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Final dissertation

Presented in order to obtain Engineering Master's Degrees
Domain: Sustainable agricultural and food systems for the south, and
Agronomic Engineering
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Year of defense: 2023

Final dissertation prepared under
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Defended on: 12/10/2023

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RESUME

Titre: Les processus de prise de décision des agriculteurs et leurs liens avec les projets de réhabilitation des *prek* dans la plaine inondable du Mékong

La prise de décision des agriculteurs dans la plaine du Mékong au Cambodge a été peu étudiée. Un élément distinctif de cette plaine est la présence de *preks*, des canaux utilisés pour l'irrigation et le drainage. Depuis les années 1990, des initiatives de réhabilitation de ces infrastructures ont été lancées, visant à améliorer l'irrigation pendant la saison sèche. L'eau est considérée comme le facteur limitant du développement agricole. L'objectif est de mieux comprendre les processus décisionnels des agriculteurs et d'identifier les facteurs qui les influencent. Premièrement, une revue de la littérature a été réalisée pour mettre en évidence les principales décisions et les facteurs pertinents à étudier. Secondement, des enquêtes ont été menées auprès des agriculteurs au sud de la province du Kandal où des projets de réhabilitation sont en cours. Puis, les résultats ont été présentés aux enquêtés. Troisièmement, une typologie a été élaborée pour l'analyse. Il est ressorti que, quel que soit le type, le marché est le facteur déterminant dans le choix des cultures. De même, les décisions concernant les fertilisants/pesticides sont principalement influencées par le marché, bien que la croissance des cultures joue un rôle. Pour l'irrigation en saison sèche, la disponibilité en eau est cruciale pour l'intensification agricole. Cependant, l'impact de ce facteur varie d'un agriculteur à l'autre. Ceux dont les revenus dépendent de l'agriculture ont tendance à s'intensifier. En revanche, les agriculteurs dont les revenus proviennent d'autres sources ne modifient généralement pas leurs pratiques agricoles. Une dernière section examine les biais et les limites de la recherche.

Mots clés

Agriculture, Système de culture, Typologie des ménages, Prise de décisions, Choix agricoles, Eau, Marché, Environnement de la ferme, Delta du Mékong, *Prek*, Réhabilitation

ABSTRACT

Title: Decision-making processes of farmers and their links with *prek* rehabilitation projects on the Mekong's floodplain

Farmers' decision-making processes on the Mekong floodplain in Cambodia has been little studied. A distinctive feature of this plain is the presence of *preks*, canals used for irrigation and drainage. Since the 1990s, initiatives have been launched to rehabilitate these infrastructures, with the aim of improving irrigation during the dry season. Water is considered to be the limiting factor in the development of agriculture. The aim of this study is to gain a better understanding of farmers' decision-making processes and to identify the factors that influence them. Firstly, a literature review was carried out to highlight the main decisions and relevant factors to be studied. Secondly, surveys were carried out among farmers in an area where rehabilitation projects are underway. Then, results were presented to the interviewees. Thirdly, a typology was made for the analysis. It emerged that, whatever the type, market is the determining factor in the choice of crops. Similarly, fertilizer and pesticide decisions are mainly influenced by the market, although crop growth play also a role. For dry-season irrigation, water availability is crucial for agricultural intensification. However, the impact of this factor varies from one farmer to another. Farmers whose income depends on agriculture tend to intensify. On the other hand, farmers whose income comes from other activities generally do not change their farming practices. A final section examines the biases and limitations of the research.

Key words

Agriculture, Farming system, Household typology, Decision-making, Farming choices, Water, Market, Farm environment, Mekong Delta, *Prek*, Rehabilitation

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FOREWORD

This document outlines the internship project of Louise Auger and Elsa Ribes, both of Engineering Master's degree students, respectively in Sustainable Agricultural and Food Systems for the south, and in Agronomic Engineering. Both followed the same option: Resources, Agricultural Systems and Development (RESAD) provided by the **Institute Agro Montpellier**.

They found their internship through an unsolicited application. Hosting institutions are the **French National Research Institute for Sustainable Development (IRD)** and the **Joint Research Unit (JRU) Water Management, Actor, Territories (JRU G-eau)**. IRD's activities are characterized by a broad range of fields: ocean resources, earth system, health, societies and biodiversity. Its main mission is to generate scientific knowledge centered on the intertropical and Mediterranean zone. JRU G-eau gathers researchers from different disciplines that work on integrated and adaptive water management issues.

There are four supervisors, two of them research supervisors, the other two academic advisors. Regarding the research supervisors, they are:

- Dr. Jean-Philippe Venot: initial training in agronomic science, PhD in Human Geography and research activities coupling anthropology of development, science and technology studies, and political ecology (JRU G-eau).
- Dr. Christina Orieschnig: initial training in ecology and civil engineering, PhD in eco-hydrological modelling (defended in 2022), modelling irrigation water management in the **Cambodian Mekong delta**, currently at post-doctoral level.

Regarding the academic advisors, they are:

- Dr. Frédéric Rossel: research training and innovation engineer, initial training in water science and technology, PhD in hydrology and climatology (JRU G-eau).
- Marie-Jeanne Valony: educational engineer, initial training in agronomic science (Joint Research Unit called knowledge, environment, societies (JRU SENS)).

GLOSSARY

BACI: data on bilateral trade flows for 200 countries for 5,000 products.

Boeung: means “lake” in Khmer. Area that is flooded temporarily every year, usually rice is grown.

Chamkar: means “farmland” in Khmer. Area that is rarely flooded, usually maize, fruit trees or vegetables are grown.

Choice: in the report, a choice is an option of a decision.

Constraint: a decision becomes a constraint when the farmer cannot make any choices on it. For instance, farmers must harvest before the flood. Here the harvest is a constraint and not a decision.

Decision: in the report a decision relates to a major choice regarding agricultural activities. For instance, a decision can be taken regarding the main tasks of technical itinerary (crop choice, irrigation choice, fertilizer application choice and pesticide choice).

Factor: something external to the farmers, influencing his/her decisions. Farmers cannot change the dynamics of factors. They do not have any impact on it.

Middle buyers: intermediaries in the value chain, who buy from farmers. They are distributors that will sell to retailers / companies / wholesalers or to other distributors, themselves selling to retailers.

Possession: a land status established during the French protectorate, which requires fewer legal steps than ownership.

Plot: a land unit cultivated by farmers. There can be subplots, and different cropping systems on the same plot.

Prek: earthen canals that are specific to the Cambodian part of the Mekong delta. They are used for irrigation, drainage, transportation, and ecosystem services.

Tool or toul: area which is higher than most parts of the fieldwork area. Vegetables are grown here. It does not mean all the plots have higher elevations, it can present low plots, also flooded.

ABBREVIATIONS AND ACRONYMS

AFD: French Development Agency

CC: Cultivation Costs

CP: *Charoen Pokphand*

DS: Dry Season

EROS: Earth Resources Observation and Science center

FE: Flooding Events

GAP: Good Agricultural Practices

IRD: French National Research Institute for Sustainable Development

JRU: Joint Research Unit

NC: Number of Cycles

PRK: Communist People's Republic of Kampuchea government

RS: Rainy Season

RCEP: Economic Partnership Agreement

SD: Sowing Date

SRTM: Shuttle Radar Topography Mission

VC: Village Chiefs

WS: Water Seller

INTRODUCTION

The Mekong River begins in China and ends in Vietnam. Cambodia is part of the Lower Mekong Basin, as are Laos, Thailand, and Vietnam. The Mekong plain in Cambodia is the beginning of the delta, which goes on to Vietnam. One of the major particularities of the region is the annual flood, which takes place from July to October. This is why it is called the Mekong floodplain. Moreover, this area presents the highest population density in Cambodia. Regarding food security issues, farming is one of the main development stakes. It explains why it is a key area for development projects, such as those by the French Development Agency (AFD). Technical studies have been carried out, and still are. However, some approaches remain missing, such as studying how farmers make their decisions, the key factors explaining them, and which choices they make.

The fieldwork area is a restricted perimeter of 42km², 50 km south of Phnom Penh, and 12 km north of Vietnam. There are major hydraulic infrastructure elements called *preks*. *Preks* are irrigation and drainage channels, which also receive sediments during flooding events. Regarding ecological and hydrological stakes, an eco-hydrological model of the area has been created by Orieschnig in 2022. In order to give perspective to her work, there are motivations to understand to what extent **water resources** play a role in **farmers' decisions**. As it is linked to hydraulics and irrigation, there is a major focus on crops, not so much on livestock. As farmers are the ones making decisions, the study is conducted at a farm scale. This approach aims to use larger-scale information to have a better understanding of some key factors and create links with farmers' perceptions.

Besides, the AFD manages *prek* rehabilitation in the fieldwork area as part of the Wat4Cam project. In this case, *prek* rehabilitation usually implies digging and deepening channels. Other infrastructure elements can also be added, such as gates or roads along *preks*. These are major changes impacting water resources, which can have an impact on farmers' decisions. This study is also an opportunity to give perspective on how these changes are relevant for farmers, or if other factors are important to consider.

Consequently, the study is focused on two main research questions:

1. Which factors influence the main choices of farmers regarding their agricultural practices?
2. To which extent will improving water availability through rehabilitating *preks* lead to changes in farmers' decision and agricultural intensification?

The goal of the literature review is to understand which approaches and methodologies can be used in order to collect the information needed to understand decision making processes. Then, contextual information provides a better idea of factors influencing farmers' decision and how they can impact them. Both reviews help to build a proper methodology, adapted to concepts and practical data. It introduces how results are made, and how they are organized. Methodology and results provide materials for the discussion, regarding limits and bias. Then further avenues of work provide a perspective before concluding on the study.

A photograph of a dirt path in an orchard. The path is flanked by rows of trees with dense green foliage. Sunlight filters through the leaves, creating dappled shadows on the ground. In the distance, a person is visible, standing near a white sack and a wooden crate. The overall scene is bright and natural.

LITERATURE REVIEW ON DECISION-MAKING PROCESSES

CONCEPTUAL ASPECTS ON DECISION-MAKING PROCESSES

DECISIONS FARMERS CAN TAKE REGARDING THEIR CROPPING SYSTEMS AND THEIR FARM

Decision-making processes related to *prek* rehabilitation imply a special focus on crop production, as cattle-breeding is not the main use of water. There are several definitions of what a decision is.

A decision is a process of adjusting practices or processes to moderate or offset damages created by a given change (Brooks and Adger 2005, Martin 2015 in Robert *et al.*, 2016). It can also be defined as a capacity to change regarding hazards and stresses (Ingrand *et al.* 2009; Dedieu and Ingrand 2010 in Robert *et al.*, 2016).

Therefore, adaptation seems an important aspect of decision-making processes, it depends on three main components:

- **quantity of information available** (Kulik and Baker, 2008 in Robert *et al.*, 2016), Simon, 1955 in Daydé, 2020). Either farmers are satisfied without optimizing, or they consider utility value for each option.
- Farmers' rationality is based on **limited cognitive abilities**: humans cannot take all the factors into account. Individuals have their own:
 - **qualitative evaluation of factors**: "farmers take into account risk related to their environment in diverse ways implying that their evaluation is mostly qualitative" (Winsen *et al.*, 2013 in Daydé, 2020),
 - **habits**: in a specific region, farmers know during which time window they must sow, weed or fertilize and take into account the crop cycles and the main weather patterns (Aubry *et al.*, 1998). Under these conditions, 'as these decisions are made fairly often, the farmer becomes experienced and develops a certain routine' (Jacobsen, 1994 in Aubry *et al.*, 1998),
- **time limitation** to take the decision (Simon, 1955 in Daydé, 2020).

Decisions can be spatially or temporally taken (Robert *et al.*, 2016). Regarding space, the decision is taken for a plot or at the farm scale. Regarding time, it can be an **anticipated adjustment** (also called "proactive decision"), or an **adjustment performed after a shock** ("reactive decision").

Therefore, there are two main spatial scales: decisions taken at the farm's scale and the ones taken at the plot scale which can be identified by the cropping systems. Schwerz (1889 in Papy, 2008) defines cropping systems as a way of improving crop production value by optimizing soil use. It is a concept allowing "trade-offs between the short-term interest of growing the most profitable crops and maintaining the productive capacity of the soil" (Schwerz, 1889 in Papy, 2008). Almost a century later, Sebillotte (1974 in Papy, 2008) spatially and temporarily specified the definition. Spatially, it becomes a "set of technical modalities implemented on plots treated in an identical way". Temporarily, it is "a succession of crops", each crop, of a species or an association of species, being conceived as "a logical and ordered combination of techniques that make it possible to control the environment in order to obtain a given production" (Sebillotte, 1974 in Papy, 2008). This is how technical itineraries emerged as a new concept, combining space and time changes.

Regarding farm scale, decisions are related to input supplies, land access (leasing, buying, selling, renting to someone else), equipment (type, buying, leasing), hiring, and commercialization. Key decisions can also become constraints if there are no choices for farmers. Having in mind these aspects, the main operations done by farmers on their crops are listed with their subcomponents in Table 1.

Table 1 Summary of decisions identified from the literature review

Source: personal

Time scale	Decisions	Subcomponents of the decision
Before sowing	decision to cultivate	cultivate or not cultivate
	number of cultivation cycles	number of cycles per plot per year
	crop type	two different entries: perennials, biennials or annuals cereals / fruit trees / vegetables
	varieties	names
During cultivation	sowing	date, plant density
	irrigation	modalities (equipment), duration, frequency.
	fertilization management	modalities (equipment, products), number of applications, quantities, date of applications.
	pest and disease management	modalities (equipment, products), number of applications, quantities, date of applications.
	soil cultivation	modalities (equipment, hiring), date
After cultivation	harvesting	modalities (equipment, hiring), date.
	food-processing and commercialization	storage, transportation, market access, market prices.

This list of decisions is a general one. For a specific area, some decisions may not be seen as such for all farmers living in it (Figure 1). For instance, if there is no one to buy avocados, farmers do not produce them at all. Therefore, it is not a decision to take into account, it becomes a constraint. In other cases, other decisions can be seen as a constraint only for some people. For instance, a farmer who does not have a large social network is not able to reach certain markets. For instance, some farmers of an area can produce vegetables because they know to whom they can sell. Others can produce vegetables, but they do not know to whom they can sell. Hence, they stop because they do not make any profits. It is a constraint only for some farmers.

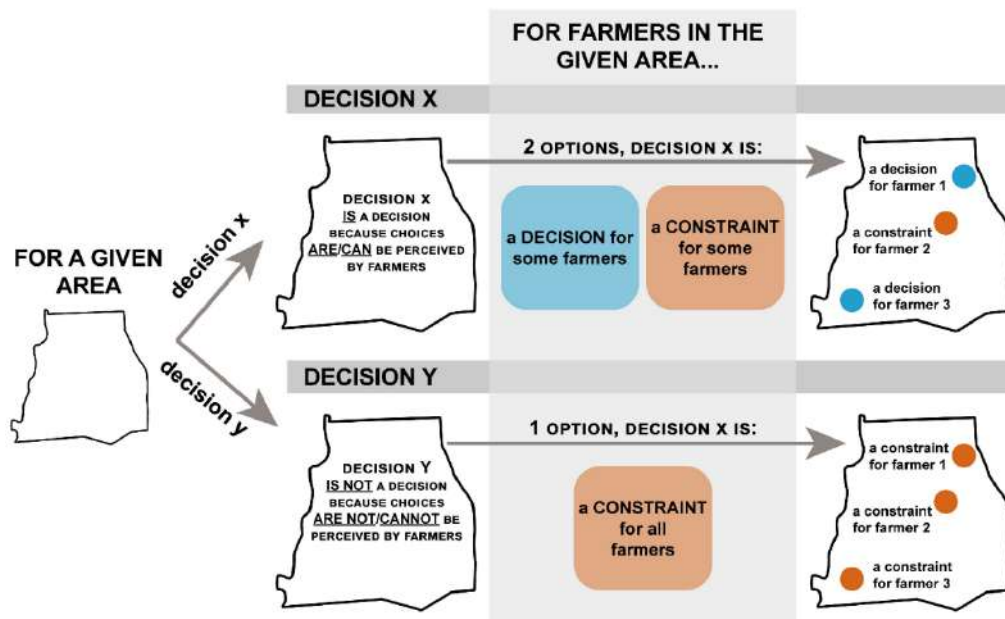


Figure 1 Schematic representation of decisions and constraints

Some decisions can be seen as a constraint for all farmers. When it can be a decision, it might not be for all farmers.

Source: personal

IDENTIFIED FACTORS

Factors are a concept designed to express what influences decisions. They relate to the farm environment, available production means, and household components. They are identified based on a literature review based on texts related to deltas and Asia.

The first category of factors is related to the **farm environment**. There are external factors that farmers usually cannot change or can only change very slightly. Regarding biophysical factors, there are: climate, pests and diseases, soil types, and water resources. Daydé explains that the uncertainty of the environment is the main factor of reactive decisions, it influences not the choice but the development of the crop (Daydé, 2020; Schneider & Asch, 2020; Papy, 2008). Road and waterways accessibility can also be a factor influencing farmers' decisions (Bosma *et al.*, 2005). Socio-economic factors can be detailed as:

- markets,
 - for inputs (prices and accessibility of fertilizers, pest and disease control),
 - and outputs (market access, selling prices) (Vandôme, 2020).
- access to advice and supports (cultivation technics, financial farm support: access to credits, farm financial management),

*“If [the selling price of] rice is too high, forcing several farmers to sell land to reimburse short-term loans they incurred to finance inputs for rice cultivation” (Bosma *et al.*, 2005)*

- policies and regulations (Ivars & Venot, 2018; Sinh, 2022),
- job opportunities apart from agricultural labor (Diepart, 2015),
- and social networks.

The second category is the **means of production**. It can be summarized as land access, labor force and equipment. Land access can be unstable, with short-term rental contracts. Land is also a capital that can be sold in case of an emergency. Moreover, the available labor force can change as the household structure evolves (Tchayanov, 1995). Outside the farm household, cost and availability of external hiring force may change (Formoso, 2016). Last, but not least, the last factor is related to equipment: quantities and diversity of available machinery, access times, and costs.

The third category is related to **household components**. The household structure can be a main factor as there are power relationship influencing decisions within the family (Bjornlund *et al.*, 2019). Farm finances can be the same as the households. Therefore, household cash management, self-production needs, and debt rates also show their importance in farmers' decisions (Bevacqua, 2017). The three categories are summarized in Table 2.

Table 2 Summary of identified factors

Environment of farms	Farm available production means	Other household components
biophysical: climate, pest and disease, soil types, water resources, roads and waterways. socio-economical: markets, access to advice, policies and regulations, job opportunities apart from agricultural labor.	land access, labor force, equipment.	power relationship, cash needs, indebtedness and access to credits.

Before detailing the study area context, as household components seem important in East Asia, household structures, and their activity systems are explained in the next part.

TWO MAIN HOUSEHOLD STRUCTURES HAVE DIFFERENTIATED IMPACTS ON FARMERS' DECISIONS

Decisions and strategies can be **influenced at the household level**. For instance, in Southern Africa, power relationships within households can have important impacts on cropping systems (Bjornlund *et al.*, 2019). In the 60s, the anthropologist Ebihara, described life in a Cambodian village (Ebihara, 1968). Her research showed farming decisions are taken at the household level, and not at the individual level. She described the two main Cambodian household structures (

Table 3). There are **nuclear and stem families**. A **nuclear family** is based on a two-generational family with the parents and the unmarried children. **Stem families** can also be two-generational, but their children are married, and possibly have children of their own.

Table 3 Main household structures in Cambodia

Main household structures	Nuclear families	Stem families
Quick characterization	<ul style="list-style-type: none"> ○ present 1 or 2 generations ○ parents with or without the unmarried children 	<ul style="list-style-type: none"> ○ present 2 or more generations ○ parents and married children with his/her spouse and possibly their own children
Complementary information	It is a basic economic unit of production and consumption. Every member cooperates in subsistence activities and shares produces, income and property.	The stem family works like 2 units (therefore like two nuclear families under the same roof). Every unit has a piece of the land that they cultivate, and they do it the way they decided. For example, if the parents owned four plots and their daughter, and her husband live with them. The parents will cultivate two plots and the daughter, and her husband will cultivate the other two as if they were their own. The income generated from the land is not shared.

As cash management, land repartition, and workforce can change between these two main household types, it might create differentiated impacts on farmers' decision. Activity system helps characterizing factors related to agricultural decisions.

ACTIVITY SYSTEMS CAN HELP TO UNDERSTAND DECISIONS IMPLEMENTED BY HOUSEHOLDS

Household structure study is a first step in understanding the decision-making processes. However, it is not enough to understand why a farmer may choose to cultivate a crop over another or to decide to sow during the Dry Season (DS). As cash management, and workforce seem important, an entrance with activity system of households is relevant.

“An activity system [is] a metasystem that encompasses [farming activities] alongside the other productive activities of the farmer and his family.” (Paul et al. 1994, in Gaillard & Sourisseau, 2009)

Moreover, what Gaillard and Sourisseau (2009) emphasized is to understand the strategies implemented at the plot level, only the analysis of an activity system, taking into consideration agricultural and extra-agricultural activities, makes it possible to understand farmers' strategies.

“The scale of the activity system makes it possible to approach the global strategies of farmers: it integrates agricultural and extra-agricultural activities, as well as so-called market activities (salaried employment, sale of agricultural products) and non-market activities, linked to the social life and identification logics of individuals.”

Non-commercial logics are important to be added in the activity system as it can have an impact on the choices made by farmers. For instance, in their 2005-paper on Vietnam, Bosma et al. (2005) describes remittances as an important factor.

“Less than 5% of the households profited from regular remittances, pensions, or irregular

remittances; the last were often used to invest in new farm components.”

INTERMEDIARY QUESTIONS

As a list of decisions, and factors stands out from the literature review, and household structure seems to be a decisive factor, the following questions emerged as a way to attempt understanding the decision-making processes of farmers in the Mekong delta:

- What are the main factors influencing cropping-system decisions?
- Per decision, what are the main choices made by farmers?
 - To what extent can household structures explain farmer’s choices?
 - Apart from household structure, which are the main factors explaining choices?
- Is *prek* rehabilitation a key factor for all farmers and their productions?



**CONTEXT OF THE STUDY
AREA**

GENERAL CONTEXT OF THE LOWER MEKONG BASIN

The Mekong delta, which is part of the lower Mekong Basin, starts in Phnom Penh, where its **first distributary the Bassac River**, called *Tonle* by Cambodians, begins. Once through the Vietnamese borders, the Mekong and Bassac River branch out before flowing in the South China Sea.

Agricultural productivity in the Lower Mekong Basin (Laos, Thailand, Cambodia, Vietnam) provides **food security** for more than **90 million people**, and the region is home to the world's largest inland fishery (Piman *et al.*, 2013b; Nhan and Cao, 2019 in Orieschnig, 2022). Both activities highly depend on the hydrological cycle of the Mekong River, a mono-modal flood pulse during the wet season. It is characterized by an annual flood in the floodplain from July to October. The annual flood pulse, from the Mekong, is vital to sustain agriculture and livelihoods of millions of delta inhabitants as it **brings fertile sediments** (Nguyen, Van Khanh Triet, 2021).

WATER CONTROL AND UPSTREAM INFRASTRUCTURES

As mentioned previously, the delta's inhabitants depend on the annual flood for their livelihoods. Yet, the hydrological cycle has experienced **strong changes in recent years** due to phenomena related to **global warming**: uncertainty of floods (early or late arrivals, early or late recessions), and of rainfalls (their intensities and when they happen). The Lower Mekong Basin has been identified as one of the most vulnerable regions in the world to global warming (Mercado and Asia Times, 2021; Eyler, 2019 in Orieschnig, 2022).

Not only global warming has been disrupting the flood pulse in the lower Mekong Basin, but **anthropogenic phenomena** have also had an impact. Figure 2 represents the hydropower development in the upstream part of the Mekong Basin (China, Myanmar, Laos and Thailand). It affects the hydrological regime and flood pulse of the Mekong (Lauri *et al.*, 2012; Räsänen



Figure 2 Map of Mekong Mainstream Dams
 Source : <https://www.stimson.org/2020/mekong-mainstream-dams/>

et al., 2017; Hecht *et al.*, 2019 in Nguyen, Van Khanh Triet, 2021), by decreasing the Rainy Season (RS) flow and increasing the Dry Season (DS) one. Moreover, as well as impacting the hydrological regime, it **decreases the load of nutrient-rich sediments** in the river's water. Therefore, it **impacts** most the **renewal of fertility** in the Mekong's deltaic plain, as there are numerous dams on the Mekong's mainstream. It has been predicted a decrease of 50% of the sediment flux in the next 20 years (Bussi *et al.* 2021, in Orieschnig, 2022).

It is interesting to note that climate change in the basin would increase the magnitude of floods by 14% and their incidence by 49%, while the development of hydropower production would reduce them by 16% and 36% respectively (Yun *et al.* 2020 in Orieschnig, 2022). Overall, average inundation duration has declined by 19 days and the likelihood of having inundations in the early wet season (July and August) has decreased by 21%. Orieschnig describes the uncertainty of the arrival of the flood as an important factor for farmers to consider in their decision-making.

THE PREK SYSTEM

A particular feature of the Cambodian part of the Lower Mekong Basin is the **presence of preks**, earthen canals. These *preks* are unique and structuring elements of the landscape. They have an important role for local populations, particularly in terms of agriculture. *Preks* establish a connection between the river and the floodplain. Their structure enables this connection by having the riverbanks excavated letting water flow into the canals. They provide different functions, such as the transfer of water for irrigation, sediment deposition, transportation and ecosystem services such as fishing, but also the use of natural vegetation for food and feed (Venot, 2019).

The *preks* were mainly built during the 1900s under the French protectorate (Figure 3). They are not found, for example, in the Mekong Delta in Vietnam. These structures were inspired by local knowledge. A legend from the Cham ethnic describes the origin of the *preks* (Venot, 2019). They were built as a way to create arable lands. However, they were not systematic,

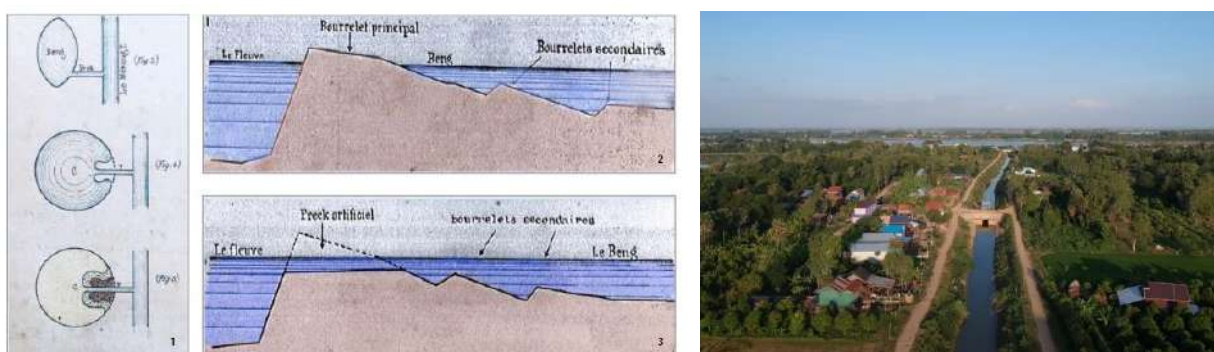


Figure 3 *Prek* systems: drawings from Barthelemy's report (1912) and a drone picture of one *prek* by Ms. Orieschnig (2020)

Barthelemy was a French engineer during the French Protectorate. He made a *prek* typology and drew them. The picture shows the Bassac River on the background, and the perpendicular canal is a *prek* (*prek* Chann), filled with water at that time.

Sources: drawings are a courtesy of the *Archives Nationales d'Outre Mer*, and the picture was taken by Christina Orieschnig

and could not be found everywhere along the Mekong River. It was during the French protectorate that systematic building of *preks* started shaping the landscape. The aim of the French engineers was to increase agricultural production, by providing arable lands through sedimentation. This primary function has evolved to have others as described above. Moreover, during the Khmer Rouge era in the 1970s, the construction of smaller channels in the *boeung* area, low land area flooded every year for many months, was made as a way to intensify agriculture. These channels are still present in the landscape and used for irrigation (INA, 1975).

These *preks* have **shaped the landscape of the area**, there are three sub-parts. They have different properties which can influence farmers in their decisions (Vandôme, 2020):

- **Chamkar**: never flooded, loamy-sandy and loamy soils.
- **Transition area**: partly flooded, loamy-clayey soils.
- **Boeung**: flooded each year for months, loamy-clayey soils.

Chamkar areas are usually at the entrance of *preks*. However, it does not always follow Barthelemy's representation. Some plots at the end of *preks* can have higher elevations than in the middle. Limits between these 3 categories are not very clear. It is confirmed with Shuttle Radar Topography Mission (SRTM) data (Earth Resources Observation And Science (EROS) Center, 2017). There is also a **soil market**. Farmers can sell their soil for construction work. A backhoe loader can knock down surface layers of soil. The elevation decreases which can change flood arrivals and departures on the plot (private communication with Ms. R. Ducrot, end of August).

Nowadays, it exists **different types of *preks***, those where there is **water year-round** with no anthropogenic interventions, and those where at some period of the year, mainly during the **DS, there is a lack of water**. These differences can be explained by differences in the depth of the *preks*, or the level of sedimentation at their entrance. These two types of *preks* have a major influence on the decision farmers might take, as if they have water year-round, they may not follow the same process in choosing crops as someone whose land is located on a *prek* that has no water during the DS.

Over the last 30 years, *prek* system rehabilitation are part of international development projects. Main idea is to improve *preks* from lack of water in DS to year-round water flow. The AFD is at least one of the examples of financial backer implementing these kinds of projects. However, it does not mean they are the only ones to act. Even if strictly speaking it cannot be called *prek* rehabilitation, some local initiatives are carried out to improve the water inflows in *preks*. For instance, farmers who own land next to the *prek* get together and can jointly hire a digger to excavate sediment for a better water inflow. This information was given by village chiefs, not only about the fieldwork area, but more generally for *prek* area (June, July and August 2023).

AGRARIAN POLICIES AND LAND MANAGEMENT

In Cambodia, there are no subsidies to support farmers. There are public Agricultural Departments (at least in each province) but not enough financial, and human resources allocated to: provide trainings on different cultivation aspects, help on scale farm financial

aspects (balance between cultivation costs and selling prices), creating and supporting market accesses (Rabun, 2015). It can be said that lack of support from public services is a common point for all Cambodian farmers.

Land differentiation have happened through History. In order to understand it properly, former and actual land policies must be detailed. **Land has had different status over time** (Bevacqua, 2017). The French protectorate established possession and ownership, but only possession remains after the independence. Ownership required more legal steps than possession. From 1976 to 1979, the Pol Pot regime failed to collectivize lands. However, production solidarity groups (*samakki bongko bongkaeun phol* or *Krom Samaki*) under the communist People's Republic of Kampuchea (PRK) government organized farm production and bought rice from farmers. Agricultural land belongs to the State but is distributed to families regarding the number of active laborers (Diepart, 2015). Even if farmers were interested to join, *Krom Samaki* organization failed because of lack of resources and farmers went back to customary practices.

This long history of land ownership status led to an incomplete land access. In 1989, Cambodians had the right to inherit, manage (*kan kap*), and use (*praeu pras*) less than 5 ha. At the same time, another law implying that "the land of the People's Republic of Kampuchea is the property of the State" still exists. Even if a Cadastral Department was launched, local officials used their position over illiterate peasants to ask for bribes or take the land for themselves, their families and friends. After two years, less than 2% of the 3.6 million applications are registered. Since lots of applicants never received the formal registration document, application receipts get treated as formal land titles. By 2000, only 14% of 4.5 million applicants received full certificates. Procedures still go on today. The only difference is the use of satellite images to locate precisely perimeters of plots.

Therefore, it **led to land differentiation**. The quantity of lands can differ from one household to another. Land differentiation can have different origins. During *Krom Samaki*, households with more active laborers could access to more lands. Distribution of lands during *Krom Samaki* depends on general rules from the PRK. However, these rules were interpreted by local authorities, which led to divergences in land differentiation. Households can also sell their lands: land transactions are correlated to capacities to mobilize capital. About 75% of land transactions depend on unproductive elements (health emergency, debt rate).

Along these lines, land access and ownership are shown as greatly varying between households and farmers. There is a differentiation in quantity of lands owned by a family, which can have an impact or influences on the decision one farmer might take compared to another.

MARKETS: ECONOMIC LIBERALIZATION AND UNSTABLE SELLING PRICES

One of the main facts regarding markets is **Cambodian economic liberalization in 1984**, which comes with being a member of **many free trading agreements**. The second one is **unstable selling prices** for farmers.

On one hand, Cambodia is on a **trend of economic liberalization**, including agricultural activities. It began its economic liberalization in 1984 and is a member of several free trade

agreements. Some are recent, such as the Regional Comprehensive Economic Partnership Agreement (RCEP) that was signed among 15 Asia-Pacific nations in January 2020 (*Regional Comprehensive Economic Partnership Agreement (RCEP)*, n.d.), and a more specific one was designed to enter the Chinese market in late 2020. Some are older, such as the 2006-bilateral trading agreement with Vietnam, which was renewed in June 2023 (*Vietnam and Cambodia sign agreement on boosting bilateral trade*, 2023). These are general economic agreements, but they also apply to products related to agriculture. Based on 2009-2018 BACI dataset, Cambodia's main trading partners regarding agri-food are Vietnam, Thailand and China (Gaulier & Zignago, 2010). Over the last few years, the country has been a net importer of food and not a main exporter. Based on 2015 data, food exportation represents 0.76 billion USD and importation 1.9 billion USD (Piseth *et al.*, 2021). These agreements are also in favor of input importations.

On the other hand, **selling prices remain unstable for farmers**. Some products can be exported, like maize. However, exportation systems to Vietnam and Thailand do not provide stability for farmers. Maize is consumed locally, but since the 90s, some major foreign companies have developed maize varieties for animal feeding (Koma, 2010). Then, farmers have shifted from local varieties to these new and more productive ones. One of the most emblematic companies for animal feeding is *Charoen Pokphand* (CP). International trading agreements could have come with contracts, and therefore value chain stability. Contracts between intermediaries could have secured the value chain, by suggesting a fixed buying price for farmers (for a certain time). Currently, there is no such mechanism in the maize value chain, as there are no appropriate regulations from companies, or policies. As prices relate on global markets, and neighboring countries' production, prices are not secured and there are at least monthly fluctuations. They also remain weak during harvesting time as local stakeholders take advantage of the harvesting season to decrease buying prices. As the offer increases, it gives more power to local buyers to negotiate prices down. It is the offer and demand economic law.

Regarding inputs, Cambodia does not produce any, and they are mainly imported from Vietnam. Pesticide chains have been studied under the project *WatHealth*, and some elements are detailed in the next part (*WatHealth*, 2021). Ones of their goals were to understand how pesticides are sold to farmers, and to what extent sellers give advice to farmers.

FIELDWORK AREA IN KANDAL

Before going any further in the methodology, this section presents the fieldwork area. It is based on literature review and interviews made regarding contextual aspects. Each farmer has an ID, sources can be mentioned along the text.

LOCATION OF THE FIELDWORK AREA

The fieldwork area is located in the South of the Kandal Province, in Cambodia. It is 50 km south of Phnom Penh, and 12 km north of Vietnam (**Erreur ! Source du renvoi introuvable.**). The National Road 21 connects both places and is the main access to go along the *preks*. *Preks* can also be water roads when the water level is high enough (above 3 m) and when there is no gate. The gate on *prek* Chann does not allow boats to go along.

