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Polder Rehabilitation, Agricultural Growth, and Inequalities

The Socioeconomic Impact of the Prey Nup Project (Cambodia)

Summary Document

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This document summarises the main results of the economic impact assessment of the Prey Nup polder project in Cambodia.

The complete analysis is available in Lagandré, D. (2007), *Étude d'impact économique du projet de réhabilitation des Polders de Prey Nup*, Éditions du Gret, forthcoming.

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Contents

Introduction: The Project and the Socio-economic Impact Assessment

Given Cambodia's population growth, increasing rice production, particularly through better control of water, is a major stake for the country's agricultural development. In 1998, the Royal Government of Cambodia began rehabilitation of the Prey Nup polders around Sihanoukville, with the financial support of the Agence Française de Développement (AFD). Implemented by GRET and Action Nord-Sud under the supervision of the Ministry of Water Resources and Meteorology (MWRM), this project started in 1998 and will end in 2007 (with some selective help given to the users' organisation until early 2008). In addition to its local importance, the Prey Nup polder rehabilitation project is a pilot project in that these polders are the first large hydro-agricultural scheme in Cambodia whose management has been turned over to a users' organisation. In parallel, this management turn-over approach has imposed itself within Cambodia's national policies.

Locally, the Prey Nup polder rehabilitation project had two goals: first, rehabilitate or create dikes, canals and sluice gates to protect 10,500 ha of rice fields from salt water intrusion from the mangroves and drain excess rainwater during the rainy season; and second, form a users' organisation, the Polder Users' Community (PUC), capable of managing these infrastructures sustainably, and notably managing water for the 10,500 ha, maintaining the infrastructures, organising elections amongst the 15,000 PUC members, and collecting water fees. These two components were accompanied by the systematic registration of more than 22,000 plots of land, the establishment of a microfinance institution (MFI), AMRET (formerly EMT), and agricultural enhancement assistance.

Polders 1 to 4 were placed in service in 2001 and the polders 5 and 6 in 2003. In 2006, the 2,700 ha that had been abandoned before the project were once again being cultivated, and the average yield on the cultivated plots had increased from 1.6 t/ha to 2.7 t/ha[1]. An estimated 15,000 additional tons of rice was grown in the area. Based on this figure, the project team estimated the additional income generated by the rehabilitation to be 1.46 million USD (Brun J. M., 2004).

In order to understand the project's direct and indirect impacts, an assessment of the rehabilitation's impact on household finances was launched in 2006. It aimed to identify the main beneficiaries of the production increases revealed by the project's monitoring and assessment system. It was a semi-quantitative study focused on the evolution of the activity systems of the households in the area. It was conducted from 5 February 2006 to 5 July 2007. It was based on an analysis of the PUC's database, which lists all the owners in the area, and on a series of surveys during which 869 families were interviewed.

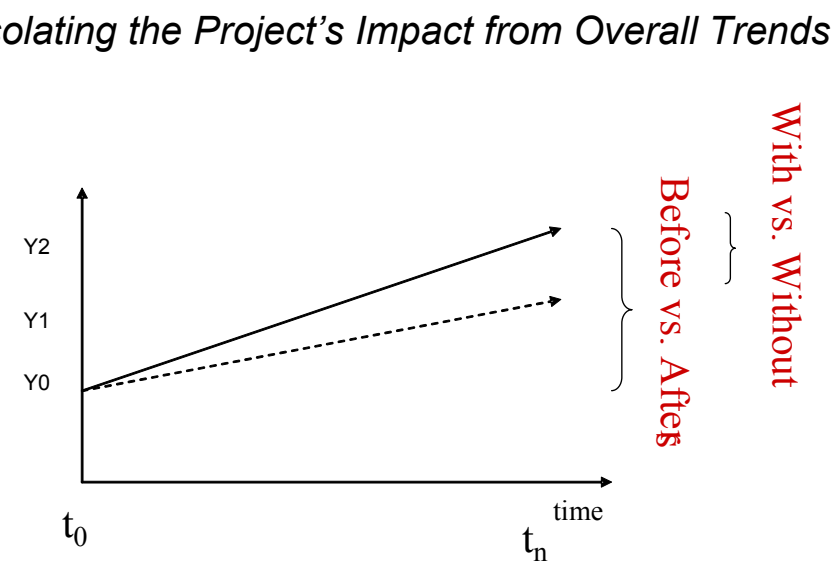
[1] Brun, J. M. (2006), *Project's rationale, achievements and stakes*, GRET.

Methodology

Two major methodological approaches can be used to assess the impact of development projects: (i) a "with vs. without" approach, which requires a detailed comparison with a reliable control zone, and (ii) a "before vs. after" approach, which allows one to understand overall economic changes in the area. With the second approach, it is sometimes difficult to isolate the project's contributions from overall trends.

In order to avoid risky comparisons with a control zone and, above all, to allow a detailed analysis of household trajectories, the before/after approach was chosen. A semi-quantitative approach based on retrospective surveys was chosen with the aim of assessing what share of the economic changes could be attributed to the project. A control zone was also surveyed to put certain evolutions in the area into perspective.

Figure 1: Isolating the Project's Impact from Overall Trends



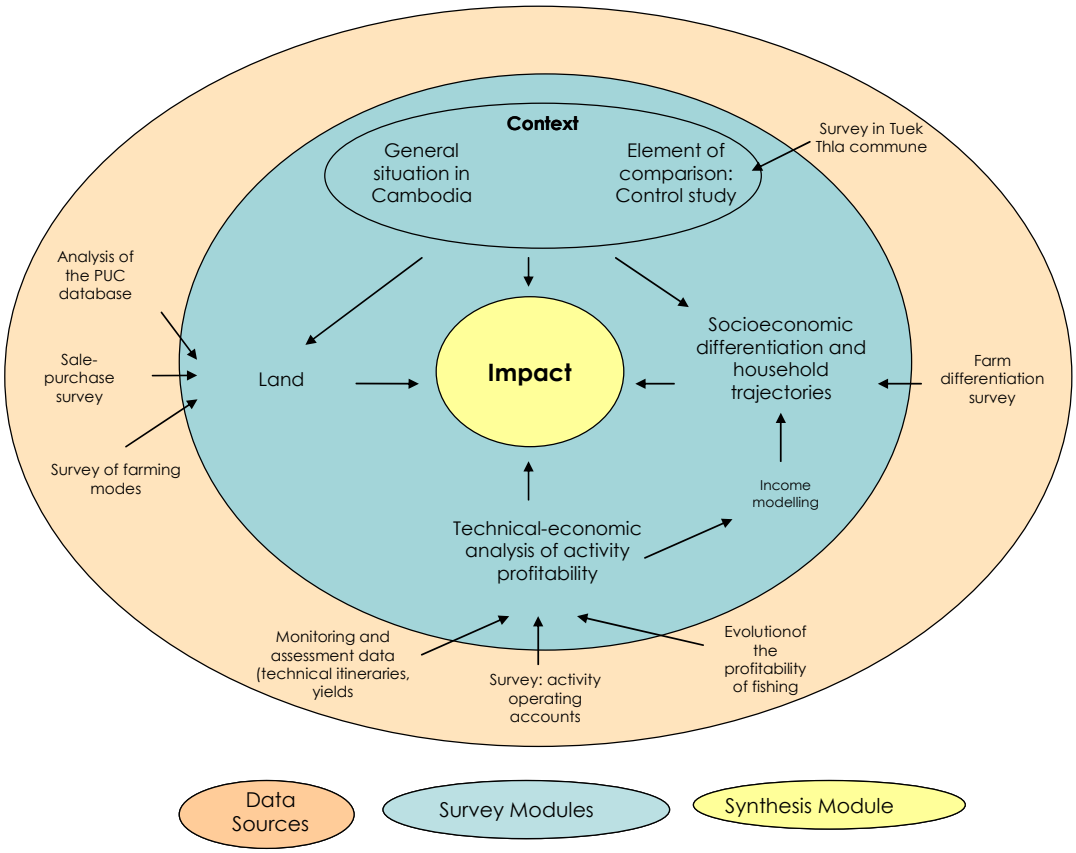
Source: Lavigne Delville (2006)

In the rest of this document, the "before" situation corresponds to households' economic situation when the effects of the rehabilitation had not yet been felt (in 1999-2000), and "after" corresponds to the time of the study (2006). The assessment of the socio-economic impacts of the Prey Nup polder rehabilitation project focused on changes in activity systems and on land differentiation.

In order to understand the numerous factors that influenced these areas and put them into perspective with the national trends, the study was based on a modular structure (4 modules were identified: the context, the land, analysis of the profitability of activities, and changes in activity systems). Each module called for specific surveys. In this way, the surveys on land were, overall, quantitative surveys that gathered data on a limited number of variables. In contrast, the survey of changes in activity systems was based on semi-qualitative interviews that allowed a typology of noteworthy socioeconomic differences to be established. The survey of the control zone aimed to provide elements for comparison and was fully qualitative.

The links between the modules are shown with arrows on Figure 2. Thus, using the turnover figures collected during the "farm differentiation" survey, the activity profitability analysis[2] made it possible to model the incomes of the sampled households. It was then possible to determine changes in activity systems for each socioeconomic group and explain them, with both the change in relative profitability of activities, the qualitative data.

Figure 2: The Modular Structure



[2] The decision was made to examine the entire system of activities, not just agricultural activities, in order to obtain the most reliable image possible of the share of agriculture in household finances.

The Prey Nup Region and its Context

- **Decollectivisation, Inequalities, Landless Farmers, and Poverty Rates in Cambodia**

After the Khmer Rouge genocide (1976-1979), the massacres, and the destruction of society, Cambodia has rebuilt itself, first under the Vietnamese occupation, then under the United Nations protectorate. The redistribution of land from 1986 to 1989 is fundamental in understanding today's Cambodian countryside. Indeed, in 1989 land was allocated in a relatively egalitarian way, but the situation changed rapidly according to the whims of a deficient legal system, abuses of power, poverty, demographic growth, and transactions. Today, approximately 20% of the rural population does not own farm land. Moreover, inequalities in access to land are sharp and increasing, with national Gini coefficients that fluctuate between 0.47 and 0.66, depending on the sources (Sophal C. *et al.*, 2001)

At the same time, poverty seems to have lessened, given that in 1994, approximately 47% of the population was living under the poverty line, while only 37% was in 2004 (World Bank, 2006). However, rural poverty has decreased much more slowly (from 47% to 43%), and inequalities in access to consumer products have increased (with Gini coefficients growing from 0.266 to 0.333).

