time in the village finally induced burden to the farmer as they have to be available in one place during a whole day, coming to the interviews. Then, some feel disturbed in their work and do not want to be interviewed. In final, this forced to take the decision to remove the landscape observation tool, the on-field data collection and modified the initial sample. The study was therefore conducted through a solely declarative way.

❖ Limits due to communication constraints are:

- The permanent need of translation as Lao people in the study area do not have even basics in English or French. In addition even the university partner in addition to his resistance to go on field had not a sufficient English level to engage in the study in the process of conducting interviews. After two different partnerships without success, it was decided to cancel the partnership and find a translator directly in Xieng Khuang. Despite the fact that experts in translation only work in Vientiane capital, it was fortunately possible to find a motivated person who worked on the study for the phases 3 and 4. Even if this translator had the agricultural vocabulary, the English translation was not sufficient regarding the needs for a qualitative study, due to the lack of experience. As the study was qualitative, the questions were willingly opened ones, to do semi-structured interviews. This lets the possibility to bounce back regarding the answers of the interviewees and thus going further in the comprehension. Finally, this type of questions was not possible to implement because of the direct translation difficulties. It was therefore decided that the questionnaires would be closed and relatively easy for a good understanding for the translator, but also for the interviewee (Larmarange and Temporal, 2006).

- The fact that as the work partners were found just before the field trip and their work are not really to be translators. This induced the need to create really simple questionnaires to be quickly understood by them and quickly translated in Lao. Thus, the vocabulary used is simplified and not really scientific as it could be expected for this kind of work.
- The communication with the local partner team who do not speak English. It was difficult to exchange and this induced misunderstandings. For example in the village selection of Pek districts, the local team made appointments for their part without explaining their criteria and discussing about it. It involved thus a bias in the sample selection and a lack of methodology explanation. In the purpose of preserving the scientific rigor this took part of the decision to not work in Pek district. This also implied the difficulty to obtain complete and clear information about the work of the local team. Finally, the limits induced loss of study time, adjustments in the study conception, and loss in data collection quality because of simplification.

- <u>Limits due to temporal constraints are:</u>

- That the study took place during the wet season. This is the period of the year with the more on-farm work. Farmers were thus not motivated to take time to answer the interviews, as they were busy on their field.
- The short duration of the internship itself, linked to the previous limits presented, and the few time dedicated to the fieldtrips. This induced important adjustments regarding the objectives, limited the possibility of deepening some questions and reduces the study design. The last limit due to the temporal constraint is the length of the study in comparison of the objectives and the time vision in Laos. Indeed, as explained previously the hierarchy organization is vertical. It thus always takes time to find the good person who has the information and to trace this person in order to reach her. The time limits of the study were thus sometimes constraining regarding the time needed to get information.

- <u>Limits in the study design:</u>

All these constraints combined finally induced a choice made for the study: to emphasis it at cropping level. The cropping system concept used refers to all the techniques applied to parcels managed in the same way; defined by a succession of crops and the technical itineraries managed for each of these crops (Ferraton and Touzard, 2009).
But the farmers' choices made regarding cropping level are also explained by exogenous determinants, from other level of decisions. So it can be a limit to the study robustness.
This is why using a global systemic approach to analyze the interlocking and interdependency of these different organizational levels (Cochet, 2007) could enable a complete understanding of farmers' decision. Nevertheless, analyzing the cropping system could enable a well-understanding of what happens in the parcel (Sébillotte, 1974). And thus, to have, a deeper comprehension of the rice practices. In the amount of time available, have studied the different levels would have alleviated the precision about the rice practice, which is the main objective of the study.

To conclude, various constraints from the data framework limited it by the reduction of response ambitions and the study design. However, these adjustments were tried to be realized with arbitration between the downward revision of initial ambitions, and the conservation of essential achievements to reach the objectives in a purpose of constant scientific rigor.

II.3.Study area

II.3.a.Xieng Khuang Province

Xieng Khuang is a province in northeastern Laos located 400 km from Vientiane capital. It has an area of 16,358 km² and is divided in 8 different districts; Pek, Phaxay, Phoukout, Kham, Nonghed, Khoun, Mork and Thatom districts. The province shares borders with Vientiane, Houaphanh, Luang Prabang and Bolikhamxay province and with Vietnam, and can be reached by plain or by overland road. The map below shows that.

Figure 8: Xieng Khuang localization and districts (Bourjac, 2017)

The capital province is Phonsavan, located in Pek district. The province has a total of 238,766 inhabitants (Lao statistics bureau, 2015). Those inhabitants are distributed in households owning on average 2.0 ha (World Food Program, 2013). This is a new capital, rebuilt after the secret war. Indeed Xieng Khuang is one of the most bombed areas in the world; is one of the most bombed areas in the world, which add an additional pressure on accessible land for agriculture because of still non-explode ordnances. Moreover, according to the government of Lao, a little more than 90% of the area has been granted for rental agricultural, tree-plantation or mining investment. This increases land pressure for family farming. Moreover, if in theory the lowlands are individually managed thanks to property title (Manivong, 2016), according to inhabitants say, if the government want to redeem the lands, farmers have no other choice than to sell them.

The province is essentially mountainous with valleys, except for the Plain of Jars which is a 1,000km² plateau located at 1,000m altitude.

These geographical levels can be linked with the common vision of the ethnicities diversities in Laos, which are the *Lao Loum*, living in the valleys, the *Lao Theung*, living in the foothills and the Lao *Soung*, living in the mountainous area **(**Barney, 1990). This classification was created after gaining independence from French colonization. In reality there are officially 49 different ethnic groups and subgroups. They were later classified on the base of linguistic origin[16]. This led to 5 groups, the Tai-Kadai, the Austro-Asiatic, the Mia-Yao, the Sino-Tibetan and the others. The two first groups are more related to the *Lao Loum*, the Sino-Tibetan to the *Lao Theung* and the Miao-Yao to the *Lao Soung*. In Xieng Khuang, several ethnic groups are present; the Thai, the Austro-Asiatic and the Mia-Yao (Schlemmer, 2015). Moreover, in 1995 the main ethnicities present were the Lao (44.3%), the Hmong (34.2%) and the Phutai (10.2%) (Schlemmer, 2015). These populations live together and constitute the Lao diversity. However, the ethnic question within Lao is a complex one. It combine society and politic and can overtone population shift, land-related conflict, social structuration and changes etc. And it is difficult, in a short time, to grasp the in and out of the question. But the ethnicities are not the only diversity in the province.

An agro ecological zoning has been done which highlighted 4 different zonings which are the Plain of Jars, the Pine tree zone, the Upland Zone and the Valley zone (Hacker and al, 1998). The climate is tropical with a cycle between two seasons, and a stable temperature average of 20.5°C. Another particularity of the province climate is the presence of smog and wind, which impact agriculture by limiting the evapotranspiration (Metz, 2008). Moreover, the soils are mainly acid and unfertile. We can find below the chart of Xieng Khuang province in 2016, based on the meteorological records in Phonsavan station, which is considered as the most representative for the province.

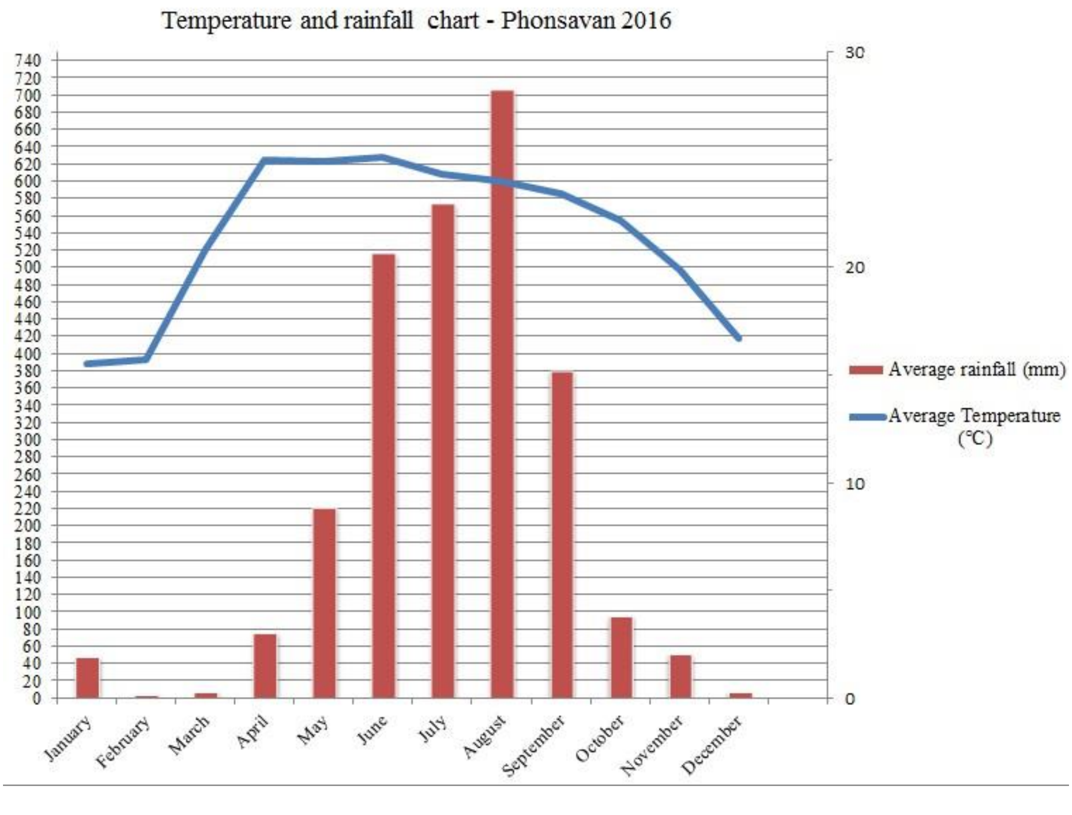

Figure 9 Phonsavan climate chart for 2016 (Bourjac, 2017)

[16] A table of these groups can be found in *Appendix 1*

We can see a spike in the quantity of rain fall from June to September, which corresponds with the rainy season and following low rainfall from October to March. This low amount of rain during the dry season, coupled with geographical conditions might explain why there is solely a rice cycle practiced during the year. According to the Provincial Agriculture and Forest Office (PAFO) the main rice fields are rain fed ones. As 90% of the households are farm households (World Food Program, 2013) and their repartition, regarding the type of production system, confirms these previous results. Indeed, 95.6% are cropping plateau or upland systems, which are more likely to be only rain fed.

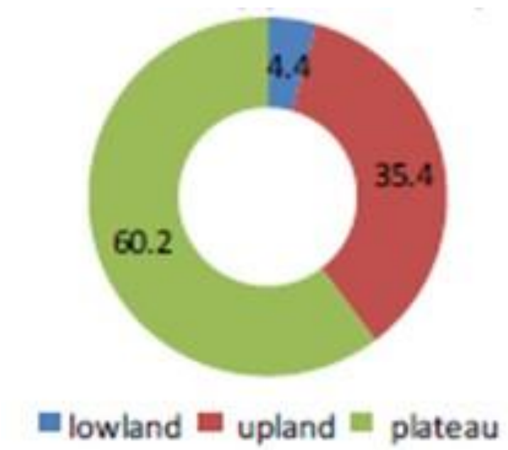

Figure 10 Household distribution by type of rice system in Xieng Khuang in 2001 (World Food Program, 2013)

In 2011, the total rice production was 100,960 tons (World Food Program, 2013). Nevertheless, Xieng Khuang was, in 2010, a province with a deficit of rice production in comparison to the need to feed all the population (Eliste and Santos, 2012). However, other crops can be found in the area, such as coffee, maize, and vegetables. There is also soybean, tobacco, sugarcane and tea. Most of those crops are commercial, and therefore enable households to buy the missing rice. Indeed, according to the National Agriculture and Forestry Research Institute (NAFRI), since the early 2000's it has been subject to an important transition from subsistence to commercial agriculture, by adding income upland activities to the lowland cropping.

Nonetheless, Xieng Khuang province is not a homogenous area and there are disparities between the districts. That is why, as the study is focused in Kham and Pek districts, the agro ecological conditions will respectively be described after.

II.3.b.Pek and Kham Districts

❖ Pek District

Pek has a total area of 1,400 km², of which 70% corresponds to the Plain of Jars and solely a small portion of the district is cultivated land. The main production system is a rotation between lowland rice cropping in wet season, and grassland with cattle breeding during dry season (Lienhard et al, 2004), on 54 km² of the district area. It has not evolved for ten years (Manivong, 2016). There are still other crops such as tobacco, eucalyptus, cassava and vegetables but in small amount. In 2015, 71,321 inhabitants lived in 113 villages, regrouped in 7 *khumban*[17] and more than 1 per 5 is situated in Phonsavan periphery (Coulombe and al, 2016).

Thus, as they are situated with good access to the province capital, they can pretend to get off-farms activities, which provide them a main part of their incomes. They own an average of cultivation lands of 2 ha. If cultivated lands only represent a small part of the district, it is because of the important urban center, the pine trees[18] forest and the soils quality.

[17] A *Khumban* is an administrative village grouping

[18] The pine trees, in Lao *Pek*, gave their name to the district

Indeed, soils are mainly red/brown ferralitics and quite rich in organic matter, but are acidic and with deficiencies in P, K, Ca, Mg and oligoes. They are therefore characterized as poor soils (Seguy, 2004). These poor soil conditions, added to the low access to irrigation, result in almost no cropping during dry season. Cirad researchers conducted an agro ecological zoning of Pek which can be found below and describe as such:

- A1 zone: Acid soils, with pine tree forests, lowland rice and grasslands and big cattle breeding
- A2 and A3 zones: Similar to A1 zone but with more small breeding
- D4 zone: mostly lowland maize production and rain fed rice

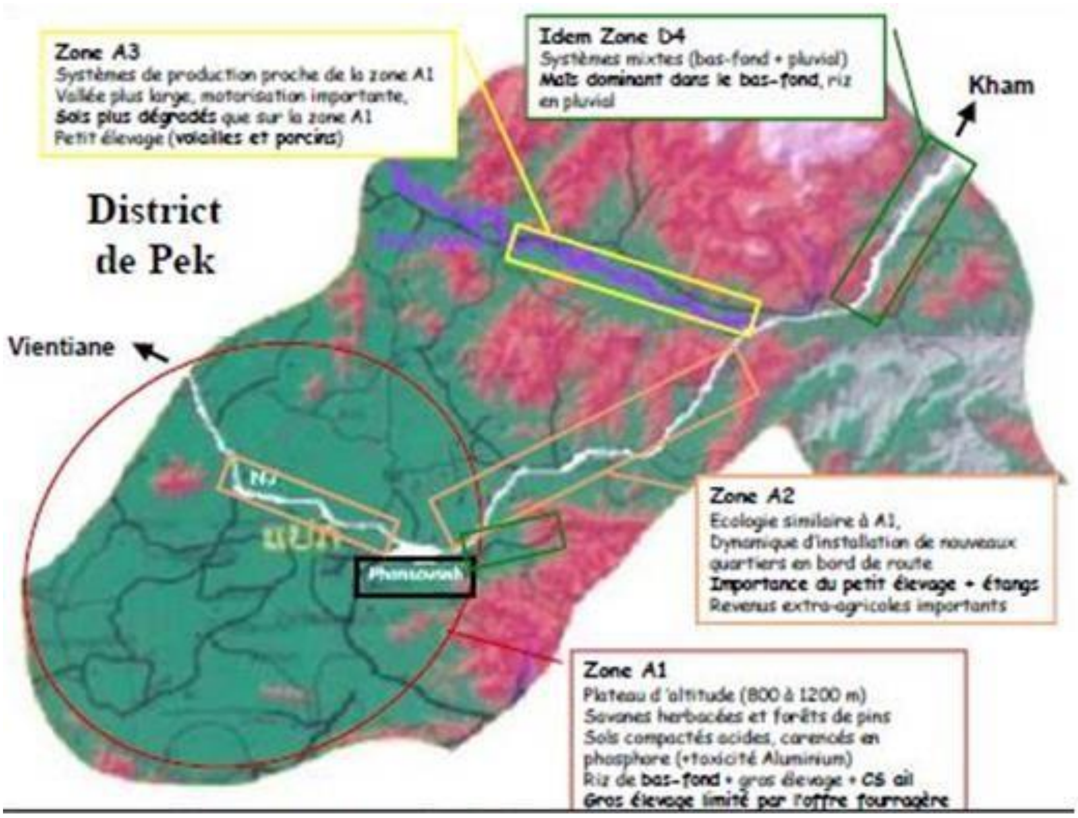

Figure 11: Pek agro ecological zoning (Cirad, 2011)

According to a NAFRI's study, the agrarian transition in Pek district in the first decade of 21th century went through the increase of upland hybrid and traditional maize cropping, the decrease of pig and buffalo owners but the increase of cattle, and most of all the increase of off-farm activities. These activities represent 50% of the household incomes and the agriculture is still subsistent.

❖ Kham district

Kham district has an area of 2,334 km² and the 47.256 inhabitants are spread in 116 villages grouped in 4 *khumban*. These inhabitants are 90% from ethnic minorities; namely *Hmong* and *Khmu* (CCL, 2012). These subgroups are classified in the Miao-Yao group. Their main source of income comes from selling farms products. Kham is considered as one of the 47 poorest districts in Laos, and the second poorest in Xieng Khuang, with more than 30% of the population considered as poor (Coulombe and al, 2016). It figures in the "high priority" list of the Lao government (CCL, 2012). According to the same study conducted by Cirad, the district can be zoned in two different parts. One of which can be named Kham basin, which corresponds to the "Zone B" in the map below, and the other which is the mountainous area, which corresponds to the "Zone C1" and "Zone C2" on the map below. Even though rice is still one of the main crops of the area, the rice production is not sufficient for the whole population.

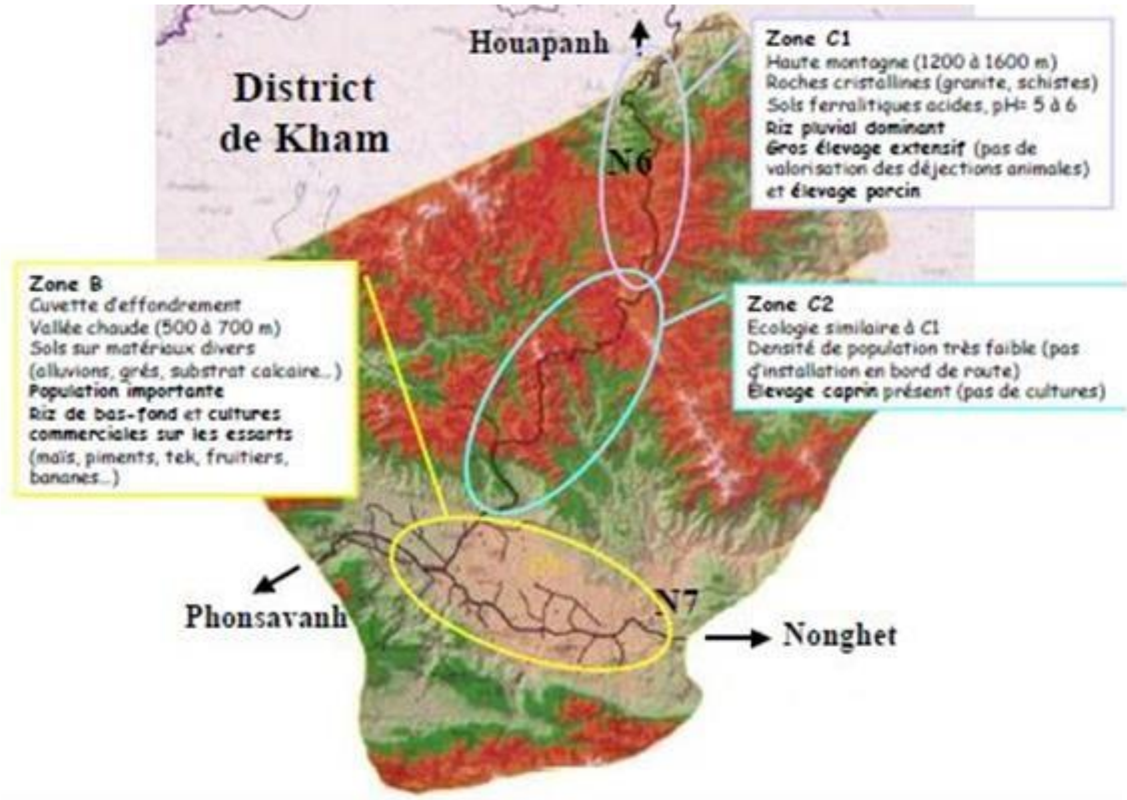

Figure 12: Kham agro ecological zoning (Cirad, 2011)

"Zone B" is a valley, around 500 to 700 meters, which is characterized by a warmer climate, good accessibility and population density. The main cropping system is the lowland rice and slash-and-burn income cropping maize or bananas. The soils of this area are loamy and fertile.

"Zone C" is mountainous (around 1,200 to 1,600 meters), quite remote, not a high density and the main production systems are rain fed rice and breeding. The soils of this area contain iron and are acidic.

The agrarian evolution since the beginning of the twenty-first century is due to the increase of hybrid maize variety used in the upland which came to substitute the poppy, upland rice fields or chili and fruit tree plantations. The maize cropping represented 85% of the upland cropped land in 2009. In parallel, regarding the breeding, the number of buffalos has decreased, possibly due to the increase of incomes allowing the farmers to buy hand-machines which take less time to work in the field. The target villages of the present study are both located in Zone B.

As it is described below, the Zone B is a plain. In this zone, the main ethnic group living there are Lao and Tai, classified in the Tai-Kadai linguistic group. This means that there was no difficulty for the translator to conduct the interviews.

In the following map, we can well notice that the villages are situated in a plain area. Moreover the two target villages are represented surrounded in red.