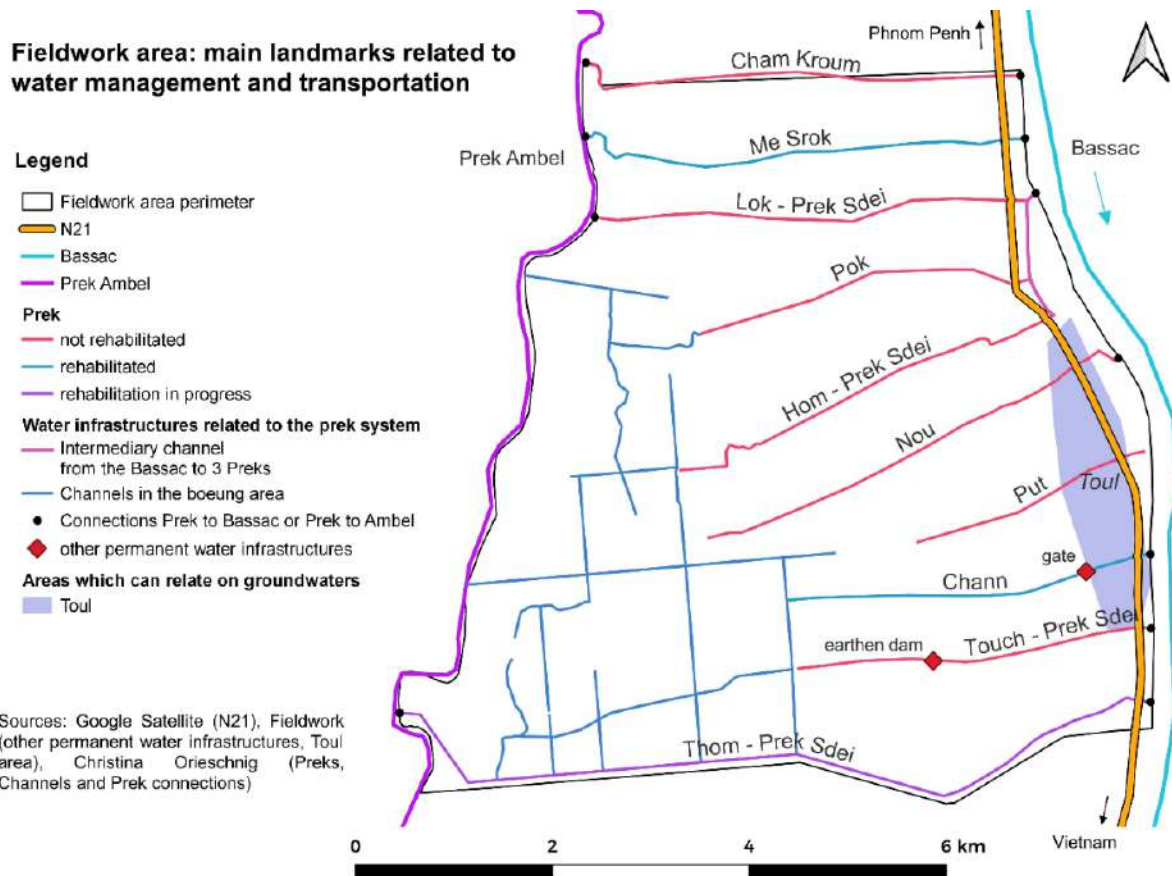


Figure 4 Map of the fieldwork area with landmarks related to water management and transportation

Source: personal

From North to South, there are 10 *preks* called: Cham Kroum, Me Srok, Lok, Pok, Hom, Nou, Put, Chann, Touch and Thom. Two of them have been rehabilitated: Chann in 2017 and Me Srok in 2017 (Orieschnig, 2022). Prek Chann is the only one with a gate. Over the summer 2023, rehabilitation of prek Thom is in progress. The current batch the AFD is working on goes from *prek* Nou to *prek* Thom.

Some of the *preks* are connected to the *prek* Ambel, a natural river which in some parts has been modified by man-made action, while others end up in the *boeung* (Orieschnig, 2022). Furthermore, some *preks* connected to the channels made during the Khmer Rouge period can have water punctually even though there is no natural water flow from the Bassac River to the *prek* (private communication from S. Massuel, in June 2023). These different infrastructures influence the water regime in the different *preks*, and therefore the availability of water for farmers.

WATER

The water regime of the study area is linked to the Mekong River. The latest brings water to the Bassac, a deltaic distributary of the river. Therefore, any changes in the hydrological cycle of the river have an impact on the area, which is a floodplain with two seasons. The RS is from

May to November (100 - 300 mm/month) with floods mainly from June to October. Then comes the recession. In some higher parts of the study area, the flood recession can end from October to December. In the lower-lying bits, the recession ends in January. The DS lies from December to April (0 - 50 mm/month) (Orieschnig, 2022), which peaked with no precipitation in April, and high temperatures (around 35°C). Some farmers in Kandal Province in Cambodia started to complain about the uncertainty of rainfalls and the reduction of the flood length and intensity, which decreases their arable lands.

"Now flood is lower than before, before 200 meters of my land were flooded and the water reached the waist. It was better because the soil could have fertility." [E_P_2023_1508_01]

It is interesting to note that depending upon their land location, farmers do not consider the RS and/or DS in the same way.

Concerning the RS perception, *chamkar* farmers, whose plots are never flooded and do not have water accumulated on their lands, do not fear RS as there is no risk for their crop during this season. However, they all agree on what they consider to be a "good rain". It should last for at least a day, and the soil has changed color. What makes them all agree on is the fact that, following this type of rainfalls, they do not need to irrigate. For instance, a farmer explained:

"From August to November, it frequently rains a lot, so I decide to plant rice instead of maize because rice loves water, and [rice] is tolerant to water in order to grow well." [L_P_2023_2607_01]

However, with rainfall regime changes due to climate change, farmers who used to rely less on irrigation for their RS cycle (less CC), now they start to irrigate during this season. Therefore, their CC are increasing, which shows a weakness in their cropping systems (from field observations).

Farmers' conditions to DS depend on the yearly **water level in their *prek***. A farmer whose lands are on a *prek* with water year-round, and farmers whose land are located on a dried *prek* from January to April have different constraints. Most farmers explained that they can pump from the *prek* to their fields when water is above their waist (the exact reason as to why, was not given by farmers). Therefore, the farmer close to the *prek* with water year-round can pump most of the time, which is not the case of the second category. It changes their possibilities, and these perceptions are crucial in understanding the way farmers will proceed when choosing which crop to grow or when to sow.

"[L_P_2023_2507_02]: If the water is above my waist in December, I choose to do red maize otherwise I will do mung beans."

The *prek* water levels are summarized in Levels of water in the *preks* As discussed above, there are some *preks* with water year-round, and others without. For instance, *prek* Put is a *prek* that is no longer connected to the Bassac River. It needs to have water pumped from *prek* Nou, through a secondary channel. On one hand, *Prek* Nou has never been rehabilitated, but has water year-round in its channel. On the other hand, *prek* Chann has been rehabilitated in 2017 by the AFD, and a gate has been installed. This latest was designed as a way to control the water flow, and to avoid the lack of water in the *prek*. However, during interviews, it was

discovered the gate is mainly used as a way to delay Flooding Events (FE) and allows to delay rice and maize harvesting operations.

[Gate Manager]: There is a benefit when there is a flood and rice is not yet harvested. It can stop water flow into the prek, and after harvest when people would like to have water to cultivate the crop, I open it again."

For farmers who do not have year-round water availability, even though water organization is quite specific to each *prek*, **four main types of social organizations** can be observed (Vandôme, 2020; Orieschnig, 2022; fieldwork observations). The **first one** is: a **water seller can pump water to the prek**. In this case, someone or a group of people pump water from the Bassac / a secondary channel / another *prek* to the *prek* during the period when it is usually dry. This period can change. For instance, water is pumped from the Bassac River to the *prek* Lok from March to July, whereas on *prek* Pok it is from February to June. Water sellers provide a service to farmers. Therefore, farmers need to pay if they want to benefit from it. There are two ways of paying, the modalities might change from one water seller to another, but usually for cereals (rice and maize) and vegetables, farmers must pay by cycle and regarding their land size. For instance, at *prek* Pok they must pay 350,000 KHR/ha at the end of the cultivation cycle. Whereas water provided to irrigate fruit trees must be paid by hour. On *prek* Lok one farmer pays 6,000 KHR for an hour to irrigate his mango trees.

A rapid history of water seller

A farmer or a group of farmers need water to irrigate their crops, he or they decide to buy a bigger pump with enough horsepower to pump water from the Bassac to the prek and therefore, to enjoy water availability and be able to irrigate and do the crop they want to do. Other farmers seeing this, decide to go up to the farmer or group of farmers to ask for water, offering to pay for it. This is how most water selling business on preks started, it always starts with a farmer. A thorough description of the different water sellers met on the fieldwork area is in Appendix 2.

The **second social organization** is **water being provided by a water leader**. About 10 years ago, the government provided pumps to enable farmers to no longer depend only on rainfalls, but to have more freedom on their irrigation practices. It is the case on *prek* Put, where there is a water leader. Here, the way water is provided is similar to water seller, yet there is a particularity on this *prek* as everyone grows the same crop, rice, and almost everyone does the same number of cultivation cycles. There is a sense of community, this might be explained by the fact that the plots are mostly lowlands, there is no longer a real connection from the Bassac River to the *prek* and the water leader has been there since 2009. For a better understanding of the organization on *prek* Put, see **Erreur ! Source du renvoi introuvable..**

The **third social organization** is **water being provided by a water community**. Compared to the second social organization, the pumped water benefits to a smaller number of farmers,(never above 10 farmers), and they only pay for the gasoline used. Whereas water sellers usually provide water to more than 30 farmers. For instance, on *prek* Cham Kroum a farmer met was providing water to a community.

"No, I don't buy any water, but I will put the big machine at the entrance of the river to the prek and we (her and her husband) will collect money from other farmers which are in the same community for the gasoline to pump water from river to the prek." [EL_PS_2023_0307_01]

[Louise]: “How many people in the community?”

“There are only 4-10 people.” [EL_PS_2023_0307_01]

The last way of getting water is for individual farmers to directly pump from another source. Some farmers can pump from *prek* Ambel, directly from the Bassac, or from groundwaters. *Toul* is an elevated area where they use groundwater, many wells can be found (Figure 5). There are other wells observed on Cham Kroum and Me Srok. Farmers see it as a way of being more independent. However, farmers usually do not use it because it is contaminated, and it kills their crops. The quality of groundwater is quite low, and the quantity of arsenic in it is quite high (Orieschnig, 2022).

“I made a well to not be dependent on water availability in *prek* and this way I can grow whenever I like.” [E_S_2023_3107_01]



Figure 5 Picture of the *toul* area between entrances of *prek* Put and Nou

Surface pump installed on a borehole, or a well, groundwater is used directly on the rice plot.

Source: personal

On *toul* area, water can also be stored in natural ponds or man-made one. Groundwater can get stored in ponds, or directly used. In spite of owning a well, neighbors have the right to use them but have to pay for the gasoline. They would prefer to use the *prek* water as it is seen as being quicker to irrigate than from groundwater. There is also a risk of severe reductions in groundwater storage in the Cambodian part of the Mekong Delta.

EXTENSION SERVICES

Regarding **inputs**, there are local input shops. Stores can be sub-depots, and big depots. There are at least two depots on the fieldwork area. Farmers also go to Vietnam because inputs are cheaper there. From a discussion with Sreytouch Heourn, former member of WatHealth project, it was explained that companies providing depots, can spontaneously organize trainings for farmers. Farmers would learn how to use company's **pesticides**, and then go to a shop to buy it. That is how marketing is done. Sellers can also provide some advice for farmers to pick up a pesticide. Regarding **seeds**, they can either buy from input sellers (locally or in Vietnam), or buy rice seeds from each other's. It is not known which rice variety are more drought resistant, and if they are hard to find. A rice variety resistant to drought was mentioned by one farmer, buying directly from one input seller. Regarding maize, traditional seeds were put on the side to buy hybrids.

“This variety I bought from the market, it is not a traditional variety. And this variety is from Thailand and some varieties are from Vietnam. For the new variety nowadays, we can't keep it the traditional way anymore. Furthermore, when we keep it and grow in a traditional way, there is no yield like growing the breeding variety right now. Compared to the new variety and old variety, the new variety produces more yield.” [E_S_2023_2306_01]

Their goal in buying any kinds of crops is mostly to get the best yields. Either they know from their experience, either they ask for advice to the seller (Figure 6). The main maize varieties are 19, 28, and 38. It relates to the number of grains per corn ear. There can be differences in varieties over cycles. There is only one farmer who mentioned different use in maize varieties regarding cultivation cycles and made the link with weather. Bought rice seeds are used for two cycles, and then they buy again. They are switching between seed reproduction and buying. About mango trees, there is only one choice called *Keo Romeat*. About vegetables, it seems that farmers mostly go to Vietnam to buy their seeds. The input seller met on the area sells pesticides, and fertilizers, but there were no seeds.



Figure 6 Pictures taken in an input seller depot on the fieldwork area

Source: personal

Regarding **technical advice**, it is nearly zero. Companies mentioned previously can provide trainings, but it would be specific to crops. The few who have had technical training are doing better than most farmers. Some stay in touch with their trainers through social media. On the field, Syngenta, and EM Company were mentioned. When the trained farmers know how to

grow a given crop, they will usually stick to it, even though another crop can be more profitable. Besides, most technical advice come from neighbors, and sometimes family.

“Because I only know how to plant corn since I know which pesticide I should use. Others know how to plant eggplants but for me I don’t know.” [EL_PS_2023_0307_01]

Regarding **equipment access**, it is not a determining factor in the decision-making of farmers in the fieldwork area. There’s no competition between farmers to have access to different machines at the time they need them. **Erreur ! Source du renvoi introuvable.** represents harvesting and land flattening operations for rice. Usually, farmers have the equipment within the hour when they call the equipment renter (**Erreur ! Source du renvoi introuvable.**). Only one farmer has reported that he grows corn sometimes because the sowing machine of green beans is not available.



Figure 7 Pictures of rice machinery, taken on *prek* Chann

On the left, it represents rice harvesting operations. The picture on the right is an adapted moto-tiller to land flatten the rice field.

Source: personal



Figure 8 Pictures taken by the house of an input seller on the fieldwork area

On the left, there is a harvesting machine for maize and rice. On the right, it is a harvesting machine for mung beans and rice.

Source: personal

“After the flood, I let one month to think if I’ll grow green bean or corn. This decision is made according to the availability of the green bean sowing machine.” [E_S_2023_2306_02]

Regarding **wage labor employment**, from an informal interview with villagers, it seems that there are less people hired in agriculture than in the past with development of machineries, at least for maize production. However, there are « still people being hired to harvest ». Meanwhile, it may be that in the past, farmers were helping each other more, and that putting a financial value on labor force gained in importance. It is between 40,000 and 50,000 KHR per day per person (10 to 12 USD). The employment cost has been increasing, maybe it is because there are less people aiming to work due to migrations (internal and external), and/or simply as inflation increased. Farmers will try to do as much as they can by themselves to reduce employment costs, but it remains an important aspect of farming activities, whatever the crops. It depends on the total production area. There is an example of a specialized okra producer:

“No, now I have people to harvest because the output buyers need to collect. This is why she needs to have a lot of people. [...] Main problem of okra, it is the need to hire a lot of people during harvesting.” [L_P_2023_0507_01]

[Louise]: “Now, what remains your main constraints regarding crops?”

“Employment.” [L_P_2023_0507_01]

This local labor force can be hired for plowing, sowing, fertilizing, spraying pesticides, and harvesting (Figure 9). Overall, it seems that main cultivation operations on soils do not change much from one crop to another.



Figure 9 Picture of land preparation and transplantation done by a farmer and his employees
Tractor weed out and make the rows. On the background, one person puts fertilizer, after hired people install the plastic, and make holes in it to prepare eggplant transplantation. The last person, transplants eggplants.

Source: personal

LAND MANAGEMENT

According to the 6 of the village chiefs interviewed, there are almost no land transactions in the area. Farmers keep their lands and only an extreme case would explain why a farmer would sell his land.

*“Had to sell all their lands (4 ha) because had to pay off credit and pay for his daughter education.”
[EL_PS_2023_2006_01]*

There are often one or two families in a village that live in Phnom Penh while they own lands. In this case, they rent the lands to farmers or hire people to work on them. The main land transaction is usually from parents to children: 50 to 90% of the land transactions in a year are from parents to children (information collected through 6 interviews of village chiefs). With the price of land increasing, most farmers, even those who are financially well-off, cannot buy new lands. Some of them might buy in an area not located in the fieldwork area.

“I wanted to buy a plot in the boeung area of Chann however, it was too expensive, and the size of the plots was too small. I accepted a proposition made by my neighbors who had a land in the boeung across the Bassac. I decided to accept because I wanted large area to do rice so I can have a lot of yield.” [E_P_2023_0208_02]

The plots inherited by farmers are often small and narrow (less than 10 meters large and more than 100 meters long). Therefore, the best option to expand the land is to rent. For instance, a farmer was offered the plot next to his by a rich family in Phnom Penh. However, as he could not afford the plot, he started to rent it. Written contracts can exist between the renter and the landlord. However, the main type of contract is oral, making the rental activity very flexible, but above all not secured, as owner can take their land back whenever they want.

“The owner wanted to cultivate the plot himself so I stopped last year, and I cannot rent another one as the land is busy” [L_P_2023_0308_02]

On the whole, even though there are not lots of land transactions, the land is sought after for rent as farmers want to expand. Yet, the uncertainty on the rental time might explain some of the farmer choices on this type of lands.

MARKETS: SELLING PROCESSES, MARKET ACCESSES AND PRICE FLUCTUATIONS

On the fieldwork area, there are three important aspects to be highlighted: most selling processes imply middle buyers, market accesses, and selling prices with high fluctuations. **Ways of selling mostly imply middle buyers for farmers encountered on the fieldwork area.** It is the case for all types of crops encountered: cereals, fruit trees and vegetables. There were no farmers met with written contracts to their buyers. **Power relationships** between producers and local buyers can be summarized in 4 possibilities:

1. Farmer has options regarding whom he/she sells, knows a lot of middle buyers, and can go for the one that buy at the highest price,
2. Farmer always sells to the same person/people because he/she has a specific market access,
3. Farmer usually doesn't know to whom products will be sold, middle buyers come on the

- plot, have more or less power to negotiate the price,
4. Nobody came to buy and the farmer did not know to whom he/she could sell, and production was not sold at a profitable price.

The degree of closeness to middle buyers can also have an impact on how farmers know selling prices. Some can call their middle buyers to know how prices evolved along cultivation season. Some do not know to whom they should sell, and they cannot have access to evolutions of selling prices. It does not help their negotiation power. They are usually the ones with less resources. Even if most of them have a phone (or a member in their family has one), it is very rarely a smartphone with full internet access. Farmers with less network try to ask their neighbors about price changes.

For **cereals and mung beans**, the price is usually fixed a few days before harvesting. Middle buyers can know farmers, and call to meet them, or they go randomly on plots. Selling prices are decided on the field. Either the middle buyer or the producer can employ the harvester. The person who harvests gets paid after the farmer gets paid. He may be paid directly, or a month later. If the harvester works with a specific middle buyer, they have an oral agreement, and they charge the farmer an additional fee for this service. Some harvesters can also recommend middle buyers. There are many buyers for maize and rice. They can be from Koh Tom, or Vietnam (usually 6-7 per village). Producers have choices regarding to whom they sell, and it is seen as easy crops to sell. Middle buyers secure the transaction by giving deposits to farmers, but there are no written agreements. For **fruit trees**, buyers can harvest directly on farmer's plots. Farmers can decide to change buyers if the price is not acceptable, or if buyers are late for harvesting. Farmers can also manage harvesting operations, and then sell fruits to the middle buyer. Producers are paid directly or after a couple of days, or weeks after harvest. Selling prices are not settled as it is the case for cereals. It can change. There are fewer buyers than for cereals (usually 2-3 per village). There is no deposit. For **vegetables**, farmers harvest and transport their production to the middle buyers, especially if it is their first transaction. Then, when middle buyers know at which time the farmer harvests, they can directly go to the field to collect vegetables.

For **fruit trees**, buyers can harvest directly on farmer's plots. Farmers can decide to change buyers if the price is not acceptable or if buyers are late for harvest. Farmers can also manage harvesting operations and then sell fruits to the middle buyer. Farmers are paid directly or after a couple of days or weeks after harvest. Selling prices are not settled as is the case for cereals. It can change. There are fewer buyers than for cereals (usually 2-3 per village). There is no deposit.

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"First time harvesting my wax gourd, I bring the product to the middle buyer, and they know my farm is harvesting now so next time when it's 10 am they will come to collect the products by themselves." [E_S_2023_0507_02]

They can change to whom they sell, but they are more likely to sell to the same person. If they have a large network and collect phone numbers easily, farmers have more power to negotiate the prices. There is no deposit. It is only when middle buyers are back from Phnom Penh that they know how much they have earned. There are also way fewer buyers than for cereals. Without a proper network, farmers are likely not to be able to sell their productions.

Overall, most farmers have the same market access for cereals and mung beans, fruit trees, and vegetables. Cereals are mainly exported to Vietnam and Thailand (Figure 10). For red maize, food companies were mentioned, such as CP. By-products, such as rice straw and maize stems, can be sold locally for livestock breeders. **Mango** can also be exported, but banana fruits and flowers go mostly on internal markets. Papaya trees are not productive yet, so it is not known where they will be sold. **Vegetables** are not exported, they are sold on the Cambodian markets. They can also be sold on markets in the study fieldwork area, but they always go through intermediate buyers if they are not processed. Main vegetables are cucumbers, wax gourd, long beans, morning glory, okra, bitter gourd, luffa gourd, and round eggplants. 19 presents an example with the cucumber value chain.



Figure 10 Schematic representation of main outlets, on external and internal markets, for the crops grown on the fieldwork area

Source: personal

Even if these outlets are the main trends, some farmers have specific market access. Instead of selling rice to middle buyers, a household producing rice can process noodles and sell it directly on local markets. Same for cucumbers, a family can produce pickles and sell it directly. There are two other options. Firstly, households having a grocery store, or a small shop can sell fruit directly, reducing intermediary costs. Secondly, those selling to middle buyers can add value by shelling green beans, or improving quality production standards (GAP: Good Agricultural Practices) to sell at a higher price. The latest can work out if they have a specific person willing to pay more for a higher quality.

Except special market accesses, all crop types have high fluctuations over the year, or even days. Some crops have less selling price fluctuation than other ones. It might have an impact on farmer’s decisions when growing a high fluctuation crop or a low fluctuation one. If there is a high fluctuation crop, they might need some strategy to get a stable income. If there is a low fluctuation crop, they can get more stability in their income, except if the price goes really down. Some 2023-selling prices from farmers are given in 20 For **cereals and mung**

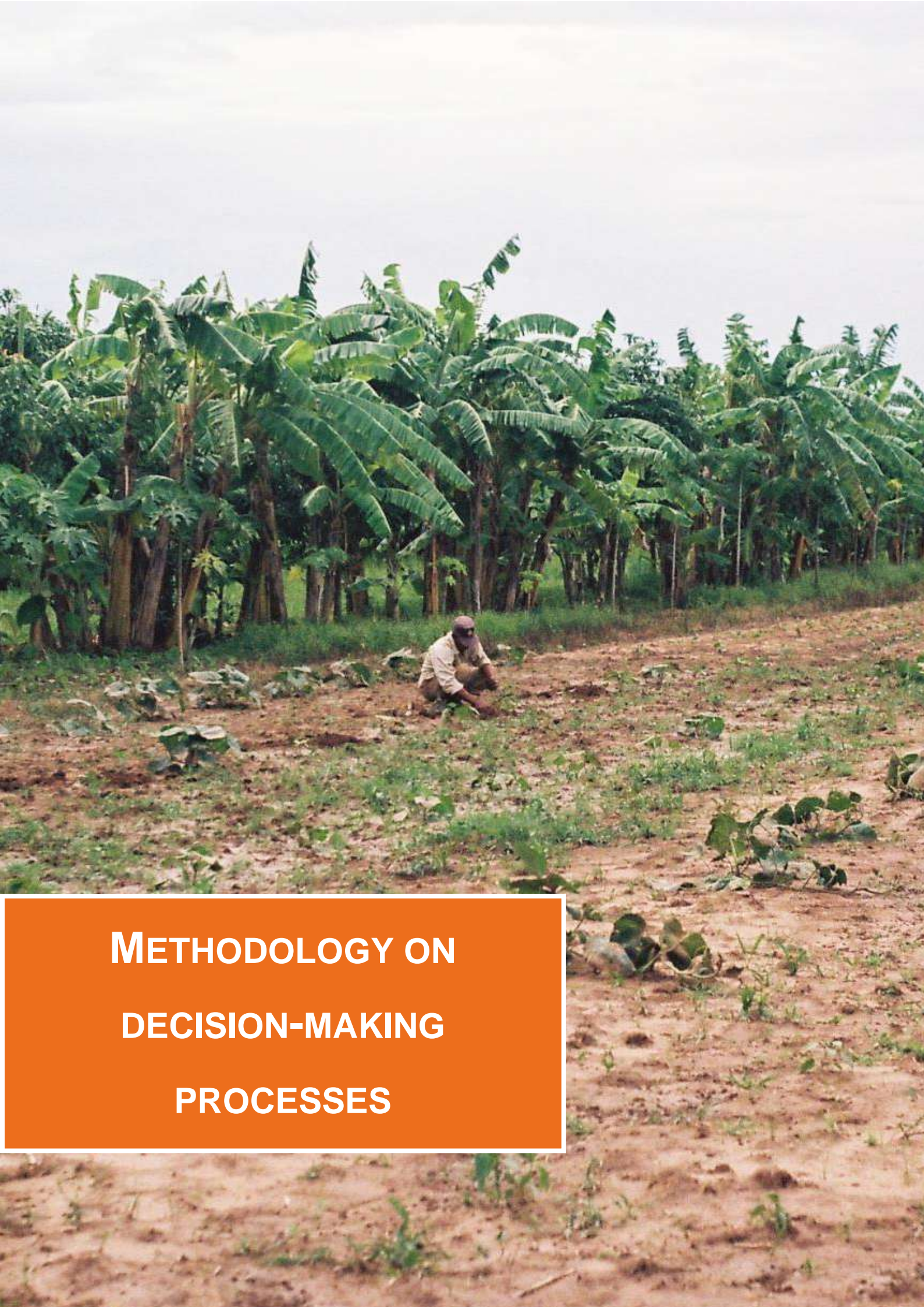
beans, the price fluctuation is mostly from one year to another and along the cultivation season. During interviews, it was mentioned that maize prices went down 6 or 7 years ago and went back up 2 to 5 years ago. Mung bean prices are also lower than last year. Regarding seasonal changes, it also happens on maize with 200 riels / kg of difference between sowing and harvesting dates. For **fruits**, price fluctuation was mostly said for mango, nothing was quoted related to bananas. It seems that bananas are a new crop in the area with a more stable selling price. For mangoes, it is mostly a monthly fluctuation because overall annual prices remain really low since 2019. Most mango trees were planted about 6–10 years ago. Back then the price was high. Over the year, the selling price can change by factor 10.

MANGO “off season from May to September. The price can go from 100 to 1000 riels / kg. It will be 1000 riels only if not everyone harvests.” [L_P_2023_0108_01]

For **vegetables**, it can even be a high daily fluctuation, up to factor 3. It was mentioned for wax gourd, and okra. There is also a seasonal change, especially around harvesting time.

It can be up to a factor 10:

CHILLY “After mango, he tried chilly, but the price was low. When he decided to sow it, it was about 20 000 - 18 000 riels / kg because some plots with chilly got destroyed, and the price was high. Then, when he started to cultivate it, it was about 13 000 riels / kg. When he harvested, it was 2 500 riels / kg.” [L_P_2023_2507_01]



**METHODOLOGY ON
DECISION-MAKING
PROCESSES**

INTERVIEWS AND OBSERVATIONS

SAMPLES OF INTERVIEWEES, APPROACH AND OBSERVATIONS

To have a better understanding of farm systems, and have individual expressions of farmers, interviews were conducted with 50 farmers. Targeted farmers cultivate lands (their own or rented) and are the ones to decide what they do. The study is conducted by 2 students with 2 translators. Each team goes to different *preks* to cover the area as much as possible. There are at least 2 face-to-face exchange sessions per day between teams in order to share mutual analysis.

Main goal is to meet farmers on their plots and make them talk about their practices as they are observed. Over the 170 plots cultivated by farmers, 82 have a precise GPS location. 8 farms do not have precise plot location at all (Figure 11). They are met at their house, or on other *preks* than the ones where they cultivate their plots.

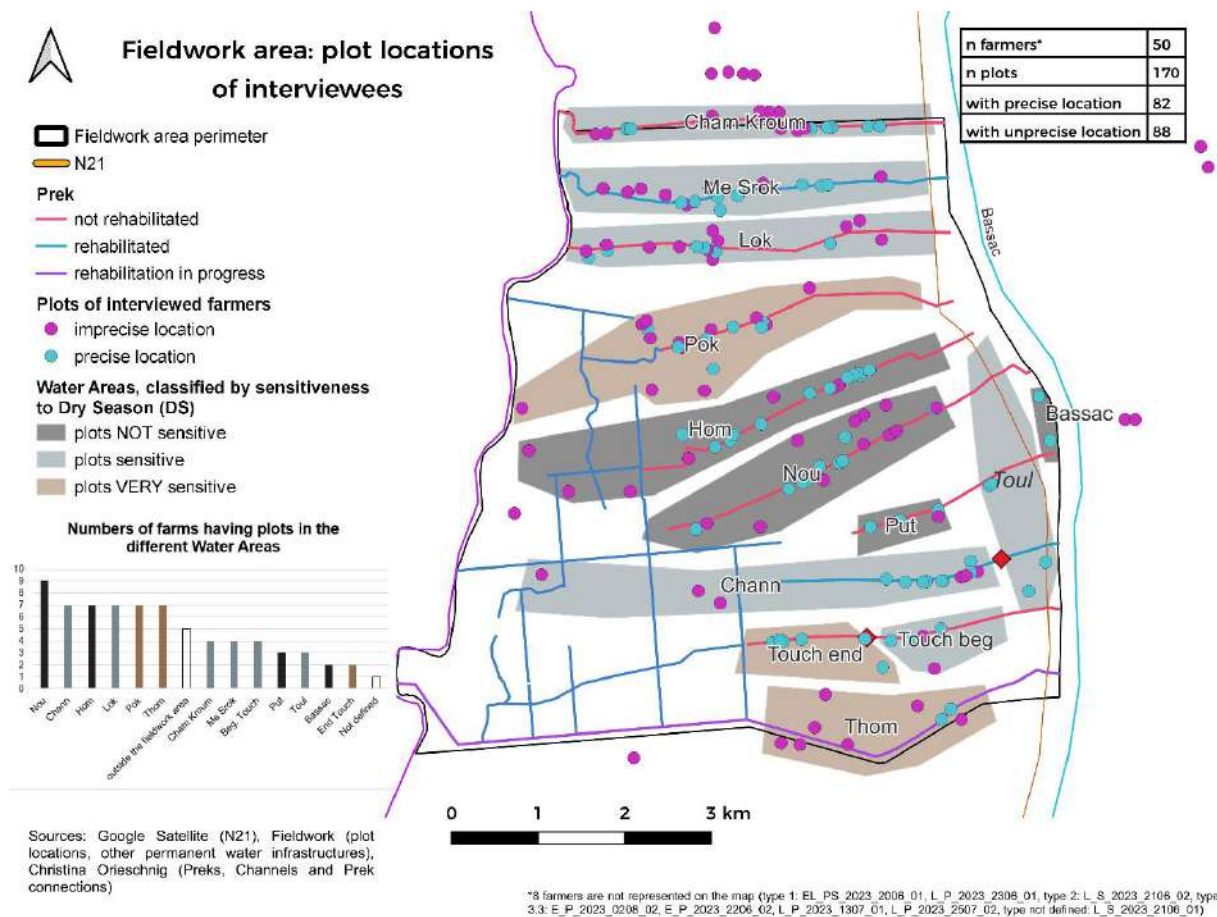


Figure 11 Plot locations of interviewees

The Dry Season indicator was made after summarizing information collected on each Water Areas.

Sources: mentioned on the map

Upon 6 weeks in the area, the workload has been divided in 4 main steps:

- Week 1: defining main decisions to study, understanding farmer perceptions, train translators, target bias in the questionnaire,
- Week 2 and 3: random sample, teams go along the *prek*, see a farmer and ask if she/he has time to answer questions, keep targeting bias in the questionnaire,
- Week 4 and 5: targeted sample, extreme profiles are asked around (usually people with lots of lands, farmers with specific crops or farm organization), some were met spontaneously, other meetings get planned,
- Week 6: focus on water and irrigation practices, and household information. Uncompleted information was filled up by meetings on missing location plots or calling back farmers.

Between each main four steps, transcripts, questionnaire adjustments to reduce bias, and intermediary analysis are done at the office in Phnom Penh. Transcripts are not exhaustive. Along interviews, students would write time marks of unclear parts, and decision-making questions. Transcripts would be written on a collaborative folder, reused to complete notes and necessary for analyzing farmer's perception. There is a good training basis to distinguish differences between questions asked and questions translated and analyze perception of farmers. The same methodology is used all along field work to improve translation quality and reduce bias as much as possible.

This flexible approach leads to different versions of the questionnaire 21. The main core on decision-making stays all along. As it was a semi-directive questionnaire, follow-up questions and slight changes in the way of asking core questions (from students and translators) are written down as it could change a lot answers and introduce bias. It is mostly a qualitative work, as interviews could have different duration between 30 min and 3 hours. Not all questions are answered by each farmer. It can be interrupted by farmer's spontaneous tasks, and main focus on contextual aspects can change as the understanding of the area evolved.

To help a better understanding of farm environments, and therefore decision-making processes of farmers, interviews are conducted with other stakeholders: 5 Water Sellers (WS), 7 Village Chiefs (VC), 1 input seller, 1 middle buyer, 26 sellers on local markets, 9 sellers on markets in Phnom Penh, the Vice Commune Chief. Water Sellers and Village Chiefs are also called back to complete missing information after interviews. Only 6 VC were called back.

As encountering farmers can take time, some informal interviews also help to have a better understanding of contextual aspects and get some sense of general decision-making processes in the area. Reports are also written down. Landscape and crop observation also help providing some insight. GPS points are collected to give confirmation to Christina Orieschnig's eco-hydrological model but are not analyzed in the current report. The following sections represents the different parts of the questionnaire.

FARM ENVIRONMENT CHARACTERIZATION

Regarding farm environment characterization, there are the following sections in the questionnaire: land, seeds, market, water, and equipment. This information are used in the

contextual part of the current report. 5 Excel files are made summarizing quotes per farmer, and prices / costs when there are given:

- **Prek:** available water supply, water services, other elements having an impact on water availability, and prices for water service costs,
- **Prices and costs:** farmers' marketing information and their selling prices, registered cultivation costs (except for water services, see *prek* file), and prices on local markets (mostly for vegetables),
- **Land:** farmers' information on inheritance/buying, selling, renting to other people, and renting from other people, and rental / buying prices,
- **Cultivation advice:** information on farmers that mentioned which types of advice they were given,
- **Employment:** information on farmers who mentioned employment of other people, and costs.

Regarding water, from interviews with farmers and WS, a synthesis of *prek* water availability is visually made (Appendix 1). *Preks* are classified in each category regarding water availability in May, and April. This classification is on Figure 11. While asking about crop cycles, flooding events (FE) are also asked: plots have flood information which are spatially registered. From this summary, a **DS, and flooding events (FE) indicators** are made. By farmer, each plot registered got attributed a number: 1 not sensitive, 2 for sensitive to DS or partly flooded, and 3 very sensitive to DS or all flooded. Then, it is divided by the total number of plots. The highest the number, the more sensitive the farm is.

HOUSEHOLD AND ACTIVITY SYSTEM CHARACTERIZATION

What came out from the literature review was that household characteristics and activity systems are main factors explaining decision in agriculture. Therefore, sections of the questionnaire focused on:

- Household structure: who live under the same roof, which activities each member does (agriculture, working somewhere else, not working, going to school),
- Finance management: who share their income and make savings with each other.

These parts are to understand to what extent the households' structure and its activities could explain choices made by farmers. To simplify the analysis and see the diversity of farmer in the fieldwork area, it was decided that a typology would be made. It is based on time dedicated to agriculture activity and member sharing their income.

Therefore, most households in the types would be characterized as a nuclear family and a stem family will be characterize as two households. For instance, if under a same roof, parents and children both work and share their income, then it is one household. On the contrary, if under a same roof parents live with their married children and her/his spouse, and they do not share their income, then it is two households.

Concerning time dedicated to agriculture activity, some choices are made. On one hand, there would be households who are only doing agriculture meaning that all their labor force can go

into the farm work. On the other hand, there are households who have other activities: either part time job, employment or had their business. It was decided that part time and full time/business jobs would not be categorized as the same available labor force for agriculture as those doing part time jobs. Finally, land rental activity is not considered as a part time job or a business but considered as a kind of remittance, as it is money that enters the household's income but does not require the working time of a household's member. The typology is made of three types presented in Table 4.

Table 4 Summary of household type characteristics

Source: personal

TYPE 1	TYPE 2	TYPE 3		
Every member, able to work, work in agriculture and their profit covers life expenses, or sometimes even not able to cover life expenses, and does not allow savings.	Every member, able to work, works in agriculture and the profit made covers life expenses and enable them to have some savings, either kept in case of emergency or directly used for the next cropping seasons.	TYPE 3.1	TYPE 3.2	TYPE 3.3
		One or multiple members having only temporary activities.	Members having at least two activities which are not agriculture (one being a full-time job, one a temporary one).	Members having permanent jobs, or their own business as well as agricultural activities.

In order to characterize farmers into one type, their raw income is asked as well as their savings.

- **Raw income** is how much money the household make without taking into account the cost of life expenses and the cultivation costs. If possible, the remittances were added into the raw income.
- **Savings** is how much a household can keep once living expenses and cultivation costs have been taken out of the raw income.

If the farmers are not able to give their savings but knew their raw income, then some questions about their expense on daily life are asked in order to do calculations of their savings. The questions focused on:

- How much they spend on food daily,
- How much they spend on their child education (weekly and/or monthly),
- How much they spend on electricity and water monthly,
- Other spending (reimbursement of a debt (monthly or yearly), accommodation in Phnom Penh for their children, land fees, university fees).

Presented **data and types are synthetized in a database**, used to characterize each farmer interviewed.

Finally, the analysis of types enables to measure if labor force for agriculture and money management could explain if one type would influence a choice over another. Furthermore,

the typology enables to see if a type would benefit differently from *prek* rehabilitation than another one.