- **Prey Nup and the Polder Area**

Two hundred kilometres from Phnom Penh, the Municipality[3] of Sihanoukville has three districts. The polders are located in the Prey Nup district, approximately forty kilometres from Sihanoukville. On the western side, they are demarcated by National Road 4 which connects Sihanoukville to Phnom Penh. Because of the easy access to the city, the polders can be considered an outlying periurban area.

The area around the actual polders corresponds to the lowlands of a coastal basin located between a small mountain range (altitude: 300m) to the west and Veal Rinh Bay (the mouth of the Kompong Smach river) to the east. Between the two is a large plain of marine swamps that spans 11,000 hectares and is five to seven kilometres wide bordered by a relatively large stand of mangrove.

[3] A municipality is the 'urban' equivalent of a rural province.

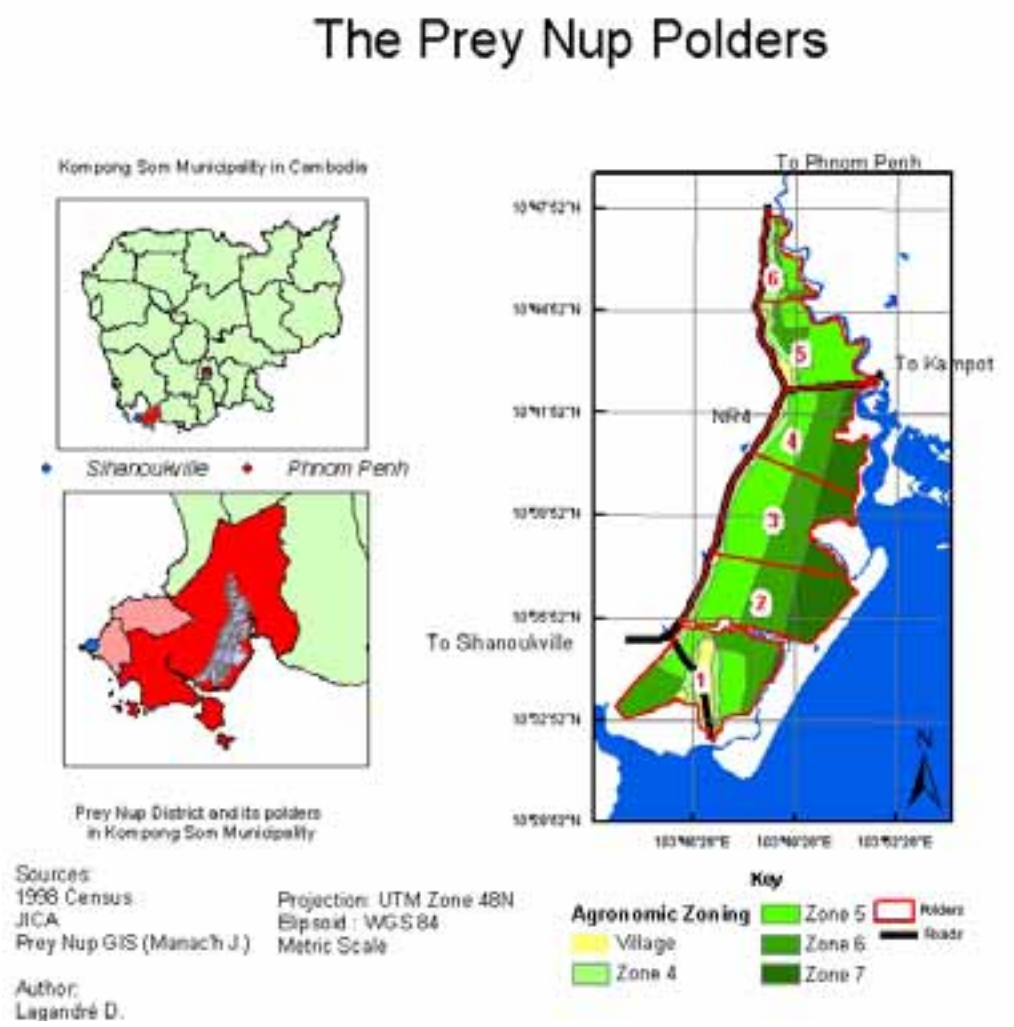
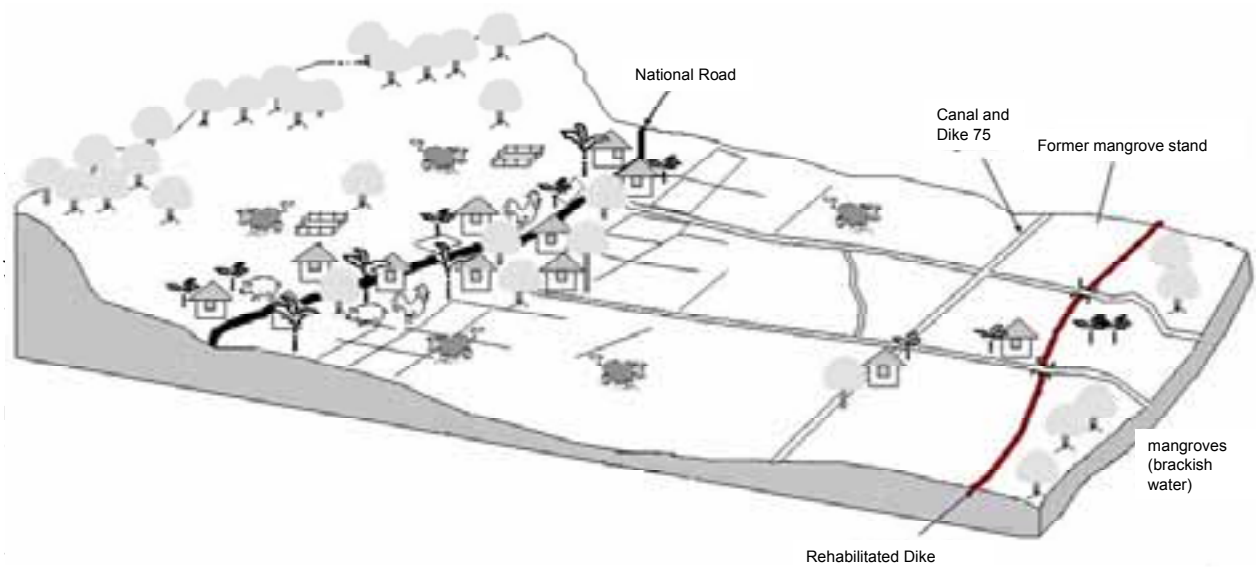


Figure 3: Transect of the Prey Nup Polders



Source: Kibler J. F. and Perroud C. (2003)

The villages are mainly located along National Road 4 and on the hill of Sre Cham (at polder 1), but some – like Bek Krang and Champou Khmao – are located within the polders.

At the beginning of the 1930s, the colonial authorities started a hydro-agricultural development project over all of the Prey Nup swampland. They created five large sections, the management of which was entrusted to the public administration. During the Khmer Rouge regime, the polders were "rehabilitated" with the construction of a dike parallel to the road (dike 75), which decreased the size of the polders by 30%. A sixth polder was created. After the Khmer Rouge and until 1998, the polders were no longer properly maintained. This is why, before the start of this project, the infrastructures had deteriorated considerably, salt water had entered the polders, nearly 3,000 ha of rice fields were abandoned, and yields were very low.

In 1998, some 9,581 households, or 53,374 inhabitants (1998 census) lived in 11 communes and 43 villages around or in the polders. The number of households in the polders seemed to be increasing more than the population. Indeed, the strong demographic growth after the fall of the Khmer Rouge regime more than twenty years ago caused an explosion in the number of new households today. The growth in the number of households within the polders seems to have stabilised at around 1.8% per year.

- **Tuek Thla Commune: A "Control" Zone**

Tuek Thla Commune was chosen in order to provide elements of comparison with how the area's economic development could have looked if the polders had not been rehabilitated. Indeed, a polder-style infrastructure had been built in this commune during the Khmer Rouge period. However, as it had not been maintained, the dike had ceased to protect it from salt water intrusion. Today, in Tuek Thla, half of the plots have been abandoned and the decline is continuing. Only 20% to 40% of households grow enough rice to be self-sufficient. Yields stagnate at 1.3 t/ha. This situation is very similar to the situation in the Prey Nup polders prior to their rehabilitation.

Demographic pressure is also very strong (population growth of 1.8% per year), leading to an increase in the number of landless farmers (22% of the population) and to a fragmentation of farms (some new households are set up with 0.15 ha of rice fields!).

Within this context, systems of activity evolve slowly. Supplementary activities are limited (very little market gardening, for example). Mechanisation has barely begun (a few tillers and no threshers). Village notables do not have strong accumulation capacities (no concrete houses, for example). Finally, one should note that, during busy working seasons, families send household members to work as day-labourers in the polders some ten kilometres away.

The Evolution of Activities and their Profitability

The evolution of household incomes is the result of changes in the profitability of various activities and the composition (in type of activity and relative share) of household activity systems. The purpose of this module is to: (i) determine the project's impact on the profitability of agricultural activities, and (ii) assess the profitability of most activities in the area in order to model household incomes. Accordingly, standard operating accounts for 29 different activities were established. The survey method used depended on the available data and the level of precision desired in function of the activities' importance for household finances.

• Increased Agricultural Incomes: a Direct Effect of the Project

The project's impacts on the profitability of rice cropping vary according to the polders' agro-ecological zones. Four large zones were defined within the polders (see the map of the Prey Nup polders) according to their topography and their proximity to the sea. The main evolutions were an increase in the profitability of rice cropping within the agro-ecological areas closest to the mangrove (and which were therefore most subject to salt water intrusion).