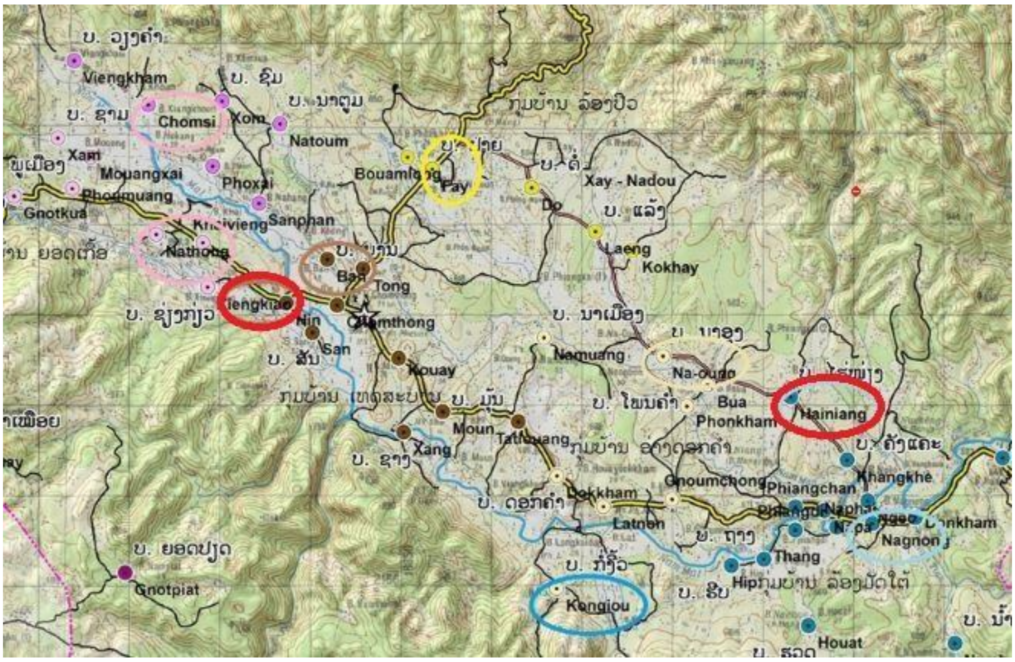

Figure 13: Xieng Kiao and Hainiang localisation in Kham basin (Bourjac, 2017)

Kham district is characterized by a basin located at the lowest altitude of the whole province (Department of Science and Technology (DST) interview, 2017) and with optimal conditions (e.g. soil fertility and depths) to get good yields. However, the quality of the rice obtained is lower. This is explained by the fact that Kham is lower than the others districts and thus have warmer temperatures.

II.3.c. XiengKiao and Hainiang Villages in Kham District

- XiengKiao village

Ban[19] Xiang Kiao is a village situated in Kham district, at 3.8 km from the district capital. It had existed since 1875, and it has grown from 28 households to the present amount of 117. The total population is 566, including 277 women. The main ethnicity of XiengKiao village is named *Tai Dam*[20]. They are considered as part of the Tai-Kadam linguistic group and the Lao Loum group. Nevertheless, it is considered as a minority subgroup in the area. This, thus bring interest from the government which try to preserve their culture. These people often live in valley of mountainous area, near the rivers, and are rice farmers and animists (Schliesinger, 2015).

The average of land owned by households is 1.3 ha. It is thus less than the provincial average. It is situated in an old bamboo forest, following a small slope from West to East.

[19] *Ban* means "village" in Lao language

[20] *Tai Dam* (Black Thaï): they are called like that according to the colour of their traditional clothing

The following information was collected during the focus group. The main income-gain activity is agriculture with 100% of the households involved. It is followed by shopkeeper (5%), service rental (10%), handicraft (71%), and selling livestock (10%). Fewer households own shops because it is more time-consuming than service rental, which can be done when decided. Regarding the livestock, there is less than one cow per household, which is not much in terms of the potential for fertilization. Besides, all households raise small livestock for the purpose to sell them when they are in need. The main purpose of the livestock is thus “capital on feet”.

Main activity is agriculture with two cropping systems: rice for household consumption in the lowlands and commercial hybrid maize in the uplands.

- The first one, which is the main and older one, is an alternation between paddy during wet season and sweet maize and vegetables during dry season. This system duty is mainly household consumption. For most of the households, rice production is enough to feed their family the whole year. If this not enough they sell vegetables or maize to buy rice. This system can be found in the valley.
- The second system is growing hybrid maize, twice a year, to sell it as food for breeds. This system appeared in 2000 and can be found in the hillside and upland. Before, farmers tried to crop upland rice in this area but were not satisfied with the obtained production, thus they decided to change it for the hybrid maize monocrop. This correlates with the government will to reduce slash-and-burn rice cropping (Ducourtieux, 2006). The cropping calendar of these cropping systems described previously can be presented as below:

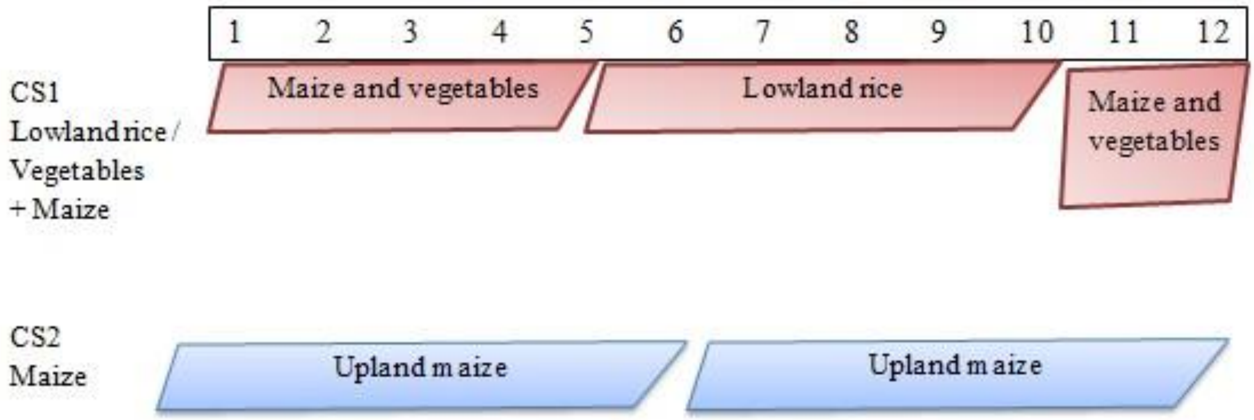

Figure 14: XiengKiao cropping systems calendar (Bourjac, 2017)

There is no rotation existing in the village. That means that those systems are conducted on the same parcels every year. That presupposes a fertility decrease.

According to the village committee, the agrarian conditions of the village are good as they do not have to face issues regarding the water access, the soil quality or diseases and pest. Their village has better conditions than their neighbors. Nevertheless, this village does not have specific irrigation systems but source water from the river and the rain.

To resume XiengKiao is interesting for the study, as it will show the SRS results in a well-off village. Indeed, it apparently has good agrarian conditions, support from DAFO and is close to the market and information.

❖ <u>Hainiang village</u>

This village, mostly agricultural, was created when grouping 3 villages together, following government policies, in 2012. These policies had the purpose to combine small villages together to facilitate the administrative work by grouping at least 100 households together. It consists of 106 households in a small basin area between mountains and other villages. These households are mainly composed of people from Lao ethnicity. They are characterised as Buddhists and lowland rice farmers, and are classified in the *Lao Loum* and Thai-skadaï groups (Schliesinger, 2015). They own an average of 2.3 ha, which is more than Xieng Kiao.
The main cropping system is an alternation between paddy during wet season followed by an association of maize and vegetables during dry season. The second cropping system is hybrid maize in uplands once a year. The calendar of these systems is represented as below:

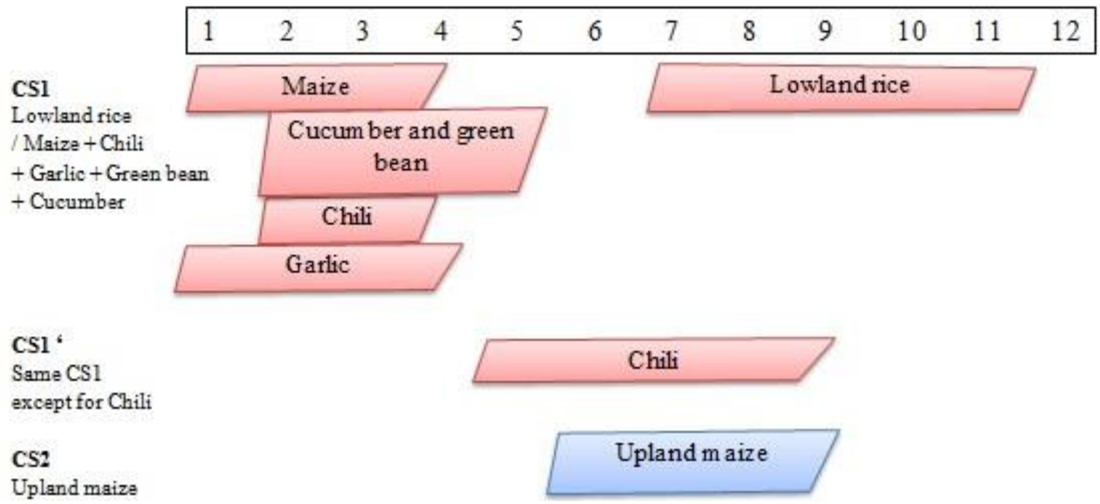

Figure 15: Hainiang cropping systems calendar (Bourjac, 2017)

We can see that there is no competition between the different calendars. Indeed, normally the upland seeding is over when the work on the rice field begins and the harvestings are not concomitants. The only potential work superposition regards the weeding but farmers give the priority to rice. Indeed, even if the maize cropping system represents more space and more income, in village perceptions the rice system is the main one because they can grow many crops in the same area and because it is the staple food. The first system stands on 84 ha and both crops are for both consumption and sale. The second one stands on 233 ha, and is only for sale. When farmers grow the CS1' system, the chili is cropped in the paddy field area which are not suitable or paddy (were the water is not well manageable for rice). This therefore shows the importance of working on rice, even with agrarian changes described previously from subsistence agriculture to commercial one. There is no rotation existing in the village as each farmer is growing the same crop every year in his same parcel. The places of the crops appear in the following figure. Indeed, the CS1 and CS1' are in the lowlands. And the SC2 is in the uplands. Some farmers also grow perennial crops such as banana, but this can be everywhere.

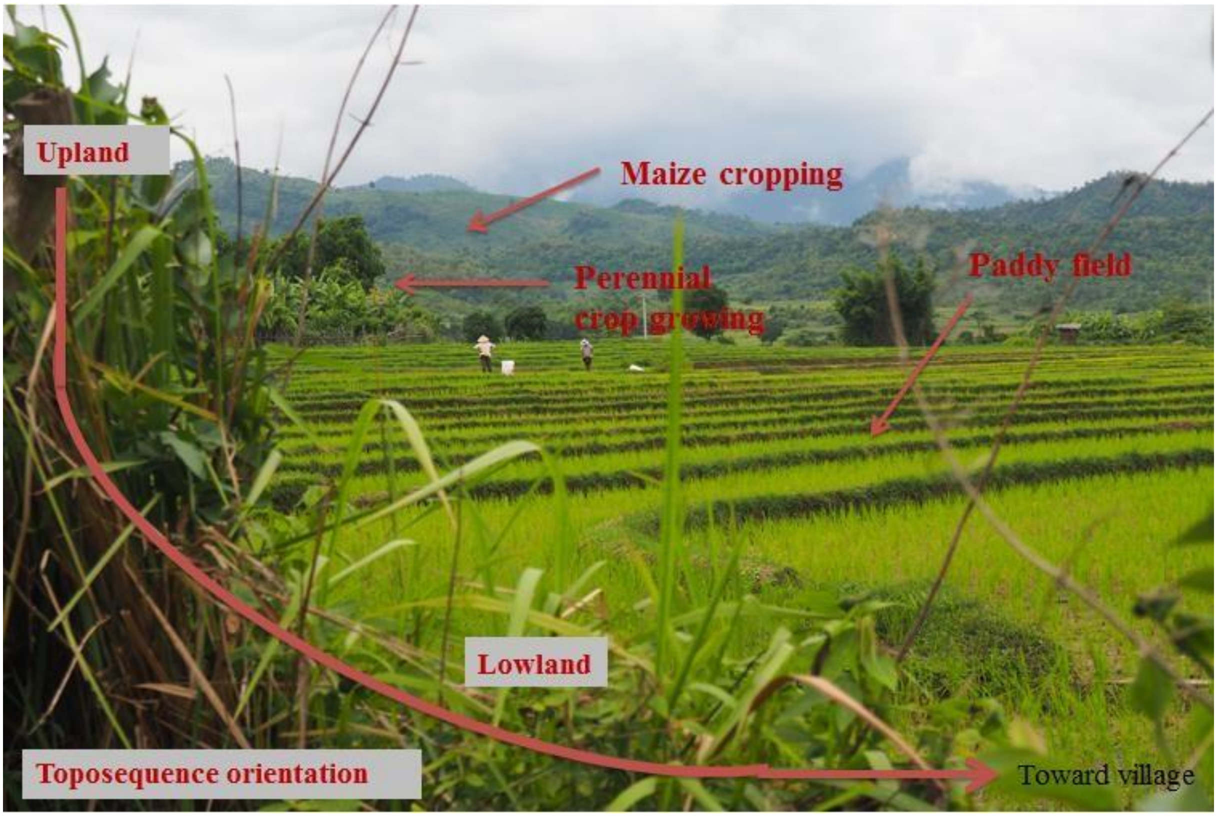

Figure 16: Hainiang topography (Bourjac, 2017)

Regarding the livestock there is an average of 5 cows per household. The main purpose of livestock is thus "capital on foot". Before year 2000, farmers breaded buffalo for animal power. But they substituted them with hand tractor as the rising of buffalo was constraining. Indeed, they had diseases issues and it needs an important access to water and food.
According to the village committee, the village has to face issues because of bad soil conditions and lack of water. The impact of this lack of water can explain why, if we look at the calendar system, we can note that the rice work is delayed compare to the other village. Indeed, they start the nursery only in July and that can be due to the delay of the rain. Nevertheless, it seems to have a better fertility potential than XiengKiao as farmers own more livestock. But, in general farmers' perceive that they cannot grow crops without using chemical fertilizers.

This village is interesting, as it has to face agrarian issues and is more remote than XiengKiao. These issues are the lack of water and the soil quality. Indeed their soil contains a lot of stones and a lack of nutrient. Usually in Lao rice-based lowland the soils are Acrisols (Schiller, 2006). These soils are characterized by clay-enriched subsoil, low inherent fertility and are weathered soil with an acid pH (Baize and al, 2008). There are not always adequate for plant cultivation. Nevertheless, by looking are ICEM[21] maps[2é] it seems that the soil in Hainiang are more likely to be Luvisols

[21] ICEM stand for International Centre for Environmental management
[22] These maps can be found in Appendix 2 &Appendix 3

This type of soil, moreover than the acidity, is characterized by leaching (Baize and al, 2008) and thus by a higher loss of nutrients. This difference in the soil type can be a first overview in the explanation of the fertility differences but would need a deeper soil analysis, which was not conducted in the present study fault of means.

Both of these villages have to face a migration of young people from the village to the bigger cities, such as Vientiane, where they study or start working and settle there. Young want to leave their village because of the arduousness of the farming work. This can thus impact negatively the labor force available in both villages.

Part III. Data collection

III.1.Survey design

Now that the study context has been explained, this part aims to present how the data was collected. The design of the survey was done following different steps from village level to household level.

III.1.a. Village selection

Once the province and district were selected the study focused on two villages that were selected to show the diversity of the area.
Crosschecking the villages, where different development intervention about rice was conducted, did initial list of potential target villages. This list can be found in Appendix 4. This was done by conducting interviews and collecting data from key informants[23]. This enabled rapid acquisition of preliminary data about the villages.
Once the potential villages were identified from this list, we selected criteria to be able to select the 2 target villages, which represented the diversity of the village and are linked with the questions about SRS (labor force needed, acreage, fertility etc.).
- The total of households: villages with not too many households to be able to have a good overview of the village.
- The geographical situation: villages from two different sub-zones of Kham district
- The quantity of livestock: one with few livestock and the other one with a lot of livestock to see the differences in term of inputs
- The household size: villages with different average size of household to be able to question the labor force available
- The land owned per household: villages with different size of land allowing to questions the link with labor and between SRS and acreage

These criteria are to help selecting villages with different opportunities and constraints in regard of rice systems and more specifically the SRS.
Finally, the choice of these villages was discussed in regard to advice of SAEDA and the logistical constraints (road access and time on the field).

[23] Those key informants are members of the organizations CCL, Cirad, TABI, SAEDA and NCMI. The list of the entire key informant interviewed during the study can be found in Appendix 5

Because of those logistical constraints we had to choose two villages in the basin of Kham because it was more accessible in the short amount of time available. Indeed, it is important to take in account that the study was conducted during the wet season and the mode of transportation used was the motorbike. The two selected villages were thus Xieng Kiao and Hainiang.

Table 2: Description of XiengKiao and Hainiang villages' characteristics (Bourjac, 2017)

	Number of household	% of farm households	% of household with livestock	Inhabitants / km²	Average cropping land / household (Ha)	Average household size	Average labour force	Total acreage of the village (Ha)
Xiengkiao	117	77.8	60	79.6	1.3	5.6	3.0	147.8
Hainiang	106	85.8	94	35.4	2.3	6.5	2.6	299.8

There is thus one village, XiengKiao, with smaller land, but a higher land pressure regarding the number of inhabitants per square kilometer and a lower access to organic fertilization. Nevertheless, referring to the hectare unity, it has more labor force (2.3 for 1 ha), is closer to the marker and can have better access to information and chemical fertilization. On the other hand there is Hainiang, with bigger land but less labor force (1.1 for 1ha) and less land pressure but a higher potential for organic fertilization.
The methodology used to select the villages thus enabled to choosing villages with different constraints and opportunities for cropping rice and present diversity in the district.

III.1.b. Village characterization

Once the two villages selected a tool was used to further examine their characterization. The methodology used was the focus group. This was selected to obtain an overview of information in a short time. The interviews lasted half a day in each village. The selected criteria for the focus group were the selection of people who represent diversity in each village. This is chosen in purpose of combining each point of view in order to have as complete information as possible. These people were namely the head of village, the village committee, the head of units and different type of farmers (young, olds and women). To get these people present we asked the team of SAEDA to ask the DAFO to inform the head of village of the focus group date and the category of people we needed to be present. In total were present around 30 participants present per village. The organization of a Lao village is explained in the following figure.

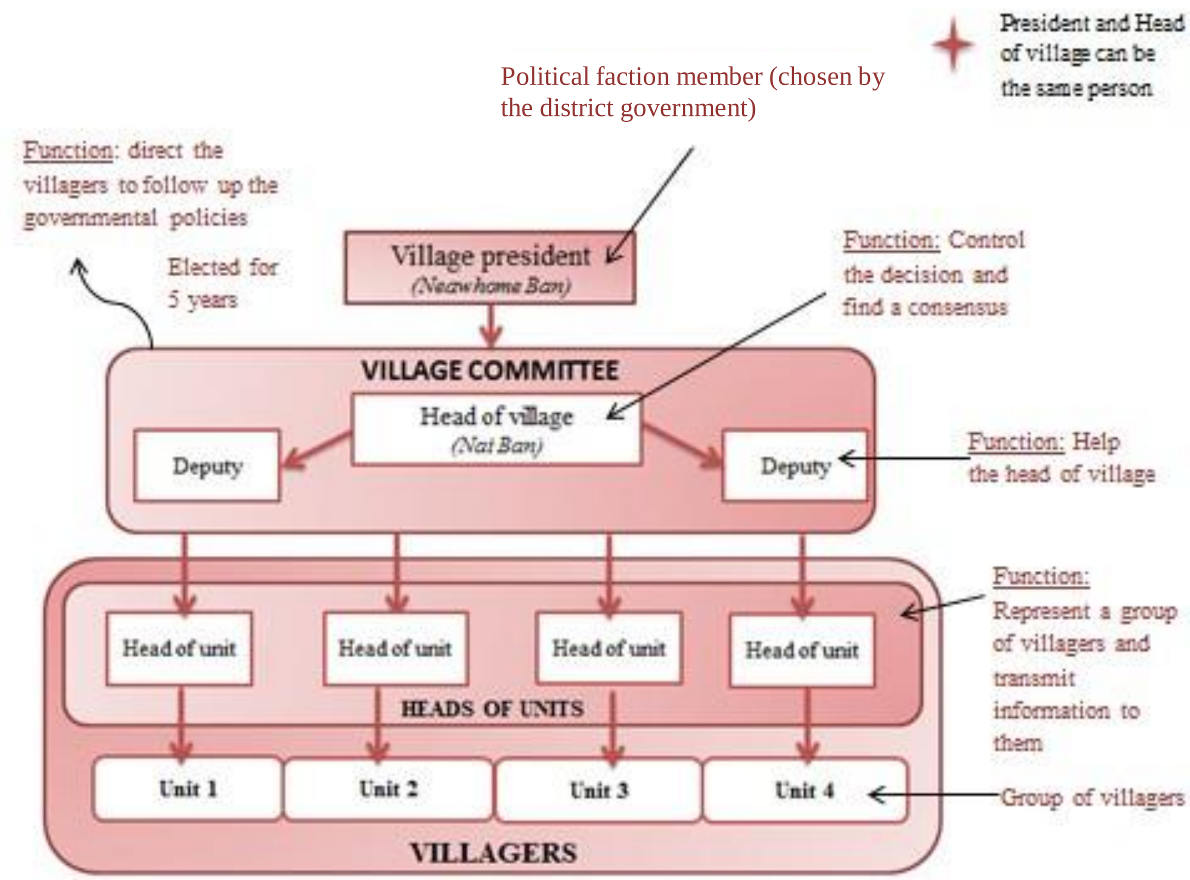

Figure 17: Description of a village social structuration (Bourjac, 2017)

The conducting of the focus group had the purpose of describing the agro ecological zoning of each village, having an initial overview of the farming systems and their history and providing access to villagers' own language and concepts. By language we mean how farmer qualify the situation of the village with their own words. For example, if they say that they have good soil quality, we asked them to describe it with their own words. Also, we wanted to understand their own terminology regarding the rice techniques or the areas in the village.

The topics approached were thus the different crop systems, the livestock, the cropping characteristic potential, the paddy cropping systems, the different sources of income, the irrigation systems and the history of the village regarding intensive rice techniques. To obtain this, semi-closed questions and open ones were asked. This kind of questions was selected, following the focus group methodology, in order to let the participants express their own perceptions, but to follow the frame detailed previously. The questionnaire can be found in Appendix 5.

In parallel to the focus group, a work of cartography was done. Indeed, for each subject possible we linked the information with a drawing of a village map to localize the data in the village. The methodology used for this cartography was conducted firstly by drawing the limits of the village with the help of the participants, then by adding the main roads and rivers to help them find the spatial orientation of the village in the maps. Finally, the different elements addressed, e.g. the cropping systems were added. The output of this use of a cartography methodology was the zoning of the villages and the characterization of these zoning.

Although the use of this tool enables this rapid collection of the desired data it also has some bias. Indeed, the grouping of people from different level of leadership (Masseran and Chavot, 2006) e.g. head of village and farmers, are combined, could modify or influence the discourse of participants. Finally, these focus groups were conducted in presence of one member of the SAEDA team and one of DAFO. Their presence thus could have influenced the answers of the farmers.

III.1.c. From household sampling to plot sampling

It was decided to capture the diversity of farming systems in which the paddy systems are part of. To do that an exhaustive household survey[24] was conducted to collect a few quantitative data describing them. The purpose of this rapid survey is led to a farm typology, which helps capturing the diversity of livelihoods systems. Based on the results of this typology, a limited number of households were selected among each type for more detailed interviews about their cropping systems. This typology would also allow a deeper understanding of the context in which the rice cropping practices are enshrined, and then possibly highlights a linkage between households and applied rice techniques. If the tool of the household typology is inspired from the agrarian methodology it had to be adjusted in the present study. It is based on a direct description of the households and not following an iterative methodology all along the study based on a pre-typology from historical observations. To collect the data quickly, the household survey was distributed to the heads of the village units with the purpose that they collect the household data for us. This was done at the end of the focus groups described previously. This method was chosen as it has been implemented in the area by Cirad to quickly collect data and empower the participants. The requested data was about the household (total number, number of woman, labor force), the different crops (production and acreage), the livestock (type and number), the assets (type and number), the incomes (type and amount) and the presence of *Kha Kib Diao* or not.