DECISIONS, FACTORS AND CHOICES SELECTED

Regarding decisions selected from literature review, there are 13 decisions identified: types of crops, decision not to plant, number of cultivation season, varieties, quantities of seeds, sowing dates, duration and frequency of irrigation, quantities of fertilizers and pesticides, number of applications of fertilizers and pesticides, number of soil cultivation operations and types, date of harvest, and decision not to harvest. **After a first week on the field** and discussions with supervisors, it has been decided to remove decisions with no direct link with water. Tables are filled up for each farmer (column: factors, lines: decisions) with 1 when a link was mentioned, 0 when there is no link. Then, individual tables are aggregated, and a writing report detailing quotes is used for the discussion. As a few answers were given regarding links between water and varieties, between soil operations and water, it became parts of the contextual part. This first working step also helps confirming that markets, and water resources are two key contextual aspects to study.

Decisions studied are the following:

- Crop type, number of cultivation cycles per year, and sowing dates,
- Duration and frequency of irrigation,
- Number of applications of fertilizers,
- Number of applications of pesticides.

Regarding factors, after discussion with translators, the term “what has an impact on your [name of the decision]” has been used to ask questions. Then, what farmers say would be written down and follow up questions asked. A visual template helps to find notes on decisions quickly on the questionnaire, and gathers main factors identified from the literature review. It is the core of data collection. Other factors can be mentioned on the field. There are not put apart, but also written down, and included in the results. As ranking factors is something hard for farmers, and interview time is limited, it is **preferred to add the contextual questions between questions on decisions**. It helps farmers to express themselves, to provide a better understanding of their situation, and to reduce bias in the translation. **Regarding choices**, it is also based on verbatim analysis, and it is the same process used for filling up factor sheets.

After week 1, tables per decision and factors are made. Columns are still factors, but this timelines match farmers' ID. **There is one Excel file gathering per sheet, each factor database, and each decision database**. To find content, there are 3 components to check: systemic visual templates per decision, the rest of the interview notes to check if there not missing elements, and a keyword search on the transcript. When a choice or a factor is mentioned by farmer, a quote or a “yes” are added in the corresponding cell. It does not take into account how many times the farmer talked about it along the interview. The process allows to use dynamic tables and to have crossed analysis. It makes it easier for the analysis as there are two people working on data, and analysis remains more accessible with collaborative shared tables. To have an overall idea of factor importance for all the study area, factors are not presented by household type. However, for decisions, tables are completed by available

household information, land ownership, DS, and FE indicators. Household types are a reference for further analysis.

IMPACT OF *PREK* REHABILITATION

At the end of the questionnaire, farmers are asked about their interest in rehabilitation. The data collection is processed as previously. This only difference is that choices are put in future tenses. As *prek* rehabilitation projects have been undertaken in the fieldwork area but not on all *preks*, some answers are given by farmers from their experience of an already done rehabilitation. On *prek* Chann, there is a specific question related to the role of the gate. Information is gathered with the Excel files of factors and decisions. It is also combined with available household information, land ownership, DS, and FE indicators. Apart from the asked question, the presentation of fieldwork results is also an opportunity to implement an interactive activity related to *prek* rehabilitation.

FARMER PRESENTATION AND INTERACTIVE ACTIVITY

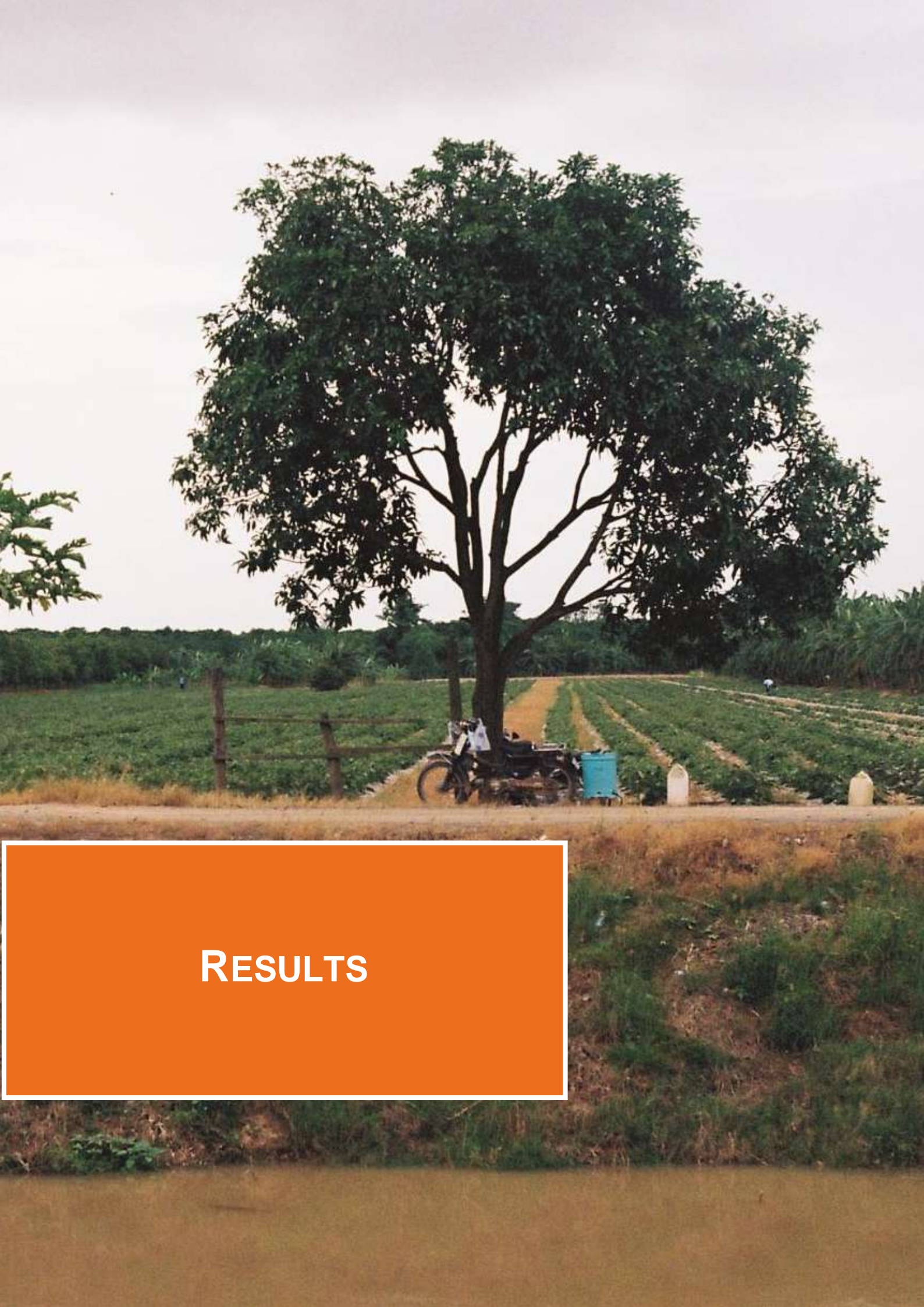
To finalize the fieldwork, a time with farmer to exchange and present the first result was organized. The overall organization of the session is 66.

PRESENTATION OF THE RESULTS AND FEEDBACK COLLECTION

The presentation was divided into different parts with time in between them to let farmers give feedback. The main goal was to give back results to farmers and provide further understandings of the choices. The presentation is in three parts, first a time discussing markets and presenting value chains in the area. The second one is about the three main strategies analyzed from the fieldwork. The third one presents factors which could explain their choices on irrigation, applications of pesticides and fertilizers. As well as how these factors could explain why they would change a choice previously made. **Feedback on the presentation** is not presented in the results, but there are summarized in 71. The presentation was followed by an activity, to make it more interactive and have farmers exchange between one another.

BOARD ACTIVITY CONCEPTION

The main goal of it was to see how *prek* rehabilitation would have an impact on the cropping systems of farmers. There are 2 boards per group: for one the *prek* was not always full of water and, for the other the *prek* has water year-round. Moreover, the activity has the aim to confirm or unconfirm the first results analyzed, which other factors might come up, and how factors could impact decisions of farmers. To do so, farmers had to decide which crops they would cultivate on three different plots (with different characteristics, never flooded, partly flooded and always flooded) and their numbers of pesticide and fertilizer applications, and how they would irrigate. They also had to justify reasons of their choices. The details of the activity are described in 66. **Erreur ! Source du renvoi introuvable.**



RESULTS

HOUSEHOLD TYPOLOGY

50 farmers are interviewed in total, enough information was gathered to sort out 45 of them in the types of households. The other 5 farmers did not have complete enough information on their incomes and savings to categorize them in one of the types. The number of farmers per household types are in Figure 12.

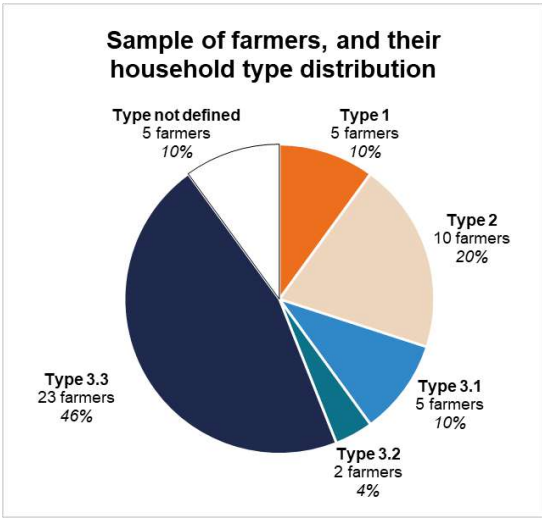


Figure 12 Sample of farmers, and their household type distribution

Source: personal

For the rest of the analysis in this part, the percentages are given for the 45 farmers characterized in the typology. It is referred as a panel.

SAMPLE OF FARMERS AND REPRESENTATIVENESS

There are 5 farmers in type 1 who have only agricultural activities with no savings. They represent 11% of the panel. 10 farmers are in type 2 who have only agricultural activities with savings, they represent 22% of the panel, and finally 67% are from type 3, who have agricultural activities and external ones. This shows that actually it is **rare to have a household only dependent on farming**, and usually a household has a diverse source of income in our fieldwork area. Within type 3, type 3.1 with occasional external activities is represented by 5 farmers (11% of the panel). Type 3.2 with occasional and permanent external activities presents 2 farmers, so they were not very representative (4% of the panel). Finally, type 3.3 represents 51% of the panel with more than half of the farmers interviewed.

Village chiefs were asked to give a percentage of households with agricultural and external activities. 4 out of the 6 villages chiefs that were called back said that more than 50% of households have diverse sources of income. It represents 60% in *prek* Pok villages, 67% in *prek* Lok village, 62% in Koh Cha. In Lor Kberng village a percentage was not given but the village chief explained that none of the households do only agriculture). Then, in *prek* Me Srok only 14% of the households have multiple activities and 21% in Anlong San Village. It confirms that most households in the area have an agricultural activity and an external activity.

ACTIVITIES AND SAVINGS

Household types are based on activity systems. In order to have an idea of their cash management, individual farmers' information is gathered by household type (Figure 13).

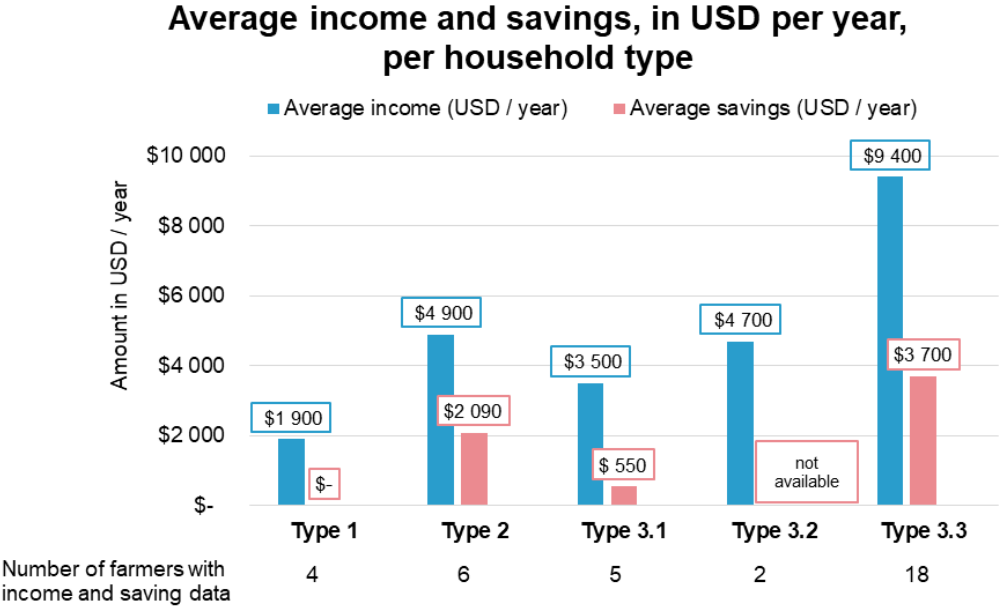


Figure 13 Bar chart representing average income and savings, in USD per year, per household type

Source: personal

Type 1: The average raw income is about 2,000\$ per year, even though the raw income can vary greatly between one household to another with the lowest being at 300\$ and the highest being at 4,564\$. It is interesting to note that 60% of them receive remittances from a family member, showing a certain dependency on outside help. For instance, the farmer with the highest income has half of it from remittances whereas the poorest farmer does not receive any.

Type 2: The average raw income is about 5,000\$ per years. The variability between the lowest and the highest is also important. It varies between 1,000\$ to 11,7000\$, 4 are above 5,000\$ raw income per year against 2 that are at 1,000\$. They can all save money, mostly around 2,000\$. There are less dependent on outside help as 40% receive remittance, the farmer receiving remittance often are the one who cannot save much (3 out of the 4 were able to save 1,000\$).

Type 3.1: The average raw income is 3,498\$ per year with the lowest being 1,000\$ and highest 6,440\$. Their average savings being at 550\$. 40% of them can save more than 1,000\$ while 60% can save less than that. Farmers with the highest saving capacities are the ones who do construction work while the other ones work mainly part day for other people. It can be as agricultural labor or at the factory.

Type 3.2: The average income they have is 4,700\$ which is representative since the maximum income is 5,000\$ and the lowest is 4,400\$, and both can make savings. However, with only one having given his saving, an average cannot be made. Both households have a member working at the factory, while another member has a part time job, and they don't receive any remittance. They are the ones taking care of others. For instance, one household has young children while the other must take care of the aging mother of the husband.

Type 3.3: Their average income is 9,455\$ with a very high variability, the highest being 20,500\$ and the lowest being 1,525\$. Yet, on the 18 farmers who answered the question on income, 10 have an income around and above 10,000\$, 5 are around 5,000\$ and finally 3 are under 2,500\$. 21 of them answered when we ask if there were able to have some savings: 18 answered positively. The average savings is around 4,000\$ per year. Only 17% receive some remittances. The **other activities** are very diverse. Among type 3.3, 17% have a member working at the factory and 13% work as a teacher. 52% have their own business which can be having a grocery store, equipment rental activity, middle buyer. Some households use the agricultural activities for their business as they do food processing. The last 18% can be employees or work as seller on the market. Interestingly, some farmers told us their farming activities are not very important but are a nice source of income that can make it easier to save a little bit and pay for child education.

CROPS, NUMBER OF PLOTS, AND LAND STATUS

In order to keep better characterization of household types, the following parts present crop types (**Erreur ! Source du renvoi introuvable.**), their land status (**Erreur ! Source du renvoi introuvable.**), and their numbers of cycles (Figure 16) per household types.

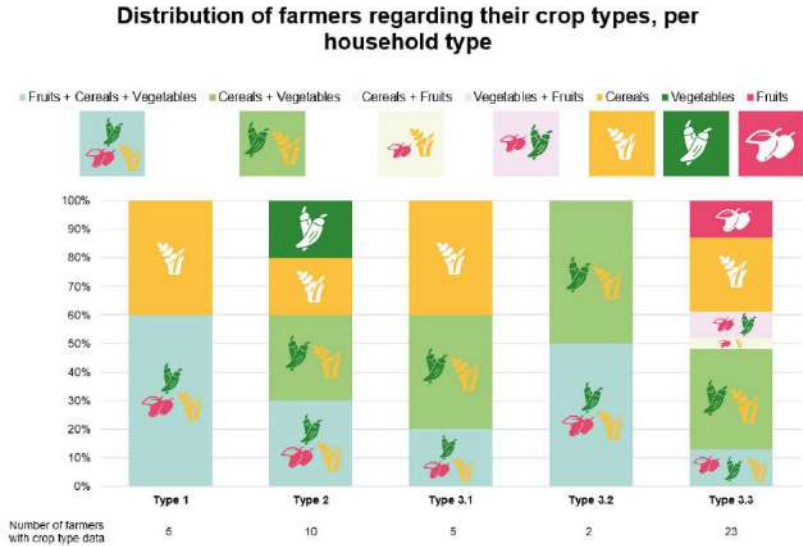


Figure 14 Bar chart representing distribution of farmers regarding their crop types, per household type

Source: personal

Within **type 1**, 40% are specialized in cereals (maize or rice) and 60% are mainly diversified with cereals, fruit trees and vegetables. It can be explained by the number of plots they have. Actually, the ones who are specialized, do farming on only one plot while the others do agriculture on multiple plots. Furthermore, cereals and especially maize are less risky as it has good yield and a cultivation cost that is not too high, assuring a more secured profit than vegetables.

Distribution of farmers regarding their overall land status (owned and rented), and average number of plots, per household type

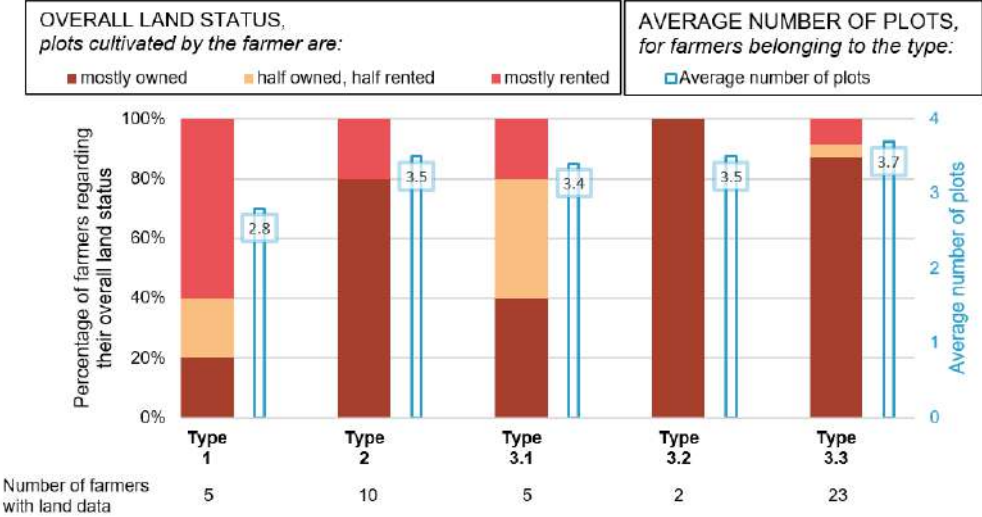


Figure 15 Bar chart representing distribution of farmers regarding their overall land status (owned and rented), and the average number of plots, per household type

Source: personal

Moreover, in type 1, 60% of them mainly rent their plots which add on the cultivation cost. Therefore, having a more secured income with cereals to pay off the renting fees might explain why they all do cereals. Furthermore, 80% do 3 cycles in the year (if their plot is not flooded) which shows a will to maximize the use of their plots. The only exception who does not do 3 cycles, is actually the poorest household and they only have a plot in the *boeung* area where the flood makes it impossible to do more than 2 cycles.

For type 2, farmer have diverse types of crops: 20% of farmers are specialized in cereals, 30% do cereals and vegetables and another 30% do fruit trees, vegetables, and cereals. Finally, 20% have adopted very peculiar strategies that have been met only once during the fieldwork. The first one, is someone who has multiple plots and has specialized in okras and the other one, is a former agricultural student who grows rare vegetables (not found easily in the fieldwork area) in net houses. But what is interesting to note is that the ones specialized in cereals have only one plot, just like those of type 1. However, numbers of plots do not seem to explain what could make farmers do fruit trees, vegetables and cereals or cereals and vegetables since the other farmers in type 2 can have the same numbers of plots and grow

very different crops. Furthermore, the **households mainly owned their land**, 70% against 20% who mostly rent and 10% who have as many plots owned as rented. Most farmers, like those in type 1, have a will to maximize their land use as 60% of farmers will do 3 cycles of crops. Once again, it is interesting to note that farmers on rented land will do at least 2 cycles of cereals, mainly maize.

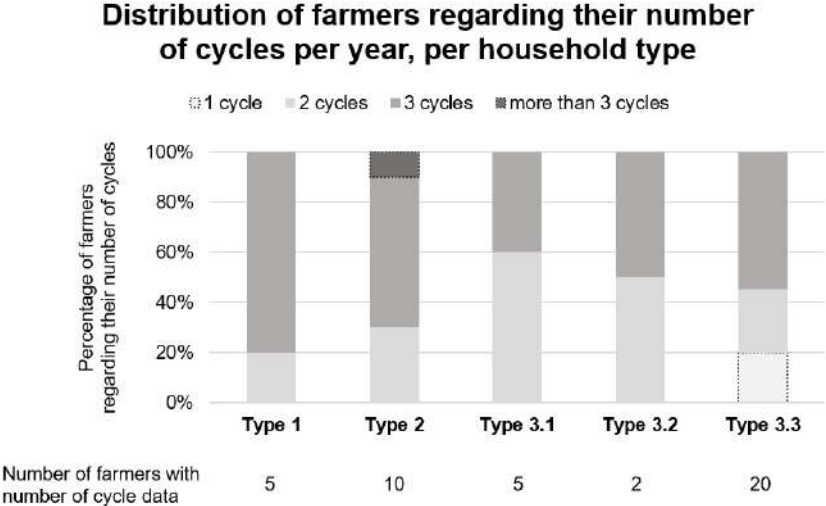


Figure 16 Bar chart representing distribution of farmers regarding their number of cycles per year, per household type

Source: personal

Within type 3.1, 40% grow **cereals and vegetables** and 40% are **specialized in cereals** while 20% are **diversified** with fruit trees, vegetables, and cereals. The one specialized in cereals do not have only one plot but they have half or most of their plots rented. Here only 40% try to do 3 cycles compared to the previous types. Moreover, farmers who have 4 or less plots, they will do 3 cycles. Yet, if they have more plots than 4, they will decrease their number of cultivation cycles. The third cycle is always a vegetable as it has less risk to get destroyed by the heavy rain that occurs during July to November. As for the **ownership of their plots**, 40% of them mostly own their lands, another 40% own half and rent the other ones and finally 20% mostly rent their lands.

For type 3.2, there are only two farmers. One does fruit trees, cereals, and vegetables on 3 plots owned and the other one does only vegetables and cereals on 4 plots that he also owns. Concerning the number of cycles both do 2 cycles. However, one might be able to do 3 cycles if there is water above 2 meters in the *prek* for his maize cycle.

For type 3.3, the main types of crops are by far **cereals and vegetables**, often with plots specialized in cereals and others in vegetable and/or vegetable for the third cycle. It represents 35% of the households interviewed. Right after come the households **specialized in cereals** with 26% of the households. The other households cultivate either fruit trees (13%), fruit trees, cereals, and vegetables (13%), fruit trees and vegetables (8%) and finally fruit trees and cereals (4%). **48% of them do 3 cycles**, which might be, as said above, 3 cycles of cereals, or 2 cycles of maize followed by a vegetable cycle. They can have a plot specialized in

vegetables where they do as many cycles as possible. For one (17%) or two (22%) cycles, it is usually because they just planted young trees or do long cycle of vegetables to benefit from

having money regularly. **87% of them are owners of their land.** Most of them (78%) own between 1 and 4 plots. But what is interesting to note here is that out of the 3 renting plots, two grow maize and the third one has mango on it (even though there are important cultivation costs). A reason that might be behind is that his other activity enables him to be secure on the renting fees and be less apprehensive of the risk involved.

Moreover, it should be noted that most farmers have at least one plot in the boeung or in the inter-preks where they do rice. Often, they did not tell us about those plots as it is mainly for self-consumption. It was later in the fieldwork that we understood these characteristics, therefore in the calculation of the average number of plots by types of households they might be missing.

SENSITIVENESS OF PLOTS TO DRY SEASON (DS) AND FLOODING EVENTS (FE)

In order to analyze plots of farmers regarding sensitivity to Dry Season (DS) and flooding events (FE), weighted indicators have been created, and are explained in the methodology. Figure 17 presents results by type for DS. Each type of farmers have plots that are not sensitive and plots that are all sensitive, except maybe for type 1 and 3.2. It might explain why there are in type 1, not able to save money, but there are not enough data to conclude.

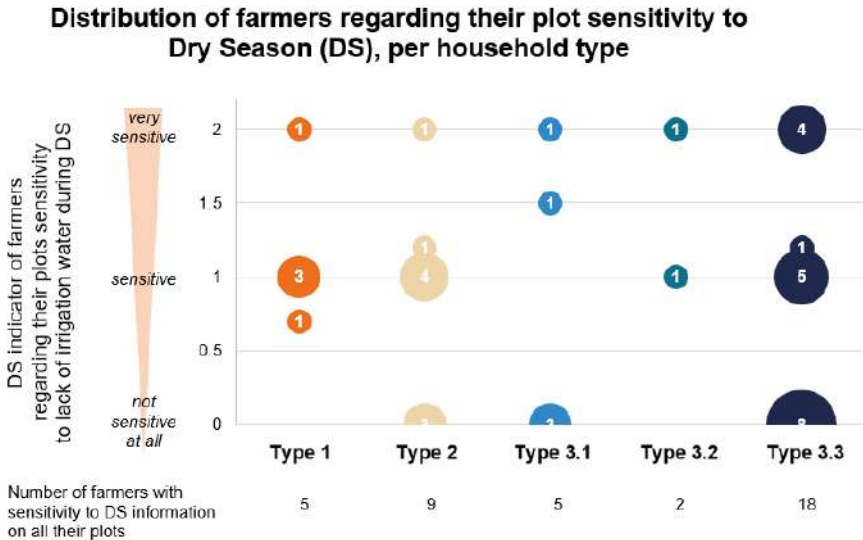


Figure 17 Bar chart of the distribution of farmers regarding their plot sensitivity to Dry Season (DS), per household type

Source: personal

On Figure 18, there is an indicator related to sensitiveness of flooding events (FE). Farmers classified in types 1, 3.1, and 3.2 seem more likely to be sensitive to FE. There are not enough data to conclude as there are less than 4 individuals in each type. However, there is a light trend for types 2 and 3 to have plots less likely to be sensitive to FE.

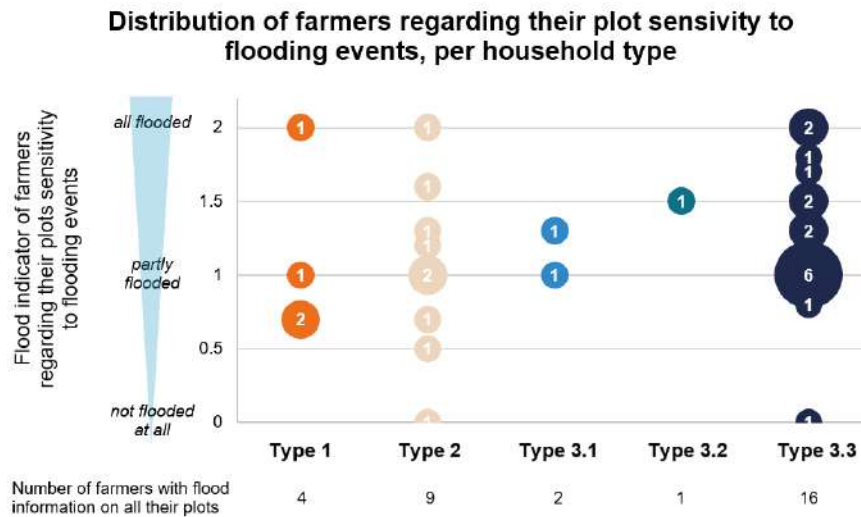


Figure 18 Bar chart of the distribution of farmers regarding their plot sensitivity to flooding events (FE), per household type

Source: personal

After describing household types, it is time to have a look at the first decision studied in this report. It is related to crop type, number of cycles, and sowing date decision.

DECISION ON CROP TYPE CHOICES, NUMBER OF CYCLES AND SOWING DATES

MAIN FACTORS FOR THE DECISION

Before having a closer look at choices under this large decision, it is important to examine factors related to this decision. Farmers are not classified by type in order to focus on an overall analysis. There are 3 graphics: one graphic **listing factors** for **crop type choice**, another for the **numbers of cycles**, and the last is related to **sowing dates**. Factors are in y axis and number of answers in x axis. Factors have been **classified in 3 main categories**: market and production costs (pink), biophysical environment of farms (green), and other families of factors (blue).

Choices of crops seem to be influenced by a wide diversity of factors (Figure 20). Our interviews highlighted up 24 reasons across the farmers we interviewed. Reasons seem to be mainly linked to the market factor. Other main reason depends on biophysical factors with the plot configuration (location, elevation) and then on household type in regard with their investment and labour capacities. What stands out here, farmers regardless of their type will try to make the best profit while balancing their cultivation cost. Yet, as they cannot emancipate from their type and the environment around them, they adapt according to their capacity for investment and labour and where their plots are.

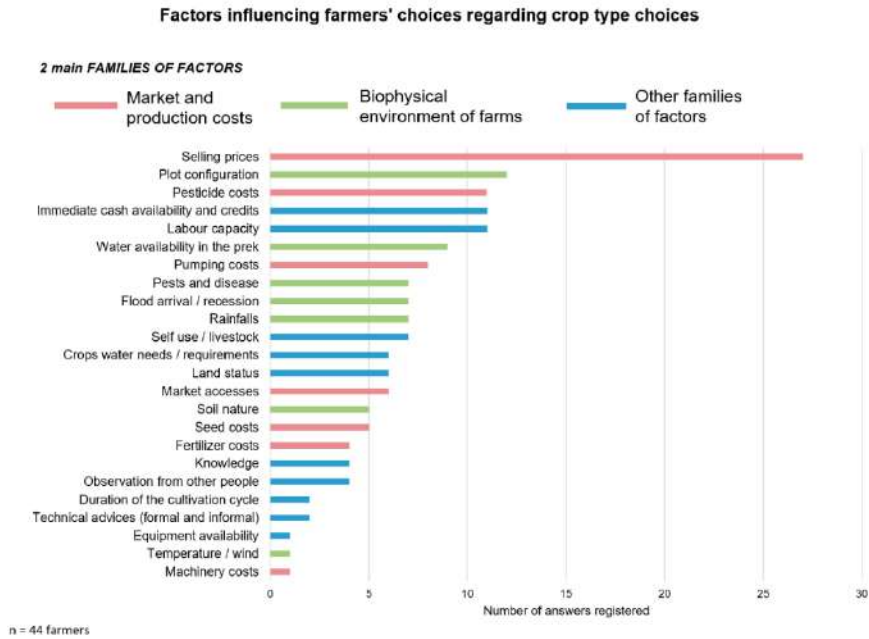


Figure 20 Bar chart of factors influencing farmers' choices regarding crop type choices
Source: personal

About the **number of cycles**, the 3 main families of factors are equally represented (Figure 19). Yet, the main factor influencing the number of cycles is when the flood arrives and leaves. As the latest is the more mentioned, this choice depends more on biophysical environment of farms than the other one.

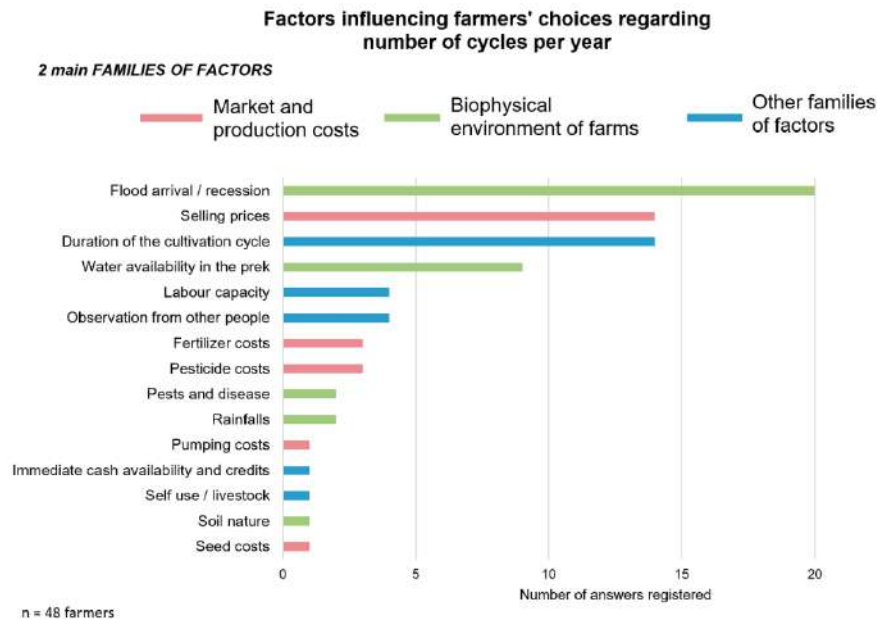


Figure 19 Bar chart of factors influencing farmers' choices regarding numbers of cycles
Source: personal

Regarding the **sowing date**, the market factor is almost non-existent (Figure 21). Therefore, this choice depends mainly on biophysical environment and on others family factors such as observation from others.

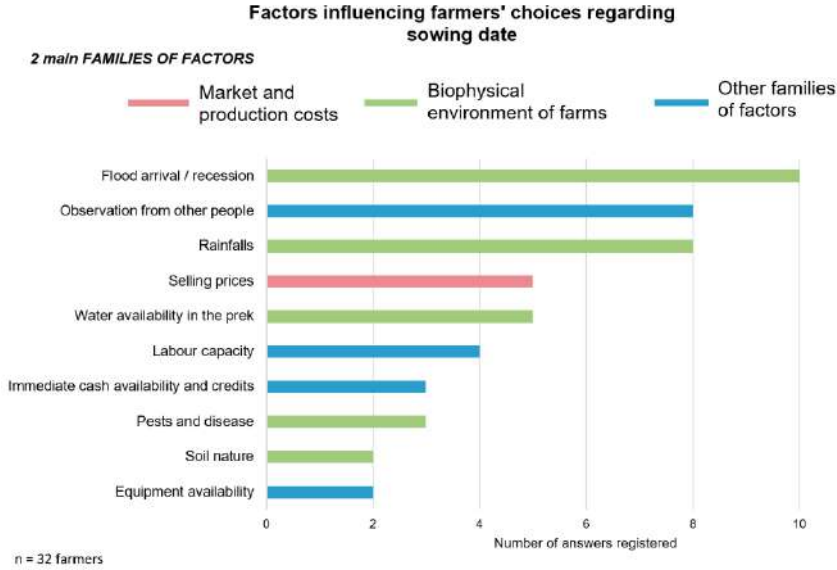


Figure 21 Bar chart of factors influencing farmers' choices regarding sowing date
Source: personal

CHOICES

One goal of this part is analyzing different choices made by farmers about their crops decision (Figure 22 **Erreur ! Source du renvoi introuvable.**). **Erreur ! Source du renvoi introuvable.**

Farmers' choices regarding crop type, numbers of cycle, and sowing date decisions, per household type

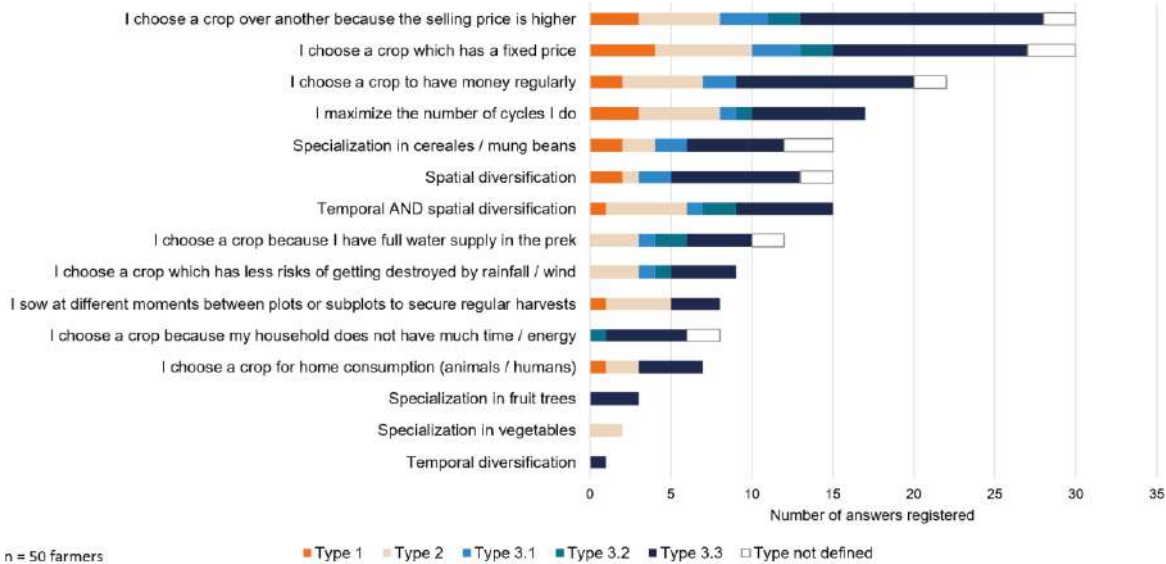


Figure 22 Stacked bar chart of farmers' choices regarding crop types, numbers of cycles, and sowing date decisions, per household type
Source: personal

Choices are in y axis and numbers of answers in x axis. Household types are presented and follow the same color code as before. It is a way to analyze whether choices are related to the different household types, or if the choices are based on other factors.

