



The Economic Impacts of PNDS Infrastructure Projects

July 2018



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A study prepared for the Ministry of State Administration
Government of Timor-Leste

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The Economic Impacts of PNDS Infrastructure Projects

Executive Summary

The *Programa Nasional Dezenvolvimentu Suku* (PNDS, or National Program for Village Development) is administered by the Ministry of State Administration in the Government of Timor-Leste (GoTL). PNDS enables villages to prioritize their local infrastructure needs and to construct projects through the provision of block grants (maximum \$70,000 per village). A total of 1,258 projects had been completed at the time this analysis began, of which 660 projects (52 percent) have significant economic impact – roads, bridges, clean water systems, irrigation projects and market structures. The objective of this economic impact study is to quantify the value of the PNDS economic infrastructure projects over a period of time for the communities which built them. The value of the projects over time can then be compared to the costs of the investments and an **Economic Internal Rate of Return (EIRR)** can be calculated for each type which will provide information to the GoTL on the relative efficiency of the investments, and their economic value to the communities.

All completed economic projects with a value of at least \$10,000 were sampled to yield 145 target projects throughout all municipalities in Timor-Leste outside the capital city. Surveys for each type of project were developed and enumerators were trained to select respondents and administer the surveys, with 1,926 completed surveys included in the analysis. **Roads, bridges, irrigation and clean water systems all exceeded the benchmark 12 percent rate of return for sound public investments** under the most conservative assumptions.

The calculation of the rate of return for **roads and bridges** includes the value of travel time saved plus the value of increased access to markets. When the increased value of sales from farmers' primary crop was incorporated, the result was strongly positive at a **25 percent rate of return** under the most conservative assumptions. Survey data revealed that farmers were transporting larger volumes and selling more to buyers, and that some buyers were now coming to the aldeia to purchase their primary output. In total 49 percent of respondents said that they now have better access to markets as a result of the new/upgraded road, and 41 percent of households that identified a person with a disability living there said that they now had improved access to health services.

The surveys for beneficiaries of **irrigation** projects contained a range of positive results. Farmers used irrigation systems **to change the composition of padi, maize and vegetables** they planted, increased the amount of padi they saved for home consumption and increased the production and sale of high-valued vegetables, with a resulting most-conservative **rate of return of 36 percent**. Findings did show that PNDS irrigation projects have leveraged construction of fishponds and are responsible for increased household consumption of fish protein.

Clean water systems are the largest category of projects in PNDS, accounting for 35 percent of all projects and nearly half the value of investment in the sample of economic projects. Time savings resulting from access to piped water is huge in Timor-Leste: 24 percent of respondents claimed that they now save more than two hours per day not carrying water, and beneficiary **households use both the time and often the water from the projects to increase their incomes**. The most conservative estimate of the value of only time saved generated a **rate of return** of 22 percent, which jumped up to **66 percent** when the value of direct and indirect uses of water were included. In addition, 5 percent of respondents reported that a person with a disability lives in their home. Of these, 82 percent said that they benefited from PNDS water, with 64 percent reporting improved health as one of the benefits.

Market facilities are a recent addition to PNDS activities, and only eight communities have invested in them – too few to calculate a rate of return, but enough to gain some lessons. **Out of the five projects** included in the sample, surveyors found **only three were operational**, although the buyers and sellers surveyed at these markets were generally satisfied with the project outcomes. The general picture of sellers is that the PNDS markets attract local sellers and those from outside the suco, and the sellers are mixed men and women. The men are younger and sell in multiple markets, bringing goods they buy from traders. The women sellers are older (on average) and are more likely to sell products produced by their household, extended family or neighbors. Markets are vulnerable to inadequate demand or supply, poor location, and/or weak management, and it is recommended that a simple but more detailed interview process be undertaken at all eight project locations to identify the key success or failure points and to develop a set of operational guidelines for market development.