In Hainiang, 72 households answered the questionnaire and in Xieng Kiao, 92. Both villages have respectively a total of 106 and 117 households. The methodology used thus enabled us to get the data for 68% and 79% of the households and we can say that our data is representative of the village population.

Finally, based on this typology, a limited number of households were selected among each type for more detailed interviews about their cropping systems. This led to total interviewee number of 31 farmers[25]. At first this number of interview was supposed to be at least 20 interviews per village, which can be sufficient for a qualitative study (Whanich, 2006). But once confronted to the field reality this amount was not reached because of the confusions in the farmers' name due to the Lao-English translation, the non-availability of some farmers and the time available in the villages. Nevertheless in the 31 interview conducted it seemed that the saturation point was reached, as the interviews did not bring new elements anymore, thus it was sufficient for the qualitative study (Aubin-Auger and al, 2008).
Likewise, these farmers were supposed to be selected also regarding the village zonings highlighted graceful to the cartography methodology. Indeed, two zonings were pointed out in each village, one with better soil and water conditions, and one with worst conditions[26]. Nevertheless, because of the constraints described before, farmers all come from the same zonings and thus this diversity was lost

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[24] This questionnaire is attached in Appendix 6

[25] The anonymous list of these farmers can be found in Appendix 7

[26] The maps showing the zoning can be found in Appendix 8 and Appendix 9

Finally, this led to the selection of one plot per household on which detailed questions were asked about the cropping practices used the year before. In the 31 farmers, 3 used different techniques of rice cropping. We interviewed them about their two different plots. This led us to a total of 34 individuals. The questionnaire used can be found in Appendix 10.

The last step of the survey design was its adaptation to collect data about the dissemination and adoption of SRS. Indeed, the 31 farmers selected are only adopters and non-adopters of SRS. Moreover they all come from Kham district. However, to understand the dissemination and the adoption it is more relevant to go through the history of each farmer with the innovation and to go further than two years before. Besides, it seemed relevant to interview also farmers who are dis-adopters. Thus, after some discussions with the partner organization it was decided to add farmers from Pek to the sample. In total 60 farmers were interviewed including 8 dis-adopters, 27 adopters and 25 non-adopters.

In the scope of a better understanding the following figure present these choices described previously.

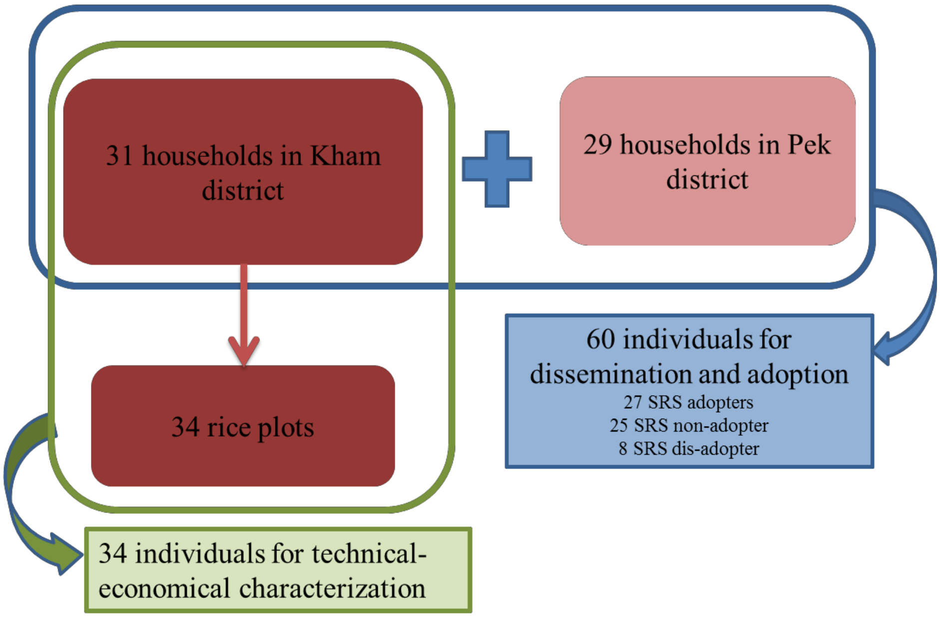

Figure 18: Explanation of the different samples used (Bourjac, 2017)

III.2.Data collected

Based on the different samples presented previously, different individual interviews were conducted with farmers to collect the desired data. To facilitate the comprehension, the following work calendar reminds the different steps of the study, including the data collection.

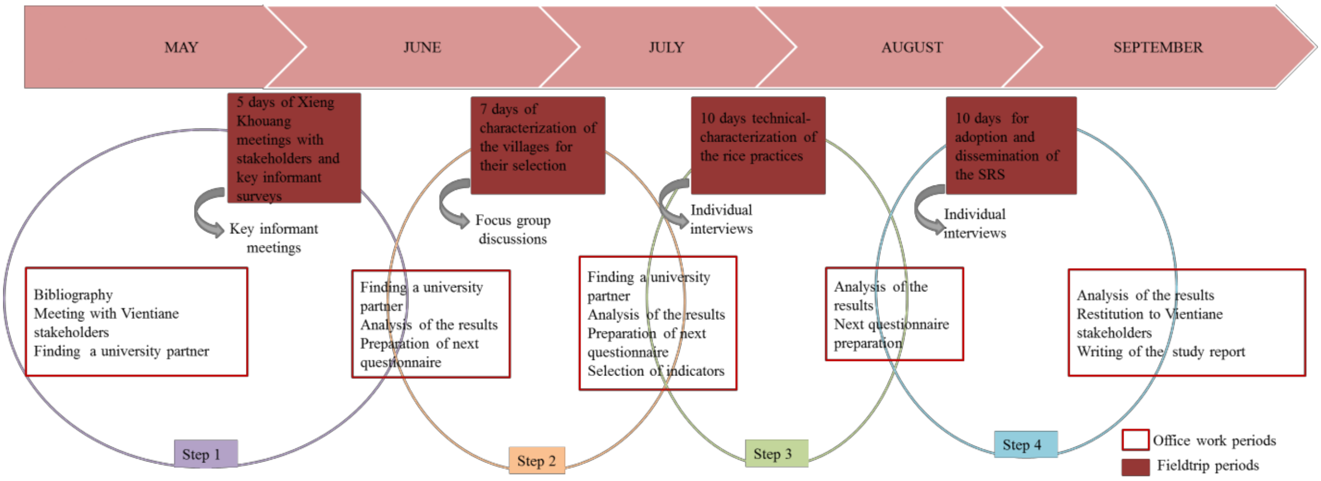

Figure 19: Description of the study calendar and tasks performed

III.2.a. Technical and economic characterization of rain fed lowland rice cropping practices

At this step of the writing some precisions about the choices made should be done. A complete cropping system study should include the description of all the cultural cycles of the system. In our case the cycle during dry season, and the one during wet season. We considered that, as the question is to compare the performances of different rice technical itineraries, including all the crops of the system would not enable to comprehend the results of the rice techniques in themselves. We thus made the choice to focus the technical and economic data collection on the rice only. Questions were still asked about the cropping system to try to highlight a potential link between the rice technique implemented and what is conducted during the dry season (previous crop, livestock, fallow).

The data enabling the characterization of paddy cropping practices were collected through closed individual questionnaire using a declarative approach.
Firstly, questions about the farming system, the different paddy cropping systems and the parcel they are located on were asked individually to farmers. Then, for each farmer one of those parcels was selected to focus the questions on a retrospective characterization (year 2016) for the technical itinerary. The selection was supposed to go through the acreage of the parcel; more than 2,000 m² according to advices of a Cirad researcher. Indeed, as a field observation using GPS measures was supposed to be conducted the risk of error is too high if the acreage is less than 2,000m². Another main criterion was that the parcel was supposed to be cropped by using the same technical itinerary. But finally, as it appeared that most of the farmers only cropped using one technique on one parcel the selection was easier. Finally, the last criterion was the localization in the topo sequence, the soil quality and the water access in order to show the diversity.

At the end of this retrospective questionnaire the same questions were supposed to be asked about 2017 cultural campaign complemented with direct on-field observations and measures. Those field observations were supposed to complement the declarative approach to get a higher quality of data. Moreover, those observations were supposed to be reported in a notebook, owned by the farmers, thus they could follow the methodology by themselves, supported by the local partner, while the study would be over. That was supposed to help them becoming more aware of what they do on their field. The protocol was really simple to implement as based on noting for each activity on the field the time spent, the number of people involved in the activity, the input used and their cost.

Finally, because of logistical constraint as the local partner refused to be part of this, the idea could not be implemented. Furthermore, it was not possible to conduct the field observation because of the low freedom of movement. Indeed, it was not possible to conduct the interviews in the rice fields. However, the understanding of the real reason of this barrier was not highlighted.

The last bias that modified the initial methodology was the length of the interview. They lasted one hour and a half. Therefore, the head of villages imposed to reduce the length, or farmers would not answer anymore. The off-putting aspect of the questionnaire can explain this. Indeed, as the same questions were asked successively but in two different years, farmers did not understand the interest in it. And because of the logistical time constraint approached previously it was not possible to manage differently to fit better to farmer will.

As moreover the following on the parcel was no possible, it was thus decided to remove the following about the 2017 campaign. Therefore, the data collected is only retrospective of 2016 campaign.

III.2.b. Indicator selection to assess the performances and sustainability of rice practices

The study demand was initially about testing indicators of performances, but it had to evolve as explained previously. We still decided to keep a bit of that methodology to give a framework for the evaluation of the SRS performances. To do this, we therefore adjusted the initial indicators regarding what was possible to do or not. Besides, it was decided that those indicators would not be the gateway of the study but would be a tools for helping to comprehend the performances. Thus, the collection of the data for calculating the indicator would be distributed in the different phases of the study.

Below we can find firstly the initial table of indicators, and secondly the one we decided to use in the present study.

Table 3: Initial indicators of performance (ALiSEA, 2016)

Social dimension	**Economic dimension**	**Environmental dimension**
Percent of time saving for women (%)	Percent of rice productivity increase (%)	Pesticide free (SRS being organic)
Degree of hardship of field work (difference between conventional and SRS)	Total production (rice + vegetable + fish + livestock) increase (LAK)	Soil fertility balance
Percent of farmers adopting/adapting SRS (%)	Return on labor (Lao Kip/day)	Agro-biodiversity increases (number of rice varieties, number of aquatic species…)
Percent of farmers who learned about SRS, from others farmers (%)	Percent different input cost as compare to conventional practice (%)	Percent of biomass recycling (compost, manures, rice straw…)
Percent of District Agriculture and Forest Office (DAFO) staff promoting SRS (%)	Percent price increases for organic rice production (%)	Water use efficiency (kg of total rice production/m3 water)

Table 4: Indicators of performances used for the present study (Bourjac, 2017)

Social dimension	Economic dimension	Environmental dimension
Percent of labor saved (%)	Percent of ice productivity increase (%)	Chemical free (% of use)
Percent of time savin for women (%)	Return to labor (% of increase)	Soil fertility balance
Percent of farmers adopting/adapting SRS (%)	Gross added value (% of increase)	Agro-biodiversity increases
Percent of farmers who learn about SRS from other farmers (%)		
Percent of District Agriculture and Forest Office (DAFO) staff promoting SRS (%)		

It is possible to note that the final list of indicators is reduced in comparison with the initial one. Indeed, some were not possible to collect, as no on-field data collection was possible. This is the case of the percent of biomass recycling or the water use efficiency for example.

Furthermore those performances indicators were tested at different levels of intensity according to the constraints of the study. For example the data for the economic dimension were fully collected. But for some, only an overview was collected. This is the case of the agro-biodiversity increase or the soil fertility balance for example. The questions to get these results will be asked only about perceptions of farmers. It is important to take in account that the technique is only implemented since 2015 in the study area. Therefore this is early to have proper results about the soil fertility or the agro-biodiversity.

III.2.c. Assessing the adoption and dissemination of SRS

The data collection for assessing the adoption and dissemination of SRS wasconducted during the last field trip which lasted ten days during the month of August. Each interview was done individually using a semi-structured questionnaire and lasted about 45 minutes. The three different questionnaires can be found in Appendix 11. The themes addressed were a bit different regarding the type of farmers interviewed. They all were questioned about when and how they heard about the SRS for the first time. For non-adopters they were asked the reasons that inhibit them to implement the technique. For adopters and dis-adopters information about the first year they used the technique (acreage, motivation), the evolution between the first year and after, the benefits and constraints felt while using the SRS and how they shared the technique with other people. Then, for dis-adopter a questioning about the reasons that led them to stop cropping with SRS technique was added. It is important to precise that the number of adopters, dis-adopters or non-adopter was selected randomly, as their selection (except for the initial 34) was done by the local partner without any scientific methodology. This is why these farmers are not representative of the behavior of farmers regarding the SRS adoption or not. The purpose of this phase of interview is to emphasize the key motivations, limits and behaviors for adoption, and the main paths of dissemination.
All these data collected was then analyzed by different methodologies. These methodologies will be detailed in the next part of the study, respectively with the results they emphasis.

Part IV. Results: Dissemination, adoption and performance of SRS

After explaining the context of the study and showing the methodology, this part has the purpose of presenting the results obtained about the SRS.

IV.1. Evolution of rice cropping, up to SRS dissemination

IV. 1. a. Rice cropping improvements

As Xieng Khuang is an area which suffered a lot of bombing and the demining is still in process. That limits the arable land availability and presupposes a need for intensification. In this sense, different organizations have conducted projects, notably in rice cropping. Some of those interventions are gathered in the timeframe below.

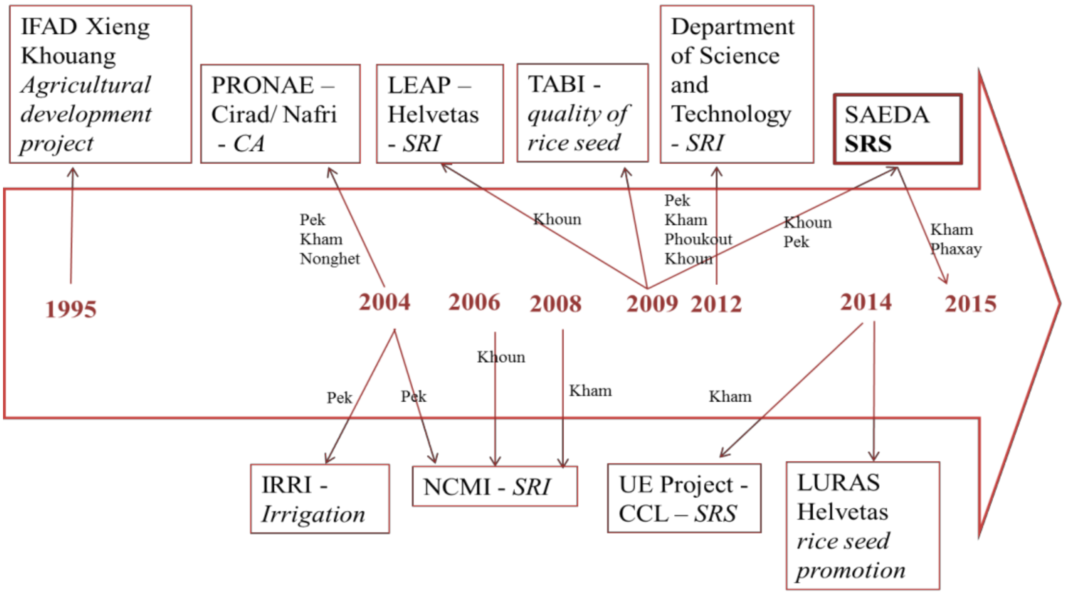

Figure 20: Timeframe of the rice interventions in Xieng Khuang Province (Bourjac, 2017)

In the last twenty years a number of diverse organizations have worked on improving systems in the province of Xieng Khuang such as local non-governmental organizations, international NGOs, international funders and research centre. The first initiative took place in 1995 from the IFAD[27]. The aim was to develop indigenous populations, in particular through the improvement of rice production. The CIRAD has been quite involved in the area since 2004 with the development of conservation agriculture, and are used to work with TABI[28] projects. TABI is a joint program between the Ministry of Agriculture and Forestry of Lao and the Swiss Agency for Development and Cooperation (SDC). They work to improve the quality of rice seed, promoting indigenous cultivar. Indeed, in the area work regarding rice is not only about promoting a one-seedling technique. The different issues, which are related, are also irrigation, conservative agriculture and improvement of rice seed.

Moreover, just like TABI and Cirad, some of those organizations are working collaboratively, in space and time. For example, the European Union (EU) project was conducted by SAEDA and the CCL; a Lao NGO and a French one, combining their teams and their assets. In addition, there was a following between the Northern Community Manage Irrigation Sector Project (NCMI) and LEAP[29] projects about SRI, and the SAEDA one about SRS.

Indeed, they based their new rice technique on observations from those projects and then promoted it, after having tried SRI and not being convinced. It thus seems that there is a large network of organizations involved in rice cropping development in the study area. But on the other hand, it does not seem to always have a good share of the obtained results. Indeed, upon asking the director of the Department of Science and Technology, it appeared that they only shared their results with their branch in Vientiane, their funders. It seems obvious that the results of one project could help improve future ones. Thus, cooperation between organizations working in the same area ought to be improved. Moreover that all the subjects they work on are related. This cooperation should go through a better communication between the projects coordinators and transparency of the results. But, this can be difficult due to their own work schedule and competition for subventions

[27] IFAD : International Fund for Agricultural Development

[28] TABI : The Agro Biodiversity Intervention

[29] LEAP : Laos Extension for Agriculture Project

Furthermore, some of those organizations are working together with the DAFO. The implication of the government goes through logistical and intern help. More specifically, in the SAEDA project, members of the DAFO team teach the technique and promote it to farmers. The link between the government and the organizations outlines the interest of the government in improving the rice quality. In that sense, through NCMI project, we can even say the government is leading the change. Indeed, they fund new irrigation systems. These are then reused by the organizations, e.g. TABI or SAEDA, working on villages where there are installed irrigation systems. The government's strong implication is an important factor to help the development of projects and initiatives. On another hand, the involvement of the government is a means for them to keep an eye on what is happening in the area and influence it in the way they want the agriculture to evolve. An interesting phenomenon that was revealed is the project management using the "farmer to farmer extension" participative approach. That means that farmers are trained to then train farmers. This enables their empowerment and to improve the trust in the techniques promoted. Nevertheless, it is important to relate the impact of those projects as they are homogeneously implemented in all the districts or all the villages, which justifies questions about dissemination of those techniques outside of the target areas.

IV. 1. b. Path of dissemination of agro ecological rice cropping, SRS case study

In that framework of organizations and projects, it is important to go further than simply target households or villages and to understand how the innovations are disseminated. This is what has been studied with the SRS case study. Firstly the data given by SAEDA and CCL were analysed. Then, further data collected through with farmer interviews was added. From the partner organization we got information about the variations in the number of households cropping SRS in Pek district. The following graph shows us the results.

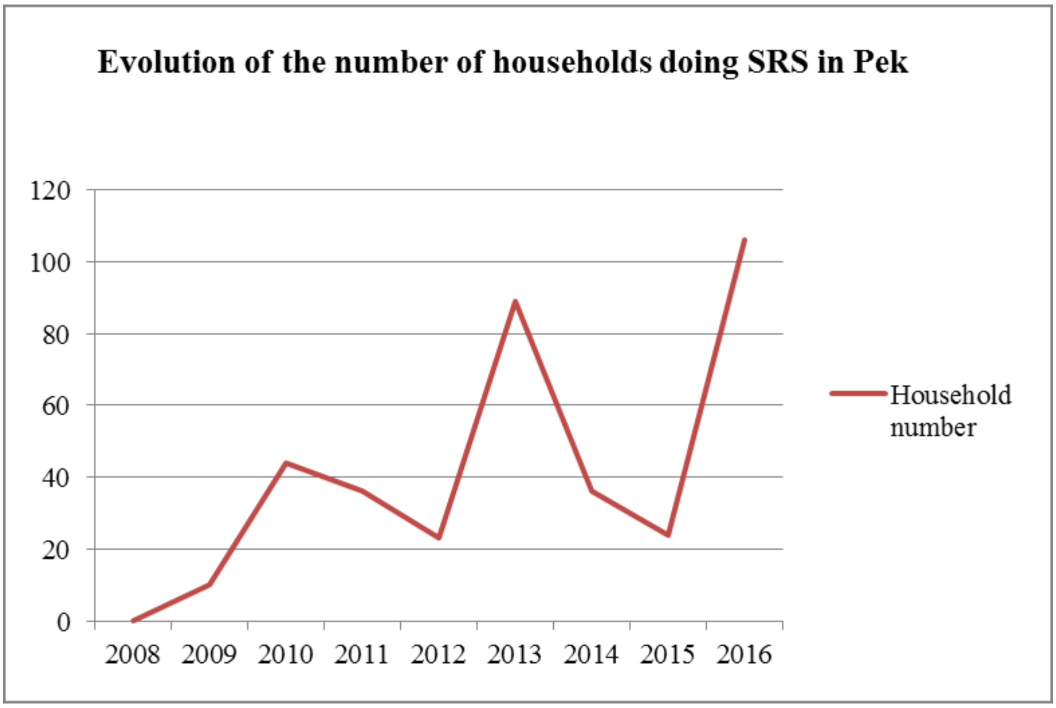

Figure 21: Evolution of the number of household doing SRS in Pek (Bourjac, 2017)

Therefore, we can notice that the variation of the number of households cropping SRS is not regular at all. Furthermore, we can see that there are peaks of adoption, which correspond to the years when SAEDA promoted the technique, in 2009 and 2015. There is also a peak in 2013, which we can only assume to have been caused by the start of the project from the Department of Science and Technology about SRI. Nevertheless we can notice that after those peaks the number of adopters decrease until the next project. Therefore, this questions the sustainability of the technique if without projects there is no adoption and worse, the number decreases.

It was thus interesting to delve deeper and focus on the means of dissemination at the farmer level. To do that we compared the answers of the 60 farmers interviewed. The comparison of the percentages of the paths of dissemination discussed can be found in the graph below.