Table 1: The Evolution in the Profitability of One Hectare of Rice by Agroecological Zone

	Zone 4		Zone 5		Zone 6		Zone 7a		Zone 7b	
	pre-project[4]	Post-project	pre-project	post-project	pre-project	post-project	pre-project	post-project	pre-project	post-project
Yield (t/ha)	2.04	2.36	2.06	2.98	2.35	2.89	2.00	2.59	2.00	2.59
Production Value (turnover in riels)	715 400	1 013 080	721 000	1 279 680	822 500	1 240 980	700 000	1 036 000	700 000	1 113 700
Profits (in riels)	75 279	71 924	22 458	242 128	-23 210	212 755	93 734	84 114	37 290	128 814
Household Profits (in riels)	116 779	97 424	68 958	276 128	53 290	246 755	189 234	173 614	132 790	238 314
Increase in Turnover		42%		77%		51%		48%		59%
Increase in Labour Productivity		36%		89%		85%		36%		72%
Increase in Profits		-4%		978%		1 017%		-10%		245%
Increase in Yields		15%		44%		23%		30%		30%

Source: monitoring data on 1,300 parcels, data from the AMVA team, and the author's calculations

A slight increase in other agricultural incomes can also be seen: market gardening, and above all pig farming facilitated by increased bran availability. Finally, we note the development of mechanised agricultural services (tillers, rice threshers, husking machines) supplied by well-off farmers.

[4] The pre-project yield data are those for the year 2000 harvest (previous monitoring had not collected sufficient data). However, the year 2000 was slightly better than other pre-project years. In 2000, the overall yield was closer to 2 t/ha than to 1.6 t/ha (the average pre-project yield). The project's impact on rice growing is therefore underestimated.

- **A Very Different Evolution of Other Economic Activities**

While commercial activities grew, revealing the area's economic vitality sparked by agricultural growth and very strong growth of the city of Sihanoukville, some activities declined considerably. For instance, the profitability of fishing clearly dropped because of the decrease in resources. Many households gave it up. Illegal logging, which was also an important source of income, fell off due to stricter controls. Numerous households gave up fishing and logging to start legal, more profitable activities. Extra-agricultural activities (like trade) therefore grew.

- **A Sharp Rise in Incomes in the Area**

Table 2: Pre- and Post-Project Incomes and Profitability

Total Income Analysis	
Pre-Project	**Post-Project**
Total Income for the Sample (in riels)	
914 524 363	1 013 121 430
Annual Income per Household (in riels)	
5 286 268	5 856 193
Increase in Total Income (extrapolated from household survey data)	
6 041 207 532	Riels
1 510 302	**USD**
Sample's Agricultural Income (in riels)	
71 697 157	190 401 810
Annual Income per Household (in riels)	
414 434	1 100 588
Increase in Agricultural Income (extrapolated from household survey data)	
7 273 233 061	Riels
1 818 308	**USD**
Increase in Income: estimate for the polders (calculated in part 1 based on the increase in yields…)	
5 840 098 500	Riels
1 460 025	**USD**

Over the course of the project, incomes in the polders grew by 10.8%. This corresponds to an annual growth of 1.3%. This growth seems relatively low compared to the official growth rate figures for the rural sector (on average 3.3% per year, according to the World Bank[5]). However, the agricultural growth rate was 20.6% per year!

The extrapolation of income growth to all households in the polders shows a total growth of 1.61 million dollars, and agricultural income growth of 1.82 million USD (or a return on investment for the project in approximately 7 years[6]).

Moreover, overall project analysis shows an annual income growth due to the project of 1.46 million USD (Brun J. M., 2006).

The income growth figures given in the previous reports were, while very positive, underestimated. Indeed, agricultural income growth that can be directly attributed to the project was revised upward by 25% following the modelling in the impact assessment (from 1.46 to 1.82 million USD).

[5] The World Bank (2006).

[6] The exchange rate used was 1.20 USD per Euro. The calculation was done in current dollars.

Recultivation, Land Markets and Inequalities: The Project's Impact on Land Tenure

The land situation within the Prey Nup polders was deeply modified with the rehabilitation of the main dike: 2,700 ha are once again being cultivated (which considerably increases the amount of land), yields have risen from 1.6 t/ha to 2.7[7] and 22,000 plots have been registered. Which plots are being recultivated and who benefits from them? What effects did these changes have on the distribution and vitality of the land market? Can a dynamic of land concentration be seen, or does the distribution of production gains benefit small farms?

- **2,700 ha Recultivated**

Because of the deterioration of the dikes and the infiltration of salt water in rice fields, a large amount of land was not cultivated before the project, or was cultivated irregularly with very low yields. The pre-project distribution of the uncultivated areas was very heterogeneous. It depended on numerous local factors: topographical level of the area, presence of water ways, maintenance or not of the main dike[8], etc. "Dike 75", built under the Khmer Rouge regime, roughly outlined the area of cultivated land.

The installation of the main dike generated a strong dynamic of recultivation of abandoned land. It varies greatly from one polder to another, for reasons that are explained below (see Table 3).

Table 3: Polder Recultivation, in hectares

	Cleared (zone 7)	Recultivated (zone 6)	Total Re-cultivation	Total
Total Surface Area	878	1 793	2 671	10 494
Average Plot Size	2.13	0.56	1.08	0.43
Polder 1	10	61	72	1 761
Polder 2	339	288	627	2 531
Polder 3	21	194	215	2 128
Polder 4	338	741	1 079	1 845
Polder 5	16	443	459	1 698
Polder 6	154	62	215	529

Source: Recultivation survey, PUC database (sample size: 1,950 users that had recultivated land)

From the village plot maps drawn up during land registration and kept by the PUC, the project staff in charge of monitoring recultivation identified lands not cultivated prior to the project. Based on the plot codes written on the maps, it was possible to identify the recultivated plots within the PUC's database. The recultivated lands were therefore calculated with precision, and the owners who benefited from recultivation were identified.

7 2002 to 2005 average.

8 In some areas, the farmers worked together locally before the project to maintain the main dike.

The polder in which the most land was recultivated is polder 4, whereas nearly all of polder 1 was already cultivated before the project. Table 3 shows two types of recultivation: cleared areas (Z7) and recultivated areas (Z6). These agro-ecological areas have different histories: zone 1, located between dike 75 and the main dike, had not been cultivated since the Khmer Rouge period. It was not redistributed during the decollectivisation at the end of the 1980s. In contrast, area 6 located in front of dike 75 was cultivated during the Khmer Rouge period. However, this area is especially low lying and consequently affected by salt water. It had therefore been abandoned little by little. Nonetheless, it was formally been redistributed during decollectivisation.

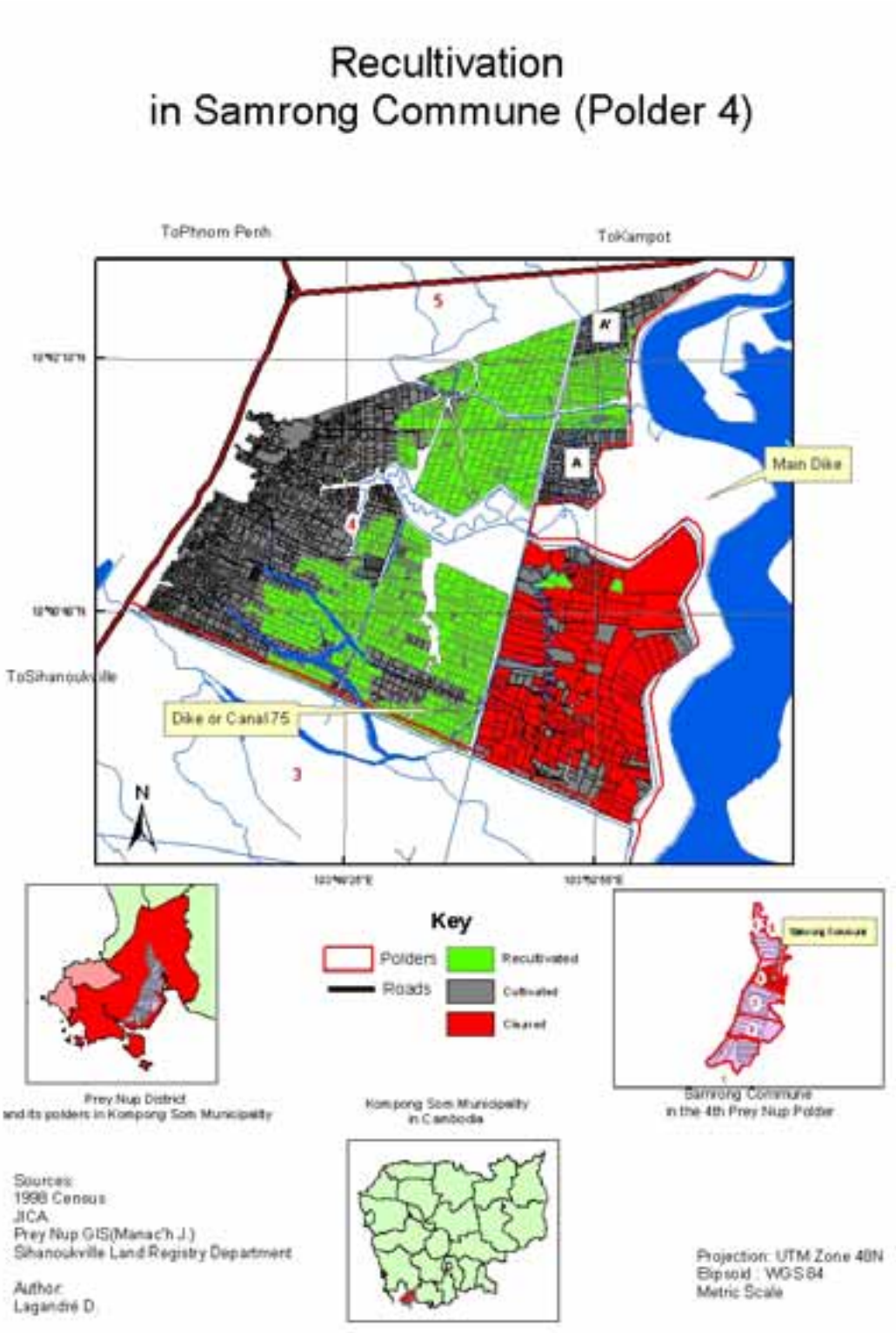
These different histories explain, for example, the differences in average plot size. They also explain the different origins of the owners: those who arrived in the polders at a late date more frequently settled in zone 7, marginal at the time, but where they could clear large amounts of land during the project.