The Economic Impacts of PNDS Infrastructure Projects

Introduction

The *Programa Nasional Dezenvolvimentu Suku* (PNDS, or National Program for Village Development) is administered by the Ministry of State Administration in the Government of Timor-Leste (GoTL). PNDS enables villages to prioritize their local infrastructure needs and to construct projects through the provision of block grants (maximum \$70,000 per village). In addition to the block grants, the GoTL provides technical and social facilitation assistance to build village-level organizational and implementation capacity. A total of 1,258 projects had been completed at the time this analysis began.

Study Objectives and Design

This study was intended to evaluate the impact of projects in PNDS which have clear, direct economic impact, namely roads, bridges, clean water systems, irrigation projects, and market structures throughout the country. The analysis follows a preliminary evaluation completed in 2016 with a small number of projects in just five municipalities, and was intended to be more comprehensive – a larger sample of projects and national in scope – and to incorporate a systematic analysis of useful results obtained from beneficiary interviews and limited qualitative experiments. Economic projects account for 660 out of 1,258 completed (or 52 percent of) PNDS projects. The project database for survey sampling was limited to completed projects with a value of at least \$10,000, and Dili Municipality was not included because of the very different infrastructure environment compared to the rural areas.

The study was a joint activity of the PNDS Secretariat, the PNDS Support Program and Timor Surveys. The PNDS Secretariat provided the overall umbrella for the work and coordinated the participation of field facilitators at the Municipality, Administrative Post and Village (Suco) levels. The PNDS Support Program contracted the lead consultant, the data consultant,¹ and Timor Surveys to implement the field surveys in all municipalities and provided operational support at all levels. Six instruments were developed, one each for roads and bridges, clean water, irrigation, market buyers, market sellers and Village Chiefs. The survey enumerators completed five days of training in Dili, and then conducted three days of test interviews in two municipalities outside of Dili, and their feedback was used to revise and refine the survey instruments. Individual surveys were completed in the field on electronic tablets, which were uploaded daily into a server. The surveys were reviewed semi-weekly by the data consultant and the Timor Surveys' field supervisor in order to clarify and correct errors and inconsistencies in responses. Once all surveys were completed, the data consultant provided the six data sets to the consultant for analysis.²

The main objective of the economic impact study is to quantify the value of the PNDS small infrastructure projects for the communities which built them over a fixed period of time.

¹ The surveys were implemented using ODK Collect, an open source application for survey data collection using tablets or smartphones. The data consultant coded the surveys and worked with Timor Surveys to provide clean data for analysis.

² While the study was a collaboration among partners, the analysis, conclusions and recommendations contained in this paper are the views of the Economic Impact Study (EIS) consultant. The consultant offers her sincere thanks for their excellent efforts, support, and good humor, without which this report could not have been prepared.

A straightforward but relatively narrow measurement is used, with all results expressed in a monetary value. The value of the projects over time can then be compared to the costs of the investments and an Economic Internal Rate of Return (EIRR)³ can be calculated for each type of infrastructure which will provide information to the GoTL on the relative efficiency of the investments, and their economic value to the communities.

Methodology

The study uses a sampling model to estimate the values of the economic projects. A key operational principle is to ensure the data are systematically conservative so that the resulting analyses do not over-estimate the actual results, and the calculated rates of return can be considered a minimum estimate.

The general approach is to use a two-part sampling process. First, a sample of representative projects is selected for the detailed survey. The second step is to survey a sample of beneficiaries for each selected project to develop average values for the responses. The sample should be sufficiently large for variations in responses to balance out, and outliers (unexplained very high and very low values) are typically discarded. The resulting averages are then applied to the overall population of project beneficiaries. The process is illustrated in greater detail in Annex 1.

For each type of project, a target number of survey respondents was specified for male and female beneficiaries together with a minimum number of total respondents needed to establish usable results as part of the overall database. Enumerators were also trained on methods for identifying respondents at various distances from the project – nearby, medium-distance and far – to get a sample distribution of project beneficiaries.⁴

Table 1. Target respondents

Type of Infrastructure	Target Male Respondents	Target Female Respondents	Total Minimum
Clean Water	*	15	10
Roads	10	10	10
Bridges	10	10	10
Irrigation	5	5	6
Markets	10	10	10