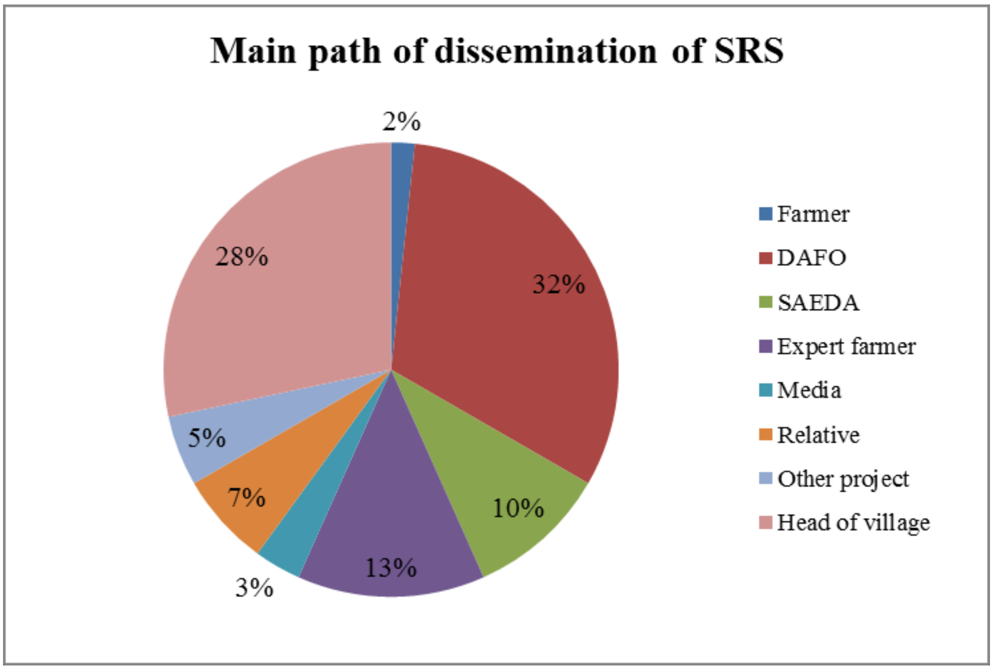

Figure 22: Pie chart of the dissemination paths (Bourjac, 2017)

This graph emphasizes that the main path of dissemination is the intervention of DAFO (32 %). It was a co-actor in all the projects about rice cropping systems in the area. Indeed, when we focused on the process of adoption of each farmer it was highlighted that the first appearance of SRS in those villages is from 2012 through training conducted by NCMI project or in the media, but for the majority, the way for they heard about SRS was thanks to DAFO or the head of village. The second path of dissemination is from the head of village, with up to 28 %. We can thus see the impact of the authority's involvement in the dissemination of this new technique, which can help the durability of the technique, and its recognition. This is supported by comments made by Levard and Apollin, 2013, who brought forward that the state involvement is important to develop agro ecology, because it is not only a short-term concept but also has a long-term performance which needs solid basis to be effective. And even if short-term impacts do not seem to be positive enough, farmers need to be sure that it will in the long-term.

On the other hand, that also shows the need to do project evaluations. In this respect, the government needs to be sure of the positive impact of the technique before promoting it.

The other paths of dissemination are from the expert farmers of SAEDA and from the staff directly, (respectively 13 % and 10 %). This can demonstrate the efficiency of the promoting technique “farmer to famer” conducted. We can notice that the share of dissemination from relatives is quite low (7%). It does not seem that there are a lot of information exchanges between farmers and their relatives. Finally, the last path of dissemination is directly from other farmers (2%). It corresponds to farmers who see the technique in someone else’s field, and go to ask him, but farmers do not disseminate the technique by themselves. The only ones who do that are the expert farmers, as written before, and they are remunerated to do it by SAEDA, for up to 500.000 kip per workshop, which is quite a lot in comparison with the remuneration of work day in Xieng Khuang Province which is 70.000 kip per day.

Even if this path only represents 2%, when linking it with farmers’ motivations, we learn that the fact of seeing that it works in someone else’s field is the main motivation to adopt the technique. This is called the imitation effect (Ruf, 2012) and has been observed several times, notably in rubber cultivation (Ruf, 2012) or cacao cultivation (Pomp and Burger, in Ruf 2012).

Then the focus was narrowed to the 35 farmers who are adopters or dis-adopters of the technique to highlight the spatial dissemination of the technique. The main scale is at village level from the expert farmer or the staff of projects to the farmers. This is not surprising regarding the work of the geographers who have pointed out that the geographical proximity encourages interactions between people and adoption (Hägerstrand in Steyer, 2003). Other scales have been identified, such as from village to another in the same district, or from village to another district, but these are minor. The higher number at intra province level is explained by the organization of workshops by SAEDA. The figure below can show us, for the 35 farmers interviewed, who did or are doing SRS the quantity of farmers who learnt from them regarding different scales:

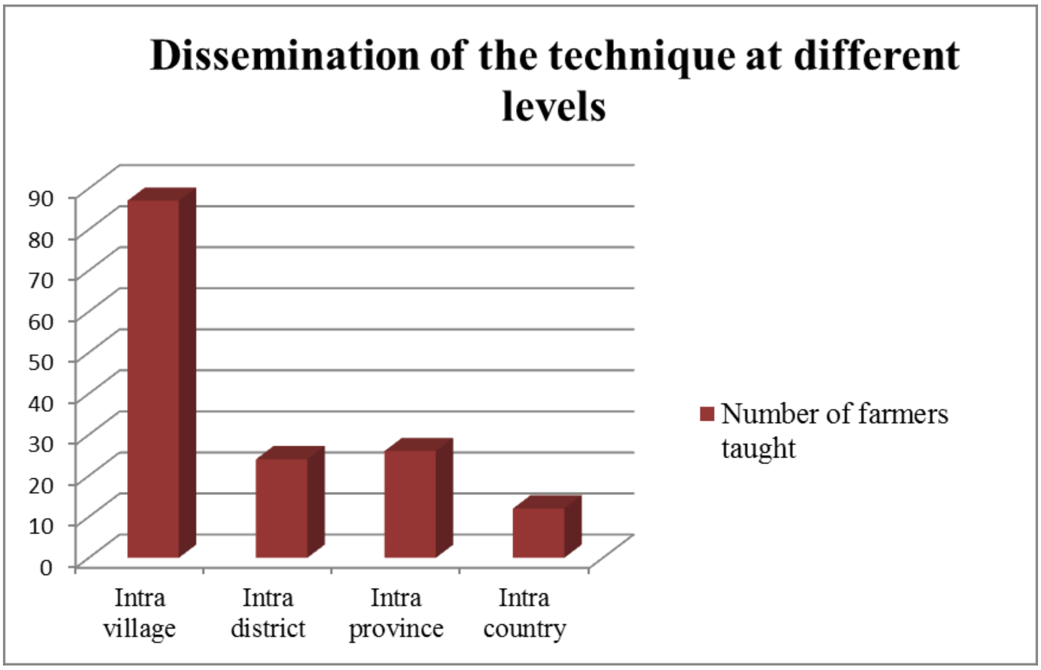

Figure 23: diagram of SRS spatial dissemination (Bourjac, 2017)

In total for the 35 farmers interviewed, 149 learned from them. In terms of proportion this accounts to 4.25 farmers taught for 1 farmer. But it is important to point out that the expert farmers are included in this figure and that they disseminate the technique much more than regular farmers. For example, the head of village of Xieng Kiao (Interviewee XK52), taught directly by himself the 29 farmers in his village, as he had been asked by SAEDA. However, within the 29 people he taught, only 20 implemented the technique. This thus gives an adoption rate of the technique of 69%. Moreover, most of the dissemination at extra village level was done on request of SAEDA. The obtained results show that the main scope of dissemination is the intra-village one. It seems to be in accordance with what all sociologists who have examined the question say about geographical proximity in the diffusion of agricultural innovation; it is important for success (Roussy and al, 2015). Therefore, these results show the interest of the innovation at level scope. This is due to the imitation factor explained previously.

That part shows that there is important framework including organizations, government and farmers that are in a process of group learning (Chauveau, 1999) about rice cropping in the area. Then, to understand the place of the SRS technique we need to go further than just understanding the paths of dissemination. Indeed, as we saw there are variations in the SRS adoption and we need to understand and describe the reasons for these differences in flux.

IV.2. Conditions for adoption of the SRS

IV. 2. a. Diversity of farming systems in the study area

As a reminder, the focus group discussions gave us general information about what crops and livestock can be found in the villages. We were curious to learn more about what are the different farm types existing in the study area. To do that, we chose to deepen our qualitative data by using statistical analysis. We specifically use descriptive statistics to describe the diversity in the population (Aktouf, 1987). Indeed, the study does not aim to proportionally represent the different cropping system but to assess the main trends. Moreover, as data is only quantitative, the statistical methodology selected is a Principal component analysis (PCA) followed with a Hierarchical Clustering on Principal Components (HCPC) to understand the structure of the dataset and categorized groups of farming system. We used the R software to do that.

The first results obtained were 4 clusters with data from both villages combined. As we assumed, the data "village" is discriminant. We expected these results as we purposefully selected two different villages to show the diversity. More precisely ,this typology showed as two clusters with well-off farmers (all from Xieng Kiao) and two clusters with the poorest farmers (all from Hainiang). That can be explained by the fact that Xieng Kiao is closer to the first main town and thus has better access to information or input. Inversely Hainiang is more remote and with bad soil and water conditions.
Moreover, the head of units who collected the data could not manage to collect the same ones from both villages, such as the incomes. This occurred because farmers of Xieng Kiao were scared that this data would enable the government to collect taxes.
Due to this bias, to present a better analysis, we decided to re repeat the same analysis but in each village separately.
In regard of the number of farmers interviewed and the time allowed to the question of farming system, these following results aim to present the main trends but are not in depth.

In Xieng Kiao we categorized 3 different production units mainly discriminated by the size of the acreage of the agricultural land, the type of productions and the household size.

- Group X1: “Worst-off subsistence system”

Farmers of this farming system are the one with the smaller households, 5.2 inhabitants in average. They also own the smaller land acreage, with an average of 0.33 ha in comparison of a total average of 0.99ha. This land acreage is mainly lowland for rice production but some also own upland where they grow rice. Those farmers might be the ones settled in the area during the second migration wave (Groppo, 1995) as they are characterized with the smaller lands. This farming system does not contain lot of livestock or asset. According to farmers, this livestock is mainly used as “capital on feet” or for religious ceremonies. This farming system is thus characterized by a low capital. Moreover, they seem to produce barely enough to satisfy the needs of the households so they solely consume their own production and do not sell it.

- Group X2: “Commercial system”

Households are characterized as owning bigger land acreage mainly to grow commercial crops such as maize and vegetables. In average they have 1.6 ha of lands where they produce 3 times more maize production than other farmers. They might be the one owning the uplands of the village, as they crop a lot of maize. In the study area, maize and vegetable productions are mostly aimed at being sold to the market. This is why this farming system is the commercial one.

- Group X3: “Well-off subsistence system”

The third farming system is the “well-off system”, named X3. Household of this system are the bigger households, with an average of 7.2 people. They mainly crop paddy rice. Owning a lot of livestock might imply that they do not need to own other production as they have capital on feet. Nevertheless, owning a lot of livestock implies to own big lands. This might be why farmers in X3 are the ones owing more lands. We can assume that they arrived in the village from the first migration wave (Groppo, 1995). The fact that they are the ones owning more assets suggests that they are the wealthiest of the village.

In Hainiang village we found the three same types of farming system, namely “worst-off subsistence system” named H1, a “commercial system” named H2, and a “well-off subsistence system” named H3. But as we got the information about farmers’ income we were able to make the farming systems more precise: group H2 is characterized with a main off-farm income, in contrary to groups H1 and H3. That means that, besides cropping commercial crops, members of the households have off-farm activities such as casual labor or service providers such as being a driver.

According to those highlighted groups and the following assumptions about innovative rice systems it is difficult to make a hypothesis about the type of farmer who would integrate those cropping systems in their system of production. Indeed, as SRI is supposedly more difficult to crop in large acreage because of its production constraints (Castella and al, 2015), we could assume that farmers from the groups X1 and H1 would be more likely to try it. But, even if they own smaller lands they above all have less labor force and incomes. And another one of the most important assumptions about innovative rice system is its labor and knowledge intensity. Moreover, it would be more risky for subsistence farmers to try a new technique, even if they would be the more needy to change their system. We thus make the assumption that the farmers owning lowland areas, with more labor force and ability to invest are the ones who are the more inclined to try a new technique.

This is why we make the assumption that farmers from groups X3 and H3 are the more likely to crop using the “one-seedling” techniques. The following of the study will enable verifying this hypothesis.

IV. 2. b. Diversity of lowland rice cropping systems

In the literature and according to the key informant interviews, there are 3 standard techniques in the common representation of the paddy cropping system of farmers in the study area. The followings techniques, using the local terminology, are called *Kha Kib Diao, Kha Phong* and *Kha Sam*.

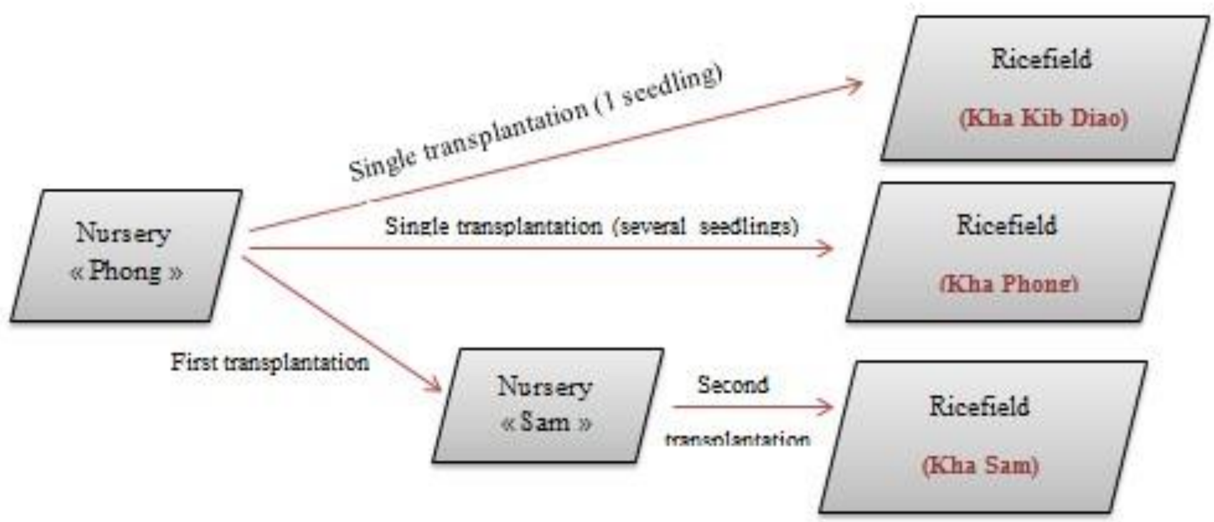

Figure 24: Traditional paddy systems explanation (Bourjac, 2017)

Kha Kib Diao refers to the fact of transplanting only one seedling per hole. *Kha Phong* refers to a technique using only one nursery and then transplant after around 30 days. *Kha Sam* refers to the fact of using a Sam, which means that after the first nursery, the seedling will be packed and transplanted in a second nursery.
The purpose is to identify, within our 34 parcels, more precisely the nuances between rice cropping techniques, to question deeper this standard classification, and to precise the technical diversity.

We firstly focused on the 17 parcels where one-seedling transplanting is used to measure the “adoption intensity” (Roussy and al, 2015). This consists in measuring for each individual plot how many principles of each technique are applied. Those two techniques were focused because farmers indiscriminately consider them both as *Kha Kib Diao*. The main principles of the two standard techniques have been chosen according to the literature. For SRS the description comes from SAEDA and for SRI it has been written from Uphoff and Tefy Saina association (1992) in the framework of the Cornell International Institute for Food, Agriculture and Development.

The principles are described below.

Table 5: SRI and SRS principles selected (Bourjac, 2017)

Principles	SRS (7)	SRI (6)
Seed selection	Yes, use of salty water	Yes, use of salty water
Seedling age	12 to25 days	8 to 15 days
Transplanting density	Transplant 20x20 or 30x30cm	Transplant in line, 25x25 cm
Water management	Maximum water depth is 10cm	Water must be drained
Fertilization	Organic fertilizers only	Fertilizer use (ideally organic)
Weeding	Manual weeding	Mechanic weeding
Cultivar	Use traditional cultivar	*Not a main principle*

The basic principle of using only one seedling hasn't been selected, as it is not discriminant between the two standard techniques. We then compared the number of principles adopted of the both standard techniques. This analysis leads us to the results in the figure below.

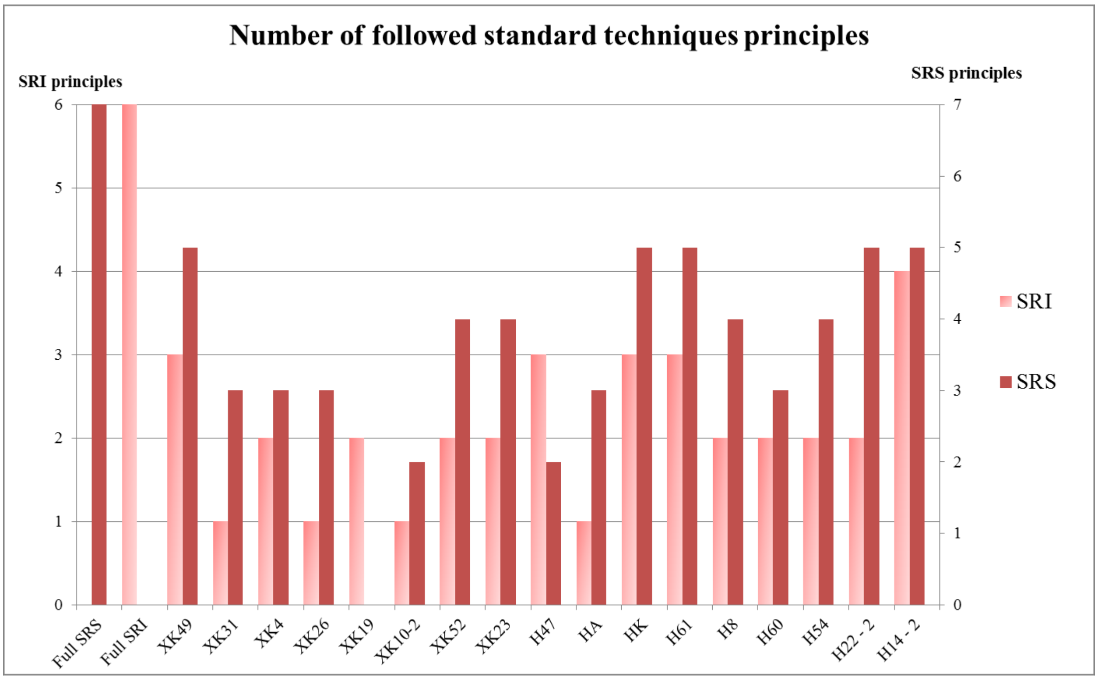

Figure 25: Comparison of SRS and SRI adoption intensity(Bourjac,2017)

The first conclusion that emerges from this analysis is that the techniques, which had been offered to farmers, are not fully adopted by them. Thus, it first outlines the importance of describing the different techniques in the area before being able to talk about the performances of one or other standard techniques, such as SRS. Secondly, we cannot validate the initial hypothesis, which is that there is no SRI anymore in the area. Indeed, we can notice on the graph that some farmers are using a technique, which follows more principles of SRI than the ones of SRS. This is the case of the individuals XK19 and H47. However we can notice that most of the farmers are using a technique closer to SRS principles than SRI. Therefore, this implies that the SRS technique has prevailed over the SRI. As the SRS was supposedly designed with local context in mind, which confirms the importance of the implementation of a technique, adapted to the local context. The SRS is supposed to have been though like that.

Furthermore, we notice from the principles that SRS is promoting to use seedlings aged "12 to 25 days". To quote farmers interviewed it seems that the "2 leafs stage" of the rice, which is recommended as the best for getting a qualitative rice growing (Styger and Jenkins, 2014), is reached in the area after two or three weeks in the nursery. It also appears that several farmers are adopting the same number of principles of one or the other techniques. But when deepening this question it seems that all farmers are not applying the same principles. They retain the principles they think appropriated to their own context. However, we can notice that the age of seedling recommended by the SRS is the main factor adopted, such as the 25 centimeters square spacing, promoted by SRI.

Moreover, we can note that farmers are also using some part of technical itinerary that are not promoted in SRS or SRI techniques.

Those results even question the use of the term "technique". Can we say that those farmers are adopting one technique or the other technique if they do not fully adopt it? And thus what do they really do? Those questions led us to conduct a deeper analysis describing the diversity of packages that farmers apply.

In order to do this, an analysis combining the 34 individuals was conducted, regardless the number of seedling they transplant. This would lead us to see whether we can go beyond the common opposition between "one-seedling" and "traditional" techniques. But also to question the common 4 groups range of technique description (SRS, SRI, *Kha Pong*, and *Kha Sam*).

To do this, 10 discriminant criteria were selected. The selection was done regarding the principles of the four common standard techniques of the study area, which are the SRI, the SRS, the *Kha Phong* and the *Kha Sam*. The discriminant criteria are:

1 - The type of cultivar used
2 - The type of seed selection used
3 - The number of days in clear water for the seed selection
4 - The seed rate
5 - The age of seedling used for transplanting
6 - The number of seedling transplanted per hole
7 - The spacing used for transplanting
8 - The maximum depth of water
9 - If there is drainage or not
10- The type of fertilizer used

We could have chosen the number of transplantations, which is one of the main distinction between Kha Pong and *Kha Sam*, but as it was strongly correlated with the age of seedling we decided to remove it. Just like the household typology, we decided to conduct a statistical analysis on the study population to enable us to get a better exploration of the qualitative data collected (Vaudor, 2016). As we have qualitative and quantitative data the statistical methodology used is a FAMD followed with a HCPC to understand the structure of the dataset and categorized groups of techniques. That was conducted using R software. This

analysis leads to a divide population between 4 different clusters, of which 3 can be described in the figure below.
Indeed, Group 2 seems to be the group of the 3 individuals that stood out from the other groups. The main discriminant criteria are the number of seedlings transplanting, the type of seed selection and the age of the seedlings. But the group 2 is the only one which is not defined by the number of seedlings used, but by the draining of water every 24 hours. `
As it contains only a few farmers, it could potentially be a reminiscence of an old project of intensification on rice production following the green revolution.

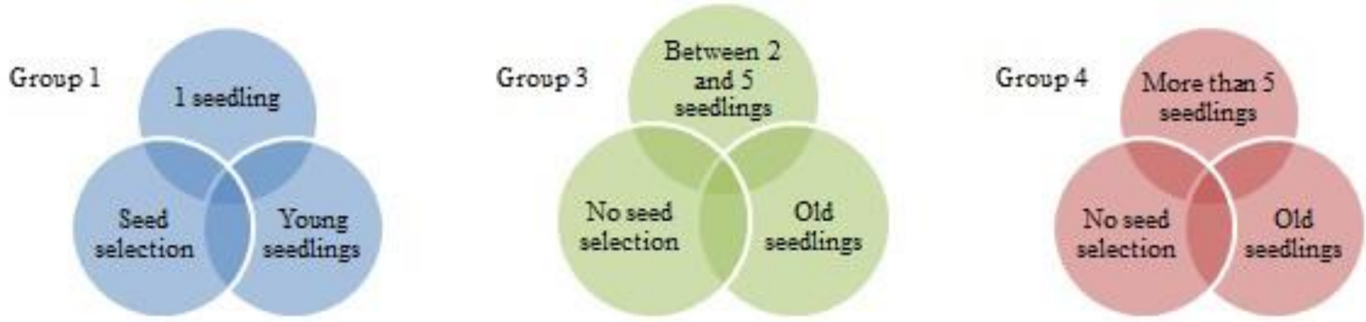

Figure 26: Farming systems differentiation (Bourjac, 2017)

Even if the inertial gain of the HCPC suggested dividing the sample 6 clusters, it does not seem to be relevant as some groups thus contain only 1 individual. And, using an iterative approach, we decided that these four clusters seem more consistent.