The owners benefiting from the recultivation (1,950 households) are essentially households that cultivated less land than others before the project. Then, thanks to recultivation, they became overrepresented within large landowner categories (Table 4). Recultivation was, therefore, a powerful way to become rich for a large number of the poorest families.

Table 4: Average Cultivated Area Pre- and Post-Project

	Pre-Project Cultivated Land (ha)	Post-Project Cultivated Land (ha)
Owners who Recultivated their Plots	0.96	2.5
All Owners	1.48	1.6

Source: Recultivation survey, PUC database (sample size: 1,950 users who recultivated land)

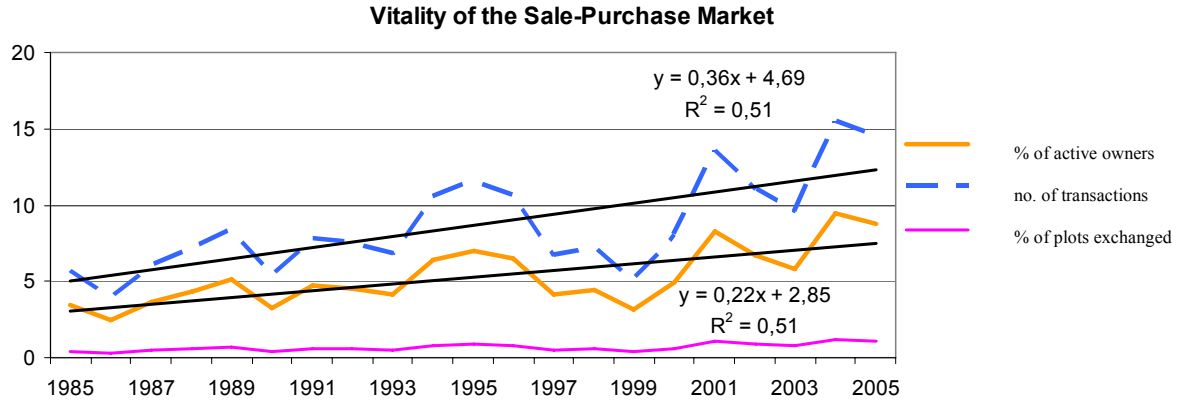


The map of Samrong Commune (left) clearly shows the location of recultivated and cleared land. This commune (the only one for which we have a digitised plot map) has largely been recultivated. As mentioned above, recultivation was very heterogeneous and depended heavily on local production conditions. For example, the areas A and A' were cultivated before the project, even though they are located beyond dike 75 (in zone 7) because the farmers worked together to maintain the dikes there. However, between the two, an area was not always cultivated because a river ran through it, making it susceptible to salt water intrusion.

- **Dynamics of the Sale-Purchase Market**

The land sale-purchase market has continuously been developing since decollectivisation. Today, approximately 8% of owners are active on the land market every year, which means that they buy or sell a plot, compared to 3.5% in the mid-1980s[9]. While a slight improvement seems to have emerged in recent years, it is not necessarily significant.

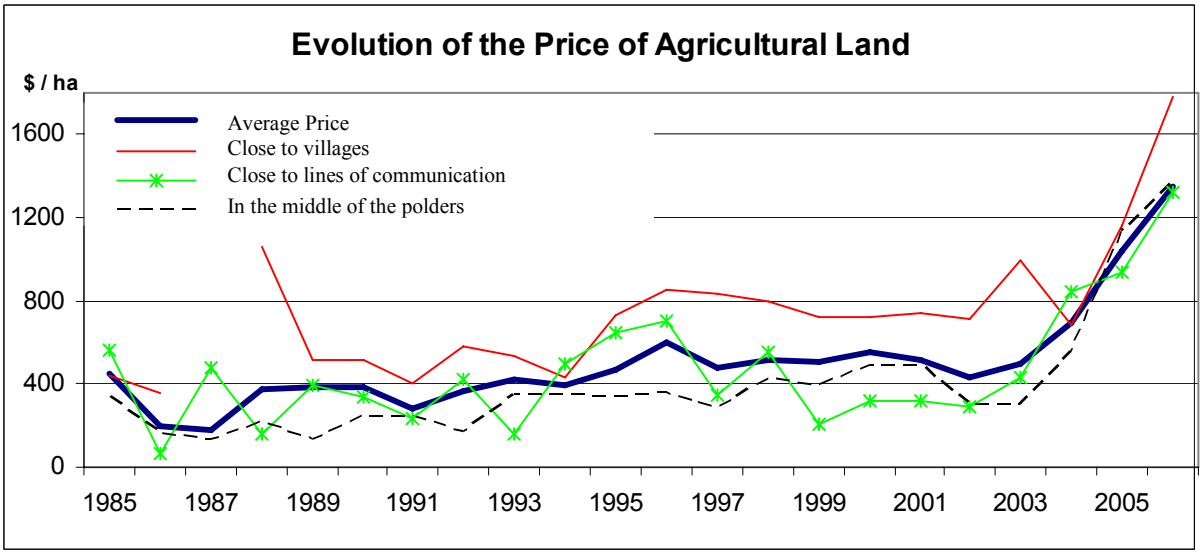
Graph 1: Vitality of the Sale-Purchase Market



Source: Sale-purchase survey (sample size: the 329 individuals interviewed and the 377 plots exchanged)

Simultaneously with this increase in the number of transactions, a steady increase in land prices was seen between 1985 and 2000–2001, with a very sharp increase from 2003 onwards in all of the polder areas.

Graph 2: Evolution of the Price of Agricultural Land



Source: Sale-purchase survey (sample size: the 258 plots larger than 0.3 ha exchanged)

This increase in price and number of transactions indicates that the market is influenced by demand. The increase in demand can be explained by the demographical pressure (which nevertheless existed before 2002-2003) and the improvement in land productivity. It is also necessary to specify that, despite a very large rise in the amount of cultivable land (up 2,700 ha), the land supply on the market did not increase very much (the number of transactions did not increase more during the project and prices did

[9] The retrospective survey may underestimate previous transactions because they have been forgotten.

not drop at all). Thus, the owners of recultivated parcels did not wish to sell (however, those who could not cultivate all their plots rented a few out).

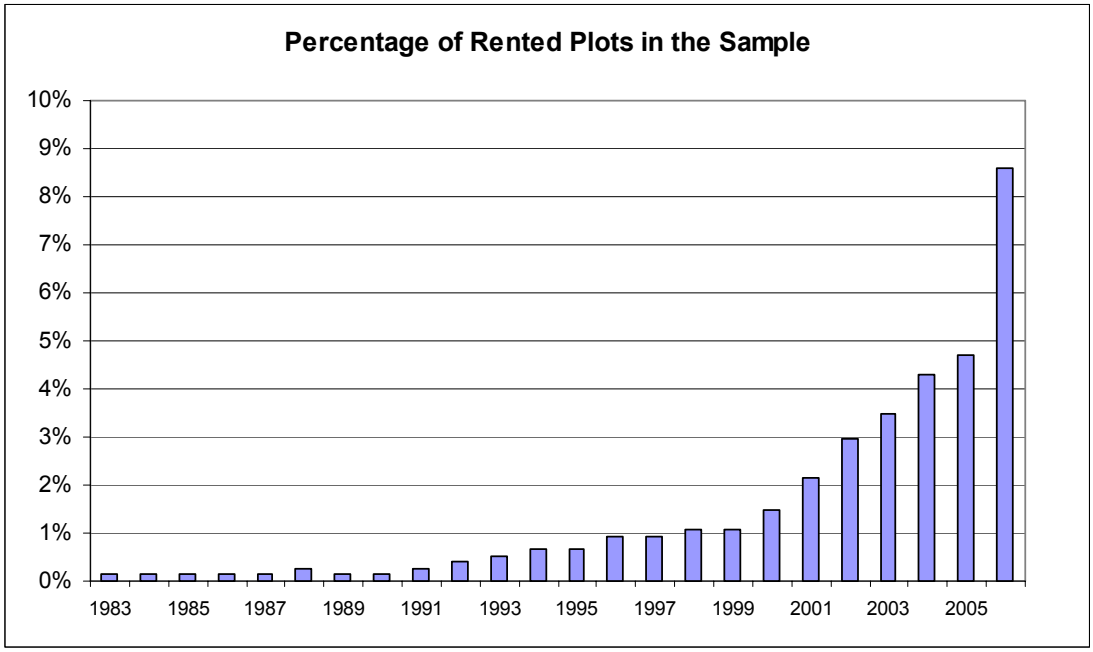
The increase in land prices may have been the result of a combination of underlying trends throughout Cambodia, and of two phenomena caused by the project: (i) the plot registration, and (ii) the increase in land productivity that stimulated demand. However, we do not have the data to isolate the respective contributions of these two phenomena from the overall upward trend in land prices.

- **Inequalities and Land Distribution**

Increase in Indirect Farming

In the context of high demographic pressure in the polders and an increase in cultivable land, a new form of land use emerged. Indeed, before the project, indirect farming had almost never been practised in the polders. Yet, since 2000-2001 and especially since 2006, this kind of land use has very clearly been on the rise.

Graph 3: Evolution of Indirect Farming



Source: Local survey (sample size: 264 rented plots)

Two interpretations are possible to explain this evolution: (i) the increase in the demand for land without an increase in the supply of land on the market (see above) stimulated the rental market, and (ii) the sudden increase in cultivated land did not allow owners to cultivate all their plots themselves, which they therefore partially rented out.

The indirect farming market is relatively redistributive, as it allows 30% of the landless to have a farm and it allows owners who possess slightly less land than average to attain self-sufficiency and, sometimes, begin accumulation. The households that rented out plots were mostly owners who left farming for other activities. Finally, rental prices increased proportionately less than yields did, which makes renting more accessible.

While the development of indirect farming lowers land access inequalities, it in no way presages a change in land ownership inequalities.

- **A Slight Increase in Land Inequalities**

The PUC's plot database provides a precise view of the land situation in today's polders. However, as it was established in 2001, it does not allow a full comparison with the pre-project situation. Therefore, a 1999 survey of 50% of the households in polders 1 and 2 was used to analyse changes in land distribution.

