ECONOMIC EVALUATION OF IRRIGATION PROJECTS IN CAMBODIA:

INFLUENCE OF INSTITUTIONAL INVESTMENTS ON THE SUSTAINABILITY OF THE SCHEMES

> Plovic irrigation scheme, Takeo province

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COSTEA
Pour une irrigation durable

This document is a synthesis of a longer master thesis written in French and entitled "*Évaluation économique de projets d'irrigation au Cambodge : Influence des investissements dans les aspects institutionnels sur la durabilité des projets*" which was conducted in 2016 by Gwenn Guillaumie, supervised by Jean Philippe Venot, and sponsored by the COSTEA « Comité Scientifique et Technique Eau Agricole», a project financed by the French Agency for Development and managed by the French Association for water, irrigation and drainage.

It does not have the ambition to present the broader debate over participatory irrigation management and operation and maintenance of irrigation schemes in Cambodia, but rather, presents the results of an empirical study conducted on 4 irrigation systems.

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> Stung Shinit irrigation scheme, Kampong Thom province

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ABSTRACT

The sustainability and the performance of irrigated systems are important issues. To face these challenges, participatory irrigation management policies were developed worldwide from the end of the 1980s, and from the end of the 1990s in Cambodia. Indeed, the management of irrigated systems by water users associations, in charge of the operation and maintenance (O&M) of the irrigated schemes, was meant to allow better performing systems. Yet, the performance of water users associations depends very much on the institutional support provided to them and on the level of involvement of water users during project design and implementation. The goal of this study is to see to what extent institutional investments in irrigation projects in Cambodia influence the sustainability of irrigated schemes. By comparing the results of 4 different projects, for which institutional support was different, we show that the latter does not have noticeable impact in terms of yield and rice income. However, the results in terms of fee collection, allowing the financing of the O&M of the schemes, differ significantly between the 4 documented projects. In the projects characterized by higher institutional investment, fee collection allows the funding of around one third of O&M needs. In the other projects, fee recovery only allows the funding of less than 3% of these O&M needs. Therefore, it is likely that institutional investment and support have an impact on the sustainability of irrigated perimeters over the long term. Taking in consideration other indicators and more diverse strategies of institutional support would be necessary to confirm the added value of such institutional investment. Furthermore, the funding of O&M needs still remains an important issue because, even in the schemes that have received a lot of support, water users are not able to meet the full O&M needs.

KEYWORDS

Sustainability, institutional investment, water users association, Cambodia, operation and maintenance (O&M), PIM/IMT

> Plovic irrigation scheme, Takeo province

INTRODUCTION

In Cambodia, one of the poorest countries of South-east Asia, the 143rd country in terms of Human Development Index (UNDP), 87% of the population lives in rural areas. Agriculture is essentially based on rice production, which reached more than 9 million tons in 2014, and represents more than 80% of the total agricultural production of the country[1]. Compared to neighboring countries, Cambodian agricultural productivity is very low. This is the reason why, since 1999, the Cambodian government decided that developing irrigation was a national priority, for improving food security, needed after the tragic period of the Khmer Rouge, and for the economic development of rural areas. A Participatory Irrigation Management & Development (PIMD) policy was developed in relation to the international Participatory Irrigation Management/Irrigation Management Transfer movement that started in the 1990s. Water User Associations (WUA), called FWUC (Farmer Water Users Community) in Cambodia, were and are still created as part of scheme rehabilitation projects. The FWUC are meant to play a key role in managing the schemes and contribute to their operation and maintenance. Indeed, the sustainability of the irrigated systems mainly depends on the maintenance done ; one of the goals of the PIMD policy being to stop the vicious circle leading to scheme deterioration and poor water services.

The success of the management transfer to the FWUC and therefore the performance of the irrigated schemes depend a lot on the water users' implication and on the institutional support provided during the project but also after completion of infrastructure work. Yet, the multiplication of irrigation projects since the beginning of the 1990s as well as the diversity of operators has led to a diversity of processes to support the creation of FWUC. The historical perspective that we have on a few projects allows comparing different forms of institutional support and their possible impact on the sustainability of the rehabilitation works conducted.

The main question of our study is therefore: To what extent different forms of institutional investment in irrigation projects in Cambodia influence the sustainability of the schemes that are rehabilitated? The aim of the study is to evaluate the largely unknown cost of supporting and building the capacity of water users and FWUC and to evaluate the added value this support may have in terms of performance and sustainability of irrigated schemes.

DESCRIPTION OF THE STUDY

The rehabilitations of the Prey Nup polders and Stung Chinit scheme respectively started in 1998 and 2001. These projects are largely considered as successful examples of capacity building of water users. Indeed, the FWUC are now working independently for over 10 years (even if the Stung Chinit FWUC receives occasional support), their authority and their importance are still recognized by farmers, and the fee collection is still showing good results. However, even if most stakeholders acknowledge that Prey Nup and Stung Chinit projects are good examples concerning farmers' involvement in water management, some of them consider that the investment needed to reach this level of involvement and empowerment is too important. They agree with the fact that institutional investment yielded some significant result but they also think it was too high and spanned too long of a period, hence can't be replicated on a wider scale. Nevertheless, very little data about the real cost of the institutional support of these projects and about its impact on the performance and sustainability of the schemes is available. This study aimed at filling this gap and at comparing forms and levels of institutional investment conducted in Prey Nup and Stung Chinit, and comparing these with other schemes rehabilitated by other donors.