The results show that the discrimination of the techniques groups is not in accordance with the main criteria of the four standard techniques described below. Indeed, there is no clear division regarding the age of seedling, which would refer to *Kha Phong* or *Kha Sam*. Reminding that the age of seedling is correlated to the number of transplantations. On the other hand, we can see that the opposition between the use of 1 seedling or more than 1 seedling finally appears clearly here. The only exception is the individual XK4 as he is the only one of the one-seedlings, which does not feet to this group but to the second one.

As the first group contains all the individuals who use one seedling we decided to compare it to the combination of the groups 2, 3 and 4. This, in order to be able to describe better what happens in the one-seedling group. The first one would be called “Group A” and the second one “Group B”. Then we conducted the same statistical analysis as before, firstly in the “Group A”, and secondly in the Group B. It is important at this point to recall that the statistical analysis conducted are here to present the main trends identified in the study area but do not have the purpose to be representative.

This methodology is summarized in the following figure.

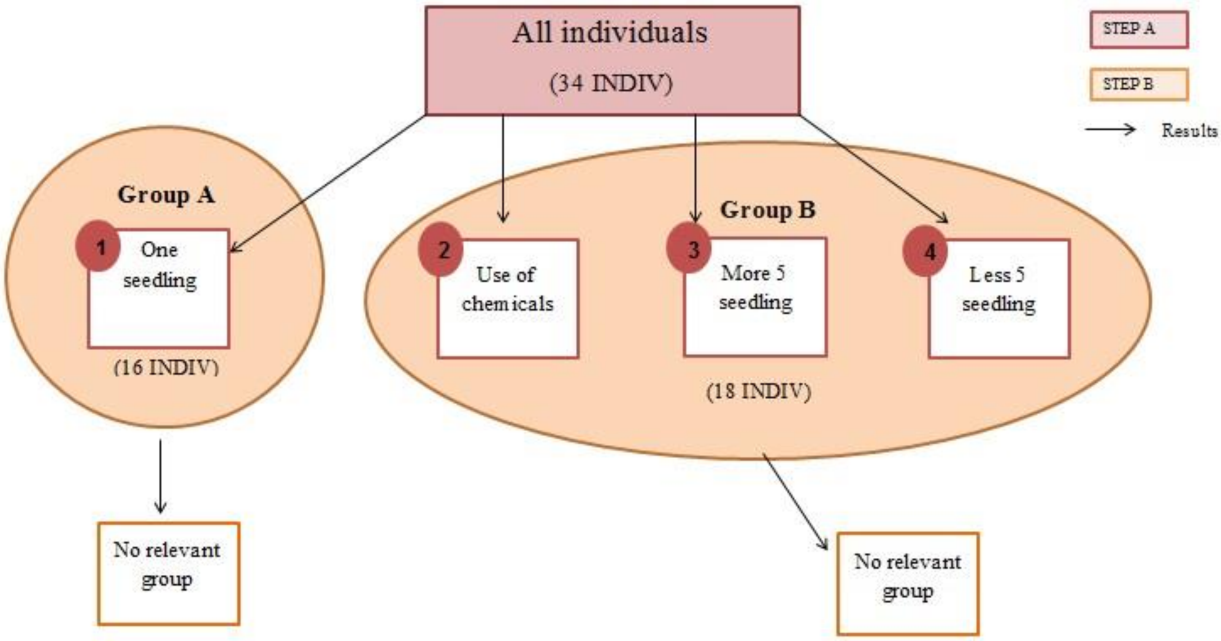

Figure 27: Methodology conducted to analyze the paddy cropping systems typology (Bourjac, 2017)

The analysis of the step B was conducted using a combination between statistical analysis to give a first overview of the possible cluster and a manual analysis. This did not lead to any relevant group, which can be characterized as a technique.
Indeed, the results obtained support the assumption that each farmer is taught a theoretical technique but then adapt it. And it does not seem relevant to regroup what they do, because there is no consistency in the differentiations. This questions the pertinence of asking farmers to follow precise techniques and whether it might actually benefit them. It would be interesting for the development sector to have a bottom-up efficient vision, by better taking into account farmers' perceptions and representations. For example, as it was explained previously, farmers, since there is 1 seedling that is used for the transplanting, consider it as one technique. The first step of the present study tried to determine if it was relevant to go further in detail about the techniques and the pertinence of comparing SRI and SRS, but revealed that it was not.

This is why for the rest of the study it was decided to adopt farmer's point of view and to compare the "one-seedling" technique in general to others. This means that at the level of the study conducted we describe SRS to be any technique using only one-seedling, as long as farmer adopts it. The group B will now referred to "multiple-seedling" techniques.

IV. 2. c. Opportunities and constraints for adopting innovative rice cropping techniques

It was interesting to consider a potential correlation between the applied paddy cropping techniques and the type of farmers. The starting assumption is that farmers from X3 and H3 groups, thus the "well-off subsistence" farmers, would be more inclined to adopt an innovative rice cropping system. Finally it appeared that farmers who adopt the technique are from all farming systems as we can see in the **figure** below. That can make us assume that the adoption kinetic is therefore not related with the farming typology.

Table 6: Link between individuals and farming typology (Bourjac, 2017)

INDIVIDUAL	XK49	XK31	XK26	XK19	XK10-2	XK52	XK23	H47	H61	H8	H60	H54	H22-2	H14-2
Farm typology	X3	X2	X1	X2	X1	X1	X2	H1	H1	H1	H2	H2	H2	H3

It is even more obvious that the SRS is mainly adopted in "worst-off subsistence" or "commercial" farming systems. Nevertheless this last observation mostly shows a limit of the study conducted. This limit is the divergence between the initial sample and the field reality where the list of farmers to interview had to be refined. Indeed, we could not interview the same number of farmer in each cluster. The explanation that emerged for this phenomenon was that one of the motivations to adopt innovative technique was the challenge of trying something new. To understand the opportunities to adopt the SRS it is important to first spotlight the expectations of farmers on a cropping system in general. To reach that, the data obtained with the revealed preferences technique (Alrikson and Ober, 2008) had been analyzed by doing a "notation system" to create a ranking of importance of the criteria selected which is presented below.

Table 7: Ranking of farmers' concerns in paddy cropping systems (Bourjac, 2017)

Rank	Criteria
1	Quantity of labour
2	Time spent in the field
3	Quantity when harvest
4	Water management
5	Quantity of input used
6	Pest management
7	Weed management
8	Quality of the rice when eaten
9	Soil fertility
10	Risks by doing this technique
11	Price of the rice when sold
12	Technicity of the rice cropping system
13	Quantity of biodiversity in the field
14	Lost after harvest

This ranking demonstrates that the two top criteria are the quantity of labor and the time spent in the field. This is really important as they are social criteria and as labor is known in literature to be one of the main constraints of innovative rice system (Uphoff, 2015). The fact that the yield only ranks third seems to be in contradiction with the initial assumption saying that the main motivation for farmers is to harvest a good yield. We will study later on whether the same conclusion can be drawn about SRS technique regarding the yield. Moreover, some environment-related criteria, such as the soil fertility or the biodiversity, do not seem to be really important for farmers, as they are only ranked as 9th and 13th respectively.

The water management is the first environmental criterion that appears in the ranking

Indeed, water is a main issue for farmers and it heavily impacts the way they can grow their rice. Finally, we can notice that the price of the rice when sold is only ranked 11th. That could show that developing and adequate market here is not a priority and the market demand (Pichot and Faure in Ruf, 2012) doesn't seem to be an adoption factor.

This is explained by the fact that in our context most of the farmers solely grow rice for their own consumption so the market is not their main objective and thus they do not focus on the price of the rice. Regarding the risk of the technique, it appears that it only comes 10th on the ranking of what is important for farmers. It thus seems that they are not strongly affected by a degree of risk. This can explain why the SRS technique is found in all types of farming system. Even the worst-off are more interested in trying the technique that worrying about the risk of doing it. Whereas according to Marra in 2003, and Couture in 2010, one of the most important constraints to the adoption of an innovation, and one of the first reasons for rejection (Feder and Umali, 1993), is the risk aversion. These expectations were linked with the farmers' perceptions of SRS. Indeed, if the technique fits their expectation this would lead to an opportunity of adoption. We can see on the following graph the perceptions of the farmers regarding the same criteria applied to SRS in comparison with other techniques.

Table 8: Ranking of farmers' perceptions about SRS performances (Bourjac, 2017)

Benefits	Constraints
Quantity when harvest	Weed management
Quality of the rice when eaten	Risk by doing this technique
Time spent in the field	
Quantity of labour	
Soil fertiliy	
Technicity	
Water management	
Price when sold	
Quantity of input	
Lost after harvest	
Biodiversity in the field	
Pest management	Pest management

It appears that, besides the weed management and the risk of implementing the technique, they all are benefits of SRS in comparison to other techniques. Moreover the three top important criteria are in the fourth top benefits of SRS technique. One other important criterion is the quality of consumed rice. According to Mr. Victor from TABI, in IRRI they got the result that one of the main motivations of farmers to crop rice in Laos is the quality of the rice. By quality we mean the taste, the grain size and the size stability. Moreover as farmers in the area are mainly cropping rice for their own consumption this factor can be discriminant for adoption of the technique, because it can give them a food security. The fact that the technique benefits are in accordance with farmers' expectations increases the probability of adopting the technique. This refers to the imitation effect as explained in part IV.I.b. When a farmer sees that the technique applied fit with their expectations in another field, they are be more inclined to try it.
Indeed, most of the farmers waited to be sure that the technique works in another field before to trying it in their own parcel.

Furthermore, one of the main paths of dissemination is the promotion of the technique by DAFO or expert farmers. It is interesting to notice that DAFO is the representation of the government at district level, and expert farmers are often important people at village level such as head of village. Thus, it seems that the strong involvement of authority facilitates the innovative technique dissemination and first tries. We can quote several farmers who said "if DAFO tells us that the technique is good, that means that it is". Even if the number of DAFO members working about SRS in Kham seems low (2 on 45), they are very present and in strong interaction with other members from other districts and the SAEDA members.

To conclude about the opportunities it seems that adoption of the technique is the result of the co-action of an observation of tangible results directly in the field and the promotion by a local authority. In that regard, Rubas (2014) wrote that in most studies about innovation, they pointed out that the presence of formal advice and information, which means from an authority, fosters adoption.

In another hand the fact that not all farmers are cropping rice using the innovative techniques shows that there are also constraints for the adoption. As it was raised before, in the criteria selected, the two constraints are the weed management, and the riskiness. By risk it means the low resistance of the young seedlings in the first weeks after transplanting. In fact, young seedlings mean small seedlings. They are less resistant to pest and climatic risks. Above all, as there is only one seedling used if something happens to it, for example a crab eating it or a heavy rain flooding it, they do not have other seedling to replace it. We thus notice that farmers strongly feel the riskiness of the technique (28.5% of the interviewees) as a disadvantage compared to other techniques. But as it was highlighted before that they have a low aversion to risk, even if farmers are aware of the riskiness it does not seems to be a major constraint for them to adopt the technique. This goes again what Menapace and al conclude in 2013 about a study conducted with fruit grower farmers. Apparently the farmers who were the more conscious of the risk of the technique used were the one who were the more averse to it. But that can be explained by the context of our area, which is a wet region where losing the harvesting does not mean losing all the harvesting. There are still available solutions: for example transplanting older seedlings, even if that means changing the technique and use more than one seedling.

As raised before, the weed management is another constraint. It emerged from the interviews that 62.5% of the farmers feel it. The critical point of the weed management is the first two weeks after transplanting. The seedlings are not strong enough to be competitive with the weed. Thus the field gest covered and this requires an important amount of labor to get rid of it. This is an important constraint for them because, as they are doing manual weeding, this is an arduous work and the arduousness of the work can have a rejecting effect (Champenois, 1979). Moreover, all along the rice season farmers have to control their rice field a lot, against the weed.

Another constraint that exists, regarding farmers who refuse to adopt it, is also linked with the age and resistance of the seedling. Indeed, as the seedlings are small they require a flat, even area, not to be submerged by water and assure an equal level of water in the rice field.

But, as the area is a basin in a mountainous area, most of the rice fields are not naturally regular. Flattening a plot requires the renting of tractor-based leveling service; which cost between 2 million and 4 million kip per hectare. This is an important investment regarding the minimal annual wage per inhabitant in Laos, which is since 2016 around 1,150 $ (Le Corre, 2016), thus 9.8 million kip. This means that, if a farmer wants to flatten one hectare of his paddy field he would needs to spend around one third of his annual wage[30].

This result interrogates the relevance to promote the technique elsewhere than in lowland flat area where the water cannot be easily managed if the main constraint is linked with the main principle, namely the age of the seedling. In addition the last constraint observed is the fact that people are used to crop using the traditional system, thus they do not know the new technique and that create a social mistrust against it. With the impact that when farmers want to adopt the SRS technique, it is quite often that some of their household members refuse them to do it. Those members can either be the wife or someone with who they share the management of the parcel

[30] It is important to take in account that this information is given for example but in reality traditional farmers do not fully fit the legal frame (Le Corre, 2016)

Furthermore, in the area the exchange labor is the only way for farmers to get enough workers. This technique of labor is based on an exchange of time. One farmer goes to work in the field of another one for an amount of day, and in exchange the second farmer will do the same. The only remuneration is time. But as people as mistrusting the technique and think transplanting only 1 seedling is too hard as picky, and they refuse to help.
To conclude the key trends of opportunities and constraints have been highlighted but they demonstrate that once again there is no common determinant existing

To conclude we can note that there are no common opportunities or constraints existing because of the diversity of contexts of each farmer (Roussy and al, 2015). But by doing a methodological triangulation for the data analysis some main trends still appears. They can be opportunities and constraints based directly on the technic or on the social environment.

IV.3. Performances of the different rice cropping techniques

Understanding the performances of SRS will help determining its place in the area and why it is interesting for some farmers and predicts its sustainability. To do that, different data[31] was analyzed by comparing the results of SRS adopters with the results of multiple-seedlings techniques.

IV. 3. a. Socio-technical performances

The socio-technical performances were studied mainly regarding the working time. As we are working at parcel level this working time is formulated in man-day (Cochet, 2002). Moreover, as it was explained previously, the only labor force available is from the family, or from the exchange of labor. As the exchange labor is an equal exchange of work time between two farmers, one day of exchange labor is accounted like one day of family work (Cochet, 2002). The methodology used for the data analysis is the use of the average. That means that the man-day indicator is calculated for each parcel. Then the averages of the SRS and the multiple-seedling groups were compared and their significance was tested to analyze the percentages.
The significance was studied using a Student test, as the variables are quantitative and independents. The software used is Excel stat. As the sample of each group is too small to conduct real statistical analysis, as smaller than 30 individuals, the following results are only here to present trends. And even if they appear as "non-significant" we chose to still present them. The number of hour per day use for those calculations is 7 hours, according to the time given by farmers during the interviews. In the literature the often time selected is 8 hours. That can explains differences in results when comparison with other studies. But this choice was done in order to maintain consistency with the declarative observation methodology used.

The results obtain regarding the working time is that the SRS enable farmers to save a total of 28.4% of the total men/day necessary for working in the rice field. The main savings come from the work on the nursery, up to 88% in comparison of the traditional techniques. That confirms the departure hypothesis, which was that the SRS enable to save labor.
When focusing in women work, it seems that the SRS technique increases it, but only up to 2.6%, which is not really significant. This goes against the departure hypothesis telling that the SRS technique reduce the women work.

[31] The table presenting some of these data can be found in Appendix 12

Nevertheless, the same comparative work at the different main activities of the rice technological itinerary shows the following results:

Table 9: Comparison of required Men/Day between Group A and Group B regarding the main paddy cropping activities (Bourjac, 2017)

Labor (man-day)	Transplanting	Weeding	Harvesting
SRS	22.4	22.2	30.1
Multiple-seedlings	39.3	17.9	40.6

The SRS technique enables saving labor, except for the weeding work. This is in coherence with farmer's discourse presented previously. Indeed, the main constraint of the technique appeared to be the weeding because of the low competition capacity of the young seedlings. Moreover, this is also in coherence with the fact that the time spent in the field and the quantity of labor is quote as benefits from farmers. We also questioned the potential schedule superposition with other crop. But, regarding the Figure 13 and the Figure 14 established, it seems that there is not. The data collected where combined with exchanges with a Cirad researcher working about upland maize production in the study area. Indeed, the two limiting weeks of rice production are during month of august after transplanting, and there is no work at this time for maize production. Nevertheless, this is general hypothesis because it was not possible to get the detailed data for each farmer.

Beside this "man-day" indicator we also focused on the performances of the techniques regarding the land acreage. It appears that in average the parcel where the SRS is adopted are smaller than the one for the other techniques. But the result is not really significant as it is about 5700 m² against 6700 m². We can only notice that these parcel averages are smaller than the provincial average, which is around 1.27 ha of paddy fields (Chantavongsa, 2015). Moreover, it appears that SRS enable a 50.2% increase of land's productivity in comparison with the group B techniques. Even if the results are supposedly not significant, they are really interesting in a context of basin lowland such as on the study area, where the land extension is limited due to the geography. This supports the consistence of the implementation of this technique in the study area. Finally, regarding the yield,which is the main developed factor of promotion of the SRS technique, it appears that there is no statistical significance increase in comparison with other technique. Indeed, we got 5.7 tons/ha with SRS, against 5.2 tons/ha with other techniques. Serpantié and Rakotondramanana (2013) noticed that the yield given by SRI technique was mostly the same or even smaller than with other techniques. It thus questioned the productive efficiency of SRI and our study comes to support his results.

What is interesting is that here we got a high yield for the traditional techniques in comparison with what is written usually about this area. Indeed, in 2015 the average of paddy production in Xieng Khuang province was about 4.4 ton/ha (Lao statistics Bureau, 2015**).** Finally, even if the yields result is not significant, apparently farmers are satisfied with SRS because they get heavier panicles and more regularly. Serpantié and Rakotondramanana (2013) in Madagascar with the Improved Rice System (a local adaptation of SRI) made equivalent observation. A significant difference, up to more 15% was observed.

IV. 3. b. Economic performances

Regarding the economic performances we chose to follow the recommendations of the agrarian diagnosis methodology, Cochet 2003 and Ferraton and Touzard in 2009. We calculated the Production Costs (PC), the Gross Product (GP), the Added Value (AV) and the Return to labour (RL). They are all expressed on LAK[32]/ day. We also calculated the land's productivity (expressed in LAK/m²). This methodology was chosen as it enables to compare two production systems. As the study was focused at parcel level, the analysis stopped at the

Gross Added Value as going further would have no consistency (Ferraton and Touzard, 2009). To calculate those economic indicators we used the following formulas:

- PC = Seed rate x Seed price + Quantity of fuel x Fuel price + Quantity Manure x Manure Price + Quantity Chemicals x Chemicals Price (LAK/ha)
- Gross Product = Production x Mean price (LAK/ha)
- Added Value = GP - PC (LAK/ha)
- Return to labour = AV / Total men-day

In the PC calculation the material depreciation are not taken in account as we are at production level (Ferraton and Touzard, 2009). The prices used (seed, fuel, manure and quantity) were collected during interviews and with observations on the markets. The seed price is individual for each farmer regarding the cultivar used. In the GP calculation the price taken into account is an average of the different selling price during the year to facilitate the calculation. As RL is computed at plot level the working time is expressed as man-day.
The results of these calculations are summarized in the following table:

Table 10: Economical results comparison (Bourjac, 2017)

Production Costs (LAK/ha)	1 846 188.0	1 022 642.0
Gross Product (LAK/ha)	20 068 872.7	17 605 112.5
Added Value (LAK/ha)	18 222 684.7	16 582 470.5
Return to labour (kip/men-day)	179 054.9	113 462.5
Land's productivity (kip/ha)	4 795.2	3 192.4

Those calculations show that the SRS techniques, contrary to what is promoted, the production costs are higher for the SRS technique. This may be explained by the high amount of manure used. Indeed, in average farmer cropping SRS use 943.5 % more manure, but only 6.2 % chemical less.

[32]LAK stands for Lao Kip

Moreover, most of the farmers who use manure also use chemical fertilizers. Thus, even if the manure is less expensive, this cost is added to the cost of the chemical. Nevertheless, it is important to note that most of the farmers don't buy their manure as they produce it directly on the farm. As the system is focused at parcel level, it was not possible to present the distinction and it was chosen to count the manure as an intermediate consumption. It would be interesting to conduct the same calculations but at farming level to think the manure as part of a system. Nevertheless, even if SRS farmers use more inputs, they get a higher gross product (up to 14%) as the yield is higher, and thus an increase Added value to 9.9%. That means that the gain due to the production offsets the lost due to the inputs. Finally, the SRS technique gives a better Return to labour than the other techniques. That means that for the same work, farmers get 57.8 % remuneration more.

IV. 3. c. Environmental performances

The environmental performances here refer to the type of fertilizer used and to the soil fertility. Regarding the fertilization, SRS is supposed to be chemical-free technique. But it appears that farmers cropping SRS use an average of 112 kg of chemicals fertilizers per hectare. This is only 6 % less than the others. On the other hand they use 943.5 % more of manure. Thus, the still high use of fertilizer does not make the SRS an environmental performing technique. However, the explosion in the quantity of compost used and the decrease in quantity of chemical fertilizers can help increasing in a long term the soil fertility. That thus seems to invalidate the departure hypothesis which is that SRS decrease the fertility of the soil. According to farmers during the interviews, they have the feeling that the fertility of their parcel increase since they crop using the SRS technique. In the same way, according to farmer perceptions, it seems that SRS enables to increase the biodiversity. Nevertheless, this need to be nuanced as no direct analysis was conducted on the parcels and unfortunately no deep understanding of the environmental performances was conducted, due to a lack of time. As we interviewed 3 farmers who cropped both a SRS plot and a traditional rice plot we compared the use of fertilizer for each farmer. They all used chemical or no fertilizer for the non-SRS parcel, and manure for the SRS-parcel.