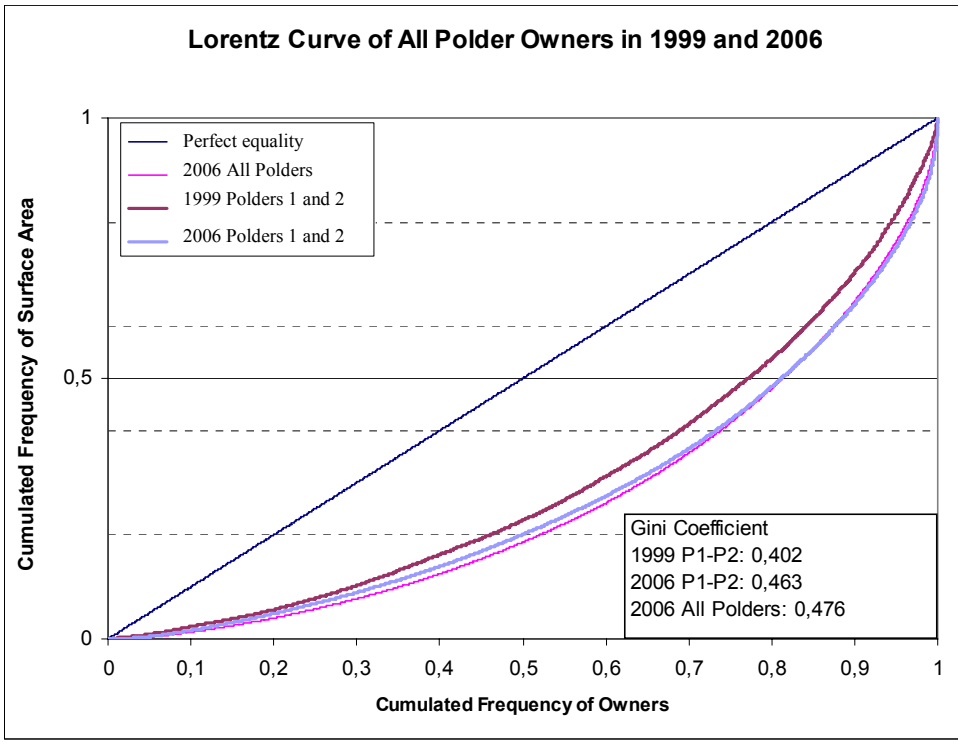
Table 5: Land Distribution in the Polders

	1999 Polders 1 & 2	2006 Polders 1 & 2	2006 All Polders
Median Surface Area Owned	1.2	1.00	1.10
Average Surface Area Owned	1.62	1.49	1.64
Gini Coefficient	0.402	0.463	0.476
% of Landless Farmers	13%		24%
Surface Area (ha)	4 292	4 292	10 492

Source: CUP database (2006), 1999 project survey of 50% of household in polders 1 and 2

Inequalities in the polders increased moderately during the project (up 0.06 points in the Gini coefficient, and up 10 points for landlessness). This change is the same as the one seen in the rest of Cambodia (20% landlessness in 2002, gaining 2 points per year). The level of land access inequalities is, however, one of the lowest cited the literature (between 0.47 and 0.66). This growth in inequalities can be explained first by the increase in the number of rural households, with a fragmentation of the smallest farms. A range of elements confirms this statement: (i) an increase in the number of households, (ii) a decrease in the median amount of land owned, and (iii) a decrease in the average amount of land owned, (iv) no strong concentration during the project, and finally (v) because 40% of landless households did not lose their land, but were newly established households that did not yet have land (85% of them have parents who own plots).

Graph 4: Lorentz Curve of All Polder Owners in 1999 and 2006



Sources: 1999: survey of 50% of owners in polders 1 and 2 (sample size: 1,071 owners); 2006 : 2006 PUC database (sample size: all owners)

- The project's first effect was the recultivation of 2,700 ha, benefiting a large share of the poor households that had arrived after the 1989 land distribution.
- The combination of the increase in land productivity and delivery of land titles provoked a rapid increase in the value of land within the polders. However, this led to only low growth in the sale-purchase market, which has been growing regularly for 20 years. The buyers are either large farmers or small farmers. We note a slight increase in land inequalities, comparable to those seen elsewhere in Cambodia, which is a result of this sale-purchase market, and even more the result of the increase in the number of households and the fragmentation of land properties.
- However, the rental market, which is in full development thanks to the project, plays a redistributive role, allowing 30% of the landless to have a farm, and allowing small land owners to increase their cultivated land and achieve or exceed self-sufficiency.

Socioeconomic Differentiation and Farm Trajectories: The Project's Impact on Activity Systems

The increases in rice production are distributed differently among farmers, in function of how much land they own and the location of their plots. This can have a significant effect when the increase allows a qualitative leap in household finances, particularly when it allows households to exceed the reproduction threshold and generate surpluses. But changes in agricultural and other incomes are not merely mechanical, with impact on households being a simple sum. In function of changes in the profitability of various activities, and in households' ability to access the more profitable activities, households modify and sometimes re-form their activity systems. They invest their surpluses in productive activities or in improving their living conditions. Analysing the project's socioeconomic impact therefore requires one to estimate the quantitative change in household incomes and assets, and measure the reformation of activity systems and households' economic trajectories. The nature of activities, asset requirements, and profitability are the main indicators for this.

- **Note on the Methodology**

The socioeconomic differentiation survey covered 173 households previously interviewed during the 1999 and 2003 surveys. This choice made it possible to steer the discussions towards changes in activity systems. The pre-project situation was approached retrospectively during the 2006 survey, but the researcher had information provided by the same households during the 1999 and 2003 surveys. This made it possible to verify the reliability of the information gathered and ask questions to verify information.

The households were divided into 8 groups according to their socioeconomic characteristics. **Group 1** consisted of the landless without means of production; **group 2** consisted of the landless with more or less capitalised means of production (fishermen for example); **group 3** consisted of non self-sufficient farm households; **group 4** consisted of little-diversified self-sufficient households; **group 5** consisted of farm households with at least one capitalised activity (such as providing the use of a tiller) and average investment capacities; **group 6** consisted of farm households with more than one highly capitalised activity (a husking machine and a semi-intensive pig farm, for example) and high investment capacities; **group 7** consisted of households with numerous profitable activities, for whom farming was secondary; and **group 8** consisted of households with a large source of outside income (see Table 6: Examples of Households in the Various Groups, below).

Changes in the households comprising these groups are presented dynamically. The groups were not compared before and after the project because they did not contain the same individuals. The comparison thus focused on the post-project status of the members of each given "pre-project" group.

The variables studied for each group were: (i) self-sufficiency, (ii) assets and (iii) income. It was therefore necessary to model household assets and income. It is relatively simple to model changes in assets because data on household belongings and their purchase prices were gathered during the survey.

However, income modelling was a more complex task using the previously calculated activity profitability data. The following equation was used:

$$Y = S(Ri.CAi) + S(Rj.Sj) + S(CAk) + C$$

In this equation, Y is income; Ri is the profitability of the sub-systems of activity i; CAi is the turnover of sub-systems i; Rj is the profitability of rice activities in area j and Sj the cultivated surface area in zone j; CAk is the turnover of salaried activities k; and C is the self-sufficiency adjustment (to take into account the savings represented by self-consumption of rice).

- **Self-Sufficiency**

The increase in cultivable (and cultivated) land and the increase in yields led to a 30 point drop in the number of households with a shortfall of rice. Access to self-sufficiency for these households was particularly important for their economic development. They effectively crossed a threshold that allowed them to think about investing and developing new activities. This evolution is all the more noteworthy because in the area around the former Tuek Thla polders that had not been redeveloped between 60% and 80% of households are not self-sufficient.

Table 7: Evolution of Self-Sufficiency in the Polders

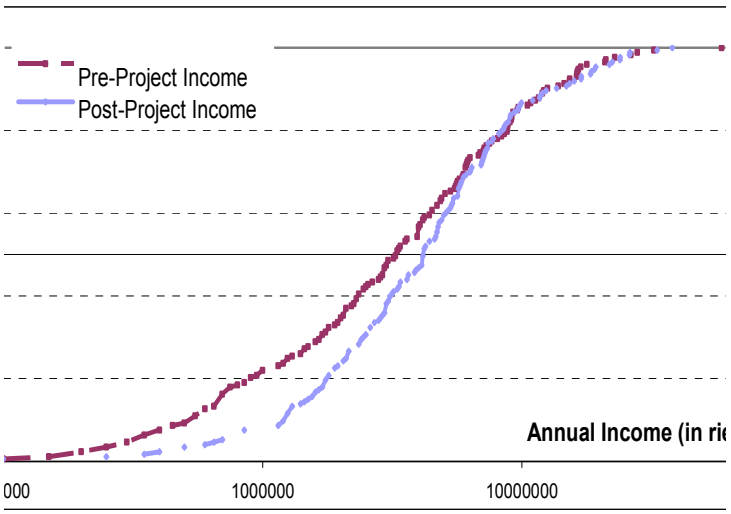
Pre-Project			Post-Project		
Number of Households	Number of Self-Sufficient Households	% of Self-Sufficient Households	Number of Households	Number of Self-Sufficient Households	% of Self-Sufficient Households
169	74	44%	173	128	74%

Source: Household survey (sample size: 173 households)

- **Evolution in Incomes**

Income distribution shows that incomes have in essence increased for the poorest households. This evolution can be seen in the evolution of Gini coefficients.

Graph 5: Evolution of Income Distribution



Source: Household survey (sample size: 173 households), and activity profitability survey

Table 6: Examples of Households in the Various Groups

Mrs Tak Sen, Group 1,

She has always lived in the polder area and therefore received 1.5 ha when land was redistributed. However, in 1996, her husband became ill and she was obliged to sell her land (for 3,000 bath). Her husband built henhouses until his death. She is a midwife and healer, but these activities only provide her with a modest income (≈5 USD/month) that is not enough to feed her two granddaughters who live with her.

She lives in a wood plank house that she was able to build in 1993 when she still owned her land.

Mr Nou Ngaol,

Group 2,

Originally from Sihanoukville, he came to the polders a few years after getting married to join his wife's family. However, as he arrived in 1990, he did not receive any land. He and his first son are therefore shrimp fishermen (a nocturnal and particularly difficult profession). Their small income (less than 2 USD/day) does not allow them to invest or save.