In terms of methodology, the study has been divided into 3 major phases. The first one was dedicated to the research and analysis of project documents of different irrigation rehabilitation projects implemented since the end of the 1990s by different donors in Cambodia. An evaluation of the investments realized as part of these projects is conducted; and a set of widely used indicators selected: the irrigated area, the yield and the agricultural income. These are evaluated over time for a sample of projects, to evaluate their performance and sustainability. A more qualitative analysis has also been done concerning the different forms of institutional support that have been provided as part of these projects. Indeed, beyond the amount invested in institutional support, the way this support has been implemented is very important, and we wanted to see if this had an influence on the sustainability of the irrigated systems. Analysis of indicators over time and of support provided to water users was done on the basis of projects' documentation, and on intensive fieldwork in 4 selected sites.

This second phase, the longest one, focused on 4 different schemes financed by different donors, and which received further support over time. The schemes studied are Prey Nup (financed by AFD), Stung Chinit (financed by AFD and ADB) and Punley and Krouch Saeuch that are part of a large project named NWISP (Northwest Irrigation Sector Project), which was financed by ADB and AFD[2]. In each scheme, interviews have been conducted with farmers, FWUC members, commune and village chiefs, and employees of provincial departments of the MoWRAM and the MAFF. Interviews have also been done with the different service providers that helped creating the FWUC and building their capacity. This fieldwork was facilitated by recruiting an interpreter.

Finally, with all the data collected during the bibliography phase and on the field, we compared the different schemes and projects, to answer our question.

1 - Perera, L.R. (2006). Factors Affecting the Formation of FWUCs in Institution Building for PIMD in Cambodia: Two Case Studies. International Water Management Institute.

2 - AFD financed the rehabilitation of one scheme and an institutional support at MoWRAM level.

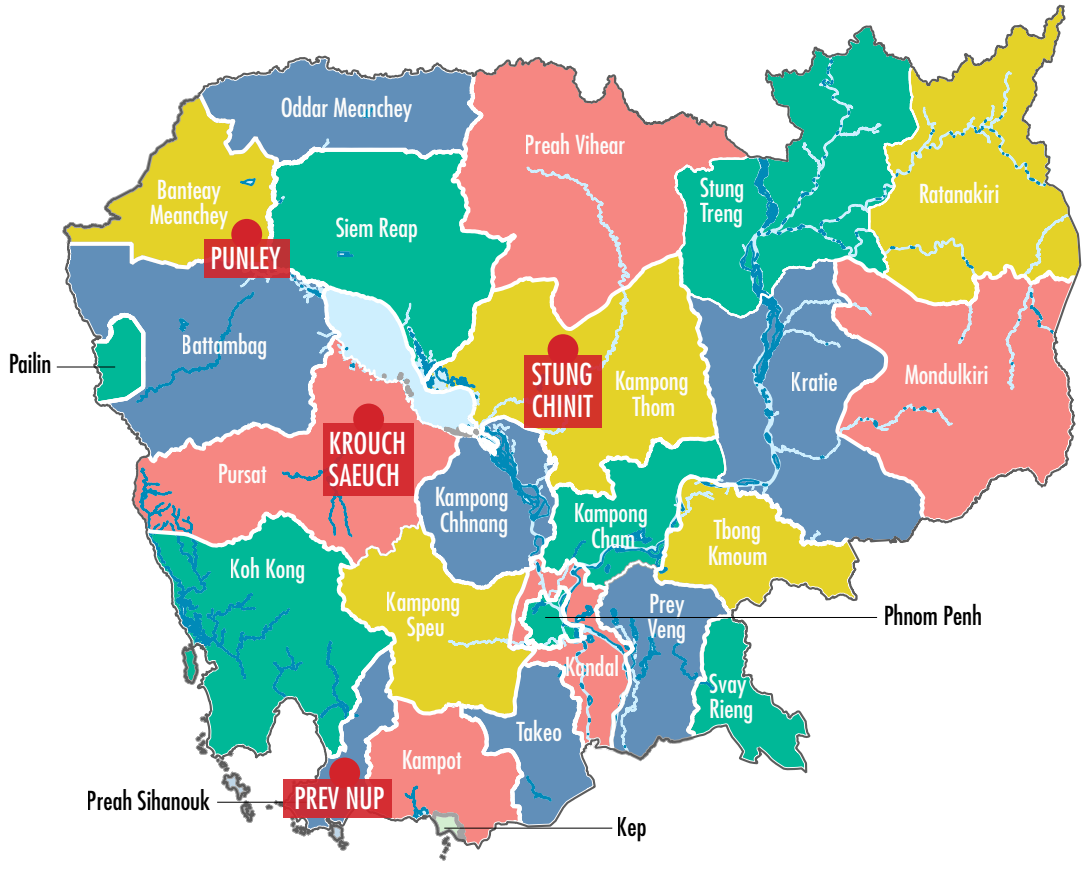


FIGURE 1 : Location of the 4 irrigated schemes studied

In the 4 schemes, the main crop cultivated is rice. The objective of most farmers is to produce enough rice for their own consumption, and then to sell the surplus.

Prey Nup is a scheme located in the province of Sihanoukville. The infrastructure is made of dykes protecting fields from seawater intrusion, and which allows keeping a given water level, collectively decided by farmers, during the rainy season. The scheme serves 10 500 hectares and around 11 000 beneficiaries. The control of water is thus partial. The project started in 2000 and was completed in 2008.