Regarding the fertility we also tried to highlight a potential link between the type of rice technique used, and what is done on the parcel during the dry season. This was done in order to potentially highlight a tendency of a fertility transfer conscience from farmer cropping SRS in comparison with other techniques. But there was no distinction on the type of parcel occupation during dry season, in function of the type of rice cropping SRS or other technique. Another environmental impact that appears is the appearance in Xieng Kiao village, since 2015, of a disease due to an insect pest. The description of this insect leads us to make the assumption that it can be the *Scirpophaga incertulus* or the *Chilo suppressalis* (Chaudhary, 2003). The impact of these insects is the death of the tiller by drilling in the rice stem, and thus no production of panicle. This can lead, in Asia, to an annual average of loss of harvesting from 5 % to 10 % and to extreme case of 60% of loss (Chaudhary, 2003). According to a member of DAFO "SRS is less resistant than traditional technique and only SRS rice is affected by it". Moreover, they link this disease appearance with the implementation of SRS. This observation makes us question the real sustainability of the technique if it facilitates the emergence of diseases and suggest a deeper observation of this phenomenon. Nevertheless, the data collection does not enable us to make sufficient assumptions about the two founding principles of environmental agro ecology (Schaller, 2013) which are: increasing the biodiversity and strengthening the biological regulation.

Part V. Discussions and conclusion

V.1. Limits of the results

The results presented need to be examined due to identified biases.

❖ Research and translation

As these results were obtained through translation and are only based on statements, it is possible that the information has been a bit altered. This is due to the potential loss of information between what farmer says and what the translator interprets, and then between what the translator says and what the young researcher interprets. To reduce this bias, the survey questions were as structured as possible.

❖ Research and farmers

As farmers knew that the present study was about SRS it is possible that they altered their discussion, whether deliberately or not, in order to fit with what they thought we wanted them to say (Pelletan, 2009). This is highly possible regarding the environmental questions. SRS is supposed to be an organic technique, and the government promotes agro ecology. Thus, they could have thought that we wanted them to say that SRS increased the soil fertility or the biodiversity. Nevertheless, if this bias was actually present, farmers would not have told us that they used chemicals. We can therefore assume that this bias is not significant. At the beginning of each interview, a presentation of the motivation of the study was given in order to try to distance the study from the institutions (Cochet and al, 2002), such as SAEDA or the DAFO, which are really influential for farmers.

Another bias related to farmer perception that could influence the results is their trust. As the time spent in the villages was not an extended period, it is possible that farmers were not fully confident with the research and thus did not give all the information they have. Finally, the last potential bias is the fact that the research was conducted in wet season during 2017 but was about the wet season in 2016. Thus, farmers were working during the 2017 rice campaign but had to answer question about the 2016 rice campaign. There is the possibility that farmers got confused on the information about last year or did not remember precisely and the results could therefore not be exact.

❖ Research and local partner

The quality of the data concerning the spread of the technique in the districts can have been decreased due to the difficult relationship with the partner association and their organization. Despite the fact that they were part of the study's conception, they were not fully engaged in the data collection. Indeed, when information was asked of them they seemed to be cautious about which data to share or withhold. It therefore took a lot of time to collect the information. Moreover, miscommunication between the different teams was prevalent, as no one ever knew who had the information or not. The rare information collected is thus not really clear and its accuracy can be questioned.

❖ Research and data analysis

The method of analysis of the data can also be a bias for the results. Indeed, for the farming typology created, the data were analyzed through a statistical methodology. Nevertheless, the way to create a typology is frequently the outcome of a finer analysis. This is done applying a progressive and iterative approach throughout the study (Ferraton and Touzard, 2009).

It is thus possible that the term "pre-typology" would better fit the one created in the present study. Nevertheless, the farming typology was not the main part of the study. Therefore, while it would be beneficial for it to be improved, this does not distort the study.

V.2. Discussions

Two main discussions are expressed in this party. The first one emerged from the SRS results, and the second one emerged from the study in itself.

V.2.a. Discussions around SRS results

The obtained results about the comparison of SRS to multi-seedlings techniques presented the place of the practice regarding its implementation and performance. The implementation of this innovative technique is the result of institutional work about agro ecology, supported by the government, which has started years ago through the implication of national and international institutions.

SAEDA has used the farmer-to-farmer approach for the dissemination of its technique. This choice seemed interesting as it empowers the motivated farmers by making them transfer the knowledge to others. This knowledge is thus vertically given from the NGO to the farmers but also horizontally from farmer to farmers. This echoes the imitation effect, which takes a key role in the adoption of the technique. The presence of the SRS is therefore the result of a combination between strong involvement of the authorities (represented by SAEDA, DAFO and head of village) for dissemination and an imitation phenomenon in farmers' motivation for adoption. This iterative blend between farmers and authorities seems to support a positive potential for the future of SRS development in the area, as they are all involved in a common process of "group learning" (Chauveau, 1999).

Nevertheless, the implication of authorities extended to outside of the study area can challenge the reproducibility of this dissemination. The example of Madagascar shows that the state involvement positively influenced the SRI development and was further considered as a prerequisite condition of its dissemination (Serpantié and Rakotondramanana, 2013). Laos is a country where the state acts as a strict power and is closely present to the farmers at district and even village level. But moreover, it is strongly linked with the local organizations and supervises them, as they still did not exist a few years ago (Decout, 2013). As the Lao government is promoting agroecology and the extension of Intensive Rice System, they are involved in this agro ecological alternative presented. But would the development of the SRS be as well disseminated in an area with a lower amount of state involvement? The adoption of the technique is majorly reliant on the representation of authority in Laos, but this does not erase the constraints felt with the technique. Perhaps in a country in which the power structures are organized differently, the decisions regarding the anchoring of SRS would not be the same (Lavigne Delville, 2003).

Excluding the question of adoption of the SRS, its performances presented interesting results, which can be discussed. The yield, to the contrary of what is promoted about SRS, is not phenomenal comparatively to multiple-seedlings techniques. In addition, the production costs are higher. At first look, the technique does not seem economically beneficial at all. But finally the gain obtained with the raising yield supersedes the loss due to the higher production costs. Moreover, the 500 kg increased of production could feed almost two people. And farmers observed that cropping SRS resulted in harvesting heavier panicles and more homogeneous grain weight, which taste better when consumed.

By taking into account the fact that the rice cropped in the study area is meant for household consumption, we can say that the SRS could help supporting the food security of the area through the food availability, utilization and stability (FAO, 2006). Perhaps this increase of consumed rice quality could be an added motivation to implement the SRS.

Otherwise, the increase of production costs is due to the larger use of manure. This phenomenon, combined with the lower use of chemicals can predetermine long-term improved soil fertility preservation. It also assumes an interesting change in fertilization transfers and use from chemicals to organic. But to reach this, farmers will need to have full support. For now, they are taught to make their own bio-fertilizer, bio-pesticides etc., but this takes too much work time for them to make enough to spread in their whole paddy field. Furthermore, it appeared that there is no market for the manure. Thus, only farmers who own livestock can utilize it or farmers who have the capacity to exchange it for something else (e.g. extra rice production) with other farmers. This can show a need to reorganize the fertilizer sector in the study area, and that further shows the disparity between the presence and absence of SRS

The reduction of labor highlighted could potentially be a solution to the loss of workforce due to the migration of the youth to the city, or could be repurposed to generate income from the implementation of another farm or off-farm activity. Besides this saved time, the SRS better values this work, and thus face one of the main issues of Lao rice cropping; the low return on labor (Eliste and Santos, 2012). This intensification also goes through better land's productivity. In the context of closed area and land's pressure, this is really important as it means that for a same area the farmer can obtain a higher income.

Pairing Xieng Khuang characteristics (a mountainous area, with low density of people but land's pressure) and the combination of performances; we can assume that the SRS is a technique, which could help confront the issues of the area and increase farmers' food security.

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But this global result needs to be scrutinized. Indeed, if globally SRS is a less-labor-intensive technique, the time needed for weeding is more important. Even if only five additional man-days do not seem important, this appeared to be a big constraint for farmers. This may be related to the hardship of manual weeding work. Moreover, the increase of women's work burden can be explained by this phenomenon, as the weeding is often known as a women's job (Uphoff, 2015).

The more critical need for weeding is related to the SRS component of using young seedlings. Being smaller and more fragile, they are less competitive with the growing weed. Nevertheless, as it has been proved that it was interesting in terms of agronomic interactions (Uphoff, 2015); we cannot conclude that the fact that seedlings are young is bad and should not be utilized. Indeed, the issue is not linked to the principle in itself but from the need of particular conditions (Chauveau, 1999) to enable its strength growing. These particular conditions are the requirement of a flat, even area, incapacity to be submerged by water, the precise water management and intolerance for climatic disease such as drought or heavy rain.

Overcoming the main barrier of the technique therefore implies the need for optimum plot conditions or to be able to undertake investments (flattening the plot, getting irrigation systems). Having optimum plot conditions is not the common condition of the study area. And not every farmer can afford to invest. We can thus potentially assume that in long term the performance of the technique will not be accessible for all types of farmers. However, everyone should reflect the success of a prospering innovation through its potential adoption. Consequently, the practice does not seem suitable to the area conditions (e.g. basin villages with not well-flatten area, no irrigation systems) the rising climatic constraints (e.g. less predictable rainfall) and the potential lower resistance to disease.

From what we have learned, the practice seems to be a capital-intensive technique, but a labour extensive one, which leads to an increased land's productivity. Strictly speaking, due to the technical performances we can conclude that the SRS is better performing than the multiple-seedling and reflects agro ecological concepts as it enables combining better economical performances, environment preservation and progress of human development. Nevertheless, if at the time of writing the technique is fixed, and the first results are promising, its sustainability cannot be guaranteed due to the challenges discussed before (e.g. weeding issue, need optimum plot conditions, climatic risks etc.). If at this point no solution can be proposed against the latter two, some could be found for the weeding issue. This could be through the integration of fish or ducks in the paddy field, as it was demonstrated that it can help inhibiting weed growth (Triplet, 2015). Ducks seems more appropriate as fish production requires good water management. Besides enabling the weed suppression, this would help increasing the available nutrients for rice and the pest management, but could be interesting for household consumption. Another potential solution, which could be proposed, is the reintroduction of the aligned square transplanting by using a tool. Farmers did not implement this principle of SRI as it is too arduous. Perhaps applying this principle would be less labor consuming for farmers than the manual weeding without aligned transplanting. We think that this principle should be coupled with mechanization through the use of a mechanical weeder. SAEDA, the DAFO or even group of farmers with shared ownership could provide them.

V.2.b. Discussions around the evaluation study

The study involved a variety of actors through national and international NGOs, a research center, universities, government members and rice producers. It was thus the theater of institutional games.

Firstly, the SRS was immediately presented in strong opposition to the SRI in order to advocate its matching with local needs. However, it has become apparent that as long as one strand of rice is transplanted, the technique is the same for the farmers. What is the interest of this strong opposition, which seems to not correspond with the farm reality? Would it not be easier to start from the beneficiaries, namely the farmers, instead of losing contact with their perceptions? Especially since the SRI technique is itself presented as adaptable (Upphof, 2015) and already supported by the Lao government. But since recently the Lao government also promotes agro ecology. Could it not be a matter of creating a spearhead to the NGO enabling to put itself in front of the stage?
Indeed, promoting a revolutionary rice and agro ecological technique can attract attention and potentially facilitate access to logistical and financial means. This questioning only intends to provide potential responses to an opposition considered when collecting data. This opposition were found between the lack of data about the SRS and the enthusiasm for its promotion and dissemination. Indeed, very little data was available about the practice that has existed for eight years. This could be explained by the lack of monitoring of the projects implemented and assessment about the SRS, as this study was the first one to do so.
The work done on Oudomxay in parallel by CCL seems to bring more solid long-term and reusable information on the technique promoted, by following a true monitoring implementation. It would be interesting to improve knowledge sharing between the organizations regarding this monitoring and evaluation. This lack of follow-up can indeed be explained by a lack of control of this type of work by SAEDA, which would only need to be filled by knowledge.

In a second step, it seemed that different actors working together did not have the same expectations. In fact, the GRET saw the evaluation as a questioning of the actual performance of the practice, where SAEDA seemed rather to wait for a presentation of the positive results of the practice. This disparity between the motivation of the actors; the GRET for the scientific recognition, SAEDA for highlighting its practice, complicated the realization of the study, having already been subjected to a great variability of factors to be taken into account. The development community is relatively small, but brought back to the scale of a country like Laos; it is not always easy to pull out of the game. Collaboration should be a mean to raise the general quality of work done, though it is not always the case as we could see with the lack of university engagement for instance.

This study has allowed us to observe and have a first professional overview of the social arena, in the sense of "heterogeneous strategic groups confrontation, driven by more or less reconcilable interests" (Olivier de Sardan, 1993), that seems to be the world of development and in that case; NGOs.

In addition, this study was chosen with the purpose to question the yield as the “be all and end all” measure of progress. The promotion of the SRS by SAEDA was based on this indicator, as it is commonly done for the promotion of agricultural innovations. In addition, this performance indicator, when used as a communication tool, is not always well explained.
Indeed, it is not always clear whether it is question of the average, maximum or minimum yields. The methodology used to collect this data is as well not always well explained. For example, in our study we used a synchronic comparison between two different fields in the same year, and obtained a gain of 10% with SRS technique. Whereas CCL used in Oudomxay and diachronic comparison with a same plot in two different years and obtained a gain of 20% with SRS technique. These conflicting data sets, taken separately, do not report the same performance of the practice. But in fact they are not presenting the same results, as they were

not collected using the same methodology. This variability can therefore sometimes lead to the manipulation of the yield data and ultimately does not represent the full complexity of farming systems.

Our study revealed that other indicators in addition to the yield could measure progress. They are, for instance, the return of labor or the land's productivity, which are thus related to land, labour and capital, and therefore address concerns related to the context area.

The study also made it clear that if yield is an important goal for farmers, there are others that are equally important, if not more so. These main concerns may vary depending on the context, but in our study, those that appear to be priorities are the time spent on the plot and the needed labour amount. But also, the quality of the rice consumed. The priority given to time and food may reveal an awareness in which social considerations outweigh economic considerations. Of course, saying that farmers of the study, which are, let us recall, part of one of the poorest provinces of the country, are not at all interested in increasing their incomes and getting out of poverty would be out of step and is not our discourse. However, this prioritization of societal and non-economic values echoes the changes that can be seen in our occidental societies that bring the emergence of new alternatives, which could be related to the broader meaning of Agro Ecology, not like here at the disciplinary level of Agriculture, but at the level of a social movement changing towards a world more respectful of Man, and Nature.

V.3. Future perspectives for research development

To delve deeper into evaluating the SRS several following studies could be implemented. First of all, the on-farm study in the same area would lead to complete results of the present study by providing agronomic data. This could be done by a follow up during one complete paddy campaign.

Another study would be to conduct the same kind of study but interviewing farmers during their transition from another technique to the SRS. This would enable the calculation of the opportunity cost. This will refine the economic analysis by not only taking in account the benefits of SRS but by comparing the gain due to SRS with the loss due to the abandoning of the other technique. Indeed the opportunity cost measures the losses that are forfeited by allocating available resources to another use (Dufumier, 2004). In this case, the loss by stopping the other technique and the other use is the SRS technique.
Moreover, studying the yield given by two different systems in the same plot will refine the obtained results by limiting bias from different factors, starting with plot conditions.
A quantitative study could be done in order to understand the phenomenon in a larger scale. For this case, it would no longer be a qualitative study with the understanding of perceptions but a quantitative one to demonstrate the results at large scale.
Finally, the last type of study which could be done would be with the same objectives of understanding the perceptions and choices of farmers and the SRS performances, but with a scope of the farming system and not the cropping system. Indeed, this would help the comprehension of farmers determinants of adoption or not, their choices and some motivations or deterrents which are external of the SRS technique itself.
The present study is the first of this type in the area and in this subject. In the ALiSEA framework or not, it would be relevant to continue the analyses of the SRS innovation which seems to settle down time by time in the area and regarding the noise made by SRI in recent days.

Furthermore, there was only one comparative study available of this kind of technique during the 1990s, and the ones conducted since have controversial results (Serpantié, 2013). There is thus a lack of information and still important questions about intensive rice systems, which must be resolved with further information.

V.4. Conclusion

Xieng Khuang is a province in North-eastern Laos, and is classified as one of the poorest in the country. This mountainous province is characterised by labour scarcity, low availability of arable land and increasing land pressure. Coupled with the growing concern about food security, it is critical to address the issue of sustainable intensification of food production, especially the staple food: rice.

This study evaluated the Sustainable Rice System, a lowland rice technique, to comprehend its place and performance to assess its sustainability in the context of Kham; one of the poorest districts of Xieng Khuang. Several interventions to improve rice cropping in the study area, combined with government policies supporting agro ecology, paved the way of the implementation of a sustainable rice system. Its spread in the area is the result of the strong involvement of both the NGO, which created it, and the government. This authority frame brought the technique to farmers who made the decision to adopt and adapt it or not. The choice is made thanks to arbitration between the desire of trying a new technique, social mistrust, the imitation effect and personal farm conditions. Nevertheless, this appropriation by farmers of the technique complicated the assessment of the SRS when referring to the technical itinerary presented by the NGO. It therefore seemed more appropriate to define SRS as any cropping technique using one seedling for transplanting, as it followed the farmers perceptions. The assessment of this practice in contrast to the multiple-seedlings techniques enables to point towards its performances, regarding the three mainstays of agro ecology; economy, environment and human development. The results show that even if the use of SRS in the context of Kham District does not vastly increase the yield obtained by farmers, they are still interested in adopting it as it provides other benefits. These are namely the increase in the return on labor and savings on the global labour need. In addition, the technique is land-intensive. These results, brought to local context, imply the interest of the study to help address food security in the study area. Regarding the environmental aspect of SRS techniques, these results show that the common use of chemical fertilizer does not really fit with agro ecological principles.

Nevertheless, the significant increase in the use of manure in comparison with multiple-seedlings cropping systems shows a positive trend in terms of environmental conservation. Moreover, as labour scarcity is and will remain a concern for Lao farmers; this study shows the importance of considering performance indicators beyond crop yield.

But even if these results are promising, the SRS does not only cause positive effects, and the technique still requires scrutiny and improvement. This could be done perhaps through better support from the technical team to the farmers and a better exchange with farmers by taking in account their experiences.

Finally, the innovative practice was assessed after only two years of promotion in the study area. This added to the complexity of evaluating a technique performance due to the diversity of variables and farmers' choices result in the conclusion that this study presents an initial overview of the state of the SRS techniques and its sustainability. But, as an expert in development in Laos said during the presentation of the preliminary results of the study, "this first study enables to show the complexity but interest of the subject, and that there is still work to do!" Studying this new technique therefore must be continued.

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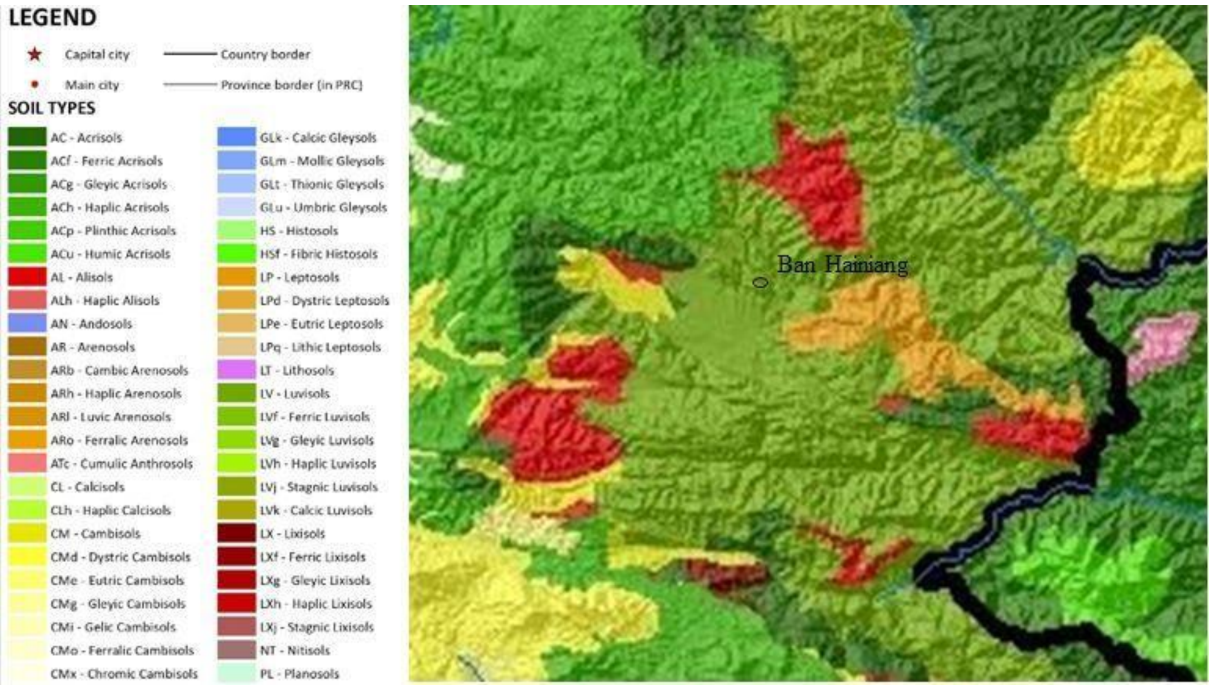
Table of Appendices

Appendix 1: Ethnicity classification on the basis of linguistic origin (Chazée, 1999)