He lives with his wife and their seven children in a wood plank house with a zinc roof, which he bought when they moved to the polders.

Mr Sam Sareun, Group 3,

He and his wife come from Kampot and arrived shortly before the distribution of land. They only received a small plot (0.37 ha) that they increased to 0.9 ha by buying another plot in 1993. With 9 people in the household, the 2 tons of rice they grow are not enough and the family must survive the 3-month pre-harvest period. They have numerous other non-capitalised activities (fishing with a rowboat, one or two free-range pigs, a few vegetables in the garden, and some day labour). Their savings capacity is very low.

They live with their parents and their children in a house built from palm leaves.

Mrs Keut Thaï,

Group 4,

From the polder area, she received 1 ha during redistribution. In 2000, she began to rent a half-hectare plot. She therefore grows enough rice (nearly 1.5 t) and is merely self-sufficient. She has supplementary activities: a little fishing, a pig, market gardening. Her savings capacity, while limited, is positive (notably thanks to the market gardening). In addition, she owns three cows.

The 13 members of the household live in a wood plank house with a zinc roof.

Mr Ung Ya, Groupe 5,

From the polders, he received 1.6 ha during redistribution and then quickly bought 1.5 ha. He therefore owns 3.1 ha, on which he grows 5.5 t of rice. He can sell more than 3 t. He also owns 10 buffalos. He has a motorcycle that allows him to provide a moto-taxi service. His wife also owns a small cake business. His large savings capacity allows him to pay for medical care without having to sell paddies.

Mrs Prum Preung,

Groupe 6.

During redistribution, she received 1 ha, and rapidly cleared nearly 4 ha in an abandoned area. She therefore grows nearly 13 t of rice. She also grows vegetables in her seed nursery. Her large surpluses allowed her to invest in a huller in 1998, which allows her to have a semi-intensive pig farm (thanks to the production of rice bran). She also owns cows and buffalos, and foothill field. She has a strong capacity for savings (notably in gold).

Mr Sam Reth Koy,

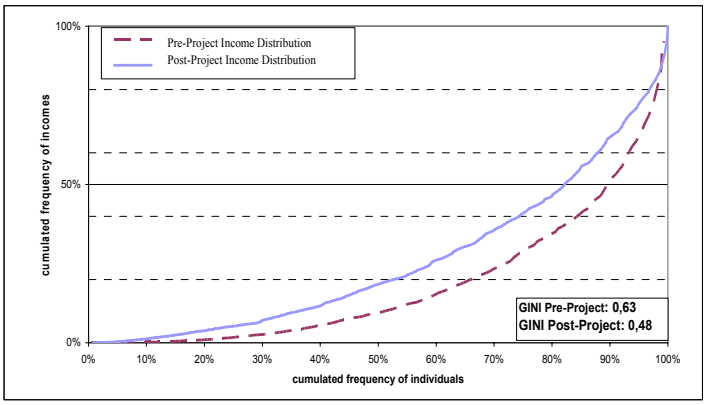
Groupe 7,

He arrived in the polders in 1994 when he left the army. He had some savings, and immediately bought 0.5 ha, which allowed him to be merely self-sufficient. He also owns foothill field and five cows. In 1996, he began rice trading. Then, in 1997, he went to Vietnam to buy a thresher. In 1999, he bought a huller, which allowed him to intensify his pig farming. Before the project, he therefore owned a huller and the associated pig farm, a thresher, a rice field, an orchard, five cows, and a rice business. His living conditions also improved (larger house, various purchases: motorcycle, generator).

Mr Los El, Groupe 8,

He worked in Sihanoukville as a civil servant until 2001. However, in 1988, he bought a few plots of land in the polders. When he retired (in 2001), he moved to the polders. He has given some plots to his children, but he still produces 9 t of paddy. He earns his living from numerous activities (market gardening, duck farm, two-wheeled tractor, his pension as department director, and above all a grocery store). He owns a large cement house and a motorcycle that he financed with the sale of his house in Sihanoukville. Mr Lo El is typical of a retiree living off his assets.

Graph 6: Gini Coefficient and Lorenz Curve for Incomes



Source: Household survey (sample size: 173 households), and activity profitability survey

Indeed, the Gini coefficient fell from 0.63 to 0.48, which shows a very clear levelling of incomes. The breakdown of income evolution by group and by activity provides better understanding of the numerous activity changes that took place in the polders.

Table 8: Income Variation by Activity and by Category Pre- and Post-Project (in riels per year and per household)

Pre-Project Category[10]	Agriculture	Mechanisation	Logging	Fishing	Extra-Agricultural Activities	Transfer Out	Labour	Total Income Growth for the Category	Growth Rate
1	21 278		-96 000	-17 349	0	120 000	10 000	37 929	3.3%
2	366 466		**908 750**	**-2 198 771**	893 023	143 500	-11 250	101 718	1.2%
3	**504 174**	107 809	-67 964	-189 413	188 599	**877 818**	204 827	1 625 852	70.6%
4	**711 487**	295 331	-181 563	-571 244	**411 161**	**526 875**	165 781	1 357 828	56.5%
5	**728 672**	186 892	-472 500	**-1 728 323**	**1 294 746**	380 250	43 875	433 611	6.5%
6	**1 331 622**	441 131	**-2 307 692**	**-1 261 944**	-278 294	-184 615	-120 000	-2 379 793	-18.1%
								Total	
Total Pre-Project Income	71 697 157	22 830 102	112 492 000	281 828 251	353 445 352	56 920 002	15 311 500	914 524 363	
Total Post-Project Income	190 401 810	57 613 126	32 724 000	132 632 331	433 433 163	132 966 000	33 351 000	1 013 121 430	
Growth	**165.6%**	**152.4%**	-70.9%	-52.9%	22.6%	133.6%	117.8%	10.8%	

Source: Household survey (sample size: 173 households), and activity profitability survey

The activities with the highest overall growth were mechanisation and agricultural activities with +165% and +152% respectively. The project had the most influence on these two sectors of activity. In contrast, logging and fishing activities fell sharply, particularly after the enforcement of the ban on illegal fishing and logging practices, and after the reduction in fish stocks. The changes seen were, therefore, the result of these differential evolutions, with the members of groups 2, 5 and 6 (those most involved in fishing and logging) experiencing large drops in income from these activities.

[10] Note: Groups 7 and 8 are not shown in the table because they did not contain enough households pre-project for changes in their incomes to be significant.

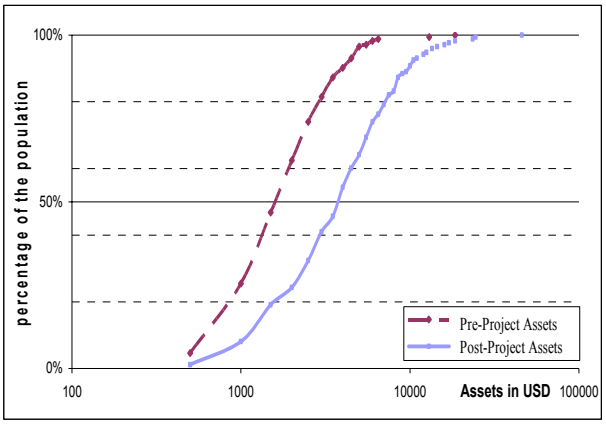
The evolution by group shows that groups 3 and 4 had the largest income increases (which correspond to the previously identified reduction of inequalities). Indeed, the high increase in agricultural incomes and incomes from mechanisation allowed them to change activity systems by giving up fishing and investing in extra-agricultural activities. Groups 5 and 6 are the ones whose agricultural incomes increased the most (which makes sense because the individuals in these two groups own the most land), but as these farms had invested heavily in fishing and logging, their total incomes rose just a little or even fell. Finally, total incomes for groups 1 and 2, that do not own farms, changed only a little (activity systems, however, changed considerably with a reallocation of activities). Numerous members of group 2 changed activities and started logging as employees of a small number of entrepreneurs.

The growth rate for total incomes in the polders was 10.8%, which corresponds to annual growth of 1.35%. This relatively low growth in an area undergoing real economic development can be explained by the very sharp drop in two of the most profitable activities in the area, which is mostly due to factors external to the project that partially mask an even more positive impact by the project.

- **Evolution in Assets**

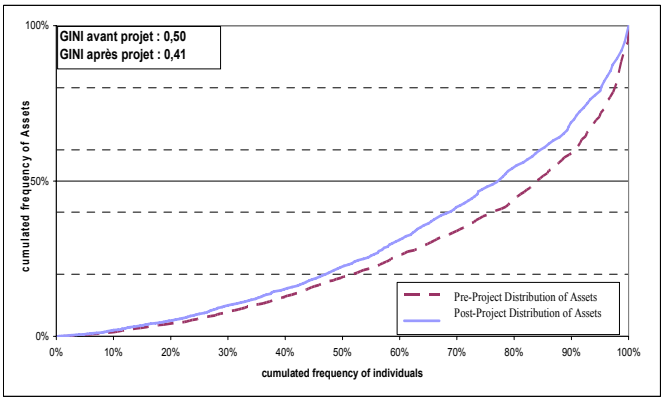
Assets increased significantly for most households. This increase was partially due to the increased value of land. However, as we shall show below, non-land assets also increased greatly.

Graph 7: Pre- and Post-Project Distribution of Assets in the Population



Source: Household survey (sample size: 173 households)

Graph 8: Lorenz Curves of the Pre- and Post-Project Distribution of Assets



Source: Household survey (sample size: 173 households)

Moreover, asset distribution was more egalitarian after the project than before. This evolution may seem paradoxical compared to the increase in land inequalities. Indeed, land assets were not the

source of asset equalisation, but rather non-land assets. Average farm households' non-land assets, and thus their investment capacities, increased the most (see Table 9, below).

This evolution in assets is confirmed by the breakdown by category of different types of assets. The essentially farm households (groups 3, 4 and 5) were the ones whose assets, and notably non-land assets, increased the most—with the exception of category 7 that comprises households whose incomes are only secondarily based on farming, and which have specific investment dynamics[11]. These households are in fact the ones that benefited the most from the project, and therefore are the ones whose incomes increased the most (above). It is not surprising that these are also the categories whose assets increased the most. Moreover, it's possible to show that the first categories invested more in productive assets, and that the higher categories invested more in non-productive assets.