Stung Chinit is a scheme located in the province of Kompong Thom. The infrastructure is made of a dam on the Stung Chinit River, a big reservoir, and a network of canals that allows irrigating about 2800 hectares during rainy season and 300 hectares during the dry season. The project started in 2001 and ended in 2008, and beneficiates about 2900 farmers.

Punley is a scheme located in the Beanteay Meanchey province. The infrastructure is made of a reservoir supplied by rainwater and by the prek Srae Mamey during the rainy season, and by a network of secondary and tertiary canals. 400 hectares are thus secured in case of lack of rain during the rainy season, and 100 hectares can be irrigated during the dry season. 545 farmers are benefiting from the project, which started in 2006 and ended in 2011.

Krouch Saeuch is a scheme located in the Pursat province. The infrastructure is made of a network of canals that brings water from the Pursat and Stung Kambot rivers. 1000 hectares are irrigated during the rainy season and about 700 hectares during the dry season. The project started in 2008 and was completed in 2011. The project serves about 500 people.

MAIN RESULTS

Level of investment

In terms of total investment, the Stung Chinit project is the most expensive (10 700 $/ha), due to the fact that the project had to be redesigned in 2003. The irrigated command area, initially planned to be about 7 000 hectares, was reduced to 3 000 hectares. Finally, at the end of the project, only 2 400 hectares were irrigated. Prey Nup project is the cheapest one in terms of total investment (1 120 $/ha) and infrastructure (800 $/ha). This can be explained by the fact that the Prey Nup scheme is not an irrigation system per se but rather a protection system against seawater intrusion and a regulation system of the water level during the rainy season. The investment per hectare of schemes rehabilitated in the NWISP project is twice the investment done in Prey Nup but 4 times less than the investment done in Stung Chinit.

Per hectare, the institutional investment in Prey Nup is the cheapest one (320 $/ha), almost 1/3 of NWISP project (900 $/ha) and 1/5 of Stung Chinit project (1 560 $/ha). Half of the institutional investment in the NWISP, though, was dedicated to capacity building and institutional and policy development at national level, mostly supporting the

MoWRAM. However, it is in Prey Nup that the proportion of institutional investments compared to the total investment is the highest (29%), twice the proportion of the other projects. This is explained by a lower total investment.

The amount invested per FWUC is very different between the projects, due to the fact that 11 irrigated systems have been rehabilitated in the NWISP project, whereas Prey Nup and Stung Chinit projects include only one big scheme. About US$3.5 million have been invested for the technical assistance to the FWUC and the water users of Prey Nup and Stung Chinit, whereas only US$460 000 dollars were spent per scheme in the NWISP project. We thought that this data should be compared to an AFD project in which more than one irrigated system have been rehabilitated. That's why we compared them to the WASP project, in which 6 schemes are currently rehabilitated. This comparison shows that the amount per FWUC is similar between both the NWISP and the WASP project (US$610 000 per scheme in the latter case). The institutional investment per hectare for the WASP project is even lower than for NWISP project (592 $/ha) if we consider the total institutional investments for NWISP but higher if we just consider the share of the institutional investment that targeted FWUC support during the NWISP. The strategies of ADB and AFD in terms of institutional investments amounts seem therefore similar. It is not only the amount invested that has an impact on the sustainability of the scheme, but the way that the institutional support is implemented and provided to the farmers and the FWUC. We did not study the WASP schemes as they are very recent, but we discussed with GRET[3] and ISC[4] who are responsible for supporting the FWUC in these schemes, and we noticed that the institutional support is more continuous and focused on the needs of the farmers than in ADB projects, in which the trainings are more theoretical, and similar in all the schemes.

In Prey Nup and Stung Chinit, the institutional investments were spent over 9 years (around 350 000 $/year/scheme), whereas the technical assistance of NWISP sub-projects lasted 4 years maximum (around 115 000 $/year/scheme). Another important element is that 2/3 of the "soft" investment in Prey Nup and Stung Chinit projects were dedicated to the technical assistance staff (national and mostly international).

Form of institutional investment

The amounts invested in institutional support differ across projects, but the main differences remain in the way that institutional support was implemented. One important difference was the duration of the support. In the NWISP project, the construction of the different irrigation schemes was delayed compared to the provisional schedule, notably because of an increase in unit cost. Most of the schemes were built quickly, in 1 or 2 years maximum, between 2008 and 2010. As the project ended in 2011, the support to the FWUC and the farmers, which was conducted only after the construction was completed, did not last much, between 1 and 2 years maximum. In NWISP, it appeared that the FWUC were weak and still needed support so the 11 irrigated schemes were included in the WRMSDP, another irrigation project financed by ADB, through which they received financial and institutional support between 2012 and 2016 (around 50 000$/scheme). In some schemes, the FWUC members abandoned their work in the FWUC, and in most schemes there is no fee collection at all. In the 2 irrigated systems we selected, Punley and Krouch Saeuch, the FWUC are still active, but told us that they still need more support and more capacity building. Indeed, the FWUC members need to have the necessary and sufficient knowledge and authority to manage the scheme, and to be respected and listened to by water users.