I choose a crop with a fixed price, or I choose a crop to get money regularly throughout the year or I choose both, 30 farmers have chosen a crop with a fixed price, 22 farmers have chosen a crop to have money regularly and sometimes both choices can be taken by the same farmer. Mainly farmers from type 3.3 (7 have chosen this choice), have chosen a crop to get money regularly throughout the year (vegetables or fruit trees). It can be explained, as they have an external activity, they do not need a secure income and having money regularly is a way to diversify a bit more their income.

"I wanted to have a plan B and be able to support my family so I decided to diversify my income by adding banana and vegetable to my mango". [E_P_2023_2206_02]

It is also the case for two farmers from type 2 and two from type 3.1 but it seems that it was not a choice for them but because of a constraint. Whereas 21 farmers (all type) will rather have a crop which has a fixed price (maize for instance) as it is more secure:

"With maize I make a better profit". [E_S_2023_0507_02]

Finally, 9 farmers (all types) can mix up the strategy when they have enough plots to diversify in vegetables and/or fruit trees (money regularly) and cereals (fixed price) at the same time.

I chose a crop over another because of the high selling price, 29 farmers out of 50 said they chose a crop over another because of its high selling prices. In this case, market prices drive farmers to do agriculture. They will always think about the profit and if they will be able to make ends meet when the cultivation cycle will be over. Cost management is crucial for every farmer from every household types.

"I bought a long time around ten years ago but I planted mango before but the mango price went down so I choose to plant banana instead right now.. After I cut down the mango, I have not yet planted a banana, so I plant round eggplant first but I cut them down and plant banana instead because when selling round eggplant with low price and compared to the cultivation cost that I spend for fertilizer and pesticide and the price is cheap so it's not balance." [L_P_2023_2507_01]

However, what changes a little bit is their perception on the high prices. For instance, bananas are seen by type 3.3 (whose main income is from an external activity) as having a good selling price because there is no cultivation cost and can be sold it at different times during the year (even though it is just some bunch per time). Whereas, for farmers whose main incomes come from farming (type 1, type 2 and type 3.1, type 3.2 and some from type 3.3), then maize is seen as a better crop to make profit because it is easy to get better yield without too much cultivation costs. These same farmers will also choose a vegetable for a third cultivation cycle based on the market prices.

"Generally, I consider what I am going to grow that could make a profit, for round eggplant first I have to follow up the market price. Are there a lot of people who grow it a lot or not? So I have to wait and see." [E_S_2023_2807_01]

The selling prices might have an impact on the switch of a crop during cultivation cycle farmers will do. For instance, if they have enough money to buy water from the water seller or to pump from the *prek* for different cycles, then they might stop mung beans to do maize. Therefore, farmers from types 2 or 3 are more likely to follow this strategy than farmer from type 1. A third of all farmers **maximize the number of cycles they do** in a year. Mainly farmers dependent on farming makes this choice. Maximizing the number of cultivations cycles can be a way to secure enough money throughout the year. Interestingly, even if all farmers have these strategies, farmers explain the crop choice mainly depends on the sensitivity of the plot to flood or heavy rain. This information can be cross read with the FE indicator per farmer (**Erreur ! Source du renvoi introuvable.**). The x axis represents value of FE indicator and the y axis is the number of farmers. Farmers with **different sensitiveness values maximize the number of cycles**. There might be a more important trend for the highest value, but it is not clear. Market prices are the second factor explaining the crop choice. For instance, farmers whose plot does not get flooded will usually do maize as a third cycle, but on the contrary the one who have a plot that does get flooded will do rice.

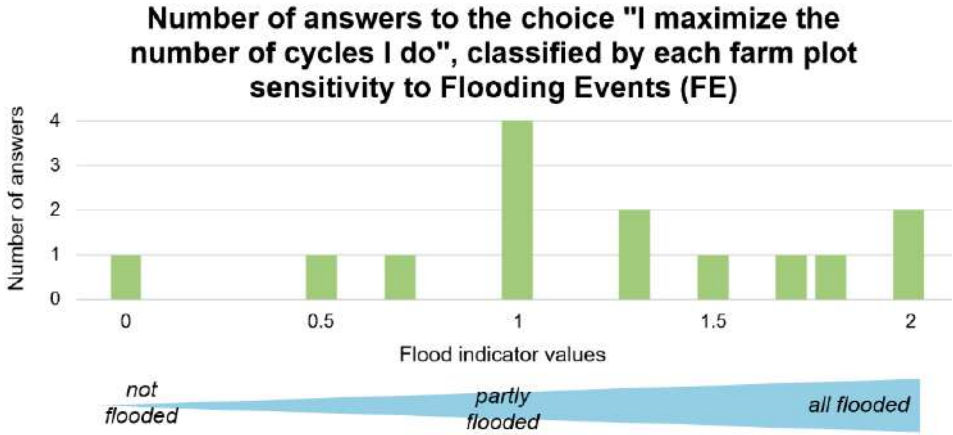


Figure 23 Bar chart of the flood indicator of farmers giving an answer to the choice "I maximize the number of cycles I do"

Source: personal

Where the plot gets partly flooded, then usually farmers choose a vegetable with low cultivation costs like wax gourd, cucumber, and round eggplant. They can harvest multiple times before plots get flooded or destroyed by heavy rainfalls.

"There is a flood for third cycle on my new rented land, so I will grow wax gourd because there is less risk to no get any profit" [E_S_2023_0507_01]

For plots less likely to suffer of too much water, farmers might go for long bean and bitter gourd. Chosen vegetables can vary between the years as it will mainly depends on market prices. Therefore, if a farmer knows that the price will get low, then they choose another crop.

"No, never, I plant every time. When cultivation costs of that crop are higher, I will plant another crop." [L_P_2023_2306_02]

To end with maximizing numbers of cycle, there is one choice only type 3.3 does. If they have a food-processing business, they maximize the number of cultivation cycles of the needed crop. **On another note**, it seems that farmers with lots of plot (more than 5 plots) usually do not maximize the number of cultivations cycles but mainly spread out the sowing dates between plots. Whereas farmers with less plots (less than 5 plots) maximize numbers of cycles. Processes are summarized Figure 24.

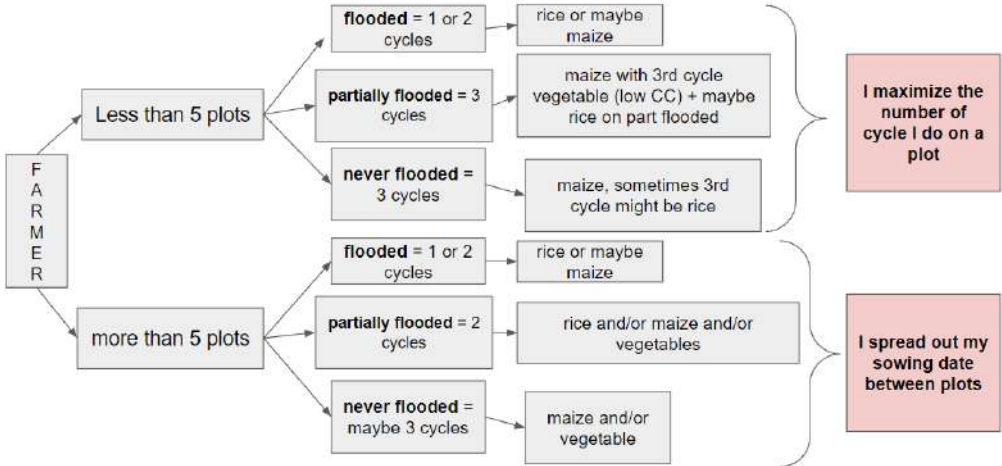


Figure 24 A decision tree leading to maximization of numbers of cycles and spreading SD using flood status and numbers of plots per farmer

Source: personal

After presenting the 4 main choices, there are 2 striking trends on choices: either to **specialize** in a type of crops or else to **diversify**. In the fieldwork, we have met 30 farmers who were diversified and 20 who were specialized. Considering specialization, specialization in cereals can mean growing rice as well as maize. For vegetables, a farmer would be considered specialized even if he does different types of vegetables and same wise for fruit trees.

Concerning diversification, farmers in the area who diversify usually **diversify spatially and temporarily**. The choice depends on two factors, types of households and locations of the plots with regard to its sensitivity of flood. First the farmers from type 1, 2, 3.1 and 3.2 who are dependent on their agricultural activity to have an income have the same type of diversification. 50% of their crop is at least cereals and then, they do a small diversification with vegetables or some fruit trees to secure an income coming from different crops. For instance,

“I have seven plots where I mainly do maize, but I have some plot where I’ll do some long beans and bitter gourd to get some money regularly.” [E_S_2023_0308_02]

However, farmer from type 3.3 were not diversified spatially and temporarily. Where the factor “household type” does not explain crop choice of farmer is concerning water. If their plots might risk getting partially flooded, the strategy is often to do a vegetable cycle when the risk of heavy rain and flood are high. This is a way to have some profit (multiple harvest) even though the crop is destroyed by the rain or flood after some time. The same factors (household and water) seem to explain that farmer **diversify only spatially**. For household types, the same conclusion can be drawn. It is interesting to note that farmers from type 3.3 whose more than 50% of their income comes from an external activity give up growing cereals and diversify with

different fruit trees and a plot with vegetables. For water, what changes is that the plot is in a part where it gets completely flooded. Therefore, farmers who have farmland plot and one of their plots in the *boeung* or in the *inter-prek* area, they will do one or two cultivation cycle of rice along with other types of crops in the farmland.

Concerning specialization, three types of specialization have been discovered on the field (**Erreur ! Source du renvoi introuvable.**). However, two are quite marginals and one is the most met on the field. **The specialization in mung beans/cereals**, 15 farmers out of 50 are specialized. Three strategies stand out, one explained by the location of plots which does not depend on households' type (11 out of the 15 are in this case). Plots in *boeung* or in the *inter-prek* can only grow rice. Moreover, since everyone is doing rice, if a farmer change crops, then will have issues with pests.

“Because I have no more land to plant other crops, I only have this rice field to plant [their land can only grow rice].” [Spouse of the farmer]

“I cannot grow during the flood, the birds would come, and I have to follow my neighbors.” [L_P_2023_0507_02]

Farmers dependent on farming intensify the number of cycles and take some risk to do a third cycle by planting rice if plot flooded or maize on farmland.

“If the second cycle of my maize in not flooded while I harvest then I will do a third cycle by planting rice. Because it is a crop tolerant to water however if flooded before harvest, I will not sow and then leave my land empty.” [E_P_2023_1007_02]

Farmers dependent on farming activities (7 out of 15 farmers are in this case, 4 from type 3.3, 1 from type 3.1, 1 from type 1 and 1 that is not categorized) have a will to specialize in maize. Most of them who have a plot on a farmland do maize if possible but because of lack of water or lack of investment capacities they will grow green beans in the DS.

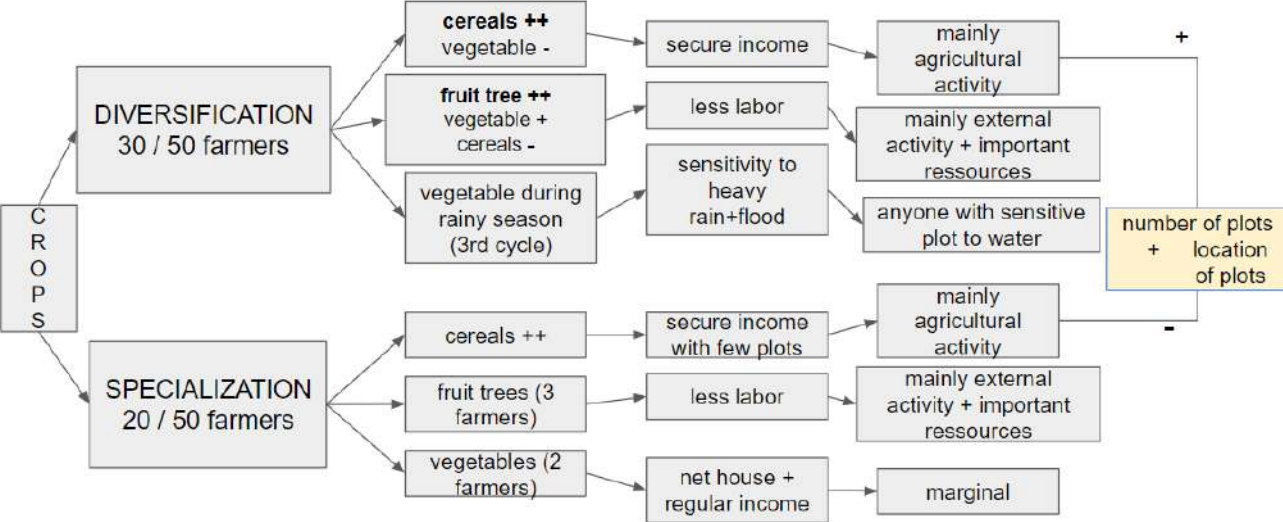


Figure 25 Visual summary representing crop choices in diversification and specialization
Source: personal

"Yes, just this year I just changed to red corn for both cycles." [L_P_2023_0707_01]

Finally, there are two others type of specialization. **The choice of specialization in vegetable**, which is quite marginal (2 out of 50). The strategy is to have as many harvests as possible and to have different sowing date to expand the number of harvests over the year. Both aims at getting money regularly during the year. This strategy needs a lot of working time; it is probably not a strategy that could be applied by type 3.

The choice to specialize in fruit trees, is made only by farmers from type 3.3. Here the strategy is to have less labor than cereals and reduce cultivation cost compared to vegetable. It is logical that farmer from this type is specialized in fruit trees as they have external activities and have less time to dedicate to farming.

Regarding other choices, **there are 5 left**: "I choose a crop because I have full water supply in the *prek*", "I sow at different times so I can secure multiple harvest", "I choose a crop for home consumption or to feed my cattle", "I choose a crop because my household does not have much time / energy", "I choose a crop which has less risk of getting destroyed by rainfalls and wind". For further analysis of the first three choices, it is detailed in Appendix 8.

Farmers who grow rice in the boeung or farmers having a plot surrounded by rice production are answers discarded from the choice "I chose a crop that has a fixed price."

INTERMEDIARY ANALYSIS

First of all, if vegetables are chosen, the main factor seems to be cash management (to have money regularly). As it is easy to have at least two types of vegetables, on the same plot or two plots, they do it to make sure to have an income if one of the selling prices is very low. It is a way to secure an income with a market that is very uncertain. Or short cycle vegetables may be chosen to be grown after maize during the RS. The harvest happens soon and regularly, if there are heavy rainfalls or an early flood destroying the crop, it is not such an issue. **Second of all**, cereals and mung beans allow to have a decent amount of money at one time (2 or 3 times per year, depends on the number of cycles) with less price fluctuations than vegetables. Related to production, farmers do not have too high cultivation costs. Therefore, it is practicable to grow this type of crops on rented plots. **Moreover**, the typology does not explain all choices, but some of them. If choices of crops are not explained by plot configuration, it can rely on activities of the household: either they depend on farming activities (more than 50% of their income come from it) and they would do similar choices, or mainly depend on external activities and their choices would be different from those dependent on agriculture. Market is the main factor concerning their choices as they are trying to find the crops that would enable the best profit (good price with cultivation cost that are not too high) according to their standards.

DECISION ON IRRIGATION PRACTICES

MAIN FACTORS FOR THE DECISION

Choices on irrigation seem to be influenced mostly by biophysical factors, not so much on markets and production costs. Visual representation of factors on frequency and on duration of irrigation is the same as for the first studied decision. Our interviews highlighted up to 9 reasons for irrigation duration across the farmers interviewed and 13 for the frequency of irrigation operations. Farmer's indicators to determine **duration of irrigation** mainly on soil nature, plot configuration, rainfalls and crop water needs (Figure 26).

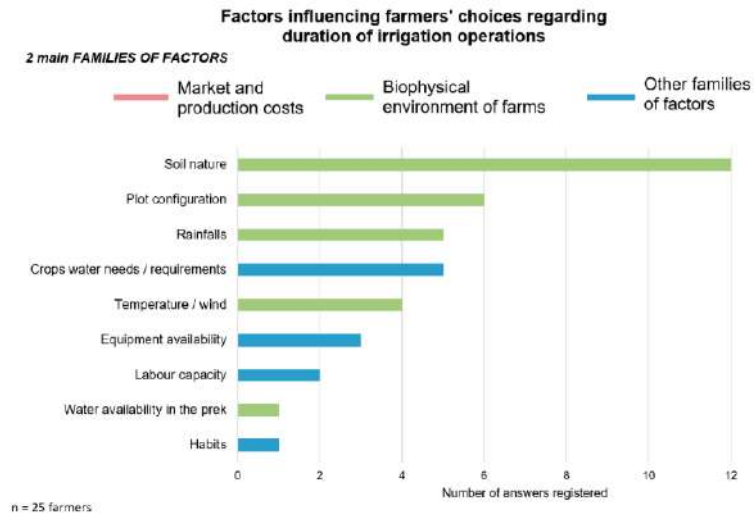


Figure 26 Bar chart of factors influencing farmers' choices regarding duration of irrigation operations

Source: personal

Even if soil nature can be mentioned regarding **irrigation frequency** (Figure 27), the main factors, by far, are rainfalls (33 out of 42) and crop water needs (28 out of 42).

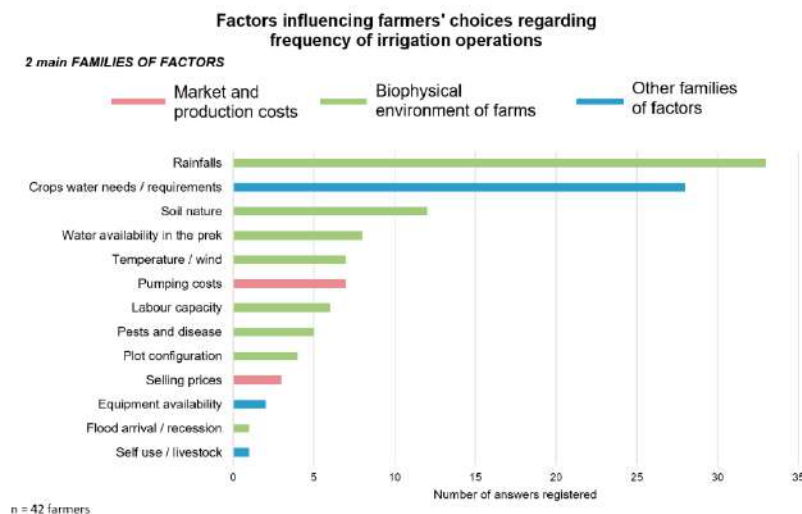


Figure 27 Bar chart of factors influencing farmers' choices regarding frequency of irrigation operations

Source: personal

When farmers say they want to irrigate more or less, they mainly refer to frequency more than duration. For each factor, there are **different perceptions regarding intensity and duration of rainfalls** that will make them wait for their next irrigation. Some farmers count heavy rains for more than 1 hour, for others a light rainfall for many hours can count in their decision to reduce the frequency of irrigation.

“during rainy season, for long bean if there are rain (rain for more than 1h) then will not irrigate in 10 days” [E_S_2023_0308_02]

“for the 2nd cycle [for maize] sometimes I never irrigate because of the rain (if it rains for 12) on the week of the date he was supposed to irrigate. For the 1st cycle, I will irrigate between 3 to 5 times, and 3rd one for 5 or 6 times/cycle.” [E_P_2023_0208_02]

Crop water needs are a priority for most farmers, because otherwise they know their yields are highly limited « will not get any yields ». Even if they do not have money available in their household, they can work apart from agriculture to be able to pay gasoline to pump from the *prek*. Except when there is drip irrigation, which is very rare, it seems that most of the time, their pumping time depends on how long water reaches the end of the plot (Appendix 9). After having this overall look at factors, it is about focusing on specific choices on irrigation.

It seems that drip irrigation is an option only if there is enough investment capacities and if the settings can stay all year along. Farmers do not settle such a system only for one cycle.

CHOICES

One goal of this part is analyzing different choices made by farmers about their irrigation practices (Figure 28). There are 11 choices which stand out regarding irrigation decisions.

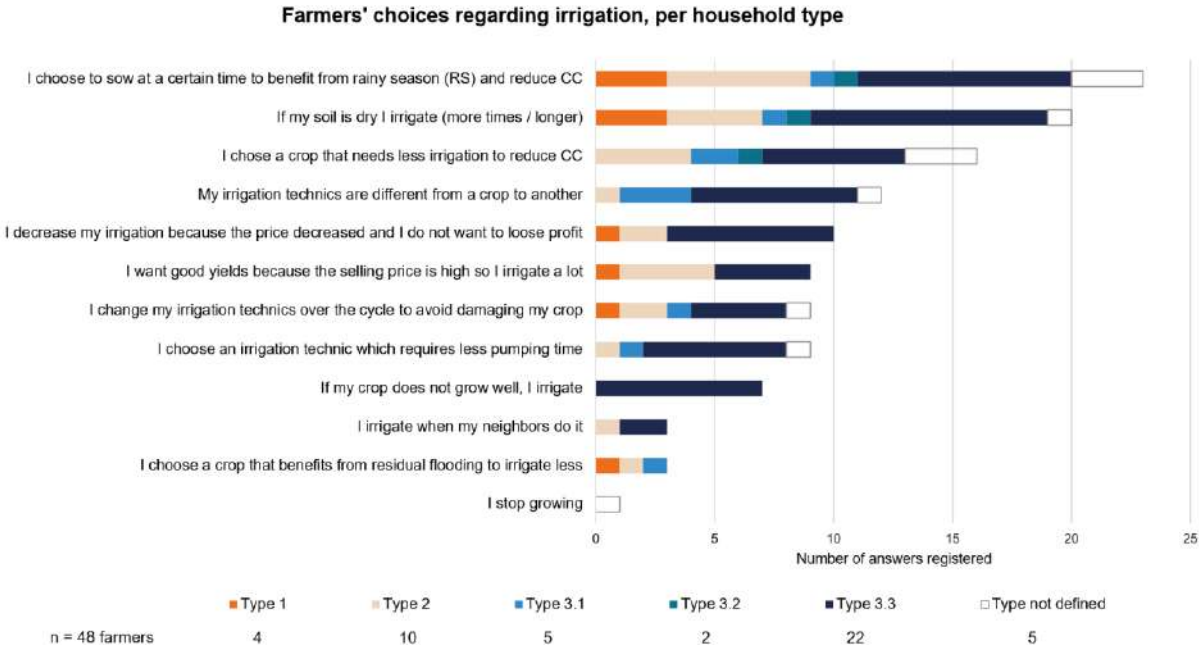


Figure 28 Stacked bar chart of farmers' choices regarding duration and frequency of irrigation decisions, per household type

Source: personal

Overall, more recurrent choices are **to irrigate when the soil is dry**, to **sow at a certain date to benefit from RS**, and to **choose a crop which needs less irrigation**. There are no main trends in combination of choices, there are no individual patterns repeating. There are no main differences between household types, as they were designed. However, **there are some trends regarding DS sensitivity** (Figure 29). The DS indicator is described in the methodology and depends on characteristics of water areas farmer's plots belong to.

- Households with **MORE sensitive plots** have more registered answers than households with not all sensitive plots regarding the following choices: “choosing crops needing less irrigation”, “sowing at a certain date to benefit from rainy season”, and “if the selling prices are high, I irrigate a lot”. There are choices constrained by the water supply.
- Households with **LESS sensitive plots** have more registered answers than households with more sensitive plots regarding the following choices: “if my crop does not grow well I irrigate”, “irrigation technics are different between crops”, “changing irrigation technics over the cycle”, and “choosing irrigation technics that requires less pumping time”.

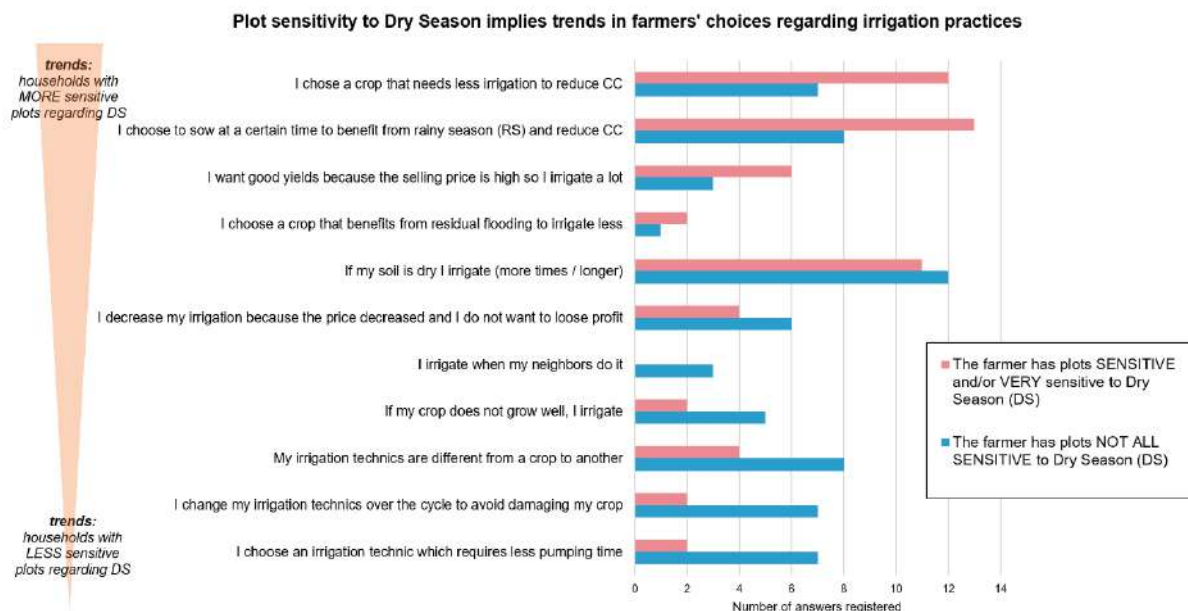


Figure 29 Bar chart of number of answers classified by each farm plot sensitivity to Dry Season (DS)

Source: personal

There are choices constrained by something else than water supply. In this case, main perceived constraints are crop water needs, ability to have access to specific irrigation equipment, and household capacities (pumping costs, time to irrigate), as main constraints. It can **be interpreted as: if water supply is not a main constraint:** farmers can have a better care of plant needs, can invest / use another equipment, or now their limited factor is their household capacities to invest time and energy in irrigation.

After presenting the irrigation decision with plot DS lenses, it is time to present the overall main choices. The first choice is “**to sow at a certain time to benefit from RS**”. Apart from rainfalls, it can be related to crop water needs, temperatures, and outlets of the crop. Rice and

cucumbers can be grown during RS to decrease numbers of irrigation. It is the same for maize, even if the choice of sowing it depends mostly on market prices. A farmer mentioned doing a 6-month cycle of rice not to irrigate it, and justified this choice by saying rice is used for self-use. Yields are not high but as it does not bring financial value to the household it justify having a threshold for input costs.

"So, I spray the seed until it grows a little bit around my knee. There is no rain but then it rains every day in order to irrigate my crop so I don't have to irrigate it anymore. So I plant it in April and it starts to rain around May." [L_P_2023_0507_01]

"Like if we plant on May, so for wax gourd, if I plant during April, the weather is very hot, there is lack of water resource, and the quality of water is also not really good, which causes some damage to the quality of the wax gourd. But if I plant wax gourds in May instead, there will be a little rainfall which causes less damage to the quality of the crop than in April." [L_P_2023_2306_02]

Then, main factors are rainfall and soil nature. It is logical that the second choice is **"I irrigate when the soil is dry (duration / numbers)"**. However, farmers also make links with temperatures, and crop water needs. Interestingly, plot configuration was not mentioned explicitly about this choice during interviews. However, on week 6, farmers were asked to show how they irrigate, it seems that they wait for their plot to be submersed, or for water to reach the end of rows. Therefore, plot configuration is a main factor of this choice. It seems they **mainly take into account dryness of soil as a factor to irrigate more times** instead of irrigating longer per operation, **even if some rare farmers** also explained they can increase duration of their operations over the year:

"If land [is] moist (dark brown), then I irrigate for 3h usually that happens after one month of growing corn because the leaf make shade and soil stay moist but before I will irrigate 5 to 6h because soil dry (white)" [E_P_2023_2707_01]

"If [the land is] dry, will irrigate longer (more 1-2 hours)" [E_P_2023_1007_02]

The third main choice is to grow a **crop requiring less irrigation**. In other words, it can be a crop more tolerant to lack of water. It can be a strategy regarding lack of water in the *prek* and, or, to reduce cultivation costs. **Farmers from type 1** do not have answers registered for this choice. As they are relying only on agriculture and are not able to make savings, they may need to optimize their system as a way to survive. **Farmers from type 2** mostly mentioned a strategy to reduce cultivation costs and would limit their number of cycles if they struggle to have available water.

"This year could not pump water from Bassac to prek so decided to do 2 cycles (green bean because does not need to be irrigated and now chili with long bean because can irrigate thanks to the rainfall)" [E_S_2023_0607_01].

"This is related to the water in the prek, like our prek nowadays there are a lot of sediments in the prek so when in dry season, there is not enough water for irrigate the crops [vegetables]. [L_S_2023_2106_02]

However, farmers from **type 3 are more likely to have bypass strategies**, as picking a variety resistant to drought, or having another activity when the level in the *prek* is low.

"I chose a rice variety resistant to drought so I can reduce my numbers of irrigation and therefore

reduce my CC" [E_S_2023_0108_02]

"I will not buy water from the water seller because I do not need to grow crops during April and May. [I have another activity to get money] when there is not naturally water in the prek for her plot 1. I have a well on plot 2 so can grow whenever I want." [E_S_2023_3107_01]

There are **8 other choices**: "irrigation technics are different from crops", "I decrease irrigation because the price decreased and I do not want to lose profits", "I want good yields because the selling price is high", "I change my irrigation technics over the cycle to avoid damaging my crop", "I choose an irrigation technic which requires less pumping time", "If my crop does not grow well, I irrigate", "I choose a crop that benefits from residual flooding to irrigate less", and "I stop growing". For further analysis, it is detailed in Appendix 10.

INTERMEDIARY ANALYSIS

Regarding a **practical way of asking farmers** about their irrigation practices, it would have been interesting to create a visual, and to translate it in Khmer. At the beginning of fieldwork, there was an important confusion about duration of irrigation. They would hear "from which month to which month" they do irrigation, instead of "how many hours do you irrigate". This bias may also be because they do not consider the number of hours per operation as it is not a part of their thought process.

There is a **trend between households' plot sensitivity to DS**. Households with **more** sensitive plots to DS expressed choices with a strong **constraint in water supply**. Whereas households with **less** sensitive plots to DS are more likely to consider **crop water needs**, ability to have access to **specific irrigation equipment**, and **household capacities** (pumping costs, time to irrigate).

To introduce a **rough idea of a decision tree**, farmers mainly drive their crop choices by the potential selling prices. Plot configuration can constraint their decision and they grow rice. For farmers with more crop possibilities, selling prices work as a balance with potential cultivation costs, household cash needs, and labor capacity. From this point, irrigation practices are adapted to biophysical factors of the farm. It depends on soil nature, plot configuration, rainfalls, water availability in the *prek*.

Thresholds of biophysical factors can change, and it is not clear what changes their perceptions. An example is given for rainfalls, a farmer decides to irrigate after it rains for one hour, another waits for 12 hours of rainfalls. It is not clear why their thresholds are different. Each choice is multifactorial, but some trends are identified by choice. In **order to identify other thresholds**, it would have been interesting to ask them directly how they change their irrigation practices in relation with their cash availability. To study irrigation practices, it would be more interesting to have a typology based on savings rather than activity systems (in other words, to change subcomponents of type 3), and to cross information with practical farms' biophysical environment data. As frequency of irrigation depends strongly on crop water needs and requirements, crossing ETp and pest and disease data related to too much soil moisture can be very interesting.

DECISION ON FERTILIZERS

MAIN FACTORS FOR THE DECISION

Main factors concerning the fertilization practices depends mainly on selling prices and fertilizer costs. Farmers aim to reduce costs. However, farmers adapt to needs of their crops and apply more if needed, regardless of their types. There are no obvious trends in fertilization which can be explained by types. It does not seem to have a link with water.

CHOICES

One goal of this part is analyzing different choices made by farmers about their irrigation practices (Figure 30). There are 9 choices which stand out regarding fertilization decisions. The main choice is “I do NOT change numbers of applications between cycles”.

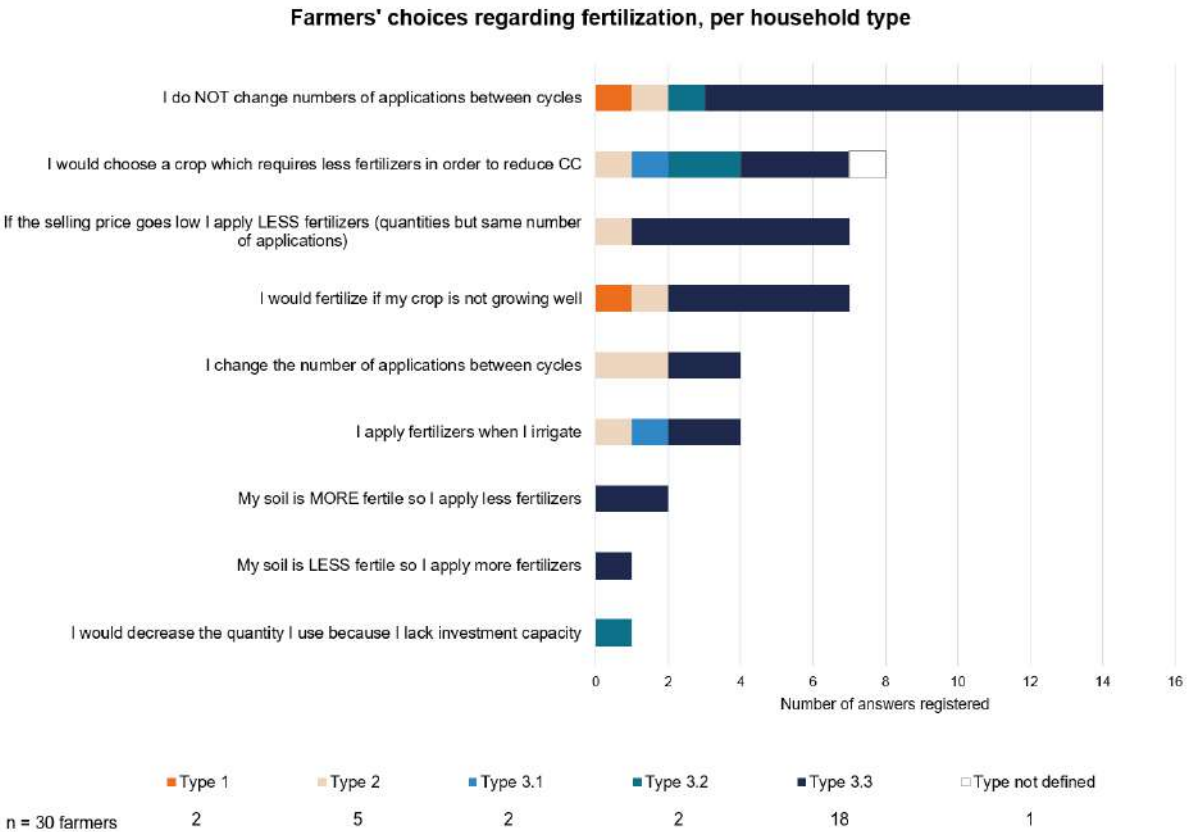


Figure 30 Stacked bar chart of farmers’ choices regarding fertilization practices, per household types
Source: personal

The first choice is about **not changing the number of applications**, it comes out mainly for cereals. They mostly do not change because they have learned to fertilize this way.

“Rice when it grows little, we apply fertilizer, and spray pesticide, and the rice starts to turn green. Rice has to follow the methodology.” [EL_PS_2023_2206_01]

Two of them, explain they experienced adding more fertilizers for the second cycle, but they did not see any yield improvements. Therefore, they no longer change.

"I tried to do more but the yield was the same so now I do the same amount for rice."
[E_P_2023_0208_02]

Another explains she does the same as it is the only amount she can afford. For fruit trees, the question was not relevant since there is no cycle, but 1 to 3 harvesting seasons. They do not change the amount of fertilizers between harvesting seasons, usually they apply during the flowering stage. Some farmers from different types gave the same explanation. Others from same types gave different explanation too. Therefore, no strategy by types can be found.

On the opposite, 4 farmers explained they "**change the number of applications**, for different reasons. For instance, during the DS, they increase the quantity of fertilizers for maize. One farmer explained it is a must to increase the amount between cycles because soil loses fertility after harvesting. While another farmer explained she does it according to her previous harvest: if the yield was good, then she decreases the amount brought for the next cycle.