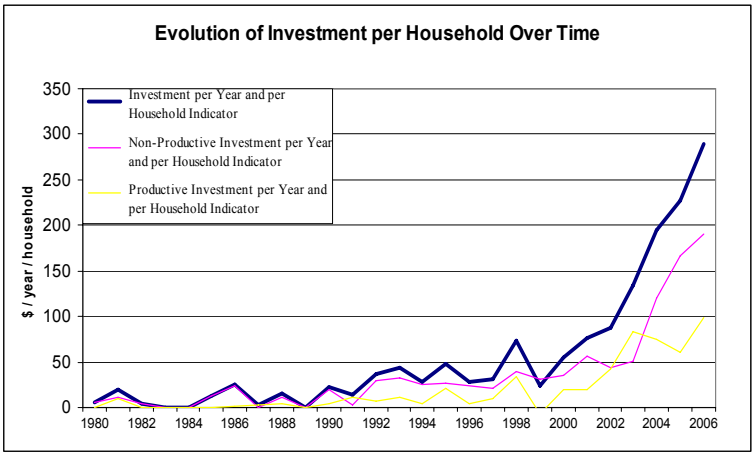
Table 9: Breakdown of the Increase in Assets during the Project

Pre-Project Category	Assets (including land)[12]	Assets (not including land)	Productive Assets	Productive Assets (not including land)	Non-Productive Assets
1	+25%	+25%	-100%	-100%	+39%
2	+119%	+26%	+193%	+20%	+31%
3	+134%	**+63%**	+192%	**+91%**	**+50%**
4	+125%	**+69%**	+152%	**+76%**	**+61%**
5	+130%	**+101%**	+115%	**+43%**	**+172%**
6	+104%	+56%	+160%	+97%	+22%
7	+ 258.9%	383.1%	229.9%	404.1%	367.0%
Total	140.6%	89.1%	163.7%	82.2%	94.8%

Source: household survey (sample size: 173 households)

This distribution of asset increases by category seems to show that assets increased the most among categories of farmers. However, in order to attribute this distribution to the project, one must verify that this increase in assets did indeed appear during the project. Chart 9 shows that investments grew sharply starting in 2001, the first year that the polders were (again) operational, and accelerated in 2003 (when irrigation began in polders 5 and 6, and the full effect on profitability and recultivation was felt).

Graph 9: Investment in the Polders



Source: household survey (sample size: 173 households)

[11] This group showed clear income growth but, as the group is very small, this growth did not impact the overall level of inequality.

[12] Before the project, the value of non-cultivated plots was not taken into consideration because they were almost freely accessible.

Investment capacity therefore increased strongly during the project, and mostly benefited average farm households. This evolution can therefore very probably be attributed to the increase in land productivity, and consequently to the project.

- **Group Changes**

All the previous quantitative indicators show that quality of life within the polders increased. But the qualitative study of group changes is one of the best indicators of the project's impact on precariousness. Indeed, the movement into a higher category shows that an economic threshold has been crossed.

As the survey was based on a semi-qualitative questionnaire, it was possible to understand household trajectories and, therefore, determine group changes.

Table 10 (below) shows the group changes that took place during the project.

Table 10: Category Change Matrix

Pre-Project Category (1998)	Post-Project Category (2006) 1	2	3	4	5	6	7	8	Total
1	**5**								5
2		**8**	1	3		2	2		16
3		2	**14**	**28**	6	3		3	56
4		4	2	**11**	**10**	5		1	33
5			1	6	**17**	**10**	3	3	40
6				1		**9**	3		13
7							**5**		5
8			1						1
New Arrivals			1	1	1			1	4
Total	5	14	20	50	34	29	13	8	173

In **bold**: category changes that account for more than 20% of the total (pre-project)

X number of households that moved to a "higher" category

X number of households that moved to a "lower" category

X number of households that stayed in the same category

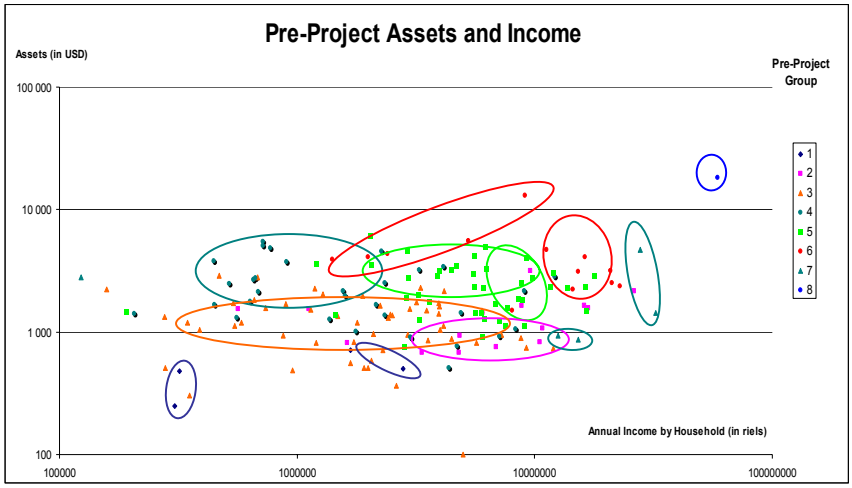
Source: household survey (sample size: 173 households)

Table 10 reveals that only 69 households (40%) stayed in the same category, 83 households (48%) moved to a higher category, and 17 households (12%) moved to a lower category. These group changes show strong upward socioeconomic mobility.

Most transitions to higher categories were due to the project, and notably the recultivation of plots, which was a powerful factor in economic change. These households have all gone through the stages of economic development essential to escape poverty and precariousness. Some households are in a situation of decapitalisation, either out of strategic choice to transmit an inheritance (gift of land to married children), or out of a need for cash to cope with an illness or other accident. Finally, some households benefited from the project without changing category (notably households whose agricultural production increased thanks to higher yields but that did not recultivate plots).

- **Summary Graphs**

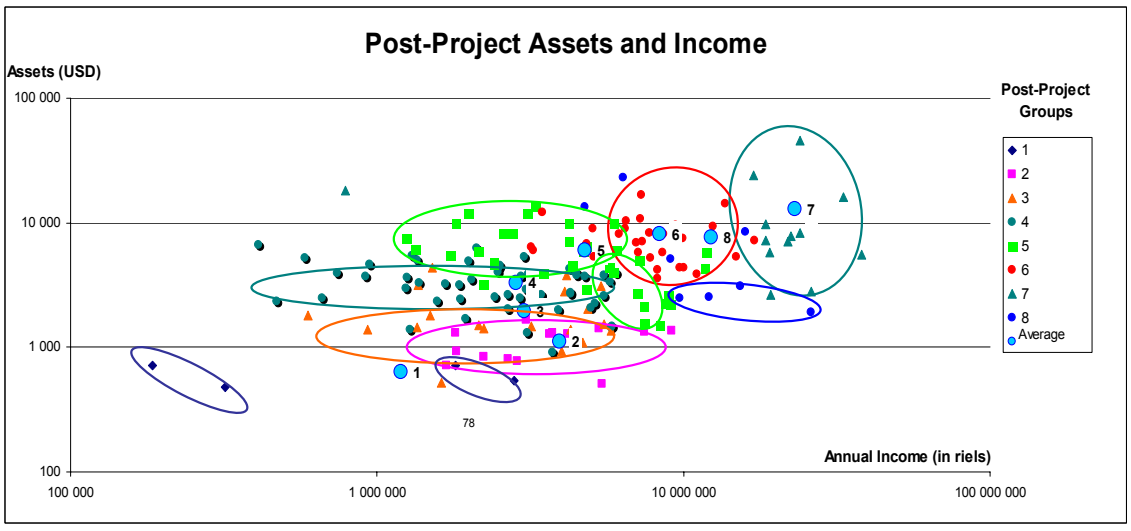
Graph 10: Pre-Project Assets and Income



Source: Household survey (sample size: 173 households), and activity profitability survey

A comparison of Graphs 10 (*Pre-Project Assets and Income)* and 11 (*Post-Project Assets and Income)* provides a visual image of how household wealth evolved. The categories, represented by ellipses on the graph, are the pre- and post-project groups. A clear shift of households towards the upper right corner of Graph 11 can be seen. Indeed, it has been shown that incomes and assets increased during the project. The shift is all the clearer when pre-project incomes were low. This shift corroborates the reduction in income inequalities, discussed above. One can also see some specific evolutions. The drop in fishing incomes can be seen via group 2, composed mainly of fishermen whose incomes stagnated (and therefore fell in comparison to the other groups). Similarly, the assets for groups 1 and 2 were particularly stable, while they increased for the other categories.