TABLE 1: Investments in the different projects studied

		Prey Nup	Stung Chinit	NWISP	WASP
Irrigated area	in ha	10 500	2 400[1]	10 761	6 170
Total Investment	M$ current	11,75	25,59	26,94	24
	$ current/ha	1 119	10 667	2 503	3890
Infrastructure investment	M $ current	8	15,5	15, 5	14,8
	$ current/ha	763	6 465	1 444	2 396
Institutional investment	M$ current	3,4	3,8	9,6[2]	3, 6
	$ current/ha	320	1 557	896	592
	M$/FWUC created	3,4	3, 7	0,46	0,6
Proportion of institutional expenses / global investment		29 %	15 %	17 %	15 %

Note: The accessibility, the quality and the precision of data has been an issue during the study. Indeed, it has been difficult to access projects' documents, sometimes completed a long time ago. Data is not always publicly available, and that is explains why we studied the approach of only 2 different donors (ADB and AFD), whereas it would have been useful and interesting to study the approaches of other donors who are also investing in irrigated schemes in Cambodia. Moreover, data is not always consistent from one document to another making it difficult to compare investment per type. This is why we complemented the quantitative analysis by a qualitative study of the forms of institutional support (see below)

1 - At the end of the project; 2 800 hectares are irrigated today.

2 - This amount includes the institutional support for the different schemes (NWISP + WRMSDP), but also the institutional investments for the government (MoWRAM and PDoWRAM).

3 - Groupe de Recherche et d'Echanges Technologiques, a french NGO, responsible for most institutional support in the framework of AFD's irrigation projects.

4 - Irrigation Service Center, a Cambodian organisation created in 2009 with the support of GRET and AFD. The raison d'être of ISC is to support the establishment of and provide services to.

In Prey Nup and Stung Chinit projects, the support to the FWUC and to farmers lasted over the duration of the project, which means around 9 years in each case. Due to this ongoing support, the FWUC were accompanied in all their activities (maintenance and administrative works, fee collection, etc) until they were able to do it independently. Indeed, the learning-by-doing process for the FWUC members is really important and ADB recognized that this process is missing in the NWISP project (interview data).

The steps for the creation of the FWUC were similar in all projects but the way the service providers implemented them were different. In all the projects, discussions were organized with farmers to explain the objectives of the projects, and to collect feedback on the future statute of the FWUC and the design of the project. However, the importance given to the implication of farmers has been stronger in Prey Nup and Stung Chinit. Indeed, the lapse of time between the beginning of the project and the election of the FWUC members differs between the projects. It has been shorter for NWISP sub-projects (1 year maximum), compared to Prey Nup and Stung Chinit (1,5 year and 3 years, respectively). During this time, several discussions and preparatory meetings have been organized in Prey Nup and Stung Chinit, to think collectively about the structure and the mission of the future FWUC. In Stung Chinit, the FWUC creation has also been delayed because of design issues, and because the project needed to be revised. Finally, the implication of farmers is critical, and has probably been stronger in Prey Nup and Stung Chinit than in the other schemes. The table 2 shows the temporality of the institutional support to the FWUC and to farmers in each of the study-sites.

Another point is about the flexibility of donors concerning the support implemented. The activities conducted in the NWISP sub-projects (during NWISP and WRMSDP projects) were more formal, and were exactly the ones recommended in the official directive (prakas 306). The activities were therefore less adapted to the specific needs the FWUC may have faced. The service providers had to enforce the same activities in all schemes, whereas the capacity, the knowledge, the skills and the needs of FWUC members are different. It seems that GRET, when supporting the FWUC of Stung Chinit and Prey Nup, had more flexibility in terms of activity and was able to focus on the real needs of FWUC members.

It seems obvious that donors have different approaches in terms of institutional support. We previously explained that Stung Chinit and Prey Nup projects are often seen as a "success" in terms of management and sustainability but also