**Women are the predominant beneficiaries of clean water systems. Enumerators were provided with a target number of female respondents and were asked to interview as large a sample of men as was practical. This resulted in approximately one third male respondents for clean water.*

Sampling Methodology

The project database for sampling included all completed economic projects from the pilot phase through the start of the evaluation preparation in April 2018. The analysis did not limit its target projects to new construction only, as the 2016 survey demonstrated that many of the “new

³ Two aspects distinguish an economic internal rate of return. A) The EIRR incorporates economic elements in addition to strictly financial ones – this analysis includes an estimated (economic) value for time saved in addition to the financial value of increased sales. B) The term internal refers to the fact that the internal rate excludes external factors, such as inflation, the cost of capital, or various financial risks.

⁴ This is particularly important for roads, bridges and clean water systems that use “time saved” as the key tool for valuing impact.

construction” water projects included the renovation and expansion of old infrastructure, and the decision was made to include renovation subprojects in the data for sampling. Finally, it was decided to exclude projects with investments of less than \$10,000 to ensure the projects being analyzed were roughly comparable.

Based on these criteria, the PNDS database was sorted and 369 subprojects were identified in all municipalities that met all the criteria listed above. Time and financial constraints required sampling these projects, and a clustered sampling process was used. All Administrative Posts in each Municipality were assigned a computer-generated random number, sorted, and the Post with the lowest assigned random number in each Municipality was selected. All economic projects in that Post were included in the survey. This process yielded a good cross-section of environments in Timor-Leste, including some rural market centers and a range of remote and less-remote areas. Because of the small number of irrigation and market projects in PNDS, the number included in the cluster sample was smaller than desired, and the PNDS Secretariat and PNDS Program Support team agreed to some calculated adjustments. In two municipalities, similar Administrative Posts were exchanged in order to include additional irrigation and market projects. In addition, two market projects were added that were easily accessible by enumerators traveling to the selected sucos.⁵ The resulting sample is listed below in Table 2 by type and location. See Annex 2 for additional details on the projects.

Table 2. Sampled economic infrastructure projects

District	Subdistrict	Clean Water	Roads & Bridges	Irrigation	Markets	Total
Aileu	Remexio	6	9			15
Ainaro	Hatu Builico	2	1			3
Baucau	Vemassee				1	1
Baucau	Venilale	1	2	2	1	6
Bobonaro	Balibo	2	5	2		9
Bobonaro	Bobonaro				1	1
Bobonaro	Lolotoe	4	6			10
Covalima	Zumalai	8	4	1		13
Ermera	Atsabe	13	4	3		20
Ermera	Railaco	12	1			13
Lautem	Lautem	9	1	1		11
Liquica	Bazartete	9	6			15
Manatuto	Laclo	4	1	2		7
Manufahi	Alas	3	1	1		5
Oecusse	Nitibe	3	2	1	1	7
Viqueque	Viqueque	4	4		1	9
Total		80	47	13	5	145

Analytical Methodology

The analysis begins with common practices – the value of the projects for beneficiaries is estimated for the most recent full year, and based on this value, a stream of benefits is calculated extending a fixed number of years into the future. Because infrastructure is expected to decline in efficiency

⁵ The two markets added are located in Vemassee Administrative Post in Baucau Municipality, and Bobonaro Administrative Post in Bobonaro Municipality.

over time, the resulting stream of value is also likely to decline; the value stream is calculated to decline by a fixed percentage every year. The actual cost of the projects and the declining annual value stream are used to calculate an economic internal rate of return (EIRR).

A benchmark EIRR of 12% is typically used for development investments: if a project has an EIRR greater than 12% it is considered good value, and if a project has an EIRR less than 12%, it should be carefully considered. If the EIRR is less than 12%, it is possible for the investment to be justified based on other criteria, for example, other measures of value, the investment benefits certain disadvantaged groups, it redresses inequalities, etc.

Differences to the 2016 Analysis

Based on experience and feedback from the 2016 pilot study, a range of changes were made in this study. First, additional components were added to the surveys to gain a more complete picture of the impact of certain types of projects.