Graph 11: Post-Project Assets and Income



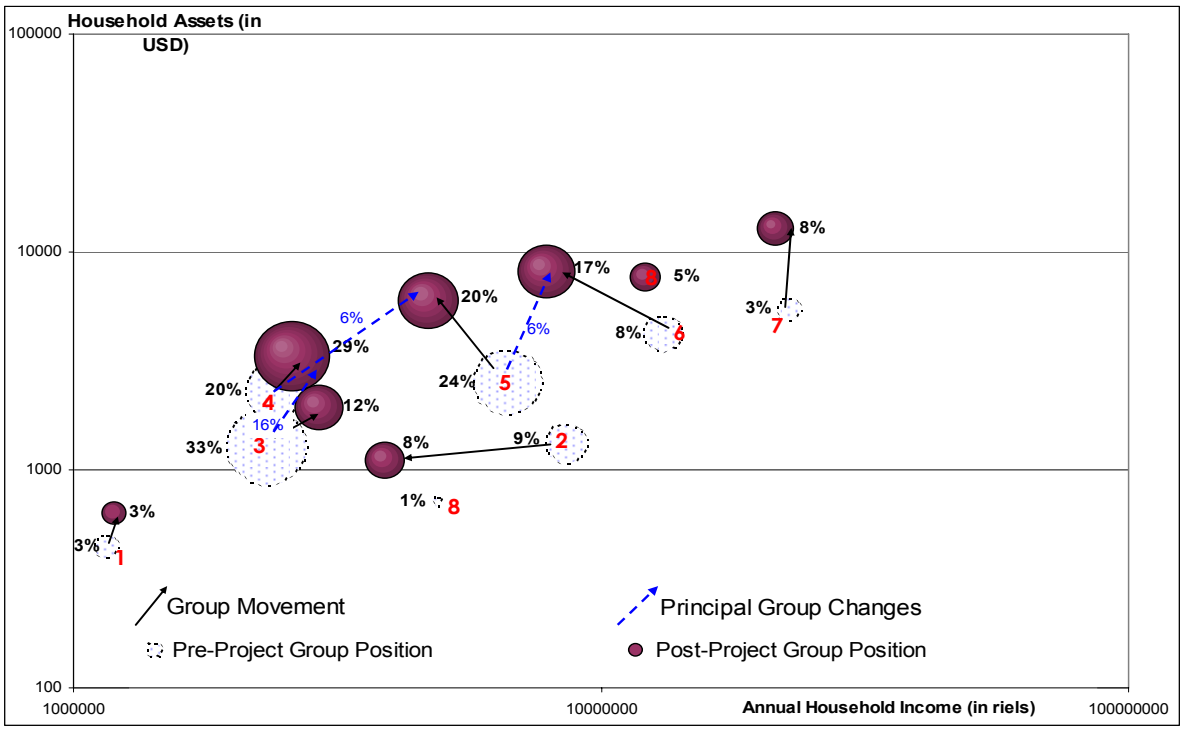
Source: Household survey (sample size: 173 households), and activity profitability survey

The number of points per group also shows the scope of category changes. The number of households in categories 4, 6 and 7 clearly grew, and group 3 shrunk.

All group changes and changes in asset and income levels are summarised in Graph 12 (*Group Evolution and Category Changes*), below. The categories are represented in the graph by circles that cor-

respond to the groups' average positions before and after the project. The circle size represents the number of households in the group. The main evolutions brought to light by the assessment can be seen in this graph. Changes in socioeconomic category are very clear (decrease in the size of group 3, numerous dotted arrows showing group changes to higher categories). Similarly, the increase in the incomes of slightly diversified farm categories (3 and 4) is considerable, while the groups with diversified finances had average incomes that fell under the joint effects of the arrival of less wealthy households and the reduction in fishing and logging for some households. This evolution confirms the drop in income inequalities discussed above.

Graph 12: Group Evolution and Category Changes



Source: Household survey (sample size: 173 households), and activity profitability survey

- The survey showed strong income growth in the area, except for fishing and logging activities, which fell sharply. Incomes from farming and mechanisation (directly impacted by the project) grew the fastest.
- Gains in rice production allowed 30% of the households, previously in deficit, to attain and surpass self-sufficiency and, by so doing, to take an important step upward.
- While maximum income gaps between poor and well-off households increased, the distribution of profits is clearly to the advantage of poor or average households, leading to a significant reduction in income inequalities.
- These income increases led to clear dynamics of investment in productive assets and housing improvement equally, which can clearly be attributed to the project. While maximum asset discrepancies also increased sharply between the poorest and the best-off, one can nevertheless see a slight reduction in assets inequalities that is more marked in middle-income categories.
- Overall, this economic vitality can be seen in farm trajectories and in strong upward social mobility: 48% of households moved to another socioeconomic category in less than 10 years.

Conclusion: a Vast and Varied Impact

The Prey Nup polders contain more than 10,000 households, almost 75% of which own farm plots. The rehabilitation of the polders therefore had a very strong overall effect on these households.

- The increase in rice production from 12,000 to 27,000 tons, and the diversification assistance provided had strong effects on agricultural incomes (+165.6% in 8 years, or more than 20% per year). The rise in agricultural incomes benefited large land owners the most (in function of the amount of land owned), but they also helped small owners and even landless farmers thanks to the development of indirect farming.

- The recultivation of 2,700 ha that had not been cultivated before the project also had a very positive effect on the population in the polders. Indeed, 1,950 families can now cultivate previously sterile plots of land. For these households, the project's benefits were massive, with rice production increases of several tons per year. A certain number of these households, which arrived in the area after land redistribution, were heavily in deficit before the project. Land recultivation was one of the main elements to explain socioeconomic category changes.

- Recultivation and the growth of agricultural production made it possible to increase the percentage of self-sufficient and surplus-generating households from 44% before the project to 74% after.

- A large number of well-off farm households entered into dynamics of economic diversification based on mechanisation and service provision (tiller, thresher, husking machine, etc.), which helped improve the productivity of the households that used these services, and consequently had redistributive effects.

- Although it was not the only source of increased household incomes, the growth in agricultural incomes made a major contribution to economic change. Indeed, pre-project agricultural incomes accounted for only 7% of total income in the area. After the project, as a result of population growth and a drop in incomes from fishing and logging, they accounted for 18%.

- The overall income increase led to significant changes in household incomes and assets, which had strong effects on socioeconomic differentiation. The survey on activity systems showed that 48% of households moved to higher socioeconomic categories, crossing important thresholds to escape poverty (from non self-sufficient farmers to surplus-generating farmers, from rice farmers with surpluses to farmers with diversified economic activities). Plot recultivation was a powerful factor that allowed movement from one category to another. These 48% of households were not the only beneficiaries, as 53% of those that did not change socioeconomic category saw an increase in their incomes and assets.

- The rise in land prices (through increased demand and plot registration) had an effect on all the owners whose assets increased automatically. By obtaining more assets without having to invest, these households are probably less vulnerable to urgent cash needs (medical care). Indeed, if the price of land doubles, they will have to sell 50% less land to pay for the same quality of care.

In a national context of sharply growing land inequalities, the polder area was also affected by this phenomenon. In this way, the growth in the number of households in the polders led to an increase in the number of landless households and an increase in land inequalities (via the fragmentation of the plots of households without other means of production).

- Nevertheless, the polder rehabilitation that affected a large number of farm households directly had numerous consequences on the reduction of inequalities:
    - The project made it possible to limit the phenomenon by preventing land grabbing, which is a large risk during any development project. This high concentration was prevented thanks to early identification of owners, strong communication during the first stage of the project, and probably also to the distribution of titles.
    - By increasing the amount of cultivable land and stimulating demand, the project allowed a redistributive, indirect farming (rental) market to emerge that allowed 30% of landless households to have a farm, and allowed some small farms to attain food self-sufficiency essential for economic development.
- This slight increase in land inequalities went hand-in-hand with a drop in socioeconomic inequalities. The vast majority of households saw a significant increase in their annual incomes and assets during the period. This is partially due to the project and its effects on farm incomes, and partially to changes in other incomes.
- While the increase in yields most benefited the households with the most land, and while well-off farmers' agricultural incomes increased, they are few in number and weigh only little on inequality measurements. In quantitative terms, the project mostly benefited the households in categories 3 and 4 (non self-sufficient and barely self-sufficient, little diversified farm households) that make up the vast majority of households in the area. These categories' incomes and assets rose very significantly, statistically lowering inequalities in wealth.
- In terms of assets, gaps also grew, but inequalities fell a little, this time in favour of middle-income categories.
- The 55 cases of falling incomes among the 173 households were either well-off households whose fishing or logging incomes dropped, households who lost capital because of health problems, or finally, households that transferred land to their offspring.
- In terms of the reduction of vulnerability, the impact is therefore quite clear, through the drop in the number of non self-sufficient households and the rise in income and assets for all households.

By extrapolating income gains revealed by the survey to the entire area, one can estimate a net increase in agricultural incomes of $1.5 to $1.8 million per year. The total cost of the project, including technical assistance, was $13 million over 9 years. The investment will therefore have paid for itself in approximately 7 years (5 of which have already passed). In vital economic contexts, polder rehabilitation is therefore a profitable public investment.

Beyond the physical rehabilitation of the hydraulic infrastructures, the project's lasting impact depends on the PUC's capacity to provide quality management and maintenance of these infrastructures, and on the government's capacity to fulfil its management commitments. The complete stabilisation of the contractual framework for management turn-over is one of the conditions for this.

By improving the incomes of a large number of households in the area and by affecting vulnerable farm households in particular, the project reduced poverty and, above all, its prevalence. Finally, it made these families more secure by allowing them to enter a dynamic of accumulation that lessens their vulnerability and plays an important role in preventing extreme poverty from increasing.

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Polder Rehabilitation, Agricultural Growth, and Inequalities

The Socioeconomic Impact of the Prey Nup Project (Cambodia)

Water management is one of the Cambodian government's priorities to increase the country's agricultural production and alleviate poverty. The Prey Nup polder rehabilitation project, which began in 1998 in the Sihanoukville region, falls within this framework. After eight years, the technical results are impressive: 10,500 hectares of rice fields rehabilitated, 2,700 hectares recultivated, rice yields increased from 1.6 to 2.7 t/ha. In addition, today, an elected Polder Users' Community is able to manage and maintain the infrastructures.

The massive increase in rice production is clear. But, in a Cambodian context marked by growing economic and land inequalities, one can wonder about the socioeconomic impacts of this increase: How were the profits distributed among the population? Did the rehabilitation significantly modify households' economic situations? Did it increase or lessen economic inequalities? What were the trickle-down effects on access to land and social differentiation?

Combining quantitative surveys of household finances and analyses of household trajectories, the economic impact assessment of the Prey Nup project provides answers to these questions:

- 1,950 very vulnerable households cultivate previously sterile plots. The benefits are considerable: a very strong increase in production and land values.
- Today, 74% of households are self-sufficient for food, compared to 44% pre-project.
- Nearly half of the households have made a qualitative leap, moving to a higher socioeconomic category.
- The income gap between households has widened, but as the gains are concentrated on a large number of small rice farmers, income inequalities (and asset inequalities to a lesser extent) have fallen.
- Because of the demographic pressure, there has been a noteworthy increase in the number of landless farmers. However, the increase in land inequalities was limited, which is remarkable in a land development zone where the risk of land grabbing was very high. In addition, these inequalities are partially offset by the creation of a redistributive rental market.

When initial land distribution is not too unequal and when land rights are secured, rehabilitating hydro-agricultural infrastructures in economically vital zones can, therefore, increase agricultural production and lessen inequalities.

Ministère des Ressources en Eau et de la Météorologie

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