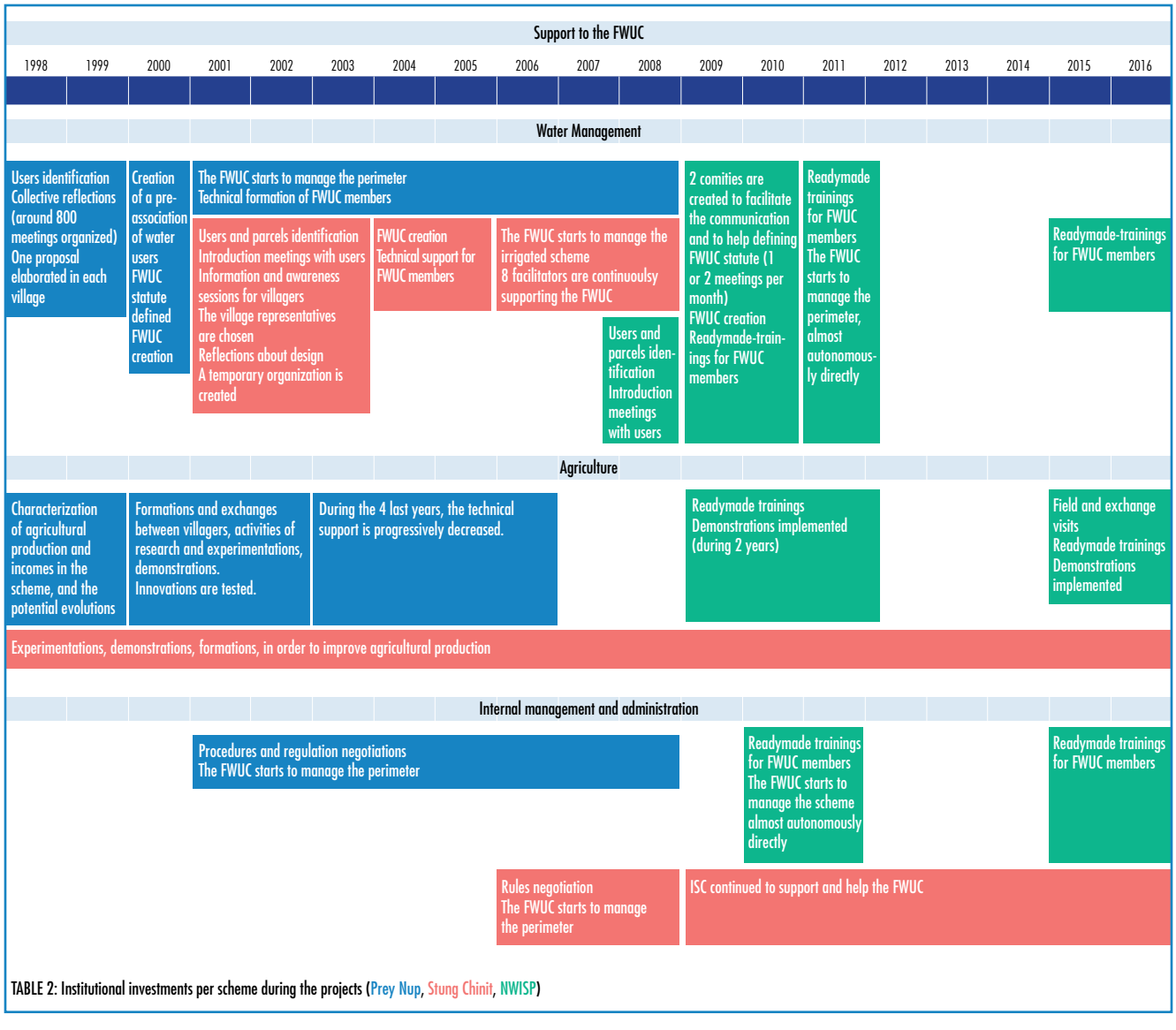


TABLE 2: Institutional investments per scheme during the projects (Prey Nup, Stung Chinit, NWISP)

considered as non replicable because of high institutional investments. Unlike what is generally said, this study showed that even if the amounts spent per FWUC is higher in these 2 projects, the investment per hectare is lower for Prey Nup than for NWISP. Moreover, the proportion between the soft component compared to the global investment is 29% for Prey Nup, 17% for NWISP and 15% for Stung Chinit. Thus, the difference between the 3 projects is relatively small.

Results of the project: yields and rice income

Part of the fieldwork aimed at assessing the agricultural benefits of the projects, to try to see if different forms and levels of institutional support translated in terms of yield and agricultural income. The results of the 4 schemes are quite different, but the differences seem mainly related to the socio-economic context and the localization of each scheme and not to the institutional support provided during the projects, namely: (1) The number of cultivation seasons; (2) The presence and the importance of alternative source of income; (3) The quality of the soil; (4) the land area per household and the (5) rice market conditions.

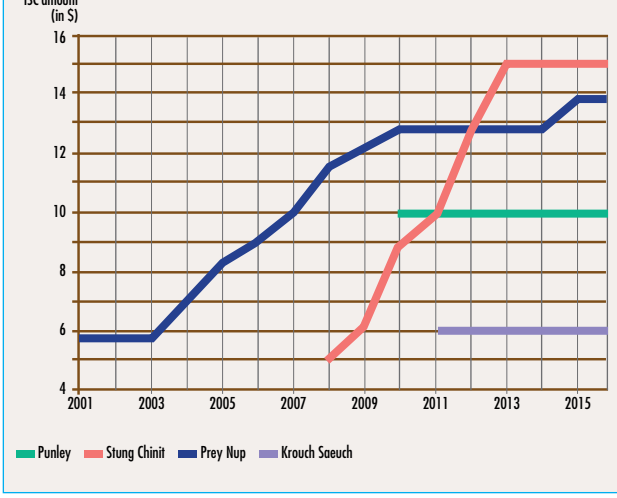
For example, in Prey Nup, only one rice season is possible and the capitalization in rice farming is low, due to the fact that young people are looking for alternative incomes, mostly as factory workers or other jobs in the cities. The soil is poor so farmers use a lot of fertilizers, and this led to high production costs and low net agricultural incomes (163$/ha/year in average). In Stung Chinit, only 18% of the farmers cultivate rice during the dry season whereas a bigger proportion was expected to do so in the feasibility study. This is explained by the fact that some farmers have only limited land and cultivate rice for their own consumption only (but also on the existence of alternative source of revenues, fetching fallen wood in the nearby large land concession). Thus, these farmers do not want to grow rice during dry season because they have no time and they don't want to invest in rice farming. On the contrary, farmers who have more land are interested in growing rice during the dry season because the net income is higher than for the wet season (390$/ha and 256$/ha), even if the production costs are also higher. In Punley, 100 hectares are irrigated during the dry season, and this is the major benefit of the project for farmers. During the wet season the yield inside the scheme is better than outside (1,9t/ha inside and 1,3t/ha outside). The water stored is not used during wet season, but secures rice farming in case of drought or lack of rain. In Krouch Saeuch, about 75% of the beneficiaries grow rice during the dry season since the project. The net agricultural income in the wet season is very high compared to the other studied irrigated systems (633$/ha) due to high-value rice varieties and high yields. Rice farming income is indeed the main income of the families in the area.