1. The 2016 analysis clearly identified the limitation of using the value of time saved as the sole measure for estimating the value of roads and bridges, and the omission from that survey of the important role roads and bridges play in increasing farmers' access to markets. This version of the survey included detailed before and after questions about the respondents' main agricultural product, types of transportation used, their cost, and how and where they sold their product.
2. The impact of clean water systems in the 2016 study was also based on the value of time saved annually collecting water. While this showed solid benefits, it was recognized that a more accurate value of clean water depends on how households use the water delivered to them (watering gardens and livestock to increase incomes) and on how they use the time saved for economic activities. Limited qualitative interviews from 2016 indicated these values could exceed the simple value of time saved, and a component was developed for the clean water surveys which compared these activities before and after the system was installed.

Second, a number of assumptions used in standard analytical practices of this type were identified in the 2016 pilot study that were considered inconsistent with the Timor-Leste environment and which could have resulted in an overestimate of the projects' value. To maintain consistency with the basic principle of making realistic and conservative estimates, this study made a series of important adjustments in the calculation methods to better reflect conditions in Timor-Leste. Overall, we call these the "Conservative Assumptions."

1. The 2016 study used the number of beneficiaries listed in the Management Information System (MIS) database for each project. Based on survey experience in the field, the number of beneficiaries in the MIS was thought to overestimate the true number. While the true number is unknown, the **number of beneficiaries for each project was halved**⁶ to provide a more conservative and realistic estimate.
2. Several of the standard calculations require valuing the time saved by beneficiaries as a result of the project, and this requires a value of labor. There are no reliable statistics on rural wages in Timor-Leste, but information from the Ministry of Agriculture and Fisheries (MAF) and several other sources put the estimated rural wage rate at \$5 per day. This was the best estimate

⁶ This was reduced further for irrigation systems, for reasons detailed that section.

available at the time, and is believed to overvalue the true opportunity cost of unskilled rural labor in Timor-Leste. No quality technical estimates for a shadow wage rate have been completed for Timor-Leste, but several other feasibility studies have used estimates ranging from \$2.00 to \$2.62 per day.⁷ This study uses an opportunity cost of labor of **\$2.50 per day**.

3. The standard analysis employed in the 2016 study uses an estimated investment lifespan of ten years for small infrastructure projects. This ten-year lifespan was generally confirmed in visits to clean water projects in 2016, where a number were found to be renovations and expansions of gravity-fed systems installed ten years earlier by IOM. However, environmental factors and limited maintenance can sharply reduce the useful lifespan of infrastructure in Timor-Leste, particularly for electrical equipment such as pumps used in more complex clean water systems. This analysis calculates values based on a **five-year investment horizon**.
4. The reduction from a 10-year lifespan to a 5-year lifespan was also accompanied by a **20 percent annual decline in the estimated stream of value** from the project, compared to the 10 percent annual decline utilized in the 2016 analysis.

⁷ Technically, this should be the “shadow wage rate” or the value of the marginal product of labor in the economy. The ADB estimated the shadow wage rate at 0.5 times the minimum wage rate (currently \$115 per month or \$5.25 per day) in estimating the returns for “Timor-Leste: District Capitals Water Supply Project,” <https://www.adb.org/sites/default/files/linked-documents/44130-022-tim-ea.pdf>. Similarly, the financial analysis for the ADB’s “Dili Urban Water Supply Sector Project,” (2006) used an estimated \$2.00 for the shadow wage rate (daily) in the sensitivity analysis, <https://www.adb.org/sites/default/files/project-document/65578/38189-tim-rfp.pdf>.

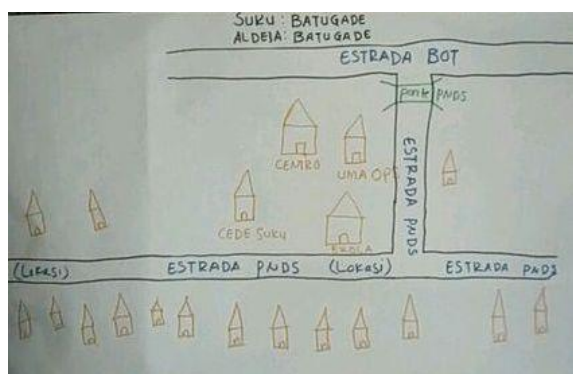
Economic Impacts of PNDP Roads and Bridges

A total of 742 respondents (346 men, 396 women) were surveyed about their use of PNDP road and bridge projects in the sample. The value of PNDP investments in the roads and bridges included in the sample totaled \$1,467,423, second largest investment behind clean water systems and 37 percent of the total sample investment.