"I use 3-4 times per cycle. And if my crop has good yield, I won't use a lot of fertilizer."
[L_P_2023_0507_01]

About the second choice, **when farmers mentioned choosing a crop which requires less fertilizers**, they all explained it is in order to minimize CC. Usually, it goes for all types of CC, and not only fertilizers (gasoline, pesticides). However, there is no types of crops which emerged. For instance, one said he does maize over vegetables, while another farmer would rather grow banana trees over vegetables.

"We grow it 2 or 3 times when we grow corn. Normally, I cultivated maize which needs less labor capacity, spending on gasoline/ fertilizer is less. Compared to cultivating vegetables, we spend a lot on pesticides and fertilizers" [L_S_2023_2206_1]

"The reason I plant bananas on all of my plots is because I know. If I plant it I am going to get profit back....I plant other crops such as round eggplant, chili and wax gourd. I need to use a lot of pesticides and fertilizer in order to grow well." [L_P_2023_2507_01]

*Some farmers would like to grow a type of crop, but because of the **soil type of their plot they do not**. It would require to put a lot of fertilizers so they decide to grow another crop. Therefore, the farmer quoted decided to grow rice instead of maize."For this type of land (lowland), we cannot plant maize and get a high yield, and if we want high yields for maize, we need to use a lot of fertilizers. Because this type of low land can be flooded easily and destroy the yield of the crops."*
[L_P_2023_0507_02]

About the third choice, **if the selling price of the crop goes low, I apply less fertilizers (quantities but same number of applications)**, 7 out of 31 answered this question. The quantity of fertilizers is reduced compared to the quantity used when the crop selling price is good/high.

[translator]: "How about fertilizer?"

"Same as pesticide. Before I take care of my mango by using large amounts of pesticides to make the appearance of mangoes look good and sell at a good price. But right now, I can't sell it at a high

price even if the appearance of my mango looks good. No matter what the appearance of mango looks like, they still buy me with the same price." [L_P_2023_0108_01]

It is important to note that for the choice "If the selling price of the crop goes low, I apply less fertilizers (quantities but same number of applications)" not only the decrease of the price has to be taken into account, but also, the final use of the crop. If it is for self-consumption, farmers will perceive them as a crop with no profit.

The fourth choice is **"I would fertilize if my crop is not growing well"**. Farmers from all household type have registered answers. The driver here is yield, the farmer would carefully observe the crop and decide to apply more or less fertilizer. He will not apply if it is not needed as it increases the CC, but if it is, he applies even if it costs more. Since all types are represented in the choice, it shows that every farmer, even if they have savings or not, can add fertilizers when needed.

"I will look clearly at the crops, if my crop grows well, I will apply less fertilizer."
[L_P_2023_0308_02]

Regarding other choices, **there are 4 left**: "I apply fertilizer when I irrigate", "My soil is more fertile, so I apply less fertilizers", "My soil is less fertile, so I apply more fertilizer" and "I would decrease the quantity of fertilizer I use because of lack of investment capacity". For further analysis, 4 of them are detailed in Appendix 11.

INTERMEDIARY ANALYSIS

The number of farmers who answered is generally low. It makes it hard to assert, or confirm, a strategy with confidence. However, a few directions can be suggested. Figure 31 summarizes various factors influencing the choice of fertilizer applications. Fertilizer needs to be used if a crop does not grow well but the farmers are careful, and do it in a reasoned manner. Nonetheless if the market price decreases, they will decrease the amount used to offset the low purchase price of their crops against the high price of fertilizers. Moreover, the type of crop chosen mainly depends on its needs in fertilizer (and other inputs, the idea being to minimize the CC). On the whole it doesn't depend on the type of households, the strategy regarding fertilizer depends mainly on cost control.

Farmers' choices regarding pest and disease management, per household type

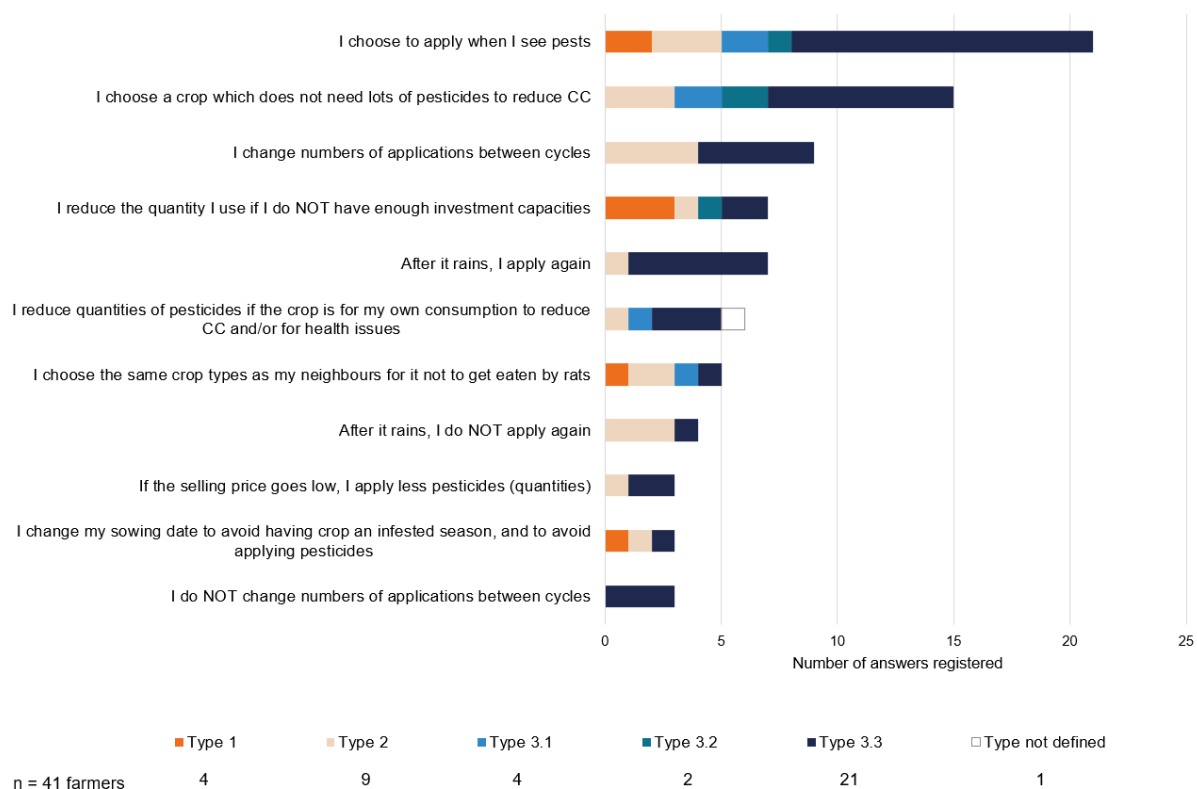


Figure 32 Stacked bar chart of farmers' choices regarding pest and disease management, per household type

Source: personal

The most common answer is “**applying when I see pests**”. There are no main trends in combination with other choices. Except that this choice does not go with “I choose the same crops as my neighbors”, and “I change my sowing date to avoid being infested”. Farmers make the link with crop development stages, observation of pests, investment capacities, following neighbors in using pesticides.

The second main answer is “**choosing a crop which does not need lots of pesticides**”. is the only answer of 5 farmers. There are no patterns in combination with other choices. However, it does not go with “if the selling price goes low, I apply less pesticides”, and “I don’t change the number of applications between cycles”. It is probable that having this decision, farmers do not have to take selling prices, and pest management that much into account. It is not a choice registered for farmers from type 1.

The third choice is “**changing the number of applications between cycles**”. It is not a choice registered for farmers from type 1. It is mostly associated with “I see pests I apply” (5 times over 9 answers). This adaptation choices might lead to changing number of applications between cycles. There are also **seasonal pest and disease plagues**, which can lead to **differentiation in numbers of applications**. Farmers also perceive **rainfalls** and **temperatures** as a factor. For trees, they are some changes in applications over years, and over the year, as development stages are different. **On the other hand**, when we asked about numbers, there are 3 farmers saying that they don’t change number of applications between

cycles. Maybe it is related to a lack of knowledge or just due to the fact that they do not take other factors into account than their habits. Here are a couple of quotes illustrating which factors farmers can consider to change their numbers of applications:

*"Yes, it has more pests in the dry season and if I don't spray it, my rice will get destroyed."
[L_P_2023_0507_02]*

"Because this second cycle has no water in the field, just this time there is rain and before that, we have to pump water into the field. And the temperature is hot and water evaporates fast, this cycle faces a lot of disease. It is not like the first cycle." [EL_PS_2023_2206_01]

"I used. For fertilizer, I applied once every 6 months. For pesticides, when the coconut is young(1-3 years old), I spray 2-3 times per month and when the coconut is growing (over 4 years), I spray pesticides once every 1-3 months." [L_P_2023_0408_01]

Over 41 farmers, 7 mentioned that they would **reduce the quantities of pesticides if they do not have enough investment capacities**. It can be related to investment capacities, ability to go to Vietnam to buy inputs, the crop type, and neighbor actions regarding cultivation itineraries. Type 1 is more represented in that choice. It might be because investment capacities are a main factor for type 1, as they are not able to save money.

"Yes, it depends on how much investment capacity I have. If I have a lot, I put in more inputs. And another option, in order to save money, I will go directly to Vietnam to buy the inputs so the price of the inputs there is cheaper than here around 170000 riels." [EL_PS_2023_2006_01]

"Mango needs a lot of pesticide so too avoid too high cultivation cost, not too much planted." [E_S_2023_0607_01]

"If there are a lot of insects in the field, we can spray it. So, it also reduces the expenditure by limiting the date of spraying. We cannot spray whenever we want because we spend a lot of investment capital and I follow each other in growing crops." [L_S_2023_2206_01]

There are more farmers in type 3 than type 2 that **apply after the rain**. It might be because there is less risk for them to invest than for type 2, as they rely only on agriculture. Farmers from type 2 are mostly not doing another application after it rains. It might be because there are more careful regarding when they are going to apply, so they do not have to apply pesticides again.

Regarding the **5 other choices**, there are: "I reduce pesticides if the crop is for my own consumption to reduce CC or if I want to *prek* my health", "I choose the same crop types as my neighbors so they are not getting eaten by rats", "I choose my sowing date to avoid having a crop in a season infested", "If the selling price goes low, I apply less pesticides". It concerns 17 farmers: 1 farmer has one answer registered, 8 farmers has 2, 6 farmers have 3 answers, and 2 farmers have 4 answers. Therefore, there are not the most important trends in terms of choices, but there are important enough for farmers to explain it.

INTERMEDIARY ANALYSIS

Compared to fertilizers, it seems **more frequent farmers apply pesticides** when they see a problem. However, there is still a balance between input costs and evolution of the selling

prices, as represented Figure 33. Bypass strategies are for types 2, and 3, not registered for type 1 households, as choosing a crop requiring less pesticides, or changing numbers of applications between cycles. **Farmers from type 1 are more likely to reduce the quantities of pesticides directly without using other strategies.** Farmers from type 3 seem to have more flexibility to buy inputs than farmers from type 2, as more of them would apply pesticides again if rains earlier than predicted.

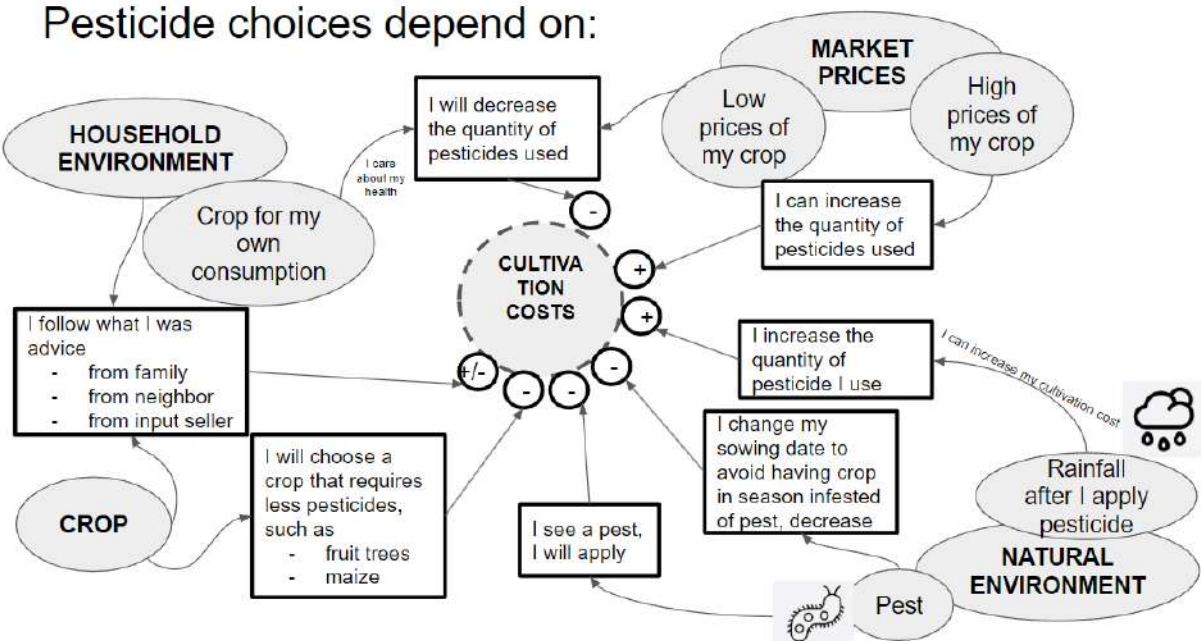


Figure 33 Summary of factors having an impact on pest and disease management practices
 This summary was made for the result presentation to farmers, end of August 2023.

Source: personal

Surprisingly, a factor did not come up much during interviews, but quite much in feedback from the presentation: it is employment. Labor force capacity has a bit of another sense here: some farmers hire because they know pesticides harm their health. Considering high costs of employment, it is astonishing it did not come up during interviews. Maybe if precise schedules of cropping systems would have been asked, it would have reduced this bias.

"I hire people to spray pesticide for me because I am afraid of the chemical of pesticide that it can harm my health." [L_P_2023_0308_01]

IMPACT OF PREK REHABILITATION

WHAT FARMERS SAY

Precarious households are afraid they would lose their lands without compensation. Some farmers say it is not a problem to them if houses get destroyed because "it is government lands". If rehabilitation is about to start, farmers would like to know 3 months in advance, this

way they do not waste a cultivation cycle. On the *boeung* on *prek* Thom, farmers renting lands from others are afraid they “won’t be able to rent again” because owners will want to cultivate by themselves. Rehabilitation has an impact on land access. However, rehabilitation and increasing land value does not seem to be connected.

As well as farmers, the Commune Chief explains that ***prek Pok*** should be a priority to rehabilitate. Farmers organized together to tell the Village Chief and the Commune Chief. ***Prek Put*** is the only channel left using gravity systems to irrigate from the *prek* to plots. All farmers do rice and organize together to irrigate. Most precarious farmers are afraid they would have to pay more money to pump. They usually have an individual pump to drain but regarding the depth of the *prek* it might not be enough, and they would have to buy another more powerful pump. **Some farmers on highlands (*toul*)** would like to have access to water in the *prek* because the irrigation would be quicker than the one from groundwater. Most precarious farmers may not increase their number of irrigations even if they have full access of water. Especially if there are doing fruit trees.

On ***prek Touch***, in DS, farmers at the end of the *prek* are provided only for maize by the water seller. They do not have water access otherwise. In that area, rice fields are cultivated only for one cycle. One farmer is interested to be a gate manager on *prek* Touch. He worked with the AFD to collect money for the rehabilitation project. A gate would allow him to harvest rice later that arrival of the flood. The **gate is used only for delaying the flood on *prek* Chann**. Rehabilitation really helped the area but today locals face challenges regarding maintenance of the *prek* and **accumulation of sediments at the entrance**. Social structures in villages do not coincide with group organization. It is mostly some leaders that will stand out and take responsibility if they see advantages for themselves.

Other farmers usually say they would be **happy about rehabilitation**, but it can be **for various reasons**. Of course, having **water all year** along is a key, but sometimes they might be more interested by a **road**. On Cham Kroum for instance, some children do not go to school because the road is terrible. From March to May, they can have water only from a tidal effect. A rehabilitation would provide more flexibility and they **would not have to wake up at night** to irrigate.

CHOICES

One goal of this part is analyzing different potential choices farmers would make with a *prek* rehabilitation (Figure 34). Half of interviewed farmers expressed choices they would take if the *prek* is rehabilitated or the ones they took after *prek* rehabilitation. Three main decisions in numbers of answers are:

- I will grow a crop which has more water requirements if the selling price is good (9 answers, only answer of 7 farmers),
- I will do more cycles if I have time (6 answers, only answer of 2 farmers),
- I will NOT change my cultivation practices: they give only one answer (6 answers for 6 farmers). It represents 20% of the sample.

These decisions have farmers from each type. An analysis is made with the DS, FE indicators, and per household type. Farmer considerations can change from both.

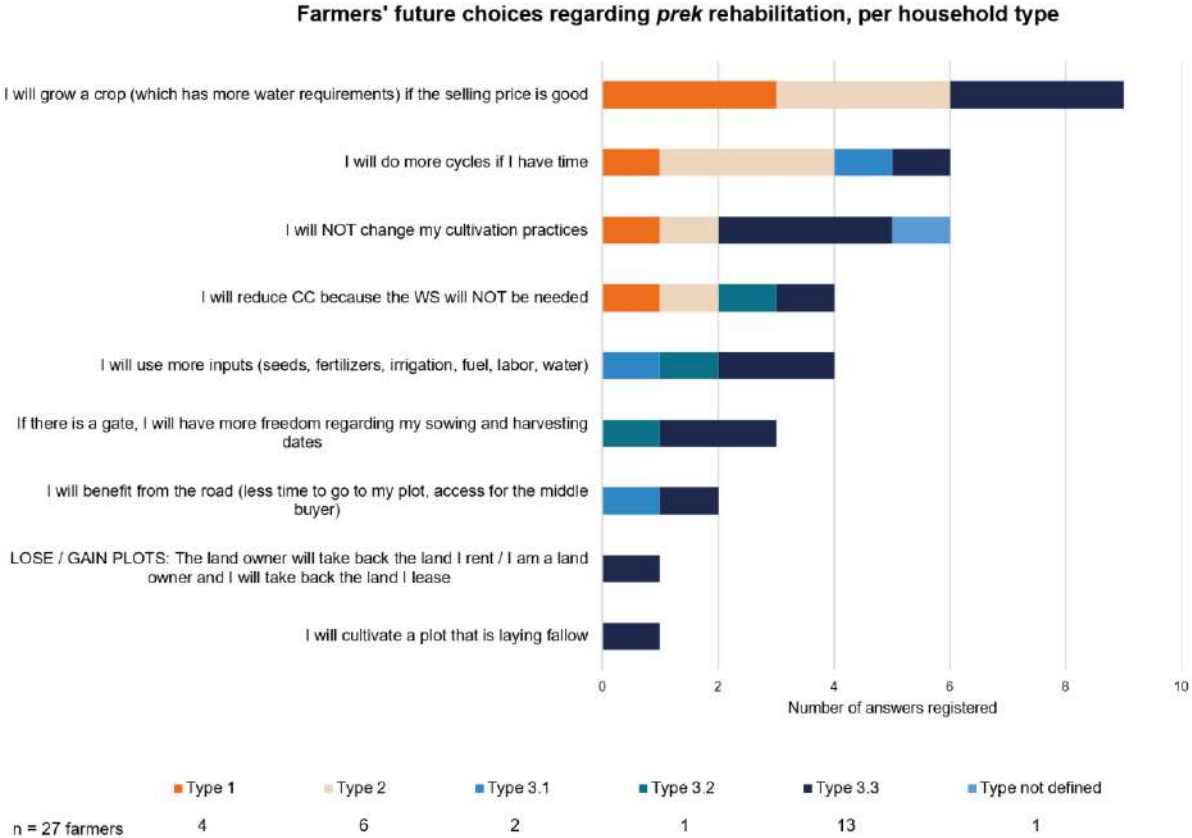


Figure 34 Stacked bar chart of farmers' choices regarding a possible *prek* rehabilitation
 Source: personal

Regarding, farmers who **will not change their cultivation practices**, out of 6 farmers, half are located on *prek* Hom. They consider that rehabilitation would not change anything. Their plots are classified as not sensitive because this *prek* already have a full water access all year. On other *preks*, the ones having fruit trees will not change their irrigation practices. These farmers are located on Me Srok, and the beginning of *prek* Touch. There is 1 household on *prek* Thom, they only have rice field and they did 2 cycles before the *prek* started to be rehabilitated. They might not do a third cycle because they are in debt, want to earn just enough money for their daughter to go studying, and focus on goat breeding.

Regarding **farmers who will change crops**, 2 farmers on Pok (one from type 1 and one from type 3.3), might change from mung beans to maize if the selling price is better. A farmer classified type 2, on *prek* Chann, switched from mung beans / maize to rice because he had a full water access, and could keep a part for home consumption. He does only rice, and his household only agriculture, but he receives hundreds of dollars per month from a son abroad in Japan. One farmer on Me Srok could start growing vegetables and cut down mango trees after rehabilitation. He is from type 3.3, so risk notion to change crops might be less than a farmer on Pok that relies only on agriculture to bring income to his household. Another farmer on Thom, part of type 3.3, did rice this year, but will go back on maize because profits are

better. There is not enough water on the *prek* due to rehabilitation. On *prek* Put, 1 farmer explains that if the *prek* is deeper, it might be able to drain and cultivate maize.

Regarding **increasing the number of cycles**, it is mostly not the main answer of farmers. When there is a lack of water, some third or even second cycles are not even practicable. It was mentioned by farmers from types 2 and 3, on *prek* Lok, Thom and Touch. Gate could also make possible to grow a second cycle of rice for a farmer from type 3.3, as it could be at the end of *prek* Touch.

Regarding the fourth decision “**I will reduce my cultivation costs**”, there are farmers from each type. This statement can come as a consequence as I will not change anything. It is not really a key decision but it shows an important perception of farmers who can try to reduce costs as much as possible.

Last 5 decisions: “I will use more inputs”, “I will have more freedom regarding sowing and harvesting dates if there is a gate”, “I will benefit from the roads”, “I will cultivate a plot that was laying fallow”, and the “landowner will take back the lands”, were given by farmers from the TYPE 3 only. This more diverse answers might be due to social context of these farmers. The important part is that no type 1 or type 2 said they would intensify their system. A couple of famers mentioned rising yields after rehabilitation, the only input they changed is number of irrigations.

The results are the ones collected from interviews; the next step is analyzing results of the board activity made during the presentation of results to farmers.

RESULTS ON THE BOARD ACTIVITY: IMPACT ON DECISIONS WHEN WATER AVAILABILITY CHANGE IN THE *PREK* AND RAINFALL CHANGE

Groups were made randomly; therefore, it is not known from which types of households the farmers are, and if a group was made mainly of one type. Moreover, farmers did not have time to complete all plots with both scenarios. Therefore, it was decided to focus on the first plot which has answers for all groups. Some comments on the other plots might be added when the choice was surprising/unexpected or can explain the decision on plot 1 (not flooded). Moreover, farmers did not consider the rainfall scenario and did like they would usually do, in a normal Cambodian rainfall scenario. They did consider the level of water in the *prek*.

To present results for **group 1**, Table 5 is a calendar for one year. There are 2 lines. One line is the plot not flooded for a *prek* non-rehabilitated. Another line is the plot (still not flooded) for a *prek* which has been rehabilitated. In cells, groups put their crop choice, from when to when, numbers of pesticide and fertilizer applications, their irrigation practices, and reasons of their choices.

Table 5 Cropping seasons and cultivation choices of plot 1 for group 1

months	JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR			APR			MAY		
10-day period	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
prek NOT rehabilitated	MAIZE 2-3 pesticides 2-3 fertilizers no irrigation reason given: "there is rain"						OKRA 10 pesticides 3 fertilizers no irrigation "easy to have yield, not hard to take care of"												MZ																	
prek rehabilitated	MZ 1			WAX GOURD 2-3 pesticides 1 fertilizer no irrigation "no need to irrigate (rainfall), cold weather, need to change crop (avoid yield decrease)"									MAIZE 2 3 pesticides 3 fertilizers 3 irrigations of 12h "high yield, high price, not flooded and have moisture"						MAIZE 1 3 pesticides 3 fertilizers 2 irrigations of 24h "high price, lower yield because less rain and soil dryer"																	

When there is **no water in the prek year-round**, group 1 chose a vegetable (okra), and a sowing date (RS for maize) to avoid irrigation to reduce CC. Maize is grown during the RS, where usually farmers tend to avoid this crop because it gets destroyed by the flood and heavy rainfalls. As plot 1 is not flooded, there is less risk. It is interesting to note, as it has been shown previously, that most farmer (except a few exception) will do maize when they can. Results may explain why farmers are willing to take the risk to grow during RS, as it is the only time where they can benefit from rainfalls. It can be interpreted as a way to optimize value of rainfalls.

It is important to note, that in the group, there was the farmer specialized in okra which might have biased the result.

When there is **water in the prek year-round**, they chose a crop that does need to get irrigated during the RS and does not need a lot of fertilizer. It can be explained by the fact that they irrigated during the DS, so as to avoid too high cultivation cost, they would rather do a crop that has low cultivation cost. It is interesting to note that farmers here explained the need to change the crop after two cycles of maize, to decrease pest pressure. It is a factor that almost never came up during interviews. Furthermore, they change the duration and number of irrigations between cycles, what seems to be the driver here is the dryness of soil. Therefore, it would seem that on a plot where there is no risk of flood, farmers would like to maximize the number of cultivation cycle of maize because it gets good price (market) and easily good yield. However, they need to change a crop after two cycles because of diseases, and they choose to do a cycle of vegetable that can get harvested for a long time that does not require lot of cultivation cost (no irrigation and not much fertilizer).

Therefore, if a prek got rehabilitated, for a non-flooded plot, farmers might intensify with more cultivation cycle of maize.

For **group 2**, Table 6 is structured the same way of Table 5.

Table 6 Cropping seasons and cultivation choices of plot 1 for group 2

months	JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR			APR			MAY		
10-day period	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
prek NO T reh abili tate d	MAIZE 1 3 pesticides 3 fertilizers 5 irrigations of 5h no reason given						RICE 3 pesticides 3 fertilizers no irrigation "for home consumption"						MAIZE 2 2 pesticides no fertilizers 12 irrigations of 4h no reason given															MZ1								
prek reh abili tate d							MAIZE 4 pesticides 4 fertilizers 4 irrigations "to sell and support household"																													

When there is **no water year-round in the prek**, the crops chosen are **only cereals** (maize and rice). The number of irrigations is much higher than the previous group, but the duration is shorter. Therefore, it could be said that they have different strategy to irrigate and spread out the cultivation cost. They do rice for home consumption when they do not have to irrigate. As rice requires a lot of water compared to maize, and this plot 1 has higher elevations, it is interesting to note farmers would grow from September to November. It is RS, and a way to benefit from rainfalls. It may also be that as there are not selling it, they intend to reduce CC as much as possible, and producing rice during RS is a way to do it.

When there is **water year-round in the prek**, there is only one cultivation cycle. Yet, it must be considered that on other plots the farmer chose to do vegetables from June to the end of August, followed by some rice (on part of the plot that got flooded) from December to February. The reason behind having only one cycle of maize can be to reduce labor and reduce cultivation cost by not having to hire people. By doing maize on the plot that does not get flooded allow to decrease the number of irrigations, as it is possible to do maize during RS with no risk of losing the yield.

For this group, it is hard to conclude on a change because of the prek rehabilitation as they almost gave no reason on why they would choose to grow this crop in this cycle.

For the **group 3**, Table 7 is structured like the two previous tables. There are results from the third group.

Table 7 Cropping seasons and cultivation choices of plot 1 for group 3

months	JUN			JUL			AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR			APR			MAY		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
prek NOT rehabilitated	MAIZE									Sub-plot 1 BANANA Sub-plot 2 MANGO																										
prek rehabilitated							LONG BEAN 10 pesticides 3 fertilizers 4 irrigations of 2h reason is to support household			MAIZE No pesticides 3 fertilizers 3 irrigations of 5h reason is to support household																										

When there is **no water year-round in the prek**, farmers decided to do maize during the RS on a plot that does not get flooded. Then, they **decided to plant fruit trees** from February. Level of water would start to get lower from May. It can be interpreted as a way to bypass constraint of water availability in the prek, and to plant trees before there is no water for them to pump. From interviews, farmers usually see fruit trees as plants which do not require a lot of water. Maybe it is because the responsive delay of their irrigation operations is much longer than for other types of plants, and they do not observe differences in yields. This option might be couple with irrigation pumping costs seen as expensive. Then, there is the additional cost of pumping from the prek to the field. Banana trees are also seen as a great crop, which does not need pesticides (even if they can use herbicides once a year, and they need to weed out). However, in comparison with other crops, farmers see it as gold: selling prices are great, they do not irrigate much, and do not have to pay for lots of inputs. Having two kinds of fruit trees instead of one, can be analyzed as a way of securing their income, in case of one selling price going down.

When there is **water year-round in the prek**, farmers decided to grow long bean for just a month during the RS. Then, they do a cultivation cycle of maize. This could be explained by the fact that farmers decided to do another cycle of maize on the third plot right after the flood. They also do wax gourd on the second plot during RS and green beans during the DS (without irrigation). As every plot are being cultivated, not having too many cultivation cycles on one of

the plots can be seen as a trade-off in terms of labor capacity. In this case, there are different strategies implemented, it can be interpreted as:

- one plot limiting CC: plot 2 (partly flooded) has no irrigation for vegetables and they do rice on the flooded part,
- two plots with not too many cycles (1 and 2 cycles) but where red maize is being cultivated to secure an income, and there is always one cycle of maize during RS. Farmers can benefit from RS, without taking the risk of losing yields.

Conclusion on activity

Usually, farmers do not think only at one plot level but mainly at the farm scale as **labor force is a main factor**. Also, rice fields on non-flooded plots were not observed during fieldwork. From informal interviews, it was understood **rice keeps been an important crop around houses for self-consumption**. It is riveting to confirm it, and to have a written record explaining they grow it mainly during RS. From the session, it is actually what stood out compared to interview results. The presentation and the board activity gave complementary results, but most **primarily confirmed factor and decision analysis**.

Every group has at least one cycle of maize with and without *prek* rehabilitation. Most groups usually wrote two cycles per plot, except the plot flooded for a long time, where only one cycle of cereals was done. On plots 2, two groups decided to grow rice on the flooded part and grow vegetables on the rest. Farmers would usually grow maize during RS on plot 1 (not flooded), especially if there is no water in the *prek* during DS.



DISCUSSION

វិទ្យាស្ថានស្រាវជ្រាវ និងបណ្តុះបណ្តាល
ស្រាវជ្រាវ និងបណ្តុះបណ្តាល

វិទ្យាស្ថានស្រាវជ្រាវ និងបណ្តុះបណ្តាល
វិទ្យាស្ថានស្រាវជ្រាវ និងបណ្តុះបណ្តាល

គណៈកម្មាធិការក្រសួង
ស្រាវជ្រាវ និងបណ្តុះបណ្តាល

LIMITS

Regarding, the **overall approach**, the study is qualitative with an iterative methodology, which limits statistical analysis. This flexible approach led to questionnaire adaptation throughout fieldwork. Some bias might have been added as not the same exact questions were systematically asked. Furthermore, on week 4, it was decided to search for farmers with large areas of lands, and other activities. It explains why more farmers from type 3.3 have been met at the time. However, from village chiefs' information, it is representative of households, as mainly farmers in the area have another activity on the side (51%).

The analysis of cash management within the household was a major part to analyze our result and characterized the typology. From literature review, women are the ones dealing with cash management. However, we have mainly met men farmers for our interviews. Some were able to answer, some gave rough ideas of income and savings. The few women interviewed, were able to explain into details how money was invested in what activity and how much was saved. It would have been interesting to meet male farmer's spouse to enable a better understanding of cash management within the households.

One main limit of the study is that some perceptions change between farmers, from a type to another they don't perceive "expensive" as being the same price. It is the same thing for fertility, and soil dryness regarding their plot locations. Therefore, this work is an introduction to differentiate differences in their perceptions, but it is not deepened. In order to do this analysis more time with each farmer, and make them describe what they are thinking by saying, for instance, "good price" would have been interesting. We started to get some idea behind those different perception but not enough to add it to the analysis. For example, a farmer from a type 3.3 which has his main income coming from an external activity, would consider banana a good price. Yet, for a farmer from type 2, maize is a crop with a good price as it gets higher yield.

It may have been interesting to have another organization on the field and have more time to analyze during fieldwork. Usually, half day or more was used to conduct interviews, the rest to transcript interviews, and write notes down. It did not leave much time to analyze at the same time. For instance, the quantity of farmers interviewed was given a priority to make sure a diversity of profiles and choices would be found. It made field day intense, not leaving much time for analyzing. It would have been interesting to limit interviews to half a day and keep 1 hour per day to fill up an excel table, as the ones used in this report.

The analysis of choices was not exhaustive as they were not directly asked to farmers. It was asked "what has an impact on your [decision x]?". It was a way to get factors influencing their decisions, and to ask follow-up questions to get to know in what way. However, it would also have been interesting to ask directly what they do and why. Choices were written post field work, based on analysis of verbatim. Maybe some answers were not analyzed, but the main choices are in the report.

Regarding **sample representativeness, and household types**, a way to be sure that the typology made was representative of the fieldwork area, was to call back village chiefs (VC) and ask them to approximate how many households depended on "only agriculture and were

struggling”, the one depending on “only agriculture and were not struggling”, and finally the one who “also had external activities”. The 6 interviews done confirmed our results. However, only 6 VC were called back and there are more villages in the area. It is not known how much exactly.

Finally, as it has been shown in the results, the typology made explains certain decisions, but not all of them depend on it. For instance, markets or access to water (water in *prek*, flood or heavy rain) explains many decisions. As savings are an important indicator, it would have been more interesting to have type 1 and 2: households doing only agriculture, and type 3, and 4 households having other activities, with type 1 and 3 not able to make savings, and type 2 and 4 able to do so.

Regarding **indicator relevance**, for the choice “I chose a crop for home-consumption or my livestock”, not a lot of answers were registered. Maybe if the questionnaire would have been more focus on livestock, there would have been more answers. However, it does seem that livestock is a main factor for the choice of crop, or for the choice of the cycle length. Furthermore, **another interesting analysis** could be to see how the **land surface** of a farmer may impact the decision on pesticides and fertilizers. Number of plots were collected but not enough total areas. It could be interesting to see if farmers with more lands reduce the number of applications of pesticides, or the amount per application. A hypothesis is; it is a way to balance his CC, whereas someone with a smaller area may increase the number of applications of pesticides, or use more fertilizers to get high yields, and therefore get some profit. The other hypothesis is for the land surface not to have impacts on agricultural decisions.

Related to **land status**, it is a first result (which can benefit from further confirmation) that usually on a rented land farmers would grow maize or rice. It can be supposed because maize and rice are a good way to secure an income. Growing these crops with a more stable selling price allows a better assurance to be able to pay the rental cost. This point was not deepened and may explain other choices. The spatial database carries land tenure data by plot, but the analysis did not consider it, compared to DS and FE.

It is believed that **characterizing every member of the households** (their ages, their activities, relationship between one another...) would be interesting to better understand choices at the household level. In the literature, Tchayanov describes how the age of members and the different stages of the life cycle of the households explains choice. In the fieldwork area, this started to be seen. For instance, teenagers not going to school would help their parents on the field. Therefore, diversification is easier if every member can work in agriculture as it demands more labor than being specialized in cereals.

Regarding the board activity, it seems that considering the time available for preparing and doing the activity, it would have been better to make it less complex. It could have been only one plot which gets partly flooded (mainly the case in our area), one rainfall scenario and 2 boards as it was done (1 *prek* not rehabilitated, 1 *prek* rehabilitated). The activity would still have been done into three groups, maybe they would have had more time and exchange more about their choices. Often, one or two farmers took the lead and did what they usually do on their plots. Moreover, since the farmers were mixed up, a paper with their name could have been added so afterwards we could have seen which main type was in the group.

Regarding schedule constraints, recruiting translators took a bit of time, and it was not possible to go on the field directly. Moreover, the study took place during the National elections, farmers were less trusting, meeting village chiefs was difficult. They were working to prepare the elections, and the week before it was not possible to go on the field. Therefore, it was less time on the field than expected.

BIASES

Regarding translation and communication bias, interviews were semi-directive. Therefore, as they were done in English, translated into Khmer and vice-versa, translation errors must have happened. In order, to offset these issues, interviews (if possible, and authorized by farmers) were recorded and then the part where it was thought some parts were missing were transcribed. However, after fieldwork it was realized some translations were not 100% accurate, and or did not have a transcript. Some data went missing.

Moreover, the number of people can create bias. There were two translators, with different English levels and transcription skills. As a way to decrease these differences, the teams (one interviewer and one translator) changed each day. For the transcripts, times between the translators were taken to let them discuss and benefit from the skills of one another. Another solution, to try and reduce bias could have been to make a common written grid for the questions of the questionnaire translated in Khmer. This is done for the main questions which have been translated in Khmer, so both translators had the same written support to formulate questions on decisions, but not for the rest.