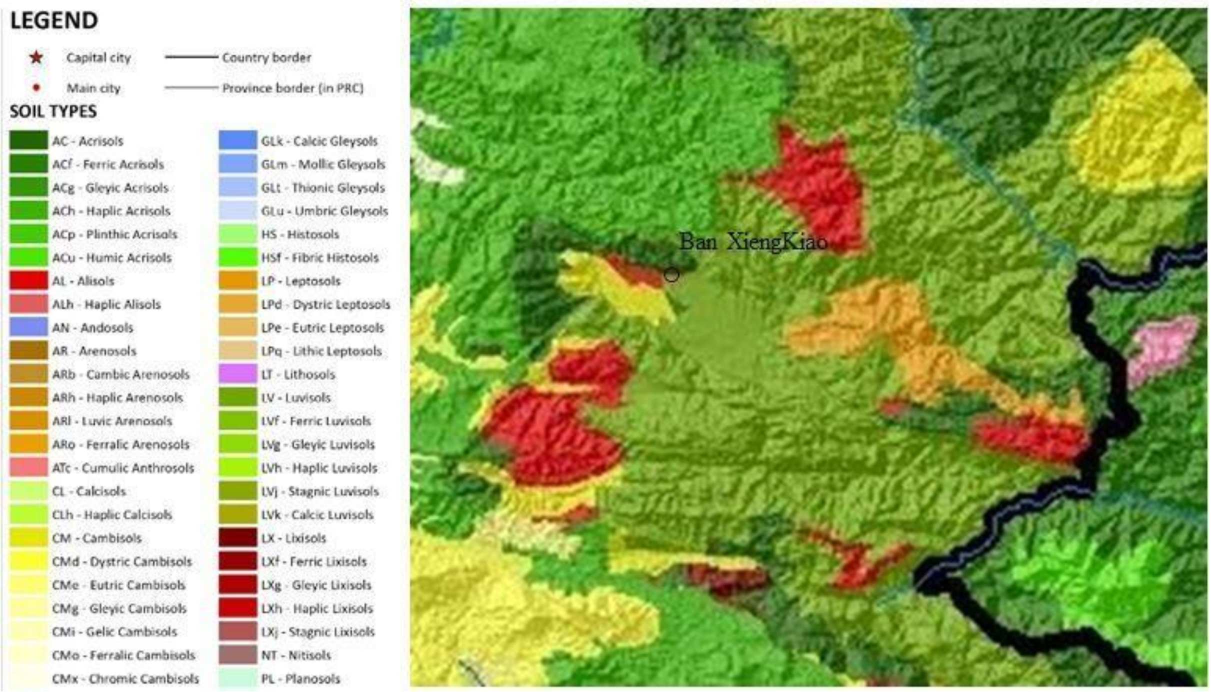
Thaï-sKadai	Austro-Asiatics		Miao-Yao	Sino-Tibétains	Others
Lao	Khamu Ou	Samto	Hmomg Lay	Pounoy	Poumong
Phoutai	Katang	Pouark	Hmong khao	Kho Pouli	Pouhoy
Phouane	Makong	Tum	Yao Mien	Kho Nuqui	Teket
Thaï Nyo	Suay	Sedang	Lao Huay	Kho Oma	Salao
Thaï Deng	Lawen	Kayong	(Lantene)	Kho Luma	Khmer
Thaï Lue	Taoy	Pouark		Mousseur	Birman
Thaï Khao	Khamu Rok	Tong		Khao	Chinese
Thaï Nyuan	Taliang	Kado		Dam	Thai
Thaï Dam	Cali	Kanay		Kho Pala	Vietnamese
Lao Isan	Khamu Lu	Tahang		Kho Pouly	
	Katu	Kate		Kho Nutchi	
Thaï Meuiy	Alak	Malheng		Ho	
Thaï Neua	Lawae	Tchaho		Kho Eupa	
Thaï Peung	Phai	Sapouan		Kho kopien	
Thaï Laan	Lamet	Chui		Nyai	
Thaï Yang	Pako	Thay Then		Noy	
Thaï Sam	Oy	Mon		Iko Chapo	
Thaï Men	Nguan	Lawi		Kho Botche	
Thaï He	Kouene	Tong Luang		Poussang	
Thaï Pao	Laoseng	Doi		Mousseu	
Thaï Kouane	Kaseng	Ksing Muul		Luang	
Thaï Kaleun	Ngae	Phong		Kui Sung	
Thaï Doi	Chieng	Khamu		Sida/Sila	
Thaï Khang	Gya Hon	Mokplai		Lolo	
Thaï Set	Sou	Salang		Keu	
Yoy	Yae	Kri		Hary	
Noa	Plrai	Aho		Alou	
Pon	Kha	Atel		Kho	
	Kha	Chatong		Tchitcho	
	Khamu	Arao		Mounten	
	Khamu khong			Panna	
	Khamu Keun			Kho Djepia	
	Kha Bit			Kho Nyahieu	
				Kho Akoui	
				Kongsat	
				Punyot	

Appendix 2: Maps of Hainiang and XiengKiao soil classification (Bourjac, from ICEM)

- Soil classification of Hainiang village



- Soil classification of XiengKiao village



Appendix 3: List of the target villages (Bourjac, 2017)

Village english	Village lao	SAEDA	CCL	CIRAD	TABI	HELVETAS	NCMI
Phosi	ບ. ໂພສີ						
Phonxai	ບ. ໂພນໄຊ						
Naphiang	ບ. ນາພຽງ						
Phonthan	ບ. ໂພນທັນ						
Hin	ບ. ຫີນ						
Ban	ບ. ບານ	X	X				X
Tong	ບ. ຕອງ						
Xang	ບ. ຊາງ		X				X
Kouay	ບ. ກວ້າຍ						
Chomthong	ບ. ຈອມທອງ						
Tatlouang	ບ. ຕາດຫຼວງ						
Moun	ບ. ມູນ	X					X
Phonkham	ບ. ໂພນຄຳ						
Bua	ບ. ບົວ						
Na-oung	ບ. ນາອຽງ	X	X		X		X
Hainiang	ບ. ໄຮ່ໜຽງ	X	X				x
Latnon	ບ. ລາດນ່ອນ						
Gnoumchong	ບ. ຍຸ້ມຈອງ						
Hip	ບ. ຮີບ						
Donkham	ບ. ດອນຄຳ						
Napa	ບ. ນາປາ						
Namhom	ບ. ນ້ຳຫອມ						
Phathang	ບ. ຜາທັ່ງ						
Houat	ບ. ຮວດ			X			
Fay	ບ. ຝ້າຍ	X	X				X
Laeng	ບ. ແລ້ງ			X	X		
Bouamlong	ບ. ບວມລອງ						
Namuang	ບ. ນາເມືອງ			X			
Namchak	ບ. ນ້ຳຈາກ						
Gnotkua	ບ. ຍອດກົ້ວ				X		
Viengkham	ບ. ວຽງຄຳ				X		
Phoumuang	ບ. ພູເມືອງ						
Xiengkiao	ບ. ຊຽງກ້ຽວ	X	X				X
Nathong	ບ. ນາທອງ	X					X
Xam	ບ. ຊາມ				X		
Natoum	ບ. ນາຕູມ						
Khaiviang	ບ. ໄຄ້ວຽງ						
Tha	ບ. ທ່າ						
Sanphan	ບ. ສັນພັນ						
Naxai	ບ. ນາໄຊ						
Naphan	ບ. ນາພັນ						
Sop-o	ບ. ສົບອໍ						
Namouan	ບ. ນາມວນ						
Samphanxai	ບ. ສຳພັນໄຊ				X		
Vangxong	ບ. ວັງຊ້ອງ						
Soumnaen	ບ. ສູມແຫນ				X		
Song	ບ. ສອງ				X		

Vieng	ບ_ ວຽງ				X		
Keoleuk	ບ_ ແກ້ວເລິກ						
Houayhon	ບ_ ຫ້ວຍຫອນ				X		
Sanfaen	ບ_ ສົບແຟນ				X		
Sanpho	ບ_ ສົບໂພ						
Sankham	ບ_ ສົບຄຳ						
Hatkham	ບ_ ຫາດຄຳ						
Gnotliang	ບ_ ຍອດລຽງ				X		
Souanmon	ບ_ ສວນມອນ						
Phiangdang	ບ_ ພຽງດ່າງ						
Sopthang	ບ_ ສົບທ້າງ						
Sopna	ບ_ ສົບນາ						
Soppeun	ບ_ ສົບເປີນ						
Phiangphang	ບ_ ພຽງພ້າງ						
Sankeo	ບ_ ສົບແກ້ວ						
Keohua	ບ_ ແກ້ວເຮືອ						
Kangkham	ບ_ ກາງຄຳ						
Phiangkhong	ບ_ ພຽງໂຄ້ງ						
Thaenchong	ບ_ ແທ່ນຈອງ						
Phahan	ບ_ ຜາຫານ						
Phonkham	ບ_ ໂພນຂາມ			X			
Phonhom	ບ_ ໂພນໂຮມ						
Namthoum	ບ_ ນ້ຳທຸ່ມ						
Phakok	ບ_ ຜາກອກ						
Sancho-tai	ບ_ ສົບຈໍໄຕ້						
Gnotpiat	ບ_ ຍອດປຽດ						
Xom	ບ_ ຊົມ						
Namuay	ບ_ ນາເໝືອຍ						
Kongiou	ບ_ ກົງວ	X	X				X
Thang	ບ_ ຖ້າງ						
Naphai	ບ_ ນາຜ່						
Nagnong	ບ_ ນາຍອງ	X	X				X
Phiangdi	ບ_ ພຽງດີ						
Phiangchan	ບ_ ພຽງຈັນ						
Dokkham	ບ_ ດອກຄຳ			X			
Bouamphiang	ບ_ ບວມພຽງ						
Phouhin	ບ_ ພູຫີນ				X		
Thsentho	ບ_ ແທ່ນໂທ						
Nanglouang	ບ_ ນາງຫຼວງ						
Houayphat	ບ_ ຫ້ວຍພັດ						
Nong-on	ບ_ ໜອງໂອນ						
Khangkhe	ບ_ ຄັງແຄະ						
Ngeo	ບ_ ແງ້ວ						
Phonchaeng	ບ_ ໂພນແຈ້ງ						
Kokhay	ບ_ ກົກຫາຍ				X		
Xay - Nadou	ບ_ ຊາຍ _ ນາດູ			X	X		
Phoxai	ບ_ ໂພໄຊ						
Mouangxai	ບ_ ມ່ວງໄຊ						
Do	ບ_ ດົ່				X		
Chomsi	ບ_ ຈອມສີ	X	X				X
Longpiou					X		

Appendix 4: List of key informants (Bourjac, 2017)

- Members of PAFO
- Governor of Peak district
- Vice head of Kham district
- Head of DAFO in Kham
- Team members of DAFO in Kham
- CCL team members
- TABI team members
- CIRAD team members
- Helvetas team member: Provincial advisor for the Luras project
- Head of Unit - Climate change and sustainable development at the Faculty of environmental sciences
- SAEDAE team members of Xieng Khuang districts and office
- Expert farmers for the SRS project

Appendix 5: Focus Group questionnaire (Bourjac, 2017)

VILLAGE CHARACTERISTICS

1 – Where are on a map the rivers, mountains, bottom-lands, roads, accommodations, the paddy areas?

2- Different crop systems in the village

Crop systems in the village	Name of the main crop + secondary crops	Upland / Lowland / Perennial	Main purpose (consumption of sale)	Total area in the village (ha)	Average yield main crop 2016 (kg/ha)	Maximum yield main crop 2016 (kg/ha)
3						
4						
5						
6						
7						
8						
9						

+ Which one is the main cropping system? + Do you know why ___ has the best yield?

+ Where are they located on a map?

2 – Different livestock in the village

Type of livestock	Buffalo	Cattle	Goat	Pig	Chicken	Fish pond	Other:	Other:	Other:
Total number									

3- Different income generating activities and level of importance

Activity	Cash crop income	Livestock income	Gift from family	Trade	Renting service	Other: Handicraft	Other:	Other:
Importance								
Number of HH								

4- How do you characterise a good/medium/poor soil condition (color, depth, stones, etc.)? Summarize key criteria.

Soil	BAD	MEDIUM	GOOD
Criteria			

+ Where are they located on a map?

5 - How do you characterise a good/medium/poor drainage condition?

Drainage	BAD	MEDIUM	GOOD
Criteria			

+ Where are they located on a map?

6- How do you characterise a good/medium/poor water access?

Water access	BAD	MEDIUM	GOOD
Criteria			

+ Where are they located on a map?

7 - How do you characterise a good/medium/poor paddy field (soil depth, color..., position in toposequence, distance to house, water, drainage...)?

Paddy field	BAD	MEDIUM	GOOD
Criteria			

+ Where are they located on a map?

8- How you characterise a good/medium/poor lowland rice crop year? (Pest, weed, weather (drought, flood), irrigation, techniques, prices, etc ...?)

Lowland rice crop year	BAD	MEDIUM	GOOD
Criteria			

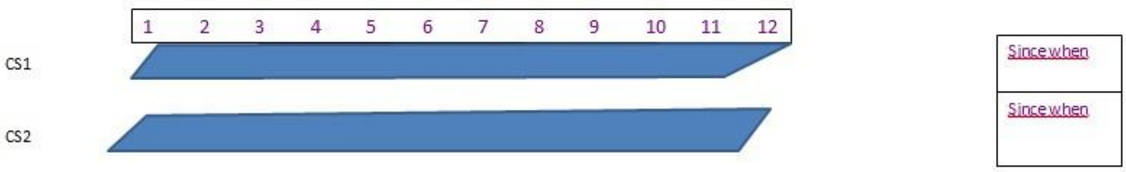
+ How would you characterise 2016: bad / medium or good? Good

+ What were the main constraints for rice cultivation in 2016? They didn't have any constraints

PADDY CHARACTERISATON

1- What are the different lowland rotation systems, including paddy rice, in the village?
   + Where they are located on a map?

Cropping calendar



2- What are the different paddy-rice cropping -systems in the village?

Paddy rice system (Lao name)	Type of seedbed – nursery (hay or na)	Transplantation (1) or direct sowing (2)	Number of transplantations	Characteristics of transplantation (density or spacing between plants, line transplanting or not, number of seedlings per hole)	Age of seedling when transplanted	Use of chemical products (fertilizer, herbicide, insecticide, etc.) Y/N	Drainage or not
1							
2							
3							
4							
5							
6							

+ Since when they are used? + How have they started?

+ Where can we find them in a map?

The last topics are simplified here in purpose of saving paper and space.

3- Type of associations

4- Type of varieties in the village

5- Type of irrigation
6- Type of pests in paddy-rice field in the village
7- Type of fertilisation used
8- Type of herbicide
9- Material used
10- History of SRI/SRS in the village
- Where are their plots located on the map?

Who is performing well SRS?	**Reasons for success?**	**Who was performing bad SRS and had to stop?**	**Reasons for failure?**

Appendix 6: Household survey (Bourjac, 2017)

ລຳດັບ	ຊື່ ຫົວໜ້າ ຄອບຄົວ	ຈຳນວນອຸປະກອນຮັບໃຊ້						ລາຍຮັບ (ເປັນລ້ານກີບ)								ທົ່ງນາ	
								ການກະສິກຳ ປ່າໄມ້ ລ້ານ				ການຄ້າ ແລະ ການບໍລິການ					
		ໂທລະທັດ	ໂຮງສີ	ລົດຈັກ	ລົດໄຖ ເດີນຕາມ	ລົດໄຖໃຫຍ່	ລົດ/ລົດ ບັນທຸກ	ຜປດ (ລ້ານ)	ເຂົ້າ (ລ້ານ)	ພືດສິນຄ້າ (ລ້ານ)	ສັດລ້ຽງ (ລ້ານ)	ອຸປະກອນ ຮັບໃຊ້ (ລ້ານ)	ຄ້າຂາຍ (ລ້ານ)	ຮັບຈ້າງ ເງິນເດືອນ (ລ້ານ)	ອື່ນໆ	ເຈົ້າເຮັດນາແບບກ້າກົບດ	ມີເນື້ອທີ່ຫຼາຍປານໃດ
No	Name	TV	Rice mill	Motorcycle	Hand tractor	Big tractor	Car/truck	NTFP inc (million Lak)	Rice inc (million Lak)	Cash crop inc (million Lak)	Livestock inc (Lak)	Renting services (Lak)	Trade (million Lak)	Daily wage, salary (million Lak)	Other (million Lak)	SRI/SRS (yes/no)	SRI/SRS surface (m^2)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

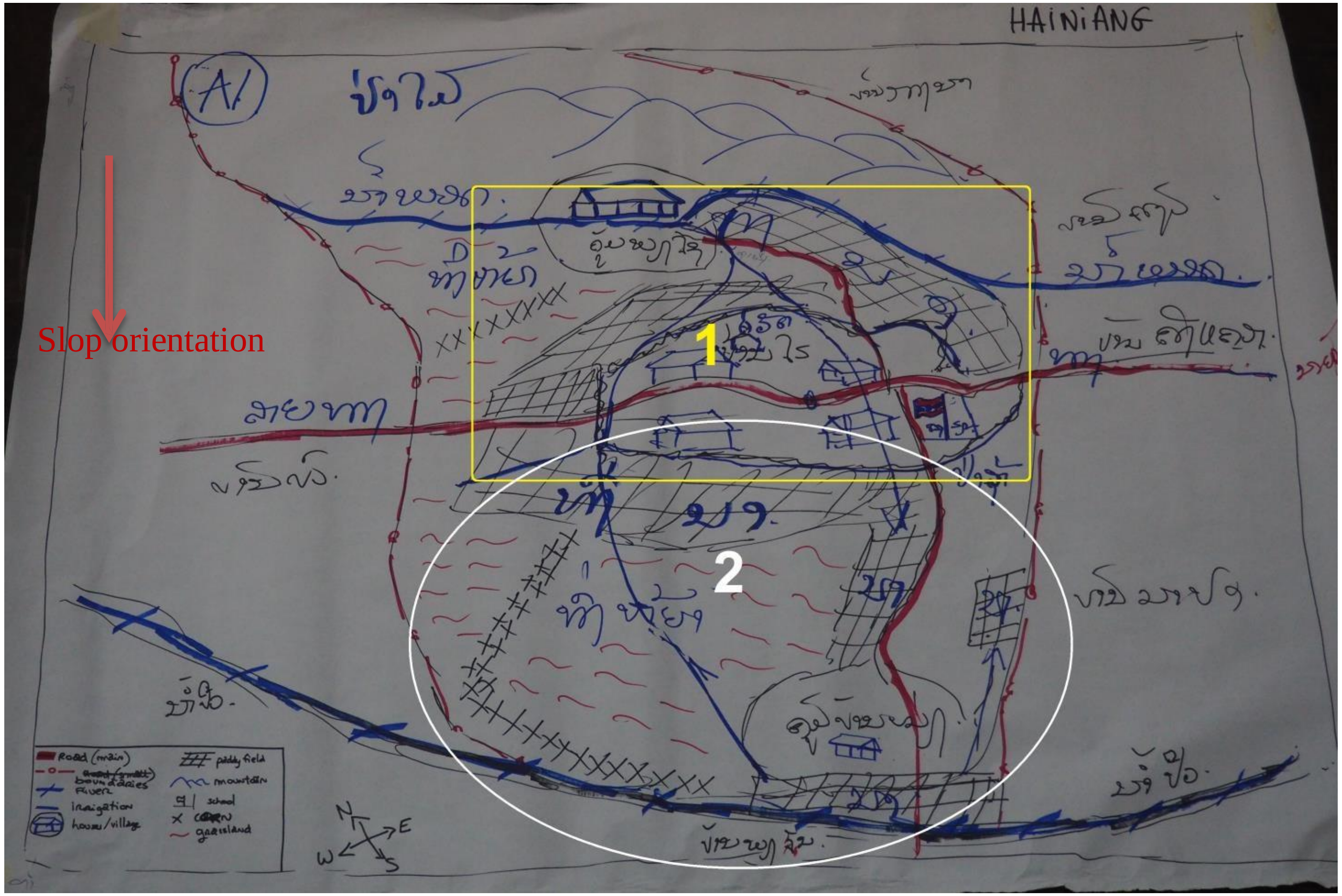
Information about the name, the main duty, the status, the number of household members, the number of women, the number of labor force, the paddy/maize/upland rice / perennial crops/ vegetables respective acreage and production and the cattle owned (buffalo, cattle, goat, pig, poultry, fish pond) were also asked

Appendix 7: List of interviewees (Bourjac, 2017)

HAINIANG		XIENGKIAO	
ID	Type of plot	ID	Type of plot
H30	multi-seedling	XK79	
H63	multi-seedling	XK1	multi-seedling
H22-1	multi-seedling	X40	multi-seedling
H22-2	SRS	XK5	multi-seedling
H36	multi-seedling	XK39	multi-seedling
H41	multi-seedling	XK46	multi-seedling
H14-1	multi-seedling	XK32	multi-seedling
H14-2	SRS	XK74	multi-seedling
H79	multi-seedling	XK10-1	multi-seedling
H45	multi-seedling	XK10-2	SRS
H47	SRS	XK4	SRS
HA	SRS	XK49	SRS
HK	SRS	XK31	SRS
H61	SRS	XK26	SRS
H8	SRS	XK19	SRS
H60	SRS	XK52	SRS
H54	SRS	XK23	SRS

31 households → 34 plots

<u>*Appendix 8: Hainiang Zoning (Bourjac, 2017)*</u>



Zoning of Hainiang village as a result of the focus group conducted.

The zone 1 corresponds to the zone with the better conditions for cropping rice.

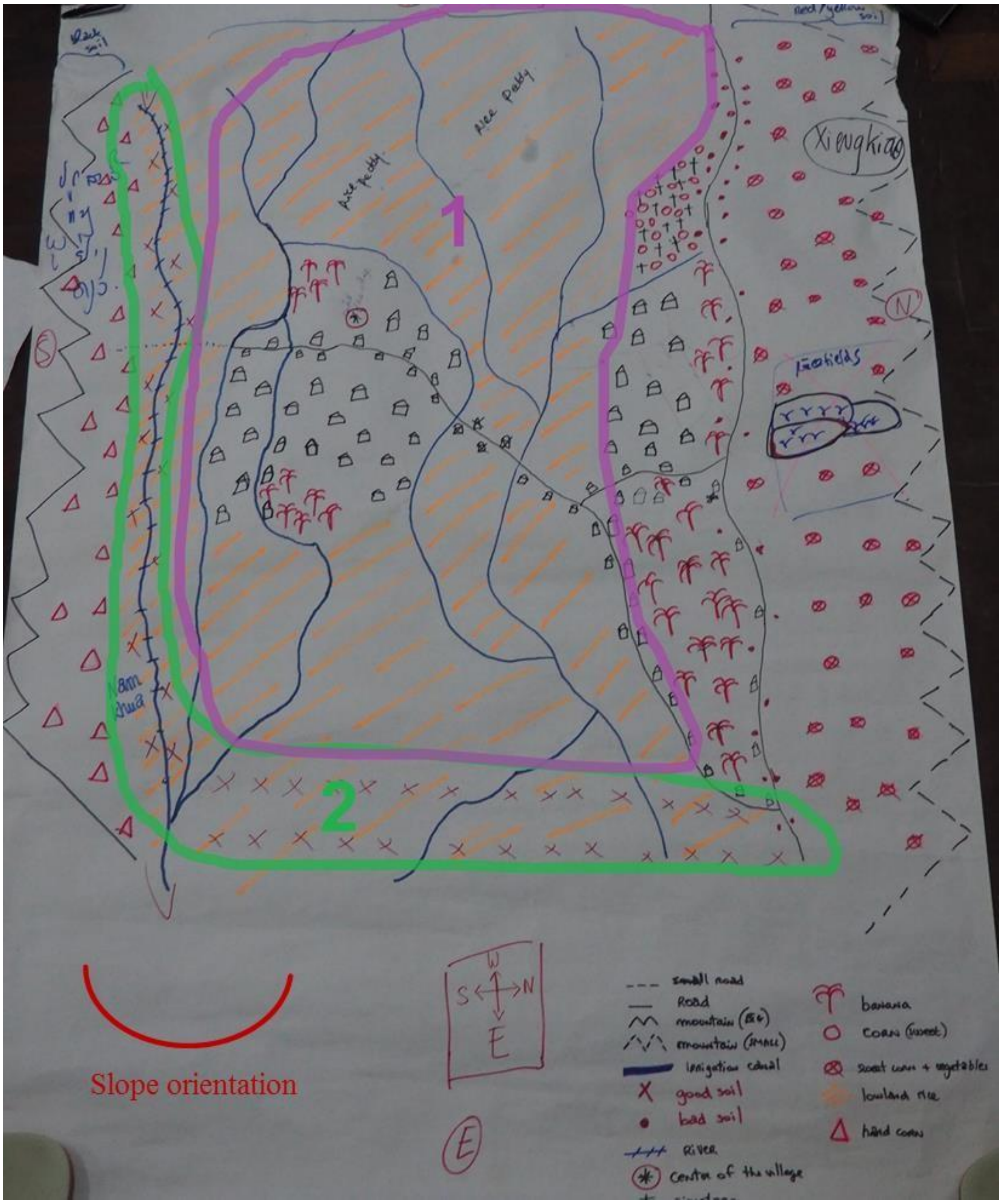
The zone 2 corresponds to the zone with the worst conditions for cropping rice.