In the 4 schemes, the agricultural income increased due to the improvement of the yield during the wet season and the new possibility of growing rice during the dry season, the latter concerning all the schemes except for Prey Nup. The rehabilitation of the schemes also led to various agricultural changes in the areas: agriculture mechanization, using broadcast sowing instead of transplanting, increase of the quantity of chemical products used (fertilizer, pesticide, etc), changing rice varieties for high-value varieties. These changes cannot be explained by the projects only but mainly because of the increase of labor cost and because of the quick evolution of agricultural practices in Cambodia (modernization, mechanization). Moreover, our results show that the distribution of the agricultural benefits was a little bit less equitable in the 2 NWISP schemes, compared to the 2 others. Nonetheless, these disparities between the 4 projects are related to the broader socio-economic and agricultural context and can't be solely attributed to the different modalities of d institutional support. The latter do not seem to impact the agricultural benefits of the projects, at least in the short term (NWISP sub projects are still quite recent), because others factors are influencing those benefits. The comparison between different modalities of institutional support should be done in schemes in which these factors are similar.

Level of fee collection

Fieldwork highlighted significant differences in terms of fee collection, probably related to the implication of the beneficiaries during the project, and to the support and capacity building provided to FWUC members. The figure below represents the ISC (Irrigation Service Contribution) fixed in each scheme since the beginning of the project. In Prey Nup and Stung Chinit, the ISC has been progressively increased until 13.75 $/ha in Prey Nup and 15 $/ha in Stung Chinit, related to the increase in project's outcomes. On the contrary, in the NWISP sub-projects, the ISC has not changed since the creation of the FWUC. In Punley, the ISC is 10 $/ha but it only concerns the land that is cultivated during dry season, which means only ¼ of the scheme. In addition, an ISC of 2.5$/ha was supposed to be paid by farmers during the wet season but they refused to pay it as they don't use the water of the reservoir. In Krouch Saeuch, the fee is only 5 $/ha, and it concerns the farmers who cultivate rice during both seasons as well as the ones who only grow rice during the rainy season. Moreover, in Punley and Krouch Saeuch, the farmers often ask for a fee reduction, so that the ISC effectively paid depends on the negotiation between the farmers and the collectors.

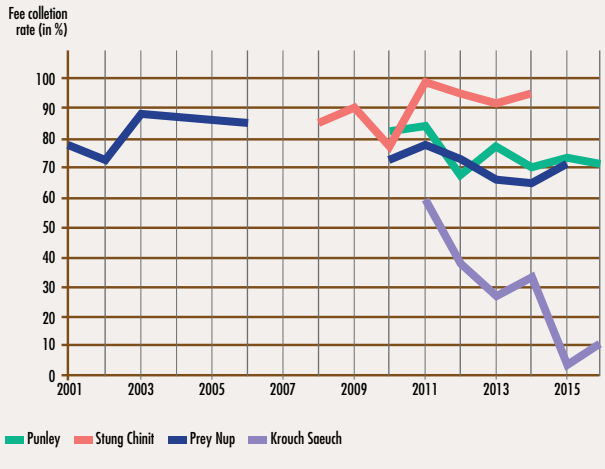
Figure 2: The ISC amount fixed annually in the 4 schemes studied



The figure below shows the annual collection rate of the ISC. In Stung Chinit, the collection rate is very good. It has always been above 80%, and, for the last five years, it appears to be at more than 90%. In Prey Nup and Punley, the collection rate is around 70%. In Prey Nup, the FWUC compensated the decrease observed over the last years by increasing the ISC from 12.5 $/ha to 13.75 $/ha in 2015. Finally, in Krouch Saeuch, the number of beneficiaries paying the ISC has fallen since the start of the project. In the first years, the recovery rate was about 40% but this quickly decreased as water distribution and pumping conflicts emerged, at both scheme and watershed level. Farmers stopped paying the fee, arguing they were not receiving enough water. Over the last two years, the recovery rate is as low as 10%. These differences in terms of fee collection show us that the beneficiaries of Prey Nup and Stung Chinit better understood the importance of the ISC.

In Punley and Krouch Saeuch, as the money collected is limited, it is fully used for maintenance work. There is no money left to develop other activities, to organize elections, regular meetings, or to give a salary to the FWUC members. Besides, the FWUC there do not prepare any provisional budget or management plan. In some NWISP sub projects, the FWUC members stopped working to focus on their own activities. On the contrary, in Stung Chinit and Prey Nup, the FWUC are almost financially independent, even if Stung Chinit still receives some support from ISC and from WRMSDP project. The members of the FWUC receive a monetary compensation, which provides them incentives to work harder.

Figure 3: Annual fee collection rate in the 4 schemes studied



SUSTAINABILITY OF THE IRRIGATED SCHEMES

Fee collection dynamics and O&M needs coverage

The long term sustainability of an irrigated scheme depends on the infrastructure condition and thus on the maintenance works that are conducted. In Cambodia, the Ministry of Water Resources and Meteorology (MoWRAM) is responsible for the maintenance of the main infrastructures whereas the FWUC is responsible for the maintenance of the secondary and tertiary infra structures and for the operation of the schemes. Table 3 below shows that the theoretical ISC, fixed in the different schemes during the feasibility studies of the projects, does not cover the O&M needs. Moreover, the current ISC is lower than this theoretical ISC. Table 3 further shows that the theoretical ISC represents 13% maximum of the added value of the project, in Stung Chinit project, and only 5% maximum in both NWISP schemes. The theoretical ISC amounts fixed during the projects are therefore reasonable for farmers.