Finally, one last bias concerning communication with farmers, is that farmers would not really dare to say no for some questions. Then, they would usually try to answer what was thought to be expected. This is why follow-up questions were really important. As well as, when they did not know how to answer, they would often describe what in general farmers do. However, thanks to transcripts, some of these biases were removed.

Regarding the semi-directive approach, interview durations were between 1h30 to 3h long. Therefore, last parts of the questionnaire got less answers than the beginning. It explains why there are less information on fertilizers than on crop choices. As there were two teams, to avoid missing information between one another, and improve the overall understanding, lunch and evening times were keys to exchange. Yet, interviews were conducted separately and both approaches are inevitably a little different and so the answers could have varied too. However, it also brought diversity in acquired data and made a richer study.

It was tried to limit bias regarding translation thanks to transcriptions. Yet, there are still some words which were not highly clear. For instance, when farmer said “have good money” it could have been interpreted as good prices or low cultivation costs. As the analysis is based on verbatim analysis, there are some bias in their interpretation. As described, oral exchanges helped to have a homogenous analysis, but it could have been interesting to write down quotes with what it means. This reference document could have help for the analysis, and to keep a written record for next students coming to the area.

As the study was conducted during the RS, therefore, farmers spoke mainly of the crop they do at the moment, and day-to-day water supply from the *prek*. As they were asked about their rotation over the year, they talked about the DS, but some could not remember what they did.

Finally, regarding the sample of farmers, it was chosen randomly, and then targeted. Still, some types of farmers may have been missed: those who did not feel legitimate, those who did not have the time (were harvesting, spraying pesticides, etc.), those who did not want to, and finally those who own land but do not work on it by themselves. Therefore, it was impossible to meet them even if it was tried to get their contacts multiple times. That would also explain why there are more farmers from type 3, than the two other ones, relying only on agriculture. Therefore, concluding on their strategies or choices is more difficult. Moreover, on some *prek*, it was felt farmers did not trust research teams, and did not really want to give answers. This was mainly on *prek* Thom where there is an undergoing rehabilitation. As they had to reduce their number of cycles because of a lack of water, they were not likely to answer question, or it must have had an impact in the quality of their answers.

Finally, the different project that happened on the fieldwork could have biased the answers of farmers. For instance, WatHealth project that underwent in the area may explain why farmers focused on the health issues (in relation to pesticide applications), even though some did not reduce their use. At the same time, farmers are saturated with projects demanding them to take time to answer questions and they never get some results back. It makes them tenser and not trusting in interviewers' regards.

FURTHER AVENUES OF WORK

There are 3 main goals in this study, **having prospect of the eco-hydrological model**, a **better understanding of the study area**, and last but not least, to give perspective to **AFD rehabilitation projects**. Regarding results on crop choices, and therefore impacting land use and other decisions regarding cultivation, it seems really important to add a component regarding market prices. GPS points of crops observed were not used for this report. An exhaustive data collection was made on Me Srok. It would be interesting to compare dynamics of cutting trees with evolution of mango selling prices and related to household types. For instance, type 3.3 can more easily have a diversification strategy to keep some fruit trees instead of cutting it. In addition, for farmers met again on week 6, some plots were delimited precisely, and have flooding information. It would be relevant to use it as a confirmation of Ms. Orieschnig's model.

In order to improve the **overall understanding**, it would be interesting to make links between farmers' perception and quantitative information on contextual aspects. A way of processing would be to go deeper on shared and not-shared perceptions of factors. It might imply to realize other medializations, for instance regarding changes of selling prices, and social network analysis typology to identify from where farmers get to know selling prices. The study identified the most important factors, but even for factors and choices shared between farmers, there is not yet obvious trends in shared perceptions. For market prices, on crop choice, the threshold is a profitable selling price, which depends on individual production systems, precise input and production mean costs. Not all farmers are able to set a threshold. About rainfalls, it seems that intense rainfalls is a key factor on frequency of irrigation, but farmers can rely on different

rainfall durations. In that sense, regarding technical agricultural aspects, it would require to conduct a precise study on technical itineraries, and socio-economical diagnosis of farms. As a diversity of threshold is now known, it would be interesting to target a limited sample representative of household types and use this precise study to go deeper on perception aspects. Also, it would be interesting to go deeper on contextual aspects such as land use. It seems that a lot will be changing in the area: it is administratively becoming a city, overall prices are going up (on a scale of 5 years), and it was heard that a channel would be built to link the Bassac River to the Ocean (Clark, 2023).

Regarding **AFD activities**, there is an important demand for *prek* Pok rehabilitation, as even farmers on other *preks* mentioned it. During the presentation, feedback was not that much on rehabilitation, but mostly on market prices, accesses, and cultivation advice to reach new markets. They are very interested in that point if reaching a higher value worth putting more efforts in improving their production systems. Labor force employment seems also to be an important bottleneck. Therefore, it would be interesting to:

- Analyze markets with higher value selling prices. Further studies can be implemented to characterize vegetable fluctuation prices, and define how to secure value chains for all crops,
- Analyze required extension services to support production systems, and individual household constraints,
- Analyze micro-finance systems farmers can trust and allow them to give up a credit system based on 30% - 40% rates. It is a main bottleneck regarding input buying processes, especially for households only based on farming activities as they are more sensitive to financial risks,
- Define production goals individually with farmers and establish their own business plans (some trainings can be provided, the work is done with one farmer, and other farmers are invited to follow the process). Mostly, they know approximately how much they spend per cycle, but they do not in details, as they do not keep tracks. It would help them to be more precise regarding their costs, and help them to follow a strategy based on their own production goals,
- Identifying potential leaders because there are the ones able to create social organization on *prek* scales (water management) and create production groups to reverse power relationships with middle buyers (markets). At least, a group of maize producers was encountered during field work, and small-scale community (10 people) worked together on Me Srok to get water.

CONCLUSION

The Cambodian part of the Mekong Delta, especially in the *prek* area, have been undergoing lots of development project mainly through rehabilitating *preks*. Yet, no study on the decision-making processes and factors influencing the choices of farmer have been done. For those projects, water is the limiting factor constraining the development of the agriculture in the area.

It was perceived the first choice farmers take is which crop they grow. From then, they make other choices concerning cultivation operations. For crop choice, number of cycles (NC), and sowing dates (SD), main factors are **market prices, and flood arrival / departure**. Then, it depends on **household types**. On one hand, agriculture, as a main source of income, usually implies reducing costs as much as possible in balance of growing a crop which has the **best-selling price**. On the other hand, households relying mostly on **external activities** (type 3) grow crops which are less labor intensive, and they might **diversify** a bit with vegetables. Strategies change regarding the **number of plots**. A farmer with a few plots, maximize the NC he can do. While one who has more than 5 plots, care less about optimizing a plot, but mostly spread out his SD between plots. **Regarding inputs**, strategies are similar between farmers, they try to optimize their profit. Yet, some difference exists between types, and the kinds of factors checked. For instance, it is less risky for farmers from type 3.3 to have higher costs than farmers relying only on agriculture, and not able to save money (type 1). Type 1-farmers need to maximize their yields, balancing CC and potential selling prices of their crops. Pesticide and fertilization applications are more likely to be managed as an **adaptive decision on perceived crop needs**. Concerning ***prek* rehabilitation**, if the plot is in the *boeung* or in the inter-*prek*, they are not likely to change their practices. Farmers from type 2, 3.1, 3.2 and 3.3 whose main income come from agricultural activities may intensify with a new cycle of maize or switch to maize, especially if they do not have many plots. Type 1-farmers might change to maize if they have enough investment capacities to pump water during the DS. Finally, there would be almost no change for type 3.3 whose main income comes from external activities as usually they have trees or vegetables. Maize seems to be the favorite choice right now because of the fixed and high selling price. However, **if there is an overall change in price, a new change in crop is to be expected**.

For farmers, market is an important issue in the area, especially as there is **no agricultural policy to protect the Cambodian market** from external competition. They suffer from a great variability in their selling prices. As **biophysical factors** are also important in their decisions, it is interesting to note climate change was never mentioned directly. However, current farmers' perceptions, and scientific previsions, observe and predict a flood length reduction, with more intense FE, and rainfalls becoming more and more irregular and intense. It does not seem farmers started to adapt. For instance, right now the strategy of having a 3rd cycle with a non-irrigated crop may evolve as rainfall numbers decrease. Moreover, there is another stake in **better characterizing household structures** as cash management and labor availability seem really important in decision-making processes (age, agricultural working hours, resource fluxes, and land management). Households are impacted differently regarding their type. Another challenge is to gain a better understanding of the technical itineraries to gain

perspective on farmers' decision thresholds and deepen understanding of their processes. From this analysis, 3 following questions are to be considered:

1. To what extent are these systems resilient to market fluctuations and climate change?
2. How structural constraints of households affect agricultural decisions?
3. How does farmers' knowledge on cultivation technics influences decisions, and what kinds of support can be appropriated to their needs, and social organizations (mostly individual farms and collective within the household)?

The main internship constraint was that, in the area, many projects took place, and farmers sometimes become weary as they reproach inaction. They are disillusioned about the value of research projects, have high expectations of feedback from research projects, and never got them. Furthermore, the limited time was another constraint to carry out interviews properly. However, being a team of 4, had enabled being more productive and through exchange to understand the different factors and decisions quite rapidly. The local team was a great help to adapt and have a good logistical support. Finally, the team organized a restitution, to present the result to farmers, to do a board activity, and hear them out on their different issues.

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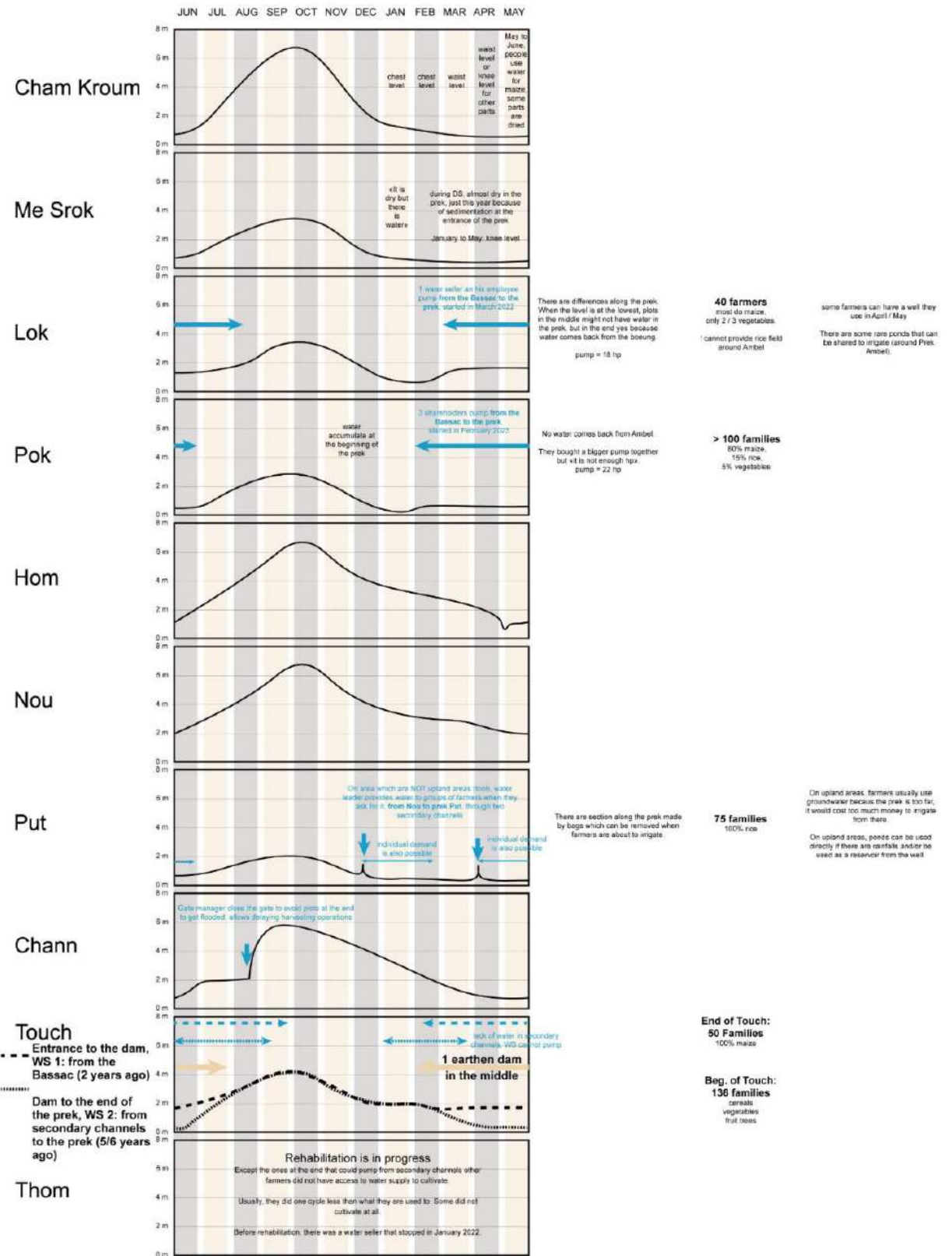
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[Appendix 10: Further analysis of 8 irrigation choices](#)

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Appendix 1 Levels of water in the preks

This visual representation is a summary of information collected from interviews with Water Sellers and farmers.



Appendix 2 **Water seller information**

WATER SELLER OF PREK LOK (11/07 PM)

Two people working as water sellers, one boss and one employees on prek Lok

1 shareholders in the water selling business

Only one water seller on prek Lok

Equipments:

One pump that is 18 hp which is placed at the entrance (beginning of the prek)

Water flow:

Flooded from August to September in the Boeung area.

There is water in the prek from August to March

Pumping time:

March-July/August: pump water

→ number of time they'll pump depends on the number of time farmer ask them

When asked for water, one pumping = the pump works for 3 days (24h*3)24 hours of pumping to 3 days

→ At the beginning, it is when farmers really need the water because right after they sow, they will pump more regularly and then decrease the number.

How do they work:

They only pump from Tonle Bassac to the prek but never from Ambel to the prek as the land is flat and water therefore stagnates in the prek.

They sometimes make earthen dams in the prek

→The dam is made for putting the pump on it and to pump water for dry season

→ made from sandy bags and always at the beginning of the prek.

Sandy bags and the pump are removed once the water in the prek is at the height of the waist of an adult man.

Rule of pumping

To start to pump, they wait that there is no water in the prek. This way, farmers really need it and will pay them. They are the one to decide the price according to their expense but will always tell the farmers beforehand.

2 types of payments, by hours and by cycles.

- Fruit trees (mango) and vegetables (cucumber, bitter gourd) are paid by the hour ⇒ 6 000 khr/hour. They do not check how long a farmer has irrigated → believes what the farmer says to them.
- Maize (did not talk about rice because do not provide farmer who does rice) are paid by cycle ⇒ 390 000 khr/ha

⇒ by cycle, the farmer has to pay after the harvest.

For pumping to their fields, farmers do it individually.

→ never organized as a group.

→ and they can pump whenever they want

History:

Started to pump for himself because there was no water in the prek during the dry season (march_july/august). The water he pumped for irrigation was mainly for his maize. Then farmers saw him do that and went to him asking if they could buy his water.

→ Beginning of pumping was around March 2022 but cannot remember the exact date.

Who are concerned by their activities:

Around 40 farmers buy water during the dry season. Some people at first ask for water too but after there is rainfall, they do not need it anymore and will not use water in the prek to irrigate.

In 40 farmers, there are 2-3 farmers who did not pay them for the service.

Most farmers plant maize (among 40 farmers that they sell water to only 2-3 farmers do vegetables).

Info:

Been water seller for only a year (started around march 2022)

→ Before that explains there was no issue with low water, think the lack of water is due to shallow prek because of sedimentation.

Explains to us that rice field can only be found around Ambel and they do not provide water to these farmers/fields.

In beoung area, farmers do 2 cycles of rice. First cycle is from November to January and second cycle is from March to May.

Farmers grow red corn, 2 cycles of corn and 1 cycle of rice.

How do they verify they are not getting cheated:

Cannot verify or check all around so some people pump their water without buying it.

Changes in rain regime:

Not much rain in 2022(February-March, maize sow).

From April to June, there is not much rain. The rain is later but more intense now.

Changes in the area/strategy:

Change to plants tree to use less pesticide

→ reduce cultivation cost

Papaya is selling price is 1000-2000 khr for 1kg

Maize price is higher (1000 khr/kg) as well as its yield but cultivation cost is higher.

Cultivation cost of rice is higher than corn

→ but resistant to water

Changed to red corn because better market access (more than 20 years, red corn is good)

Excavation:

Prek has never been excavated

→ Excavation would be too expensive for everyone.

Will be happy to have rehabilitation even if there are water seller because are mainly farmers and would enjoy water year-round

WATER SELLER ON PREK POK (12/07 AM)

3 shareholders in the water selling business

Equipments:

2 pumps

- one that is 12 horsepower hp (not used for business)
- one that is 22 hp (stay at the entrance of prek on sandy bags from february to end of june)



Water flow:

August/September - November : water flow from Tonle Bassac to Boeung area

November/December - July : water accumulate at the beginning of the prek

Pumping time:

Nov-Feb: water in prek

Feb-June: pump (the number of time he'll pump, depends on the number of time farmer asked him)

June-Nov: water in prek

Can go from 3 hours of pumping to 3 days, depends on land size and number of farmers asking for the water. When a farmer asks him, he usually can provide 2-3 to 5 days after the demand but can provide 100% of the water asked.

How do they work:

Carry the machine together at the beginning of the pumping time (february) and same at the end (june). During the day, one stays at the pump to verify everything works and the other two can go work on their fields. During the night, the three of them stay at the pump to verify everything goes smoothly.

Rules of pumping:

They will accept whenever a farmer calls him.

There are 2 types of payment, by cycle (depending on the size of land) and by hours.

- Fruit trees by the hour \Rightarrow 6 000 khr/hours, have to pay directly after irrigation. It is not him who checks how long he has irrigated, believes what the farmer says to him.
- Rice by cycle \Rightarrow 400 000 khr/ha
- Corn/vegetable by cycle \Rightarrow 350 000 khr/ha

\Rightarrow by cycle, the farmer has to pay after the harvest.

History:

Started to pump for himself because there was no water in the prek during dry season (february till june), farmers then went to ask him if he could pump for them as long as they pay.

Grouped with two other people as a way to be able to buy a bigger pump and provide more water to every farmer, even if still not enough hp.

Who are concerned by their activities:

Most of the people in the village are provided by his service \Rightarrow more than 108 farmers (90% farmers of village).

Share part of where the water goes:

- 5% goes to vegetable
- 80% goes to maize
- 15% goes to rice

Info:

Maize can be grown in 2 cycles now, it has been the case for the last two years thanks to water sellers. Before that, farmers were doing green beans, if some rain then vegetables, if no rain another cycle of green bean. Now they have switched to maize because it has a higher selling price.

They are waiting to know if the prek will be rehabilitated before buying a more powerful pump. Moreover, they need to make sure people need their services and that they will get paid because some farmer did not pay this year. It is a bit of a struggle for them as they had to go on credit for gas to use the 22 hp pump. if decides to keep doing that then will only provide farmers who paid them.

How do they verify they are not getting cheated:

Verify the moisture of the soil in plots and some farmers who get their services, will tell them if someone uses water and not paid for it.

Change in rain regime:

Now the rainy season starts later and the time between rainfall is longer, when it rains it is more intense.

Rain (usually storm) → then no rain for 2 to 15 days → rain etc...

Excavation:

Lots of sedimentation at the beginning of the prek, excavation could be good but also could have an impact on the houses and market at the entrance.

2-3 years ago, the prek had been excavated by a private business to get the sediment out and sell them (10 m deep on an area of 100m long, [GPS point](#) of where it has been excavated). Now there the water can stay a bit longer for 2-3 days.

Would not work with them now because work only where the sediments are of good quality which is not the case in the entrance.

5 years ago, excavation provided by the government yet sediment already went back up. (sedimentation of 1,5 m high in 5 years).

WATER LEADER WATER COMMUNITY ON PREK PU (13/07 PM)

Chief of water community

2023: Last year doing this job, will retire next year.

Equipments:

Three pumps got from the government.

- 2 pumps are using electricity (5hp,20hp)
- 1 pump is using gasoline (38hp), no longer uses this one
- 20 hp and 38 hp pumps use pipe of 30 cm of diameter
- 5 hp pump uses pipe of 15 cm of diameter

Water flow:

There is no natural flow in prek Put because it is no longer linked to the Bassac or Ambel. So the water needs to be pumped from December to February for the first cycle of rice and then from March to June for the second one. Then there is water in the prek that stays.

Floods usually happen from August to November.

→ early flood will arrive at the end of July

→ late flood will arrive at the beginning of September

Floods always go back at the end of November, and if a bit early like at the end of October then farmers still cannot grow rice for another month.

Pumping time:

Begins to pump from December, when he installs the pump, to February and will repump from March to June. If the date changes between cycles, the season cultivation of when he will pump for farmers is always the same → 2 month and a half

→ Pump from prek Nou to secondary channel ⇒ varies between 8h to 20h per 1 time

→ 1 hectare cost 26 900 riels for the electricity which equals price to irrigate 1 ha (per time for gravity irrigation)

How do they work:

November-December : Month where farmers start to sow rice seeds.

December : Start to prepare the pump, to install the pump at the beginning of the cycle, farmers will join and help.

Pumping from Prek Nou to the secondary channel then goes naturally to Prek Put, where farmers have made earthen dams that are connected by underwater pipes that they close with bags filled with rice straw (so get water gradually and can open it by removing the bags).

Expense for pumping the water from Nou to secondary channel:

→ total 190000 riels if using electricity, 480000 riels for gasoline, for gasoline one stop use it.

For the harvest period, 15 days before harvest, farmers will let the water drains out (usually by pumping it out) of the field, then harvest beginning of March

Meetings to inform water will be pumped : *"It can be less depending on whether they are busy or not. Sometimes 30-40 people and after they get the information, they will pass the information to other farmers who haven't attended. We all need to work together on this."*

Rule of pumping:

Before pumping, organize a meeting with farmer to know when pump and when to sow (rice only)

→ Accept to pump whenever someone ask him during the first cycle (Dec/Feb) and second cycle (Mar/Jun)

After irrigation, farmers get charged ⇒ 1kw selling price of electricity for farmers is 950 riels, the bill for electricity is 1kw cost 750 riels , so 1kw of electricity he got 200 riels.

→ "Because they form a group of 3-4 so I will give them an invoice for the total area of the plots. Then they collect each other's money based on my calculations in order to pay me back. Also farmers don't want to pay credit to me for too long, it might increase the money by the end of the cycle so they need to pay me first when it's just a little"

→ *"for uplands like Toul (what we call chamkar, part that never gets flooded) need to use the water pump to irrigate their fields. So they form together as a group and they need to total land area for me and I am going to give them an invoice and they need to collect their money for me based on the area of their lands. So for 1 hectare of land per once irrigation is 26 900 riels."*

He needs to pay 1500 riels every month because he is charged by public service as a way to not lose his electricity bill.

History:

First, in 2009 requested a pump to enable farmers to not only depend on rain. At the time he was also the Commune chief, so made a meeting with 38 farmers that were complaining of lack of water. He went to the agricultural representation of Province and District. Then they all came to visit the village and know if they approve of the pump or not. This way he became the chief of the water community.

→ *"Farmers are satisfied with him to be president and all of them are happy because it's drought at that time but he make it possible for agriculture"*

Then in 2012, got 2 new electric pumps from the government. Always worked the way he is working now, according to him on Prek Put, except on the Toul, irrigation is gravity fed.

Who are concerned by the activity:

Around 60-70 farmers get services from him and grow rice.

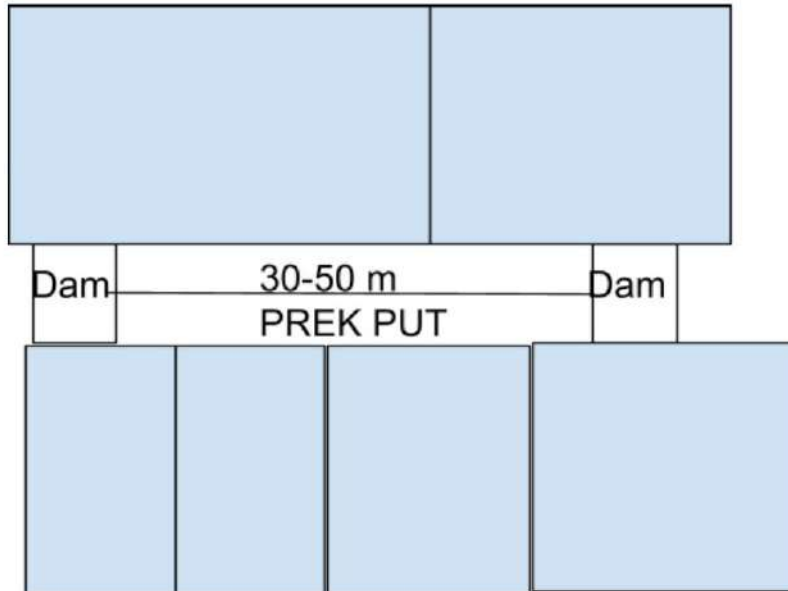
Info:

20kw of electricity equal to irrigation water for 2 hectare

No farmer uses pumps if they have low land, which is mainly the case on Prek Put. Here they do gravity irrigation.

12 kg of rice sell price is 15000 riels

Dams on the prek are every 30m to 50m,



Excavation:

1995: Excavated the prek from 1.5-2m deep on a length of 10m-20m after the pagoda, around the middle of prek but bank collapsed.

→ "I used to excavate 1,5m-2m deep and 10-20 m long and the soil in the bank is collapsing.

[Elsa]: Where is on the prek that has been excavated?

[Siden]: Where is on the prek that has been excavated?

[Water Leader]: Around the pagoda, almost middle of the prek.

[Water Leader]: They excavated in 1995. They took the sediments to put for land around the beginning of the prek to make it become upland."

Need for rehabilitation

This is according to him, the people here doesn't want the rehabilitation because prek will be deeper so impossible to do gravity irrigation, it will double price and explains that even if get rehabilitated, there will still be no water available all year round because soil is sandy loam (erosion), bank collapse will happen.

Monday 19th of June WS of prek Touch Entrance

WATER SELLER AT THE ENTRANCE OF PREK TOUCH (19/06 PM)

Water seller at Prek Touch that pumps from Bassac to the prek.

Gender: M

Age: 42

Villages: Po Thireamea and Po Thireamea Kor

History

He has been a water seller for two years. He said that in two years, the number of cultivated lands increased (the ones that were laying in fallow now are cultivated). Before 2 years ago, he was also the water seller but the pump was public (government).

There was an election and the farmers voted for him to be the water seller.

Equipments

He has two pumps at the entrance of Prek Touch. Their location is permanent. There are 30 horsepower (hp) and 6 hp. He uses both when the need is high. It is the case most of the time. He uses only the 30 CV when the need is not high but it is in rare cases. It happened just once in the two years he has been officially a water seller.

Water flows

Water flows naturally into the prek from November to January, then the water seller has to pump to keep having water. During the late month of April to late May, the water in the prek is at its lowest as it is at its lowest in the Bassac too.

	JUL 022	AUG 022	SEP 022	OCT 022	NOV 022	DEC 022	JAN 023	FEB 023	MAR 023	APR 023	MAY 023	JUN 023
<i>name</i>	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III
Bassac level								enough so no limitation to pump	in March it starts to decrease		lower than his waist	
Bassac > prek	pumps up to 24h / day				water flows naturally to the prek			pumps up to 24h / day	intermediary between 24h and 3h	pumps 3 h / day	pumps up to	



Pumping time

Will measure the water level in the Bassac, if above his waist can pump otherwise cannot. (waist level = 1m20)

When farmers **harvest** in February, there is no problem because he can pump 24 hours a day in high demand.

But in March, the Bassac starts to be low (from his side, water approximate 1m40).

From late April to late May, the Bassac level is lower than his waist and he can pump only 3 hours a day.

Hours of pumping

Feb – 24 h a day corn/rice – March // March – Apr // Apr - 3 h a day - May // May – 24 h a day – Sep

There are tensions on water, especially from April to May

During DS, there is tension because only 20% of 136 families can get water. “Apart from the cultivation season, there is a minimum of 10 ha”.

There are no earthen dams during DS

He said that there are dams during DS but actually on the field, we saw one in July. It is said that it separates the prek in two parts. From interviews with farmers, we learnt that there is another water seller at the end of prek Touch.

How does he work with farmers?H FARMERS?

He conducts meetings to inform farmers before pumping water “He is flexible with farmers”. He influences farmers to tell them when to plant in order to manage the water demand. He works in two villages *Po Threamea* and *Po Threamea Kor*.

The farmers go to him to ask for water. He can say:

- yes he can provide and guarantees he will
- no he cannot

When he conducts meetings, it is mostly with 20 families. The rest of the families “are informed by the 20 families”.

Rules of pumping:

He requires at least 10 ha to get irrigated apart from the cultivation season. Before excavation (he did it himself), he did not accept mango and banana, especially in DS (even if there are more than 10 ha).

Costs

crop types	price per...	price	details
fruit trees	price per hour	2\$/hour	usually, farmers irrigate 1 or 2 in one month so pump directly from prek and afterward pay the water seller
rice, maize	price per cycle (3-4 months)	100\$/ha	usually farmers irrigate 2 per week, so ask before hand the water seller because needs lots of water and pay at the end after the harvest) this explains why farmers organize together to get water at the same time
vegetables	price per cycle (3-4 months)	100\$/ha	

Only prek Touch's farmers pay the fees (he talks about surrounding preks). He does not use prices from other preks because Touch is not rehabilitated.

How does he make profit from this business?

Take 12% from the price so profit = 12.5 USD / ha (so from 100\$), the season is 3/4 months for corn.

He applies three rules

He must follow three rules:

- if machine broke, will have to repair on his own (uses the money gained from water selling activity)
- he must make sure to pump enough water for every farmers
- if there is no water in the river, the farmers cannot blame him

Who can have access to this service?

He works on two villages: Pou thirea Mea and Pou thirea Mea Koo.

During the high irrigation season (February) for irrigation on Prek Touch, there can be up to 136 families that can ask for water at the same time. During the low irrigation season, there are about 30 families (without mango and banana)

Why 136 families?

1. Of the 323 families of Po Remea village, 120 families do not work in agriculture ⇒ 203 families in agriculture.
2. Of the 203 families, 27 are on Prek Chann and 176 families are on Prek Touch and do agriculture.
3. Of those 176 families, there are 40 families growing mango and banana. They "don't need much water". They irrigate 3 / 4 times a month. Therefore, 136 families produce rice and maize.

Conclusion: for Po Remea village

Around 40% of the families do not have agricultural activities.

Around half of the families do agriculture on Prek Touch, from this half around 20% have fruit trees.

Excavation

For the first time this year, he excavated the Bassac for two hours. It happened "1 month ago", so it was mid-May. It was only one time. He did it at the entrance of the Prek because he had fear that farmers would face a lack of water. For the excavation, he paid for everything because he feels responsible for it.

Before excavation, he did not accept mango and banana, especially during DS, not even if farmers would reach the minimum of 10 ha.

WATER SELLER AT THE END OF PREK TOUCH (08/08 PM)

Water seller presentation

Water seller at Prek Touch that pumps from the channel coming from Prek Chann to the Prek Touch. The pumping station is at the intersection between channel n°4 and the Prek. Not in touch with the village chief.

Gender: M

Age: 37

Village: Po Thireamea (where his house is)

History

The WS took this role because he needs to irrigate his plot at the end of the Prek

He has been a water seller for 8 years. He has a plot at the end of the Prek that he needs to irrigate (1ha of maize on "farmland" at the end of the Prek, 3/4 ha with his family in law's plot). "Some farmers that have some lands do not care about water but he has to do it [irrigation]." They stick to rain-fed crops.

It is the largest maize plot around his neighbors: "He has the biggest plot at the end of the Prek so his neighbors look up at him anyways so he has to pump". His neighbors follow his lead.

He stopped being the water seller for the whole prek

Before he was the water seller of all the prek, but he cannot handle it: "a lot of work to do". He was not getting "profits". His plot is at the end of the prek, so it "takes a long time for the water to go".

"[L]: Is it the reason that there are two water sellers today?"

"[WS] Yes. If he does not get any benefits back, he will not do it."

Equipments:

He has two pumps to pump from the channel to the prek:

- 30 hp: he rarely uses it because he pumps for his own use for his rice field "no profits".
- 25 hp: uses it most of the time (can put it on a truck).

He has other pumps to pump from the prek to the field:

- 4 pumps 15 hp,
- 3 pumps 6 hp.

He has gotten a lot of pump since he is married. He bought the big one for his own lands. Even before becoming officially a water seller, since he bought the big pump, farmers could buy the gasoline and use it.

When it is the pumping season, he has only one pump installed at the end of Prek Touch. The location is permanent.

L: "there are examples all around the world of collective water managements"

WS: Before it was a government machine, but when it got broken, farmers preferred to go individually".

He has no idea how many pumps were given by the government. It was given 10 years ago.

Water flows:

The water can flow naturally in the prek from January to August but in February and March, it can dry out for two weeks straight. For the channel, the water can come from Prek Chann or the "prek from Vietnam, Teav". When the WS was called back, he said that:

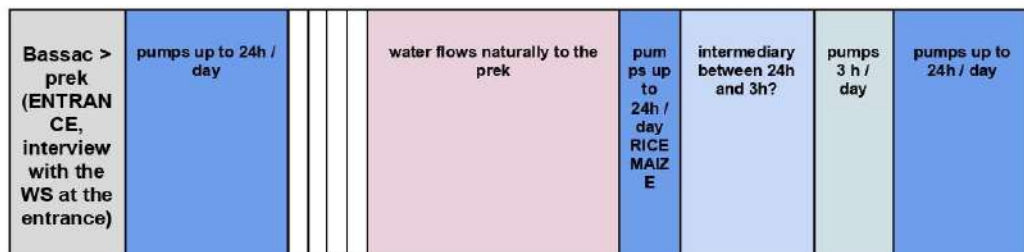
"the channel can be dry for two weeks straight. It can happen multiple times per year. From January to March, it can happen 3 to 4 times [that the channel dries out], he cannot predict because it is nature."

The WS said that sometimes "2AM he goes to pump and he has to wait to 5AM for the water to come.". When he was called back, he explained that "it is natural flow of water. Water can come from the river and from the Bassac. It happens at night. It is a tidal effect."

In April, at the beginning of the prek, there is a lack of water but only for a few days, not like at the end of the prek. There is no water in April at the end of the prek.

Sometimes there is no water that he can pump "just once in a while".

	JUL 022	AUG 022	SEP 022	OCT 022	NOV 022	DEC 022	JAN 023	FEB 023	MAR 023	APR 023	MAY 023	JUN 023	
<i>name</i>	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	I II III	
Channel > prek <small>(actual interview, same each year)</small>	L_P_2023_3107_01, water at the end of the prek comes back between beginning of June and beginning of July farmers at the end of the prek can buy water until the water flows again (so it is from the other water seller, at the entrance). The [natural] water flow can come back in November.					<i>L_P_2023_3107_01</i> pays water that month to the water seller at the end of the prek	pumps a higher number of times, mostly 24h / day	pumps, sometimes lack of water for 2-3 days	lack of water, does not pump	<i>L_P_2023_3107_01</i> end of the prek is dry			
prek (actual interview)								dries out for two weeks					
Earthen dam <small>(actual interview, we saw it)</small>	1 earthen dam							1 earthen dam					
Bassac > prek (actual interview)										lack of water for a couple of days			



For farmer L_P_2023_3107_01, the end of the prek is dry from December to May.

Pumping time:

He pumps from January to March when the demand is high. If there is still a bit of water, "farmers won't buy water from him".

When farmers harvest in April, there is a problem because he cannot pump to provide water and the yields decrease. They sow in December or beginning of January when the flood is gone.

Hours of pumping

He pumps for 11 hours to 24 hours.

There are tensions on water, especially from April to May

During DS, he does not provide water because there is no water from the channel.

Farmers harvest before there is no water anymore.

This year for instance, the WS sowed late and his yields decreased because there was "no water from the channel in April".

1 earthen dam from February to August

There is an earthen dam from February to August. It always goes to the same place (GPS location has been taken). The VC put it "to make the boundaries between the water sellers".

The vice village chief paid for it and also still pays for the maintenance.

"- Why is it him and not farmers that paid for the dam?"

"- He is a village chief, so he cannot collect money.

"- Why didn't you do it?"

"- The village chief is the one who takes care of it because if he does not do it, he is the one who loses money."

How does he work with farmers?

How does he know the demand is high or low?

He goes to the field every day. If the water level in the prek starts to be too low he pumps again. "Too low" means his waist level in the prek. He will stop to fill up the prek when it reaches around 1m70 (head level).

Number and duration of irrigation from the channel to the prek

For his pumping season, he will irrigate between 3 to 5 times per week. It depends on the level of water at the end of the prek.

- *minimum number of hours*: from 7AM to 6PM
- *maximum number of hours*: 24h

There are tensions between the beginning and the end of the prek

The WS told them to buy from the first part of the prek but "they [farmers] are lazy". "They prefer to pay for water from one person."

Rules of pumping

He uses the end of the prek like a storage area. When the level is low and farmers ask for it, he will fill it up.

"- How does he know exactly which are the families that pump?"

"- They tell him that there is a lack of water and the WS knows the size of the land."