A satellite map of each zone with the interviewed farmers' repartition can be found on the following pages of the Appendix.

Zone 1 of Hainiang village and localization of the farmers interviewed

Zone 2 of Hainiang village and localization of the farmers interviewed

Appendix 9: Xieng Kiao Zoning (Bourjac, 2017)

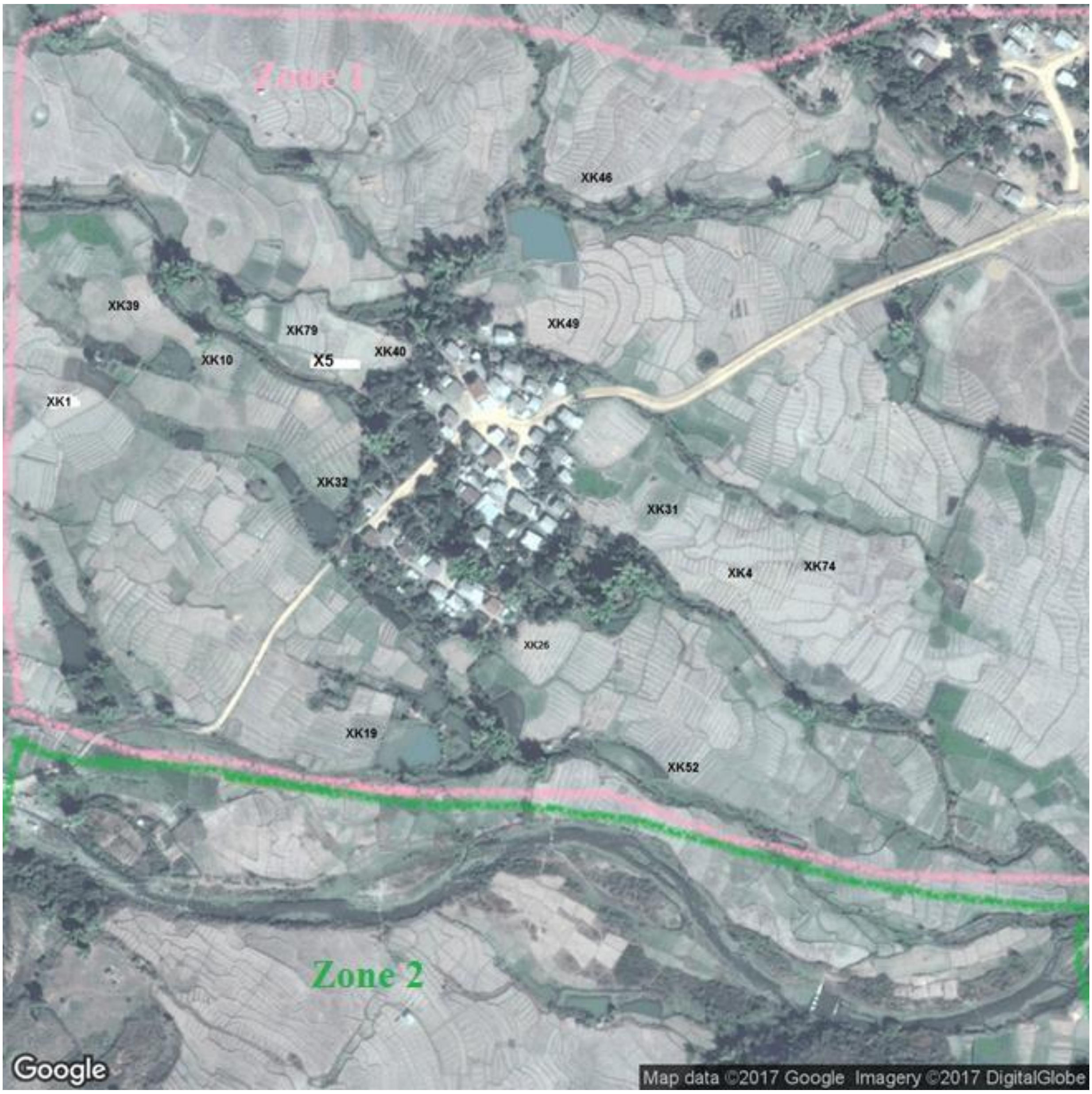


Zoning of XiengKiao village as a result of the focus group conducted.

The zone 1 corresponds to the zone with the better conditions for cropping rice. The zone 2 corresponds to the zone with the worst conditions for cropping rice.

A satellite map of the village with the farmers repartition can be found on the following pages of the Appendix

Zones of Xieng Kiao village and localisation of the farmers interviewed



Appendix 10: Individual interviews for technical itinerary description at plot level (bourjac, 2017)

Questionnaire characterisation of rice cropping systems – farmers

➢ **Presentation of the informant**

- Name: Nickname: ID No:
- Name of HH head: gender: age: education:
- Name of spouse HH head: gender: age: education:

- Total area of the farm (ha): - Total paddy area (m2):

- Total paddy rice production 2016 (kg): Quantity of rice production sold (kg):

- How many months for consumption:

- How many paddy rice varieties? What are their names?

- **How many rotation systems:**

Type of crop	NO	YES	Date of sowing	Date of harvest
1 season rice				
Spring crop				
Winter vegetables				
Winter grassland for livestock				
Other:				

Rice cropping system 2016 in the one plot selected

Name of the plot				
Type of the rice cropping system				
Cultivar used				
Size of the area (m²)				
Type of ricefield	Na non Na loum Upland	Na non Na loum Upland	Na non Na loum Upland	Na non Na loum Upland
Description of the soil	Good Medium Bad	Good Medium Bad	Good Medium Bad	Good Medium Bad
Description of the topography	Flat Mountainous	Flat Mountainous	Flat Mountainous	Flat Mountainous
Type of water access	Irrigation River Rain	Irrigation River Rain	Irrigation River Rain	Irrigation River Rain
Capacity of drainage (= ability to remove water or not)	Good Medium Bad	Good Medium Bad	Good Medium Bad	Good Medium Bad
Transplantation	One Two	One Two	One Two	One Two
Seedbed	Hay Na	Hay Na	Hay Na	Hay Na
Age of seedling				
Number of seedling in one hole	One Less than 3 More than 3	One Less than 3 More than 3	One Less than 3 More than 3	One Less than 3 More than 3
Fertiliser	Organic Chemical	Organic Chemical	Organic Chemical	Organic Chemical
Herbicide	Organic Chemical	Organic Chemical	Organic Chemical	Organic Chemical
Pesticide	Organic Chemical	Organic Chemical	Organic Chemical	Organic Chemical

- Plot characteristics

Name of the paddy cropping system: Area of the plot (m²):
One block or several:
Since when do you do same technique than in 2016?

	Good	Medium	Low
Situation in the village			
Water access			
Drainage capacity (= capacity to remove water or not)			

	Colour	Deepness	Sand	Rock
Soil description	Red Yellow Black Grey Other	Less than 20cm More than 20cm	None Few A lot	None Few A lot

- Crop succession

Name of crop	Date of sowing	Date of harvest	Quantity produced (kg)
Chili			
Garlic			
Sweet Corn			
Rice			
Grassland			
Other			

SEEDBED OPERATION	Family work force + Exchange labour				Wage labor	Tool used	Input used	Quantity (precise the unite)	Price (in LAK /unit)
	Women Number	Men Number	Children number	Time of work (day)	Time of work (Men / Day)				
SEE BED Ploughing (NP1a)									
Ploughing (NP2a)									
Harrow (Ha)									
Fertilizer (NFa) - chemical - Menure									
Weeding (NWa)									
Sowing (Sa) Rice seed									
Other (NOa)									
Use of pesticide (NPa)									
SAM Ploughing (NP1b)									
Ploughing (NP2b)									
Harrow (NHb)									
Fertilizer (NFb - chemical - Menure									
Weeding (NWb)									
Use of pesticide (NPb)									
Sowing (NSb)									
Other (NOb)									

PLOT OPERATION		Family work force + Exchange labour				Wage labor	Tool used	Input used	Quantity (precise the unite)	Price (in LAK /unit)
		Women N°	Men N°	Children N°	Time of work (day)	Time of work (in MD)				
Ploughing (P1)										
Ploughing (P2)										
Harrow (H)										
Repair dyke (RD)										
Repair/ clean irrigation (I)										
Fertilizer (F) - chemical - Menure										
Withdraw (WD)										
Seedling transport (ST)										
Transplantation (T)										
Weeding (W)	W1									
	W2									
	W3									
Use of pesticide (P)										
Harvest (Ha)										
Milling (M)										
Other (O2)										

Date : Id N° :

Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sept				Oct				Nov				Dec			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

Seed selection		Transplantation		Water Management		Material used		After harvest	
Origin	Own field ☐ Bought ☐ Hybrid ☐	Scale	No ☐ Yes ☐ Which size:	High of water when transplanting (cm)	Less 10 ☐ 10 ☐ More 10 ☐	Mechanical	Yes ☐ No ☐	Purpose of the rice	Eat ☐ Sale ☐
Salty water	Yes ☐ No ☐	Aligned	Yes ☐ No ☐	Remove water from the plot	Yes ☐ No ☐ When ☐	Origin	Own ☐ Neighbour ☐ Relative ☐	Reuse of waste	Yes ☐ No ☐
Number of days in water after		Tool used	None ☐ ☐	High of water during cycle				If yes, how?	
Technique of sowing in seeded	Broadcast ☐ Sewed ☐	Quantity transplanted (kg)		High of water in seedbed					
Quantity sowed (kg) / ha		Deepness of transplanting (cm)							

Appendix 11: Questionnaires for assessing SRS dissemination and adoption (bourjac, 2017)

Questionnaires for SRS adopters

- **Presentation of the informant**

- Name:

Village name:

ID No:

- **History, reasons and way to do KKD**

➤ When did you hear about KKD for the first time?

➤ How have you heard about it the first time?

Relative ☐ SAEDA ☐ DAFO ☐ CCL ☐ Workshop ☐ Other ☐

➤ What was your first thought about KKD when your first hear about it?

➤ In what year have you started to crop KKD?

➤ What convinced you to start cropping KKD?

- SAEDA says ☐
- What another organisation said ☐
- CCL says ☐
- Saw on someone else field that it is good ☐
- DAFO says ☐
- Other reason

➤ What was the main motivation for you to change to KKD?

➤ M² of the surface in KKD when started:

➤ Why this surface?

➤ M² of the surface in KKD in 2016: M² of the total paddy area in 2016:

➤ Why not in all the area?

➤ Did you get some help to implement KKD? From who?

➤ What cropping system did you do before KKD?

Kha Sam ☐ Kha Pong ☐

➤ When you started cropping KKD, did you try to implement SAEDA principles?

➤ If there are some steps that you do differently, why do you think it is better for you?

➤ What evolutions have you done since you started the KKD? Why?

-

-

- **Effects of KKD**

➤ Order of importance of benefits / disadvantages of KKD

	BENEFIT	DISADVANTAGE	ORDER OF IMPORTANCE
Time spent in the field			
Quantity of labour			
Quantity of input used			
Biodiversity in the field			
Pest management			
Weed management			
Water management			
Soil fertility			
Quality of the rice when eaten			
Quantity when harvest			
Lost after harvest			
Risk by doing this technique compare to other			
Price of the product when sold			
Technicity			

➤ Strength of conviction about KKD?

1: I feel only benefits

2: I feel benefits stronger than disadvantages

3: I feel benefits and disadvantages almost the same

➤ Have you shared this technique with someone else?

➤ If yes, how have you done?

Talking with friends or family ☐

Presentation during workshop ☐

People went to see on the field ☐

Other ☐

- Approximately to how many people?

- Where? Village / District / Province

Questionnaires for SRS dis-adopters

Questionnaire farmers who stopped KKD

- **Presentation of the informant** Village name:

- Name: ID No:

- **History, reasons and way to do KKD**

➤ When did you hear about KKD for the first time?

➤ How have you heard about it the first time?

Relative ☐ SAEDA ☐ DAFO ☐ CCL ☐ Workshop ☐ Other ☐

➤ What was your first think about SRS when your first hear about it?

➤ In what year have you started to crop KKD?

➤ When did you stop KKD?

➤ What convinced you to start cropping KKD?

- What SAEDA says ☐ - What another organisation said ☐
- What CCL says ☐ - Saw on someone else field that it is good ☐
- What DAFO says ☐ - Other reason ☐

➤ What was the main motivation for you to change to KKD?

➤ M² of the surface in KKD when started:

➤ Why this surface?

➤ Why not in all the area?

➤ Did you get some help to implement KKD? From who?

➤ When you started cropping KKD, did you try to implement SAEDA principles?

➤ If there is some that you did differently, why do you think it is better for you?

➤ What evolutions have you done when you were doing KKD? Why?

-
-
-

➤ What cropping system did you do before KKD?

Kha Sam ☐ Kha Pong ☐

➤ What cropping system do you do since you have stopped KKD?

Kha Sam ☐ Kha Pong ☐

➤ Why do you do this system?

- **Effects of KKD**

	BENEFIT	DISADVANTAGE	ORDER OF IMPORTANCE
Time spent in the field			
Quantity of labour			
Quantity of input used			
Biodiversity in the field			
Pest management			
Weed management			
Water management			
Soil fertility			
Quality of the rice when eaten			
Quantity when harvest			
Lost after harvest			
Risk by doing this technique compare to other			
Technicity			

➤ Order of importance of benefits / disadvantages of KKD

➤ So what was the main reason for you to stop KKD?

➤ Strength of conviction about KKD?

1: I felt only benefits
2: I felt benefits stronger than disadvantages
3: I felt benefits and disadvantages almost the same
4: I didn't felt benefits

➤ Do you know other farmers who have the same main issue but continued to do KKD?

➤ If yes, do you know why they are able to continue and you aren't?

➤ Have you tried to solve this problem before to stop KKD? If yes, how?

➤ Have you shared this technique with someone else?

➤ If yes, how have you done? - Approximately to how many people?

Talking with friends or family ☐
Presentation during workshop ☐ - Where? Village / District / Province
People went to see on the field ☐
Other ☐

➤ Would you like to start KKD again?

➤ What would you need for that?

Questionnaire for SRS non-adopter

- **Presentation of the informant** Village name:

- Name: ID No:

- **History, reasons and way to do KKD**

➤ When did you hear about KKD for the first time?

➤ How did you hear about it the first time?

Relative ☐ SAEDA ☐ DAFO ☐ CCL ☐ Workshop ☐ Other ☐

➤ What was your first think about SRS when your first hear about it?

➤ What does interest you in KKD?

➤ What doesn't interest you in KKD?

➤ Have you ever wanted to try KKD?

➤ If yes, why you never tried?

➤ Would you like to try now?

➤ If yes, what condition would you need for it?

➤ Why did you choose to do the system you do know?

➤ Have you ever tried another rice cropping system than the one you do?

➤ If yes, what interested you in it?

➤ If yes, why you haven't continued to do it?

➤ What criteria are the more important for you when doing rice cropping system?

	Order of importance
Time spent in the field	
Quantity of labour	
Quantity of input used	
Biodiversity in the field	
Pest management	
Weed management	
Water management	
Soil fertility	
Quality of the rice when eaten	
Quantity when harvest	
Lost after harvest	
Risk by doing this technique	
Price of the product when sold	
Technicity	

Appendix 12: Data for the socio technical calculations (Bourjac, 2017)

Socio economical performances "1 seedling"	**XK49**	**XK31**	**XK26**	**XK52**	**XK23**	**XK10-2**	**HA**	**HK**	
Plot acreage (ha)	1,00	0,30	0,46	0,30	0,20	0,60	0,30	0,30	
Yield (ha)	5 225,00	6 666,67	6 358,70	7 500,00	5 475,00	3 975,00	6 750,00	8 000,00	
Man-day (women)	46,00	36,67	19,57	65,00	25,00	20,83	46,67	76,67	
Man-day (total)	78,75	94,94	64,32	114,16	68,47	186,91	129,01	170,65	
Production Cost (Lak)	394 000,00	303 333,33	202 173,91	390 000,00	270 000,00	523 333,33	600 000,00	2 753 333,33	**Averages**
Gross Product (Lak)	18 287 500,00	23 333 333,33	22 255 434,78	26 250 000,00	19 162 500,00	13 912 500,00	23 625 000,00	28 000 000,00	0,54
Added Value (Lak)	17 893 500,00	23 030 000,00	22 053 260,87	25 860 000,00	18 892 500,00	13 389 166,67	23 025 000,00	25 246 666,67	
Return on labour (Lak/day)	227 219,05	242 562,90	342 893,36	226 521,97	275 937,20	71 634,94	178 475,20	147 946,20	6 116,23
Land's productivity (Lak/ha)	1 789,35	7 676,67	4 794,19	8 620,00	9 446,25	2 231,53	7 675,00	8 415,56	82,52
Manure quantity used (kg) (ha)	150,00	133,33	108,70	333,33	0,00	166,67	466,67	33,33	123,86
Chemical quantity used (kg) (ha)	0,00	1,25	0,00	0,00	0,00	0,00	0,00	181,82	1 969 267,15
	H61	**H8**	**H60**	**H54**	**H22-2**	**H14-2**	**H47**	**XK19**	21 406 797,50
Plot acreage (ha)	0,90	0,20	0,60	0,20	0,50	0,90	1,00	0,40	19 437 530,35
									190 991,85
Yield (ha)	4 833,33	3 150,00	6 666,67	4 600,00	7 650,00	3 055,56	5 200,00	6 637,50	5 114,83
Man-day (women)	76,67	230,00	92,50	240,00	148,40	27,94	45,00	40,83	215,39
Man-day (total)	118,43	90,51	168,61	162,00	184,60	46,68	97,02	82,92	119,78
Production Cost (Lak)	556 666,67	6 015 000,00	6 378 333,33	3 750 000,00	4 126 000,00	113 333,33	1 386 000,00	1 777 500,00	
Gross Product (Lak)	16 916 666,67	11 025 000,00	23 333 333,33	16 100 000,00	26 775 000,00	10 694 444,44	18 200 000,00	23 231 250,00	
Added Value (Lak)	16 360 000,00	5 010 000,00	16 955 000,00	12 350 000,00	22 649 000,00	10 581 111,11	16 814 000,00	21 453 750,00	
Return on labour (Lak/day)	138 134,93	55 356,06	100 559,74	76 233,76	122 692,31	226 661,00	173 310,43	258 738,69	
Land's productivity (Lak/ha)	1 817,78	2 505,00	2 825,83	6 175,00	4 529,80	1 175,68	1 681,40	5 363,44	
Manure quantity used (kg) (ha)	0,00	225,00	0,00	0,00	1 200,00	388,89	0,00	25,00	
Chemical quantity used (kg) (ha)	0,00	180,00	503,75	210,00	0,00	0,00	431,43	288,46	

Socio economical performances "Multiple-seedlings"	XK79	XK1	X40	XK5	XK39	XK46	XK32	XK74	XK10-1	
Plot acreage / ha	0,54	0,80	0,25	0,60	0,52	0,30	0,30	0,75	0,70	
Yield (ha)	2 962,96	4 050,00	6 400,00	4 333,33	4 326,92	5 000,00	5 000,00	4 586,67	2 764,29	
Man-day (women)	32,41	80,00	133,00	59,44	90,38	130,00	105,56	74,92	20,00	
Man-day (total)	85,34	197,05	197,35	106,03	173,63	234,72	225,58	148,71	110,25	
Production Cost (Lak)	729 629,63	113 750,00	518 400,00	155 000,00	1 367 307,69	1 046 666,67	390 000,00	72 000,00	1 980 000,00	
Gross Product (Lak)	10 370 370,37	14 175 000,00	22 400 000,00	15 166 666,67	15 144 230,77	17 500 000,00	17 500 000,00	16 053 333,33	9 675 000,00	
Added Value (Lak)	9 640 740,74	14 061 250,00	21 881 600,00	15 011 666,67	13 776 923,08	16 453 333,33	17 110 000,00	15 981 333,33	7 695 000,00	Averages
Return on labour (Lak/day)	112 969,26	71 357,50	110 877,12	141 582,39	79 348,73	70 098,70	75 847,80	107 468,84	69 792,90	0,61
Land's productivity (Lak/ha)	1 785,32	1 757,66	8 752,64	2 501,94	2 649,41	5 484,44	5 703,33	2 130,84	1 099,29	
Manure quantity used (kg) (ha)	0,00	0,00	0,00	58,33	0,00	0,00	0,00	0,00	0,00	4 916,61
Chemical quantity used (kg) (ha)	187,04	0,00	24,00	0,00	211,54	26,67	13,33	17,33	0,00	71,41
	H30	H63	H22-1	H36	H41	H14-1	H79	H45	XK4	153,73
Plot acreage / ha	0,70	1,10	0,70	1,40	0,80	0,50	1,00	0,30	0,40	968 818,73
										17 208 132,91
Yield (ha)	7 071,43	6 545,45	5 785,71	6 847,14	5 000,00	6 300,00	6 400,00	6 666,67	3 375,00	16 239 314,18
Man-day (women)	75,91	90,00	67,14	36,25	61,25	150,00	43,64	84,46	22,50	111 609,86
Man-day (total)	204,88	146,75	171,45	64,15	111,43	269,89	134,49	210,58	128,58	3 156,78
Production Cost (Lak)	257 142,86	750 909,09	715 714,29	859 285,71	4 783 750,00	1 500 000,00	2 063 000,00	340 000,00	765 000,00	18,33
Gross Product (Lak)	24 750 000,00	22 909 090,91	20 250 000,00	23 965 000,00	17 500 000,00	22 050 000,00	22 400 000,00	23 333 333,33	11 812 500,00	113,46
Added Value (Lak)	24 492 857,14	22 158 181,82	19 534 285,71	23 105 714,29	12 716 250,00	20 550 000,00	20 337 000,00	22 993 333,33	11 047 500,00	
Return on labour (Lak/day)	119 550,25	150 989,38	113 936,44	360 172,58	114 120,19	76 143,34	151 220,52	109 188,76	85 922,61	
Land's productivity (Lak/ha)	3 498,98	2 014,38	2 790,61	1 650,41	1 589,53	4 110,00	2 033,70	7 664,44	2 761,88	
Manure quantity used (kg) (ha)	0,00	0,00	0,00	0,00	0,00	0,00	240,00	0,00	50,00	
Chemical quantity used (kg) (ha)	378,57	322,73	428,57	55,00	76,25	0,00	168,00	196,67	50,00	