TABLE 3: O&M costs and ISC in the 4 schemes

	Prey Nup	Stung Chinit	Punley	Krouch Saeuch
O&M costs ($/ha/year) (estimated in the projects' documents) (FWUC part)	25.92[1]	41[2]	32.7[3]	43.5
O&M needs per scheme ($/year) (FWUC part)	272 160	114 882	13 080	43 500
ISC expected, fixed at the beginning of the projects ($/ha/year)	Progressive increase until 15	Progressive increase until 25	10 in dry season and 2.5 in wet season	7.5
Real ISC ($/ha/year)	Progressive increase until 13.75	Progressive increase until 15	10 but often less in dry season (around 7.5 in practice) and 0 in wet season	5 but often less
Real ISC compared to the O&M needs	53 %	37 %	23 %	11.5 %
Added value of the project (increase of the net agricultural income) in $/ha/year[4]	218[5]	197	263	410
Theoretical ISC compared to the added value of the project	6.9 %	12.7 %	4.8 %	1.8 %

1 - AFD. 1996. Étude complémentaire du Projet de Réhabilitation des Polders de Prey Nup
2 - ADB. 2009. Cambodia: Stung Chinit Irrigation and Rural Infrastructure Project - Completion Report.
3 - Feasibility documents assess total O&M costs as corresponding to 5% of the infrastructure costs (2/3 being under the responsibility of the FWUC and 1/3 under MoWRAM responsibility)
4 - Before/after for Stung Chinit and Prey Nup and without/with for Punley and Krouch Saeuch.
5 - The added value of the project, calculated as the difference between the yields before and after the project, is higher than the net agricultural income calculated. It is surprising, but may be explained by production costs and paddy prices that have evolved. It can also mean that rice farming before the project was not lucrative.

Taking a closer look at the amount of money collected (table 3), we see that, in the best cases, the fee only covers 37% of the O&M needs. Indeed, as the recovery rates are lower than 100%, the percentage of O&M needs covered does not reach the percentages of table 2. 37 % is the current situation in Prey Nup and in Stung Chinit. In Punley and Krouch Saeuch, less than 3% of the O&M needs are covered. The different FWUC do not have the budget allowing an optimal maintenance of the irrigated systems; In Stung Chinit and Prey Nup, nevertheless, the FWUC can at least conduct the most urgent maintenance needs.

Beneficiaries and FWUC members are more aware of the importance of fee collection in the schemes of Prey Nup and Stung Chinit. Indeed, the involvement of the beneficiaries during the project has been essential for them to understand the objective of the irrigated system and the role of the FWUC, and feel some responsibility in the scheme

management and water distribution. Whereas, in the NWISP project, the institutional support has been too short, and led to a lack of capacity of FWUC members to manage the scheme properly and to better understand how to implement the activities under their responsibility. In Krouch Saeuch, for example, the agricultural benefits are high, but conflicts appeared between farmers within the scheme and between the scheme and neighboring irrigated systems, especially those located in the communes that are located downstream. Individual farmers pump as much water as possible, especially during the dry season. Due to that, downstream farmers, as well as communes representatives, complain to the FWUC that they receive too little water. However, the FWUC does not have the capacity to deal with these problems. In Punley, there are less problems and almost no conflicts because more than 80% of the beneficiaries come from the same village, so they know each others. The difference between the projects is quite relevant, and may be related to the institutional support provided to the FWUC members and to the empowerment of farmers, which lasted longer in Prey Nup and Stung Chinit. In conclusion, an effective institutional support, flexible, and long enough to allow the FWUC members to assimilate the scheme management, could allow better results in terms of fee collection over time (both in terms of fee rate and collection rate).

Farmers willingness to pay

Table 4 shows another result of our study. The current fee in each scheme represents only 8% maximum of the net agricultural income of water users. In Krouch Saeuch, in which the net agricultural income is the highest, it represents only 0.6 % and only 10% of the farmers are paying the fee. Most of them do not pay because they do not understand the importance of the fee, and do not trust the FWUC; farmers have a very low satisfaction level due the occurrence of conflicts. As water distribution is not efficient, and depends mostly on the location of the rice fields, farmers do not think that they should pay, at least until conflicts are resolved. So farmers seem to be in a financial capacity to pay the relatively minimal fee, they are not willing to do so. Notwithstanding this general statement, the willingness to pay of beneficiaries is different between Prey Nup/Stung Chinit and Punley/ Krouch Saeuch. Consequently, this shows that investing in institutional support enhance willingness to pay.

TABLE 4: Impact of the fee on the net agricultural income

	Prey Nup	Stung Chinit	Punley	Krouch Saeuch
ISC ($/year)	13,75	15	10 (for dry season)	5
Net agricultural income per year and per hectare ($/ha/year)	163	315	407	813
% of current ISC compared to the net agricultural income	8 %	5 %	2 %	0,6 %
% of ISC that would cover 100% of O&M needs (FWUC part) compared to the net agricultural income	16 %	13%	13%	9 %

> Stung Shinit irrigation scheme, Kampong Thom province

In addition, if the theoretical ISC (the one that would allow covering 100% of the O&M needs) was implemented in the schemes, it would represent 16 % of the average net rice-farming income. Farmers could in theory pay this fee, even if it could be difficult for the poorest families. The remaining problem is the huge gap between this theoretical ISC and the farmers' willingness to pay. That is why, beyond improving institutional support provided to farmers and FWUC members, it is necessary to improve the revenues derived from agriculture or think of different infrastructure designs that are less expensive, at least in terms of O&M. This would increase the sustainability of the infrastructure and therefore the sustainability of the benefits of irrigation projects over time.