The minimum level of water he needs in the channel to be able to pump is around below his waist. It should be about 80-90cm.

Costs

crop types	price per...	price	details
fruit trees			
rice, maize	price per cycle (3-4 months)	300 000 to 350 000 riels /ha He asks for 350 000 but sometimes farmers give only 300 000 riels.	
vegetables			

How does he make profit from this business?

He does "not get any profits from this activity" but he can "cut some cultivation costs" "save some gasoline costs" for his plot of maize. He is getting paid by 40 farmers after the cultivation season, after harvest. There are no formal agreements. If they refuse or do not pay, the WS cannot do anything.

What if the pump breaks?

If the machine breaks, he will have to repair it on his own, with his own money.

Who can have access to this service?

Most of farmers produce maize

He can provide 50 farmers. There are the one after the earthen dam, at the end of the prek. Over the 50 farmers, it is mostly maize "before they did rice but not anymore". There are rice fields but they pump by themselves in the channel.

"How does he know they don't take water from the prek?" "He pretends that nothing happens. They will come to confess later [that they did not pay]"

Some farmers do not pay him. Usually, over 50 farmers, around 10 people do not pay him back.

Why don't they do rice anymore?

[WS] "- Rice is hard to take care of and rice prices were very low at that time."

[L] "- What does it mean to be hard to take care of?"

[WS]: "- Fertilizers are expensive, they need to pump a lot of water, a lot of money on gasoline, and lots of rats."

[L]: "- What does it mean prices were low?"

[WS]: "- The yields were low because of the rats and cultivation costs were high."

[L]: "- How many years ago was it?"

[WS]: "- It was 2 to 3 years ago."

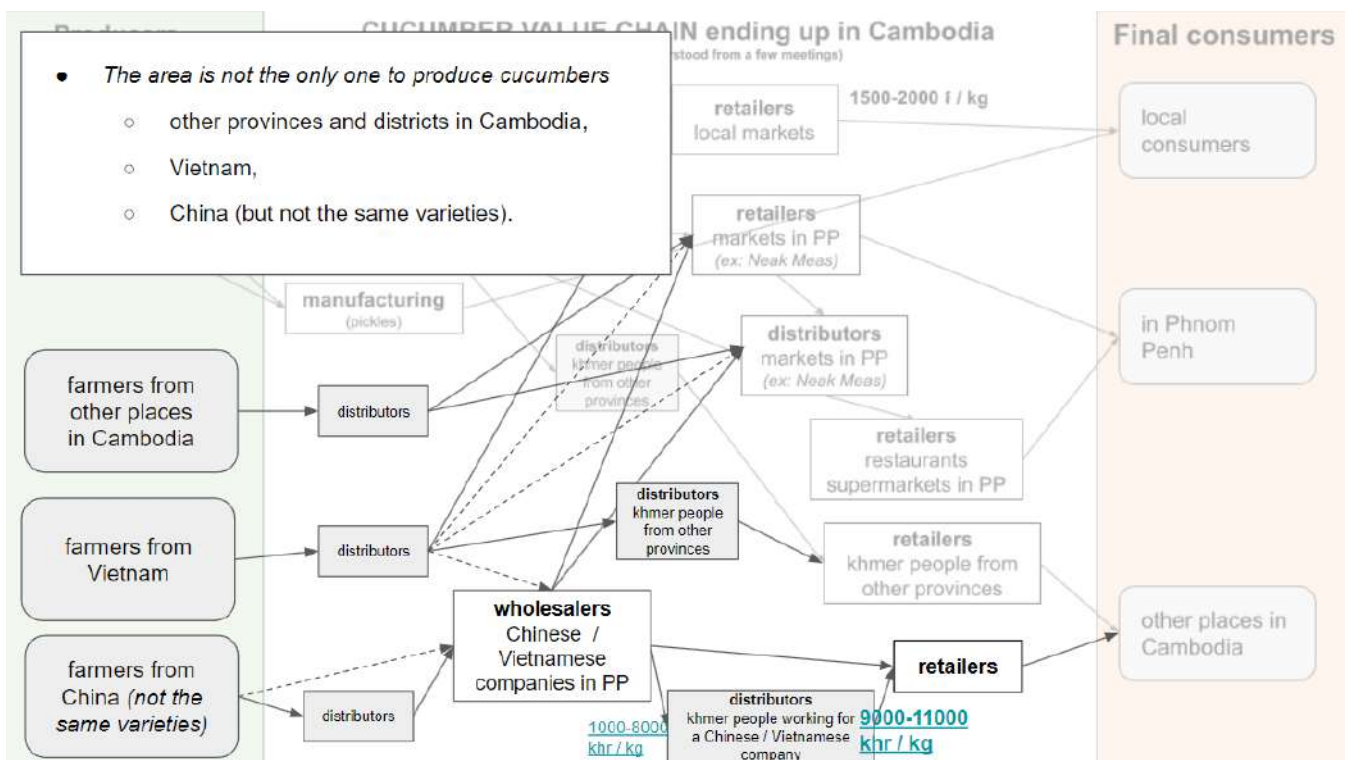
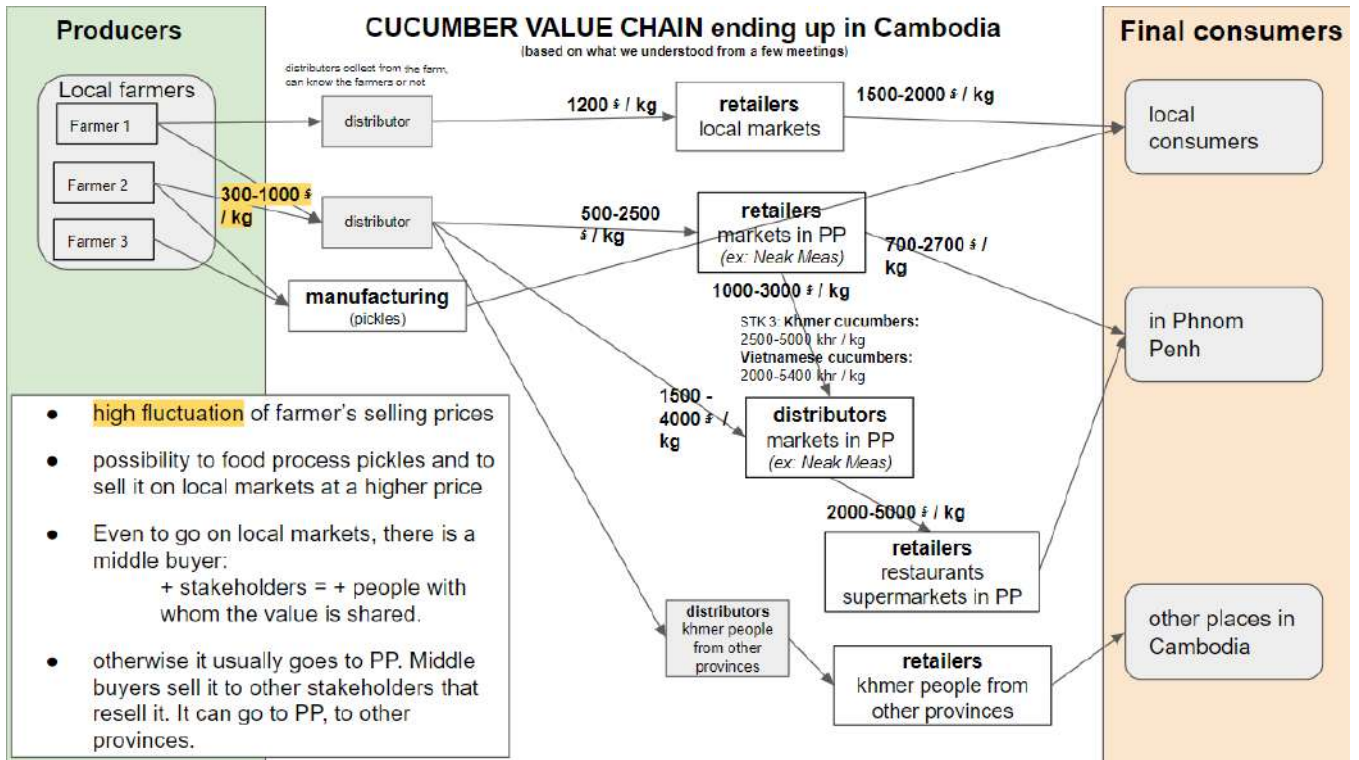
Excavation:

Regarding the excavation, he paid excavation for 100m of the prek, for 4m deep. He paid with his money, there was no communal funding. It took 7 hours.

1 hour is 160 000 riels \Rightarrow 1 120 000 riels for one time

The excavator put the soil on the road, so they can build the road. He rented the excavator to make the prek lower and install the pump.

Appendix 3 Cucumber value chain



Appendix 4 Summary of selling prices given by farmers

		Min price	Max price	Number of farmers who gave a price
Maize	grains	400 KHR/kg	10 500 KHR/kg	9
Rice	paddy	550 KHR/kg	3 000 KHR/kg	4
	straw		250 000 KHR/ha	1
Fruit trees	papaya	100 KHR/kg	1 300 KHR/kg	3
	banana	800 KHR/bunch	2 500 KHR/bunch	4
		200 KHR/kg	300 KHR/kg	1
	mango	100 KHR/kg	600 KHR/kg	3
	longan		10 000 KHR/kg	1
Vegetables	green beans	3 000 KHR/kg	4 500 KHR/kg	4
	cucumber	150 KHR/kg	1 800 KHR/kg	5
	okra	500 KHR/kg	2 000 KHR/kg	1
	bitter gourd	200 KHR/kg		1
	long beans	100 KHR/kg	2 000 KHR/kg	2
	mung beans	3 000 KHR/kg	4 000 KHR/kg	1
	pumpkin	600 KHR/kg	1 000 KHR/kg	1
	chinese cabbage	2 000 KHR/kg	4 500 KHR/kg	1
	choy sum	1 500 KHR/kg	2 500 KHR/kg	1
	pok choy	1 500 KHR/kg	3 000 KHR/kg	1

Appendix 5 Questionnaire used for farmers

version 5

Questionnaire Farmers | DATE: _____ Interviewer: _____

Interview N°: _____ Translator: _____ Prek: _____

Context where is conducted this interview, are they a lot of people around, is the person relaxed or a bit annoyed

Gender of the farmer: _____ Recorded: Yes / no _____ First meeting location: plot / farm / farmer's house / village center

Internship presentation

1. two agricultural students from France,
2. this is our last year internship to get our graduation,
3. our research institution is French,
4. our internship is about understanding the way farmers take decisions, so why you take the decisions you take,
5. We have no connection with the Cambodian government,
6. We know that there are a lot of rehabilitation projects in the area and we are not linked to them,
7. We are interested in knowing your interests in rehabilitation and if there are other issues to highlight.
8. We will come back to present our results before going back to France in August.
9. Please the questions are about your practices, not the one that your neighbors do, we are not here to judge you or give advice. We really just want to understand what you do.

Our names are ...

- What is yours?

Name: _____ Age: _____

- In which village do you live?

Residential village name: _____ Nomad: yes / no

Part A: Choices

Choices 1 and 2: Number of cultivation cycles and types of crops

Plots

- How many plots do you have? _____ location of all the plots: ask to go with the farmers DRAWING: *put both plots and distances between each other and the road*
- Can you draw it? **STEP 1/2/3** 1) the interviewer asks ID of plots and subplots 2) ask for the size of the plot 3) number of cultivation cycles 1 are = 0.01 ha // 1 acre = 0.40 ha
- Between which preks do you have plots? _____

FLOOD:

per plot:

- TIME: when can the flood:
 - arrives the earliest? the latest?
 - leaves the earliest? the latest?
- SPACE:
 - never flooded
 - sometimes part of it ⇒ SIZE
 - sometimes all the plot
 - always a part of it ⇒ SIZE
 - always all of it

Do you pump back to the prek when flooded? yes/no when?

<p>0 Between which preak? _____ _____</p> <p>Resuable to irrigate yes / no</p> <p>From which preak? _____</p> <p>Where on the preak? end / middle / beg details by where: _____</p>	<p>1 ACTUAL CULTIVATION SEASON C0</p>	<p>4 after filling up the table with the rotation THE CULTIVATION SEASON that 6 goes before C-2</p>																																																									
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Choice 1

- What has an impact on your decision of the number of cultivation cycles?
- What makes you decide to plant [x] cycles of cultivation instead of [y]?

CHOICE 1: NUMBER OF CULTIVATION CYCLES														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented

number of cultivation cycles	
------------------------------	--

- How does rainfall impact your decision on the number of cultivation cycles?

- How does the water level in the prek impact your decision on the number of cultivation cycles?

- How does flooding impact your decision on the number of cultivation cycles?

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TABLE A: cropping season

plot n°	if sub-plot ID	if subplot size	crops	cropping season																						
				JUN 022	JUL 022	AUG 022	SEP 022	OCT 022	NOV 022	DEC 022	JAN 023	FEB 023	MAR 023	APR 023	MAY 023	JUN 023	JUL 023									
1, 2, 3, etc.	ex: 1A 1B 1C 2	size unit	name																							

Lands

- Do you own some lands that are **NOT** cultivated by your household? yes / no
 - If so, why and who works on these lands? neighbor / kinship / outsiders, from where: _____
 - Is it an oral contract?

- Land cultivated for a **SHORT** period (<4 years) of time
 - What has made you buy / rent? plot near your house / plot closer to your other plots / grow another crop
 - other:

- Was it hard to have access to these new lands? Did you have a special opportunity? Why did you buy there instead of another place?

- o When you made this decision, who was available to work in farm activities in your household? _____
- o Was it enough? yes / no
- o If not,
 - Did you hire people?
 - Did you stop another activity to work on your new lands?
 - Did you sell other lands?

- Land cultivated for a LONG period (>4 years) of time
 OWNED: How did you get the land you own? inheritance / bought
 RENTED: What type of contract do you have, written or oral? written / oral

- Did you sell some land in the past? yes / no
 - o Which plot? (location, size, characteristics regarding soil type, irrigation access, flooding)

- o Why did you sell it? to grow another type of crops / have money to invest in something else
 - other:

Crop changes and outlets

- Besides the crops you mentioned earlier, are there any other crops that you have planted before?

- Is there a crop that is important to you? Which ones? _____
- Why? (multiple cycles in a year, important part of cropping income, fodder for animals)

- Do you keep part of the production for yourselves or for animals? yes / no
 - which products? _____
- Do you food-process any of your productions for selling? (rice milling, rice straw, maize grain threshing, maize grain drying)
 - which products? _____

• Sold products: when are prices fixed, selling location, where the product goes, services provided by buyer, type of contracts

Crops (report from Part A)	PRODUCTS	OUTLET		selling location	WHERE THE PRODUCT GOES?	Do you sell to middlemen?	middlemen				type of contract	
		Home consumption or fodder (food for animals)	Sold cropping products				possible number of middlebuyers	Where is that person from?	prices with middlebuyers	Do you sell to the same middleman?		
	Asparagus		Sold cropping products	on the field, market, at their home F / M / H	local markets, PP, Vietnam	yes / no		fixed in advance OR on the field?	villages, from outside		yes / no	W : written / O : oral for mango, there are contracted farmers

- Can you describe how the sale is made by crops ? (harvest first, you transport to middle buyer / middle buyer harvest and transport himself, who is the harvester... for rice/corn and vegetable)

6 **CROP:** fruit/vegetable/cereal

4 get money before harvest get money when middlebuyer get harvest

3 farmer harvest MIDDLEBUYER HOUSE
 LOCAL MARKET
 FARMER FIELD

1 Knows time to harvest: Call middlebuyer
 Middlebuyer comes to plot
 Farmers observe

5 when and how is the price is:

2 harvester hired by farmer
 harvester recommended by middlebuyer
 harvester hired by middlebuyer

6 how many times does the harvest happen

JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
1	2	3	4	5	6	7	8	9	10	11	12

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1	2	3	4	5	6	7	8	9	10	11	12

6 CROP: fruit/vegetable/cereal

4 get money before harvest get money when middlebuyer get harvest get money after product sold

1 Knows time to harvest: Call middlebuyer Middlebuyer comes to plot Farmers observes

2 farmer harvest harvest hired by farmer harvest recommended by middlebuyer middlebuyer harvest harvest hired by middlebuyer

3 MIDDLEBUYER HOUSE LOCAL MARKET FARMER FIELD

5 when and how is the price is:

6 how many times does the harvest happen

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
1												
2												
3												
4												
5												
6												

- Is your production sold at the same time as your neighbors? yes / no
 - How does it work?

- How do you find potential buyers?
 - Do you choose buyers or do they come to you? If you choose, how do you find buyers?
 - Are you entitled to them because of credits?

Choice 2

- What has an impact on your decision of types of crops?
- What could make you decide to choose another type of crop?

CHOICE 2: TYPES OF CROPS														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented
types of crops														

• Why do you choose [crop x] over [crop y] for the same cultivation cycle [ex: C0, C-1, C-2]?

• How does rainfall impact the choice of crop you will cultivate?

• How does the water level in the prek impact the choice of crop you will cultivate?

- How does the flood impact the choice of crop you will cultivate?

- Why do you diversify with multiple crops / get specialized in one crop?

Choice 3: Seeds and varieties

- For the [crop x] = _____, for this plot, n°: _____, how many bags of seeds do you use? _____ What is the weight of one bag? _____
- Do you change the quantities of seeds from one cultivation cycle to another cultivation cycle?

- Is it possible that you get less seeds that you need and you will cultivate only a part of it? How do you adjust to the quantities of seeds you can get?

- Where / when do you get your seeds (bought or produced by you or a neighbor)? What are your main constraints?

- Do you have a choice in the variety of the seeds you choose? Does it change from a year to another? Which varieties are easy to find?

- Do you choose drought-tolerant varieties or pest and disease tolerant varieties? For which crops?

- When you choose one variety over another, do you change your sowing date? How?

- Are the (rice / corn) varieties different from one cultivation cycle to another?

- What has an impact on your decision of the variety?

CHOICE 3: VARIETIES														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented
varieties														

Choice 4: Sowing and plantation date

- What has an impact on your decision of the date you have decided to sow or plant?

CHOICE 4: SOWING AND PLANTATION DATES														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented

sowing and plantation date

- What makes you decide to plant a bit later or earlier?

- How is it different between [crop x] and [crop y]?

- How does rainfall impact the date you will sow/plant?

- How does the water level in the prek impact the date you will sow/plant?

- How does the flood impact the date you will sow/plant? How many days after the flood recession can you sow? Why is it your minimum?

- When you sow, do you care about the harvest date when you choose to sow? Do you take into account the risk of early flooding?

Choices 5 and 6: Number and duration of irrigation operations

Water access

- To irrigate your plots, do you pump directly into the prek or do you organize with your neighbors? yes / no
 - Description per plot.

plot n°	pumping in the prek directly	organization with neighbors	pond (yes/no)	groundwater (yes/no)

- o If it is collective, why?
- How many are you?
- Does it change from one year to another?

Water seller

- Do you need services from water sellers? yes / no
 - o From how many water sellers? _____
- What defines the costs? (quantity, duration) How much is it?
 - o Is it different from one crop to another? How?
 - o If there are multiple water sellers, is there a price difference between them? How? Contact?

- From where to where do they pump?

water seller	From where?	To where?	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
		prek												
	prek													

- How do you get the services from a water seller?
 - frequency of contacts,
 - ways: meeting, by phone.

- o Should it be a minimum of farmers, plots, etc.? yes / no
 - Is it different between crops?
 - minimum: _____

- Are there some periods when the prek should be dry and thanks to the water seller there is water?

- Are there some moments when the water seller cannot provide irrigation for you? When? Why?

On Prek Chann and with a farmer who has plot on transition and boeung

- Can the opening of the gate be a problem regarding your crop cultivation activities? yes / no
 - o If so, why? (strong flow destroying your crops, especially in the boeung area or bank collapse)
 - o If so, who do you contact to solve the problem?

Back to the choice

- How many times do you irrigate? Is it different from one crop to another? Can you describe your irrigation by crops?

- What has an impact on your decision of the number of irrigation?

CHOICE 5: Number of irrigation														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented

Number of irrigations	
-----------------------	--

- How does rainfall impact your choice on the number of irrigation? Can you explain it? After how many days without rain, will you irrigate again? Is it heavy/light rainfalls? (explains what do you mean by heavy or light)

- How does the level of water impact your choice on the number of irrigation? How high the water level in the prek must be for you to irrigate? (at least ankle, knee level, 2m) How do you measure the level?

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- How does the flood impact your choice on the number of irrigation?

- Why is the number of irrigation for the [crop x] is more than for the [crop y] ? Why?

- When you have water, what is the maximum number of hours you can irrigate? Is it different from one crop to another? How?

21/36

- What has an impact on your decision of the duration of irrigation?

CHOICE 6: Duration of irrigation													
A	B	C	D	E	F	G	H	I	J	K	L	M	N
crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented

Duration of irrigations	
-------------------------	--

- How does rainfall impact your choice on the duration of irrigation? If you decrease by how much time ?

- How does the level of water impact your choice on the duration of irrigation?

- How does the flood impact your choice on the duration of irrigation?

- Why do you irrigate more hours with [crop x] compared to [crop y]?

Choices 7 and 8: Number of applications (pesticides and fertilizers)

- How do you approximate the number of applications of pesticides you do?

- Per year, very approximately, what are the maximum applications of pesticides you can do? _____

- What has an impact on your decision of the number of applications for pesticides?
 - What could make you decide to do more applications of pesticides? Or less?

CHOICE 7: Number of applications for pesticides														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented

- How does rainfall impact your choice on the number of applications of pesticide you'll make? Can you explain it?

- How does the level of water impact the number of applications of pesticide you'll make?

- How does the flood impact the number of applications of pesticide you'll make?

- How do you approximate the number of applications of fertilizers you do?

- Per year, approximately, what are the maximum applications of fertilizers you can do? _____

- What has an impact on your decision of the number of applications for fertilizers?

- What could make you decide to do more applications of fertilizers? Or less?

CHOICE 8: Number of applications for fertilizers														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types.	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented
Number of applications for fertilizers														

- How does rainfall impact your choice on the number of applications of fertilizer you'll make? Can you explain it?

- How does the level of water impact the number of applications of fertilizer you'll make?

- How does the flood impact the number of applications of fertilizer you'll make?

Choice 9: Number of soil cultivation operations

Equipment / type of operations

- Which machinery, pump, agricultural equipment do you use for your crops?

Name	Equipment status			Number	Characteristics	Conditions						
	owned	Public	Belongs to one farmer and shared			rented	From who?	From where?	Is there a minimum to have access to this service?	For how much?	For which service?	operators included?
pump, harvester, tiller, back pesticide sprayer, back seed sprayer, plough	and shared				If pump, from where to where, change of location	Battambang, Vietnam	number of plots, number of farmers...	COST, for free, fuel cost shared	period of time, total sta?	yes / no	if credit, do you pay after harvesting?	

Name	Equipment status			Number	Characteristics	Conditions					
	owned	Public	Belongs to one farmer and shared			Rented	From who?	From where?	Is there a minimum to have access to this service?	For how much?	For which service?
pumps, harvester, tiller, back pesticide sprayer, back seed sprayer, plough					CV, size if pump, from where to where, change of location	Batambang, Vietnam	number of plots, number of farmers....	COST, for free, fuel cost shared?	period of time, total area?	yes / no	if credit, do you pay after harvesting?

- Related to the weeding operation, do you do it by hand or do you use a machine? hand / machine
- What do you do by hand?

- RICE: How does the rainfall, floods, and available water irrigation impact your decision to prepare "slurring" (mise en boue)?

- [crop x] = _____ What is the number of soil cultivation you do? Which ones?

Back to choice

- What has an impact on your decision of the number of soil cultivation operations?

CHOICE 9: Number of soil cultivation operations														
TIME:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	crops	market access, prices, transaction types	immediate cash availability and access to credits	cultivation costs (INPUTS)	labour capacity	equipment availability	soil nature	water resources	air temperature	observation from other people	technical services (informal and formal)	pest and disease	self use / livestock	land: owned or rented
Number of soil cultivation operations														

- How does rainfall impact your choice on the number of soil cultivation operations?

- How does the level of water impact the number of soil cultivation operations?

- How does the flood impact the number of soil cultivation operations?

- How does the type of crops have an impact on the number of soil cultivation operations? Do you prioritize one crop over the other for an operation?

Choice 10: Date of harvest

- Do you harvest earlier if there is an early flood? What do you change?
DIFFERENCES BETWEEN FRUIT TREES AND VEGETABLES

- For the date to harvest, would you rather let "rot" your crops than harvest it if the flood is early than harvest it not ripped? yes/no Why?
DIFFERENCES BETWEEN FRUIT TREES AND VEGETABLES

- Do you harvest earlier if there are early rainfalls? What do you change?
DIFFERENCES BETWEEN FRUIT TREES AND VEGETABLES

Part B: Open characterization (Day 1 - xx min)

Livestock

- Livestock: yes / no

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- Which animals belong to the household? How many? Who tends to the animals?

animal species (breeds)	number of animals	number of animals that are not owned	How do they eat? (stay at home and they receive food, graze on other plots)	What do they eat?	Who does tasks related to livestock? (household members: who?, labor exchange or hired workers: who?)	sold?	self consumption?

- How has the change of crops in the area impacted your livestock rearing?

Household activities

- married: yes / no
- children: yes / no, number: _____
- Who lives with you? Who works in agriculture? Are there other family members that do not live with you and work on your farm? Do you share your income with them

status regarding the interviewee	Number	Duration of the stay	Work for the farm?	Jobs?	Other activities?	Details
children, parents, mother / father in law, wife		permanently	<u>croops</u> , <u>livestock</u>	wage labor (construction, garment, institutional job) <u>agricultural wage labor</u>	fishing, input seller, water seller, equipment rental, land rental (to someone else), other business	wage
the interviewee	1					

- Your household is you, [your wife], [your children], ...
- Do you **RECEIVE** money from family members that do not live with you? yes / no
 - remittance from family members, (% of household's income, USD/year or on average in USD/month): _____
- Do you **SEND** money to other family members that do not live with you? yes / no
 - remittance to family members, (% of household's income, USD/year or on average in USD/month): _____
- What is the annual income of people sharing an income?
 - ⇒ able to answer: Do you include other activities that bring money or only agricultural activities?
 - if it includes all the activities, what % is due to agriculture?
 - ⇒ not able to answer: we ask for each crop (we know selling prices so we ask *about yield*)

harvests	MACHINE: one harvest	all year along	a couple of harvest per year (btw 2-3)	all year along	By HAND: multiple harvests	By HAND: one harvest
crop	RICE MAIZE MUNG BEANS	BANANA	MANGO	PAPAYA	LONG BEANS, OKRA, EGGPLANTS,	MORNING GLORY

	GREEN BEANS					CUCUMBER, BITTERMELON, WAX GOURD		
	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____	0) one plot: plot n°: _____ / all of them nb of trees: _____ age of trees: _____ 1) nb of bunches per time: _____ 2) nb of times per year: _____	PLOT n°: _____ kg per harvest: _____ which month: _____ kg per harvest: _____ which month: _____ kg per harvest: _____ which month: _____	PLOT n°: _____ kg per time: _____ nb of time per year: _____ number of trees: _____ age of trees: _____	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____	cultivation costs: ● equipment ● irrigation costs ● gasoline ● fertilizers ● pesticides ● seeds ● hired people (harvest, carrying bags, transportation, spray pesticides, fertilizers)	% to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____

• From the revenue that all the members of the household gain, after removing the costs of cultivation and other activities, what is the percentage of the income from agricultural activities? _____

• Is agriculture a priority for your household? How? _____

version 5

- Are you trying to develop a certain crop? What is your strategy regarding agriculture? Are you looking to buy new lands issues, you cannot? How do you manage a limited workforce? If you rent, where is the money coming from? or due to other
- When do you need the most people to help you on the farm? Why?

- Do you have enough members in your household? From what age to what age do household's members work the most on the field?

- What makes you hire people?
 - Is it because you don't have time to do it and there is a working peak (what is considered no time)?
 - Work somewhere else?
 - Avoid spreading pesticides for health issues? For health issues, what is too old to spray pesticides:_____

- Regarding the total working hours of household members, is it more in agriculture or in other activities? What is the part dedicated to agriculture? (fill up the graph, one cell is 10%)

--	--	--	--	--	--	--	--	--	--	--	--

- Regarding the total investment capacity of household members, is it more in agriculture or in other activities? What is the part dedicated to agriculture? (fill up the graph, one cell is 10%)

--	--	--	--	--	--	--	--	--	--	--	--

- What is the household annual revenue? Is it in USD? Please put a cross on ones of the following chart:

<p>Annual revenue per HOUSEHOLD (USD)</p>	<p>If precise revenue per household in the last year: _____ USD/year</p>
<p>MONTHLY average revenue per HOUSEHOLD (USD)</p>	<p>if precise average revenue per household: _____ USD/month</p>

Interests in rehabilitation

- Do you benefit from rehabilitation projects? yes / no
- What is your interest in it? or your non-interest?

--

- Do you think your yields will increase? or did it increase with rehabilitation? (double / triple / ...)

 - Give an example with a specific crop

• On the prek, is there a specialization or a diversification that happened / will happen before / after rehabilitation?

• If you don't need a water seller anymore / will not need it, what is the amount of money you will save per year?
o Give an example with a specific crop

• Basically, you have / you will have a higher investment capacity, in what did you / will you invest it?

• Now, what remains your main constraints regarding crops?

• On this prek, did the rent of lands change? (price before and after) How? Did a lot of people sell / or are selling their lands? To whom?
o Usually, what is the range of the value of lands? What makes the price higher / lower? Is the rehabilitation made / will make the prices higher?

- Regarding sediments, what changed / will change before / after rehabilitation? (depot on the plot, obstruction of the creek after a certain time)
 - If sediment deposits, how do you manage sediment deposits? (in the creek, on your plot)

Land value

Land rental activity

- How many plots do you rent to other people? _____
- IF ONE: renting price: _____
- IF MULTIPLE: is the renting price different between your plots? Why? value difference between cultivation cycle / location / other
- other: _____

Land rented from someone else

- Does the price change during the year? yes / no, Why? (season, location, other) How does it change (increase during DS...)?

Output storage

- Do you store any of your productions? Why? (selling value improvement)
 - Are there some storage facilities in the area? Are you part of it? Why?
 - If so, do you know who manages the storage facility? Can we have their contact?

version 5

End of the interview day 1

- also we will present our results at the end of August
- Phone number: _____

FILL UP THE agreement FILE and SAVE IT!

36/36

questions to add to farmers v5 - 21th of July

Questions to add to farmers v5

Work with Siden and Ryma - Friday morning 21th of July

location of all the plots: ask to go with the farmers **DRAWING: put both plots and distances between each other and the road**

FLOOD:

per plot:

- **TIME:** when can the flood:
 - arrives the earliest? the latest?
 - leaves the earliest? the latest?
- **SPACE:**
 - never flooded
 - sometimes part of it ⇒ **SIZE**
 - sometimes all the plot
 - always a part of it ⇒ **SIZE**
 - always all of it

HOUSEHOLD:

- how many members live under your roof?
 - Do you share your income with them?
 - What do they do?
 - Who works in agriculture?
 - Who has other jobs / activities that bring money?
 - wage?
 - What is the annual income of people sharing an income?
- ⇒ **able to answer:** Do you include other activities that bring money or only agricultural activities?
- if it includes all the activities, what % is due to agriculture?
- ⇒ **not able to answer:** we ask for each crop (we know selling prices so we ask about yield)

1/4

questions to add to farmers v5 - 21th of July

harvests	MACHINE: one harvest	all year along	a couple of harvest per year (btw 2-3)	all year along	By HAND: multiple harvests	By HAND: one harvest
crop	RICE MAIZE MUNG BEANS GREEN BEANS	BANANA	MANGO	PAPAYA	LONG BEANS, OKRA, EGGPLANTS, CUCUMBER, BITTERMELON, WAX GOURD	MORNING GLORY
	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____	0) one plot: plot n°: _____ / all of them nb of trees: _____ age of trees: _____ 1) nb of bunches per time: _____ 2) nb of times per year: _____	PLOT n°: _____ kg per harvest: _____ which month: _____ kg per harvest: _____ which month: _____ kg per harvest: _____ which month: _____	PLOT n°: _____ kg per time: _____ nb of time per year: _____ number of trees: _____ age of trees: _____	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____ PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____	PLOT n°: _____ crop: _____ cycle from when to when: _____ tons: _____
cultivation costs: ● equipment ● irrigation costs ● gasoline ● fertilizers ● pesticides ● seeds ● hired people (harvest, carrying bags, transportation, spray pesticides, fertilizers)	% to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____	% to remove for the cultivation costs: _____	% to remove for the cultivation costs: _____	% to remove for the cultivation costs: _____	% to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____ % to remove for the cultivation costs: _____	% to remove for the cultivation costs: _____

questions to add to farmers v5 - 21th of July
(added after the session)

QUESTIONS

- Can you describe how inheritance works? When do your children inherit lands?
- For what tasks do you go on credit ? Are you always able to reimburse? or do you go on credit more than one year with the same person?
- Do you pump water back into the prek?
- irrigation calendar, can you describe how you irrigate?

plot n° or sub-plot ID	crops	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	
		I	II	III	I	II	III	I	II	III	I	II	III	I

- instead of number ⇒ date of soil cultivation operations
- Is there always water in the prek? If not, when is there no water (month, approximately)?

THRESHOLDS

- ❖ from which selling price is it profitable?
- ❖ after how many days without rain, will you irrigate again? Is it heavy / light rainfalls? Can you describe what you consider heavy rain? Light rain?
- ❖ What makes you irrigate longer a crop? Can you describe it?

Friday 28th of July (v1), Friday 11th of August (v2), Monday 14th of August (v3)

Date of the call: _____ Who called? _____	
complementary questions - Friday 28th of July + Friday 11th of July	
Question on water: which plot? _____	
Can you describe the water level in the prek throughout the year?	
From where do you get your irrigation water? differences between plots?	Prek?
	Ponds?
	Well?
Is it always the same source of water throughout the year? if groundwater: is there any time through the year you can use it? How deep is your well? How many years ago did you dig it? Was it already on your plot?	

Friday 28th of July (v1), Friday 11th of August (v2), Monday 14th of August (v3)

<p>When you do your irrigation, how do you proceed? Describe it please.</p>	<p>Equipment used: _____ (hp if missing)</p>
<p>Do you change the way you irrigate depending on crops? (not talking about how many times but really how you do the irrigation, pump water into secondary one then gravity irrigation etc)</p>	
<p>Between January and April do you choose a crop not to have to irrigate? (january-april, novembre-janvier) Why?</p> <p>If the prek is rehabilitated, will you change that?</p> <p>If so and if the price of when you pump on your own (individual) is still high, are you so sure?</p>	
<p>What would you change if there was rehabilitation?</p>	

Friday 28th of July (v1), Friday 11th of August (v2), Monday 14th of August (v3)

Question on household	
with whom do you share your income?	
for each person <ul style="list-style-type: none"> • job / activities • wage (if possible) 	
How do you share your income?	
Everyone gives all they have?	
Someone pays for daily expenses (food and another for electricity, water? How much is it?	
% of income from agriculture (crops / livestock) / from other activities	
per year, are you able to save money?	
if so, how much?	
thanks to which activity?	

Friday 28th of July (v1), Friday 11th of August (v2), Monday 14th of August (v3)

	savings only for you? or shared with everyone?	
Did you have another activity before that that you stopped? Why?		
	same for the other spouse	
Questions on plot identify the plot we miss information for		
Can you describe the location of your plot?		distance from the N21: _____ distance from the prek: _____ which side: _____
Did you manage to expand your lands? Why? Was it a part of your goals?		
<i>If land rented</i>		
Why not buy the land?		
<i>If land bought</i>		
	How did you manage to buy your land?	
	by your own savings? thanks to which activity?	

Friday 28th of July (v1), Friday 11th of August (v2), Monday 14th of August (v3)

	by borrowed money/credit? bank? family?	
<i>If we don't have the info</i>		
For each plot, which part gets flooded?	how many meters:_____	
How is it flooded? From rain, or by prek?	which plot? plot n° _____	
	From when to when usually?	
	How early can the flood arrive?	
	How late can the flood arrive?	
	How early can the flood leave?	
	How late can the flood leave?	
	How high can the flood be on your plot? min / max	

Appendix 6 **Session organization and details of the board activity**

PRESENTATION

Before starting the presentation, hands out with the result in Khmer was handed out to farmers as a way to facilitate their understanding and for them to keep record of what has been done.



The first part of the presentation was about market. It was decided to start with this as it is one of the main factors that came up regularly in the field, regarding decision-making processes. Moreover, farmers met explained that they would like to understand better how market works.

- The presentation lasted 16 minutes and another 15 minutes was for farmers to write down their remarks on paper that was collected at the end of the feedback.

The second part of the presentation was to display the three main strategies that resulted from the analysis of the fieldwork. Some time for feedback was provided.

- The presentation lasted 20 minutes with 15 minutes more for feedback. The strategy of using paper to write down their remarks was used again. It was thought a good way, to have the feedback of everyone and not only the one confident enough to speak up in front of an audience. Three translators, that were part of the presentation, went to help farmers write down their remarks to avoid losing the feedback of those who cannot write.

The third part of the presentation was about the factors that could explain the choice made on irrigation, pesticides and fertilizers. It was presented as factor that could explain choice and that could also explain why they would change a choice previously made.

- The presentation was 20 minutes long and a break was proposed after. Giving time to read the papers with the feedback.

After the break, a short time answering or responding to the papers was taken. Finally, an activity was organized with the farmers.

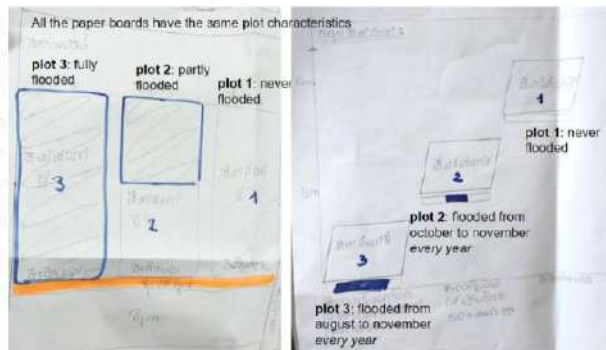
ACTIVITY



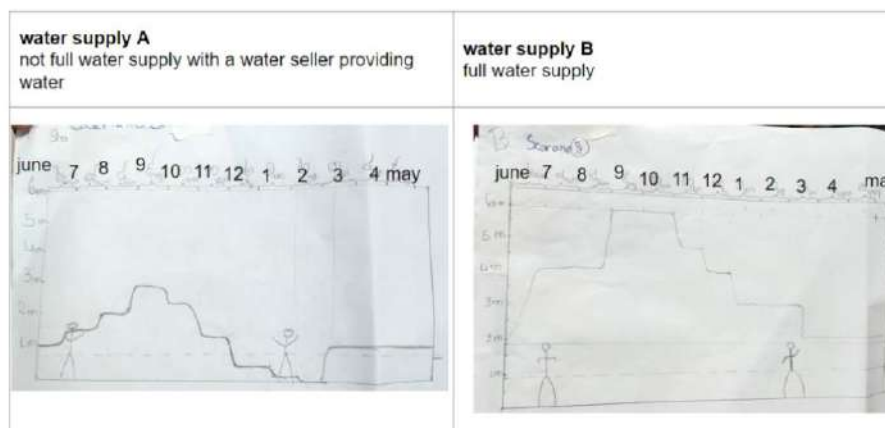
For the activity farmers were asked to be divided into 3 groups of 10 people.

The activity was to see if *prek* rehabilitation would have an impact on their cropping system.

In order to do so, farmers were given three imaginary plots with different characteristics (one being completely flooded, one being partly flooded and one that does not have issues with flood).



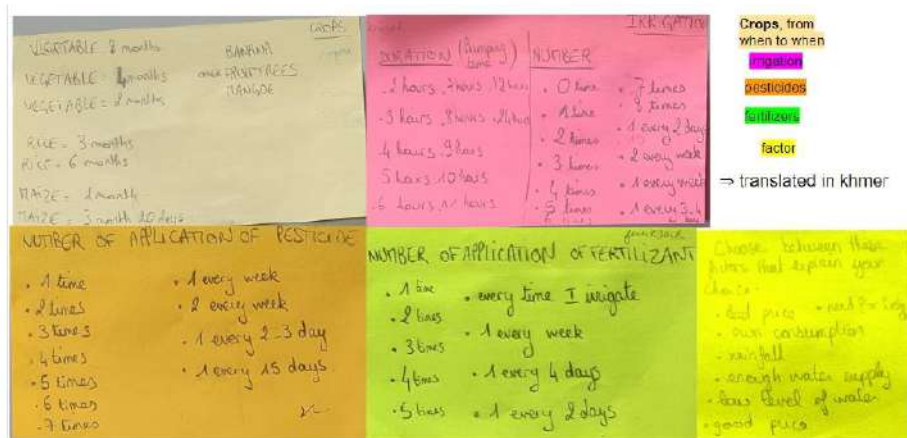
They were distributed board with a *prek* not rehabilitated (water underneath the waist high from January to March) and one being rehabilitated (water above the waist high year-round), with the location of their plots and finally a calendar for each plot.



Moreover, to see if the rainfall regime could have an impact on their choice for their cropping systems. By group, they had a specific rainfall regime written down in khmer and describe before starting the activity.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
group 1	1 time / 2 weeks, big drops (few or many hours)		1 time / week, small drops, many hours		almost everyday, ++ small drops for many hours, + big drops once every 3-4 days		<div style="text-align: center;">  </div>					
group 2	1 time / 2 weeks, big drops (few or many hours)		almost everyday, small drops, many hours 		almost everyday, ++big drops for few hours +small drops for many hours							
group 3	1 time / 2 weeks, small drops, many hours → up to 2 days		1 time / week, small drops, many hours		almost everyday, ++big drops for few hours +small drops for many hours							

Finally, once farmers have understood the location of their plots and their characteristics, as well as their rainfall scenarios. They were asked to write on sticky note which crops they would choose and place it on the calendar and to add on different sticky notes how they would irrigate it, how they would fertilize it, how they would apply pesticides and the last one was a sticky note for them to write down the reason behind their choice.



Back in Phnom Penh, a time with the translators was taken to discuss the results of the activity.

Dynamics for each group

group 1

The group is sitting. But after a while, they started to get up except the one who participated less.

At first they did not want to work together because they do not have the same crops and thought that it would be impossible to choose if they did not want the same things. But after some discussion they agreed to participate.

There were 4 people who took the most place and speaking time, however there was some real discussion between everyone and if some farmers did not agree with the 4 leaders they would speak up."



group 2

The group is standing up. Group dynamic even though some people are on the side. [Siden]: "People quite old."



group 3

The group is sitting. Group dynamic, some people are writing but almost all of them are involved. There is one leader (a woman) who talked quite a lot during the feedback moment. Some farmers are on the side. There was also the WS from *prek* Touch who said "I don't not know how to do it."



Appendix 7 Farmers' feedbacks

FEEDBACK OF FARMERS OF THE PRESENTATION AND ACTIVITY

Process

- put what the farmers wrote (write stickers) by main themes on a paperboard (green stickers)
- translate the white stickers in English (yellow stickers)
- add other observation or farmer sayings (orange stickers)
- presentation from translators to Elsa and Louise
- theme by theme: presentation, reporting and discussion

Feedback result and first analysis

Picture of all the stickers classified



Technical advices

Stickers

"He wants technical support on vegetables such as wax gourd and how to get high yield."

"I want technical support of spray pesticide/apply fertilizer in the right way"

"I request technical support on crop cultivation."

"Give technical how to grow to get high yield and could competition with neighbor country"

"Farmers want to be trained the technique of planting cucumber"

1 paper about processing

"Related to processing, lack of knowledge of processing their vegetables, and packaging also needs support."

Analysis

Farmers want different kinds of technical support. They want to know how to get technical support.

"They can be specific like wax gourd but they ask for technical advice for vegetables in general."

"talked about that they want technical support on wax gourd to get high yield, they have request on crop cultivation"

Interpretation: crop cultivation means that they want to know about technical itinerarie [Siden]: *"what they should do and therefore how to decrease costs." "If they don't decrease costs, at least they would have more yields and therefore more benefits."*

"would like to learn on the right way to spray pesticides and how to apply fertilizers the right way"

Another thing about technical advice, in the discussion with farmers once we explained that food processing is a good way to increase the value of their products and get higher prices, they explained that they are lacking knowledge on how to process food and how to process their harvest (can be both post harvesting and food processing) so how to have nice packaging and so on. It could be interesting for them if some training is made on post harvesting and food processing.

General feeling and potential bias of the presentation:

Farmers talked mainly about vegetables as it is a crop that requires more care than rice, maize or fruit trees. However, we have to take into account that during the presentation we talked a lot about vegetables which might also explain their focus on it.

4 papers were written on it but it is not relevant because people could have discussed and then written on the same paper. Some of them told our assistants directly.

It was general feedback regarding technical advice.

If they talked that much about vegetables, we think it is because we talked about it during the market presentation. Usually from interviews, it seems that farmers know how to grow cereales, and what is the best way. Then the investment capacities would explain why they don't do it the right way."

Additional information

One guy talked about maize. *"Before he used animals to tillage."* They were using their cows. He did not spend money on fertilizers. The price back then was 700 riels / kg for maize, there was no cost for tractors, and labor was not expensive. He could

do 2 cycles as he does today. After harvesting the first cycle, they would hurry up to sow the second cycle. The only thing that changed for him is the use of fertilizers."He does not understand how fertilizers work because he said that the "soil is getting unhealthy"."

Interpretation: it could be about using more pesticides and fertilizers. Maybe it is linked indirectly to fertilizers because they can use irrigation to apply fertilizers, and that might have an impact on pests and diseases. They use pesticides to cure but not as prevention, and because they have been growing the same crops, maybe this is why pests / disease can start to have tolerance. Farmers did not mention anything about pest resistance. If pesticides do not work, they change the pesticide type or they mix it with other pesticides.

Water

Regarding water, it was mostly the lack of water that was mentioned by farmers. They just want to have water to have water all year around. "*The problem is only the lack of water, especially during the dry season.*" The 3 Prek that were mentioned (on 3 papers) are Prek Touch, Thom and Pok.

Thom: "*Farmers facing the problem of lacking water in dry season*"

Toch: "*Lack of water in dry season*" *Request to ministry of government help.*"

Pok: "*I have a request to you to have a water supply because I don't have much water to irrigate my plot.*"

General feeling and potential bias of the presentation:

The farmers here were mainly well off, so the water shortage is a real issue for them. If we had farmers where the price of pumping from the Prek was an issue then maybe the lack of water would not be such an issue.

Important to note that not that many farmers out of the 30 talked or wrote about the water shortage. It seems that the market prices came up more often.

From the interviews, it has been said that farmers can destroy wells in the northern part because "*it is killing the crops*". They would prefer using surface water. Hypothesis [Siden]: "*they would use groundwater only on a Toul area because it is not contaminated by arsenic (maybe wells are less deep than on the Prek, maybe it is another surface water.*"

Additional information

One farmer on Prek Pok that we met during week 6 on the field, came to us after the session. He said that farmers on Prek Pok requested the Village Chief to do something about it. "*The Commune Chief was also requested.*" He hopes that one organization can do something about it next year. He is active on Prek Pok.

Labor

3 papers

"There are 80% of farmers on Prek Sdei that grow rice, maize and mung beans and the crops they grow on 2-3 ha."They have to hire 2-3 people."

"There is a labor problem because it is more expensive to hire now compared to before."

"If were the one to sell directly their crop then they would not have time to actually take care of their vegetable (apply pesticides, apply fertilizers, weed etc)"

Additional information

Less demand in agricultural laborers because of agricultural machinery?

When there was no agricultural machinery, wage labor was not in competition with agricultural machinery. During fieldwork, one lady was met and she explained that she is an agricultural laborer and that some farmers *"still hire some people to harvest maize"* (the day we were on Toul).

It seems that there are still people that work as agricultural labor but it seems that the demand is less than before because there are tractors and harvesting machines.

Who are agricultural laborers?

- farmers who have time for it and need money: people who cultivate smaller plots might have more free time and can work as agricultural laborers for other farmers. It can be hard for agricultural laborers to find a job, as they don't have skills for other types of jobs. Therefore, they can only work in agriculture.
- people that have no land [Siden]: *"for instance, people from the Cham ethnic group are fishermen but during the season where they cannot fish they would work as agricultural labor."* However it is important to note that they would rather work as fishermen than as agricultural labor.

Which kind of activities can agricultural laborers do apart from agriculture?

In the area, they can work in a factory, as construction workers, work as waiters in funerals, weddings or other ceremonies. Those different jobs do not represent the same amount of time required. For instance, someone working as a waiter would need to do the job for only a couple of days (lasting the time the ceremony is held) but if the person works as a constructor then it can last for more than a week. Yet for agricultural laborers, the job is needed for only one or half a day. This can explain why mainly farmers are also working as agricultural laborers (E_S_2023_0507_02). There are also different ways to work in a factory, as a full-time employee (majority of the cases) or work as an extra who brings some work home and then gives it back to the factory.

All of this work is mainly extra work to get a better wage as it is rarely full-employment.

Market

13 papers

"High yield, Low Price of the products, Request for fixed price market"

"Why do Khmer Vegetables get lower price than imported vegetables?"

"1: Can NGOs help to give some seed for farmers to plant? 2: About market price, can you help us? 3: About fluctuation in the market prices, how can you help us?"

"Request for market price to be fixed?"

"For maize seed it is very expensive but when selling, the price is low." "Could you help us find the market? Vegetables are cheap here so what can farmers do?"

"When I get the yield of the crop, how can I sell it? Market access?"

"I want the market price to be fixed but what is also important is for the price of fertilizer and pesticide to be low." "Because if I don't use both fertilizer and pesticide, I won't get the yield."

"Farmers need to be trained on how to plant cucumbers to sell them in a specific market at a good price."

"When farmers form a community to sell cucumbers, we need a fixed price for us to do that."

"If farmers got the yield of cucumber, I want a fixed price from the middleman so I have a motivation to plant it all year round."

"If we plant soybean and mung bean from April-August, we won't get any yield and if I plant mango, the price is cheap."

"When we get high yield, we get low prices." "I want to sell my yield with a fixed price so I have motivation to do so." "I want good market price access."

"When we get the yield of vegetables and If I sell it directly by myself in the local market, I have no time to weed out, irrigation, putting pesticide and fertilizer."

high yields / competition with neighbors countries,

Would like to know how to grow vegetables with high yield and how to get more competitive with neighboring countries."

Overall ideas of team observations during farmer's discussion

7 papers

For woman who grow okra she mentioned that in order to get high selling price, she has to be smart about the month if there are lots of farmers growing okra at the same time she won't grow it at all while in that time she will let the soil rest and the month no farmers grow okra she will grow it and the selling price is also expensive.

There is a group of farmers who said that the game of making the decision is just like a research team interviewing them in the field.

The reaction of a farmer said that this presentation is just about the reflection of the research team.

There, a guy said that because the price of vegetables is low, he decided that his daughter should stop cultivation and work in the factory.

Another strategy that farmers use is to predict the market and always be prepared and have plan B.

About the game it's hard for them to communicate because the ones that don't do crops like others, they don't say anything because it's not what they know.

One farmer requested at least one presentation like this once every 3 months.

Appendix 8 Further analysis of 3 crop choices

I chose a crop because I have full water supply in the *prek*, only 11 out of 50 farmers talked about having full water supply in the *prek* as a main factor to choose a crop. It is interesting to note that there is no real distinction between the different household types, it seems that the majority of the 11 farmers who answered the question will intensify with a cycle of maize during the dry season if there was enough water supply in the *prek*.

*[Ryma]: "So uncle, earlier you said you didn't plant corn this year because it doesn't have a full water supply and you decided to plant wax gourds instead. So does the lack of water in the *prek* is the main factor that impacts on your decision on changing the type of crops you plant?"*

"Yes, if there is a lack of water, I will change the crop to cultivate." [L_P_2023_2306_02]

The 39 other farmers who have fruit trees plot, who are specialized in vegetables, or who have a plot in the inter-*prek*, *boeung* might not change their crops if there was full water supply in the *prek*. Farmers who are diversified might add a cycle of maize in their rotation but on the whole will not change their choice drastically.

I sow at different times so I can secure multiple harvest, 8 farmers out of 50 have discussed this choice. It depends on two factors, reducing labor (also cultivation cost) and compensate lower market price. What is striking is that every household types are explaining that by having different sowing times for different crops enable them to decrease the labor forces needed for agriculture. This way, they can work on the plots without having to hire someone which allows for a decrease in cultivation cost and have money more regularly.

"I decided to sow at different times because I can spread out my workforce and not hire too many people and make some profit. It is also a way for me to have money more regularly." [E_P_2023_2707_01]

Farmers who depend only on farming to take care of their households mention that by having different sowing times allows them to compensate for lower price of crops from the previous harvest.

"I prefer to plant at different time to help recover if an harvest has low price". [E_P_2023_0208_03]

I chose a crop for home-consumption or to feed my cattle. 7 out of 50 farmers have made the choice of growing a crop that will not be sold after the harvest. Here two strategies can be described concerning the choice of crop for consumption. One factor is the presence of livestock while the other one is about having enough rice to eat. For livestock they might choose to do short cycle of maize or rice (harvest only the stem). Finally, farmers who are not really dependent on farming might choose to not do cycle of rice, if they had a good enough yield from the previous cycle (enough to sell and enough to keep for home consumption). None of these strategies can be explained by the household's types. Concerning presence of livestock (4 out of 7):

"I do heavy seeds rice as a way to avoid buying foods for cows and I can do everything by myself (almost no cultivation cost just fertilizer for 50 000 riels/cycle) and harvest whenever I have time".

[E_P_2023_2707_01]

Moreover, it is important to have in mind that almost everyone who does rice will keep some part for their home consumption. But they were not considered in the number of farmers who are doing “**I chose a crop for home consumption**” because the way they are thinking about the crop will be for selling and not just for their consumption.

Finally, first it is important to note, that mungs beans and cereals have been put in a same category for specialization as both are harvested at the end of the cultivation cycle. The differences between the two is that mung beans do not require irrigation.

Appendix 9 Water resources, and irrigation technics by type of crops

This document was written after week 6, as a written record of what was observed in terms of sources of water, and irrigation techniques. Pictures from week 6 can be found in a shared folder on Google Drive.

DIFFERENT WATER RESOURCES

Prek

Individual and collective organizations

Generally, pumping from the prek to the plot is done individually.

Constrained supply around rice cultivation: the example of prek Put

The only prek where there is a constrained social organization is prek Put. Irrigation is gravity-fed. Farmers irrigate rice using water from prek Nou. There is one person responsible for taking water from a channel coming from prek Nou to prek Put. When the water level is high enough in the section in front of the plot to be irrigated, the water flows by gravity, from the prek directly to the plot. At the end of prek put, all farmers produce rice. There are no other crops. If there is pumping, it is to drain the water from the plots.



*prek Put: as explain by the prek leader, there are sections all along the prek
Small groups can have a mutual organization to irrigate at the same time. Besides,
individual request for irrigation is also an option.*

Blocking water entrance into the prek: example of Prek Chann

The gate delays the arrival of the flood by closing it. This saves farmers time when harvesting. There's a manager for the gate. He does not always open the gate. Farmers can, but they have to ask him permission to use the equipment to open the gate. The equipment is stored at the house of the manager's son, who lives next to the gate (and whom we looked after as a farmer).

Water Sellers (WS) are farmers who bought equipment to pump from channels / other preks or from the Bassac River

On prek Lok, Pok, Touch, farmers invested in pumps to be able to pump from the Bassac River into the prek. Besides, on prek Touch, there is another Water Seller (WS) who pump from a channel at the end of the prek. Water Sellers and pumping locations seem to be changing a lot regarding the prek water supply.

As it requires a lot of work, if the service is not well paid, WS would prefer not to have this activity. It is more difficult to control the water intakes from the prek to the plots, when there is only one partner rather than when there are several.

Other communities besides WS?

The question stays on air. However, it is known that small groups (not more than 10 people) can get organized without having to use WS services.

Intermediate systems to store water

There are intermediate systems to store water. On Cham Kroum, and Me Srok, water tanks were observed. Farmers fill up their tanks from the prek.

Punctual use of secondary channels

Perpendicularly to some preks, there are residuals of gravity irrigation systems. It may be that punctually farmers can use it when the level in the prek is really high, or as a way to drive water from one place to another (individually or collectively).

Prek Ambel and Bassac

Plots along the Bassac are irrigated directly from the river. Prek Ambel can also be used directly for irrigation. It was the case for farmers met on Prek Lok.

Water from wells / boreholes, going directly to the plot

In some cases, the water may come directly from a borehole (recognisable because the water is clear, as it was seen on Toul between Put and Nou). Wells / boreholes cannot accommodate a submersible pump because the diameter is too small. Farmers lower the pipes and use surface pumps.



The water is coming directly from a borehole (Toul between Put and Nou). It is an irrigation operation of a rice plot, but the same system can be found for other crops in this area. The difference for rice plot is that water supply goes directly from the pump to the field, whereas pipes are generally used for vegetables.



This picture was taken on a earthen wall of a cucumber plot on Toul area (between Nou and Put)

In between preks, ponds do not appear to be used as a source of irrigation, although this is the case on the toul area

Ponds between preks

In between preks, there are some ponds which were enlarged by the government 30 / 40 years ago (e.g. Me Srok). This has enabled farmers to put land at the end of their plots, and as it seems, to extend their cultivation area. However, from a couple of informal interviews, they usually do not irrigate from it. In theory, they could irrigate the ponds but the direction of the slope would not help them, as it would probably cost more to irrigate from the bottom to the top than from the top to the bottom.

On toul, ponds can be used to store, and pump water to irrigate, but not all of them

Ponds can be natural, as is an example in this picture taken in the toul area. It is not used for irrigation. Interestingly, this picture represents a lowland on the toul area (even if it means "hills", it is not always high elevation).



Between prek Nou and prek Put, some ponds were deepened to take out the soil. It is mostly used for construction. From then, as it is deeper, farmers can use it as a reservoir to pump from boreholes, or to simply use rainfall water.



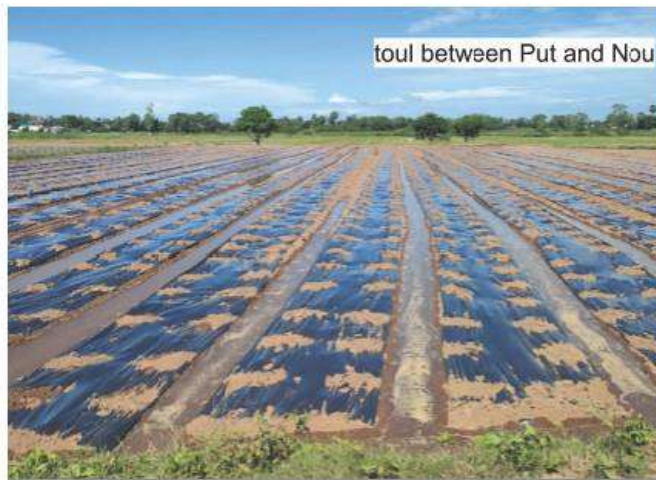
On the toul area, some farmers can pump from groundwater, even it is not theirs, and store water in ponds

The owners open up access to the boreholes/wells to small groups of people (less than 5 according to our quick interviews). Farmers have to pay for the energy to pump from the borehole/well.

IRRIGATION TECHNIQS PER CROP TYPE

Vegetable irrigation

Two kinds of irrigation techniques were observed. It can be rows which are filled up with water. If there is too much water, and it is on highlands, farmers can drain easily.



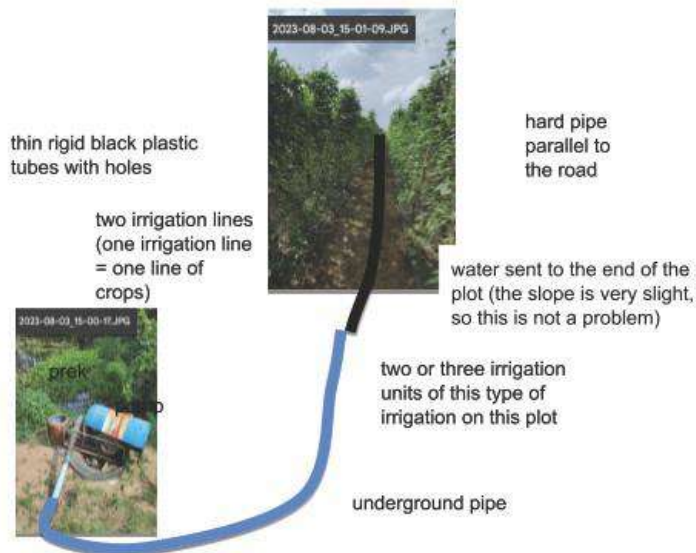
toul between Put and Nou

vegetables
on mounds
trench

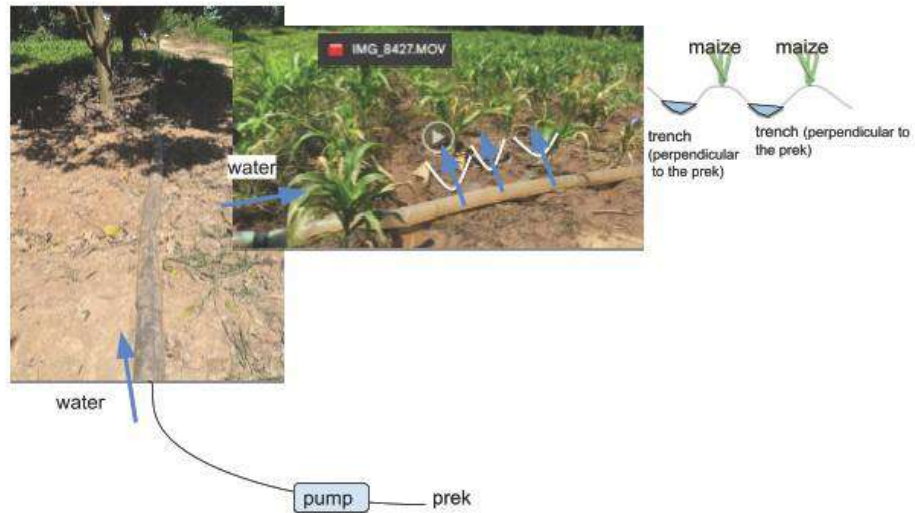
This is the first irrigation before planting (they irrigate more than during cultivation). It was about to be a cucumber plot.

Drip irrigation techniques were also mentioned. Generally, the lines follow the crop lines. There is a larger pipe parallel to the road, connected to perpendicular pipes (with regular holes, but no drippers). Sprinkler irrigation was not observed (maybe once during the whole field period, on one plot, maybe on prek Nou).

DRIP IRRIGATION, example with long beans



Maize irrigation



Finally, as with the vegetables, maize is grown on a mound. This is to provide drainage to prevent root to rot in the rainy season.

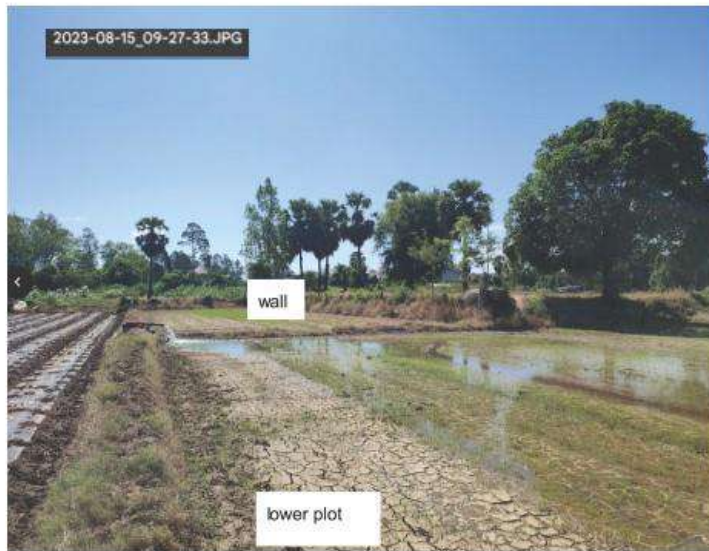
In the photograph top right, there are holes in the flexible hose to bring water to the trench of the plot at the same time.

When the plot is not flat, farmers can make a wall at the end of their plots, irrigate the end by a pipe and when it is moist, they irrigate the head. (ex on prek Touch for a maize plot)

Rice irrigation

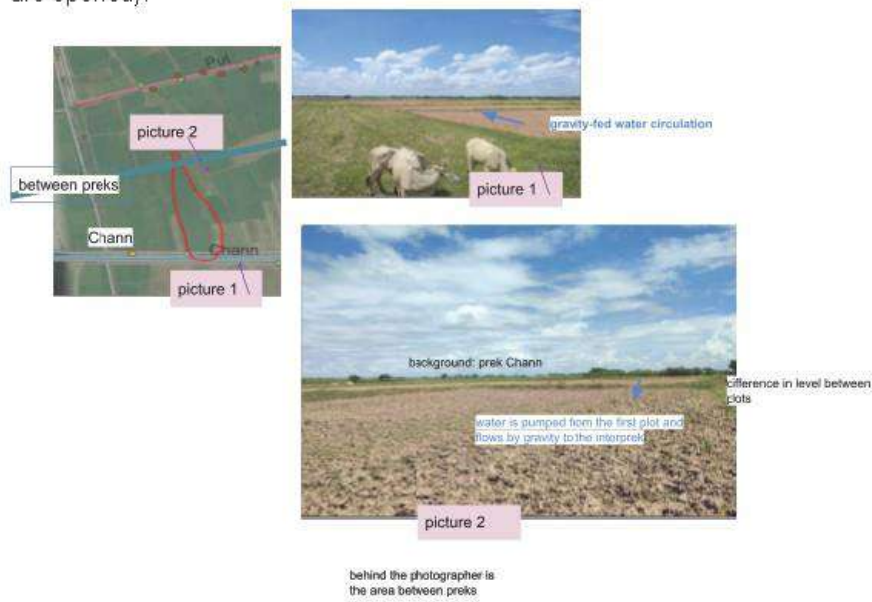
Manage supply and drainage with low walls

Rice plots always present earthen walls to keep the water in. As there are made from soil, they can easily be opened or closed. If the plot is higher, and the wall opened, the water runs off onto the lower plots (belonging to the same owner or to a different owner). There must surely be agreements between neighbors to manage the differences in altitude between plots.



Pipe end (individual prek pumping)

On prek Chann, there is an example of individual pumping from the prek (pictures from the 16th of August). The farmer uses a flexible pipe to reach the closest plot to the prek. From there, the water reaches other plots by gravity (as the earthen walls are opened).



Directly at the end of the pump

A rice plot on the toul area can directly be irrigated from a surface pump. It goes from the borehole / well > to the pipe > to the pump > to the plot. It was also observed from the pond, to the pump, to the plot.



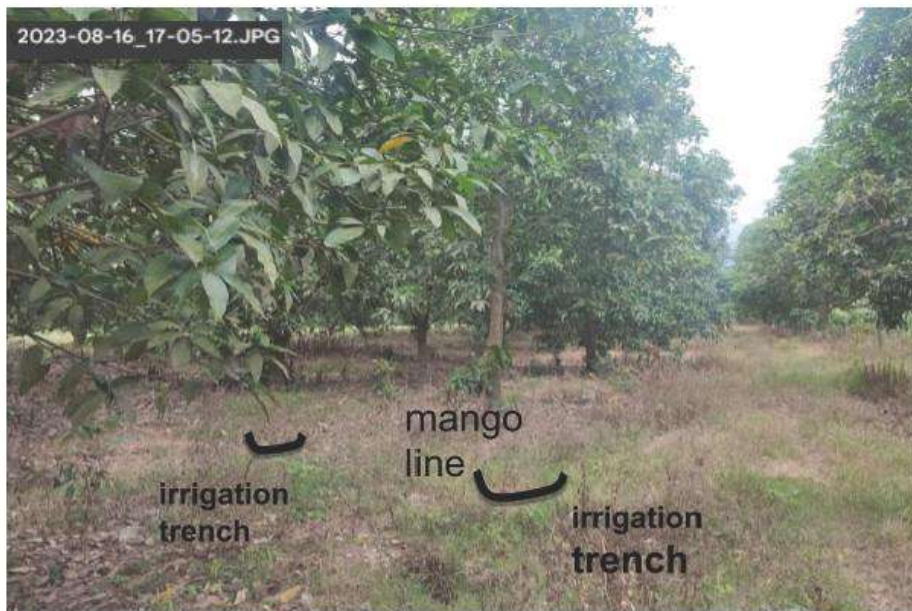
The same system can be found for other crops in this area: the difference is that the water is sent directly from the pump, whereas pipes are generally used for vegetables.

Fruit trees irrigation

Farmers put the end of the pipe in one trench, wait until the bottom of the plot is reached, and then move the flexible pipe to the second trench, etc. From interviews, it seems to be the same irrigation method for bananas and other fruit trees.

As with maize and vegetables, the mango trees are on mounds. We did not see any basin irrigation. This seems logical for several reasons:

- Hypothesis 1: the plots are long and large: manual irrigation per tree would take too long.
- Hypothesis 2: fruits do not allow enough benefits to invest in drip irrigation systems.
- Hypothesis 3: in the case of "too much water", the water can drain down the slope and prevent yields from decreasing because of too much humidity which can cause disease. For mango, the main stake is rainfalls during flowering.



Appendix 10 Further analysis of 8 irrigation choices

Regarding other choices, there are 8 left:

Irrigation technics are different from crops, it is mostly related to water needs. From observations, rice farmers do walls around their plots to let it submersed, they do rows for the other crops. Plants are on top of huts. It can spatially change as on toul, there are groundwaters. Farmers can pump directly from it instead of pumping from the *prek*, which is far away. It is possible to encounter two types of trees on the same plot, and farmers do the same numbers and durations of irrigation as it depends on filling up the rows.

Decrease irrigation as an adaption to the outlets, for self-use, farmers can drastically decrease their irrigations. About mango, farmers pay irrigation per hour. Because the selling price is low and irrigation costs are high, they limit their irrigations, even if it means reducing the produce quality.

Irrigation technic that requires less pumping time, mostly type 3 are part of this choice. It might be because there are able to take the risk of investing in drip irrigation, because of diverse sources of income. If a plot has a hilltop in the middle, even if it is to irrigate maize, farmers can also do small walls around their plots, start by irrigating the end of the plot, and then go to the head. They reduce pumping time to irrigate their plots.

If the selling prices are high, farmers can choose to irrigate more. It is a choice which was registered for all type. The risk is higher for types 1 and 2 which rely only on agriculture to balance their incomes. If the price at harvesting times goes low, then producers can risk a lot of money.

Adaptation of irrigations over the cycle, farmers change how they irrigate over the technical itinerary. Even if not many questions were asked regarding these aspects, farmers could mentioned it by themselves. It can be related to crop needs, but also to water availability in the *prek*. One farmer having mango plots on different *preks*, sets a higher producing goal on Cham Kroum, than on Lok because water supply is more suitable on Cham Kroum.

If my crop does not grow well I irrigate, the reactive decision is told by type 3.3 farmers. As these households have permanent jobs only, they might not consider agriculture as their main activity and do not anticipate irrigation schedules. It might happen because drainage is more needed than irrigation, or because farmers consider irrigations needed to apply fertilizers.

I choose a crop that benefits from residual flooding. It can be the case with beans and maize.

I irrigate when my neighbors do it. This answer was registered on *Prek Put*. On other *preks*, other small communities (less than 10 people) can also have their own pump apart from main WS.

Appendix 11 Further analysis of 4 fertilization choices

Regarding other choices, there are 4 left:

I apply fertilizer when I irrigate, 4 out of 31 answered this question. They did not really describe why they do it. For example, one farmer explains that during the RS, the crops do not need to be much irrigated but if he needs to apply fertilizer then he'll irrigate (5/6 times per cycle). There is a correlation between fertilizing and irrigation water. Whether one irrigates when one needs fertilizer or else one adds fertilizer when one irrigates. One farmer explains,

"For the dry season, I need to irrigate first before putting fertilizer on and for the second cycle, after rainfall I am going to apply fertilizer after because I can't apply fertilizer when the soil is dry because it didn't work that way." [L_P_2023_3107_01]

My soil is more fertile, so I apply less fertilizers, 2 out of 31, answered the question. One has a plot on different *preks* and he explains that he does not use the same quantity for the same crop between his plot on Nou and his plot on Chann (less at Nou (50 kg) than at Chann (100kg)) while the other says

"No, I don't apply. It's okay because soil has been good already." [L_S_2023_1007_01]

My soil is less fertile, so I apply more fertilizers, 1 out of 31, answered the question, the same farmer as above

I would decrease the quantity of fertilizer I use because of lack of investment capacity, 1 out of 31 answered, the person explain that she uses less fertilizer than some neighbors, 6 bags of 50kg of NPK compared to 8 and it is because she lacks the money.

ABSTRACT

Title: Decision-making processes of farmers and their links with *prek* rehabilitation projects on the Mekong's floodplain

Farmers' decision-making processes on the Mekong floodplain in Cambodia has been little studied. A distinctive feature of this plain is the presence of *preks*, canals used for irrigation and drainage. Since the 1990s, initiatives have been launched to rehabilitate these infrastructures, with the aim of improving irrigation during the dry season. Water is considered to be the limiting factor in the development of agriculture. The aim of this study is to gain a better understanding of farmers' decision-making processes and to identify the factors that influence them. Firstly, a literature review was carried out to highlight the main decisions and relevant factors to be studied. Secondly, surveys were carried out among farmers in an area where rehabilitation projects are underway. Then, results were presented to the interviewees. Thirdly, a typology was made for the analysis. It emerged that, whatever the type, market is the determining factor in the choice of crops. Similarly, fertilizer and pesticide decisions are mainly influenced by the market, although crop growth play also a role. For dry-season irrigation, water availability is crucial for agricultural intensification. However, the impact of this factor varies from one farmer to another. Farmers whose income depends on agriculture tend to intensify. On the other hand, farmers whose income comes from other activities generally do not change their farming practices. A final section examines the biases and limitations of the research.

Key words

Agriculture, Farming system, Household typology, Decision-making, Farming choices, Water, Market, Farm environment, Mekong Delta, *Prek*, Rehabilitation

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