This work also highlights the fact that very little data is available concerning the O&M needs of irrigated schemes. The data available in the project documentation is, in general, vague, and the FWUC do not know what amount of money they would need to cover the operation and maintenance needs. More work should be done on this matter, and the FWUC should be trained about the issue of maintenance and sustainability. Finally, some other qualitative indicators should also be studied to better analyze the impacts of irrigation projects, and enhance our understanding of the added value of institutional support in terms of sustainability. The limited time for this study forced us to choose some specific indicators, but the discussions we had with farmers allowed us to initiate a reflection about other indicators. The equity in terms of water access and water availability is, for example, an indicator that appeared to be important during the study. Indeed, in Krouch Saeuch for example, the benefits of the project, as well as the fee collection results, are directly related to the geographical localization in the scheme. Farmers who have land around the secondary canal N°1 are almost the only ones to receive the quantity of water they want, and thus to pay the fee. This indicator has an important impact on the willingness to pay of water users, and therefore on the sustainability of irrigated schemes. Other indicators, as access to credit or the existence of a rice market are also likely to impact the sustainability of irrigated systems.

CONCLUSION

This study showed that different modalities of institutional support led to different results in terms of the level and recovery rate of the irrigation service fee, and consequently in terms of long term sustainability across 4 irrigation schemes. It also showed that differences in institutional support do not lead, as we first imagined, and in the lapse of time between project completion and the realization of the study, to better performance in terms of yields or rice income, which seem mostly determined by environmental and socio-economic conditions.

The study highlighted significant differences between the 4 irrigated schemes studied in terms of fee collection and collection rate. In Prey Nup and Stung Chinit, the amount of the ISC was regularly increased, to meet the financial needs of the FWUC and part of the management and maintenance needs. However, the amounts collected in these 2 schemes only cover about one third of the O&M needs that are meant to be under the responsibility of the FWUC. The situation is much worse in Punley and Krouch Saeuch where fee collection only covers 3 and 1% of the O&M needs under the responsibility of the FWUC. We also showed that farmers would have the capacity to pay more as the current ISC rate only represent about 8 % of farmers' net agriculture net income in the 2 first schemes, and 2 % in the two others.

Clearly, farmers' willingness to pay is a key issue. This willingness to pay depends on the quality of the service farmers receive but also on the support provided to them during and after the project. In Prey Nup and Stung Chinit, the institutional support was much longer and more intensive than in the NWISP schemes, and the methodologies implemented were different. It seems worthwhile investing in supporting FWUC members and farmers, as it allows a better implication of water users, strengthens the FWUC and increases farmers' willingness to pay the ISC. In the case of Prey Nup and Stung Chinit, FWUC members have been able to acquire certain skills to manage the scheme; they progressively recognized the importance of the FWUC and appropriated their own responsibilities. A longer and consistent institutional support has allowed the FWUC to gain its legitimacy and trust from water users, leading to a higher willingness to pay.

However, even in the case of Prey Nup and Stung Chinit, the amount to be collected still needs to be increased so as to cover the O&M needs under the responsibility of the FWUC. This appears to be possible given the economics of rice production in several of the schemes and would also be a way to hold MoWRAM accountable for his responsibility of maintaining the structuring infrastructure. Assuming 100% recovery rate, an ISC that would allow covering the full O&M needs under the responsibility of the FWUC would represent between 8% (in the case of Krouch Saeuch) and 16 % (in the Prey Nup scheme) of farmers net agricultural rice income. In these conditions, it would be interesting to see how, beyond the technical support provided during the project, the willingness to pay of farmers could be enhanced to ensure the sustainability of the irrigation schemes. One way could be through agricultural support to intensify rice production, encourage diversification, but also provide knowledge and expertise regarding the quick and far reaching agricultural changes that are at play currently in Cambodia (emergence of new markets for instance). Enhancing the sustainability of irrigation scheme could also come by thinking differently about irrigation infrastructure and design systems that would be less expensive in terms of recurrent O&M.

Finally, the study showed that institutional support does not constitute the bulk of investment when donors rehabilitate irrigation systems. In Prey Nup, the institutional investment per hectare is less important than in the NWISP project. Further, institutional investment only represented 24% of the total investment (17% for NWISP and 15% for Stung Chinit). This is significant, but holds the promise of reducing the frequency of future reinvestments due to deteriorating infrastructure. A significant share of institutional investment goes towards national and international consultants. Strengthening the local capacity of irrigation stakeholders and service providers could be a way to reduce these costs of FWUC. This is the idea that underpinned the creation of ISC. Cambodian operators are needed to implement long term and meaningful institutional support to FWUC and farmers; these service providers also need to interact more closely with the provincial and district departments of MoWRAM, which also need to be strengthened. Indeed, during our interviews with employees of these departments, we noticed that they have no specific budget to support the FWUC and that they are not completely aware of the situation and the issues faced by FWUC.

In conclusion, this study used economic tools to provide insights on the consequences of investing in the soft components of irrigation on the performance and sustainability of irrigation systems. The study's limitations are linked to the quality and consistency of publicly available secondary data as well as to the indicators studied; further work on the relationships between the modalities of institutional investments and the distribution of costs and benefits of irrigation projects would allow addressing some of these shortcomings.