Prior to the survey, the enumerators consulted with the Hamlet (Aldeia) Chiefs to determine a destination common to beneficiaries for each project (for example, a market, health center, etc.) that required the most frequent use of the project road or bridge. Beneficiaries were surveyed on the time it took them to reach the common destination before and after the project, during both the dry season and the rainy season.



*A rural road in Suco Baduro, Lautem
One of the PNDP infrastructure projects assessed*



*Example of a “common destination” map for a
PNDP roads and bridge project in
Suco Batugade, Bobonaro*

While estimating the value of time saved traveling to a common destination is the standard method for analysis, it is a small part of the value of roads and bridges in rural areas. As discussed above, a more complete picture of the value of the infrastructure to communities in Timor-Leste should include the impact on agricultural activities and access to markets, and a range of questions was added to the survey to estimate these.

Survey respondents were also asked about the type of transport used and the time required to reach the common destination in both dry and rainy seasons, both before and after the PNDP

road or bridge project to identify efficiency changes in modes of transport. Transport times were weighted by the proportion of dry and rainy months, and these weighted-average before and after times were compared to obtain the annual change in travel time.

Agriculture was assumed to be the most important source of household income in rural areas, and a range of questions were asked (before and after) about how the road or bridge would affect income from their most important crop, including:

- Whether buyers came to farmers to buy their harvest
- What kind of transport those buyers were using
- What kind of transport farmers used to take their product to buyers
- The cost of transport to buyers
- Production and revenues for their most important crop

The increased value of sales for their most important crop results was combined with the time savings to gain a more complete picture of real impact of investment in roads and bridges, and a more realistic rate of return. The detailed changes in transportation and new economic activities are described in sections further below.

Rate of Return

The conservative estimated rate of return (half the MIS beneficiary numbers, \$2.50 daily opportunity cost of labor, 5 year projected lifespan, 20 percent annual declining value stream) is outlined in Table 3.

Table 3. Estimated Rates of Return on Roads & Bridges

	Conservative Assumptions
total beneficiary households in sample	2,877
total value of time saved annually year 1	14,343
value of increased sales from main crop year 1	723,725
total investment in the sample	1,467,423
EIRR	25%

A yield of 25 percent EIRR was calculated, well above the 12 percent benchmark.

Transportation Changes

The results of questions about changes in transport and travel time are summarized in Table 4 below. The key observations from this table are that transport by foot and horse declined, while motorized transport increased, especially by pickup and big truck. This is an important indicator of improved access to agricultural markets, and the positive results are reinforced by the reduced average travel times. The large increase in average transport cost for big truck was curious, and the result comes from one aldeia which was inaccessible previously but where respondents reported they now pay \$40 (dry season) and \$50 (rainy season) for transport to the common destination. The answers were consistent from various respondents within the aldeia, so the data was retained.

Table 4. Types of Transport Used, Cost and Travel Time

	change in # respondents	change in average cost of transport to Common Destination	change in average # minutes to Common Destination
foot	-62	0.00	-23
horse	-4	0.00	-61
bicycle	0	0.00	0
motorbike	1	-0.78	6
own motorbike	6	-0.29	1
car	1	0.00	-4
own car	0	0.46	21
microlet	9	0.07	0
pickup	14	-0.16	-67
big truck	34	7.14	-5

The important results in this table indicate a shift away from walking and using horses, to increased use of pickups and big trucks – exactly what we would expect to see after building roads or bridges. This shift is also reflected in the section below detailing respondents' reasons for being satisfied with the project (they like being able to transport larger volumes of goods).

Table 5. Changes in Market Access

	before	after	% change
# farmers reporting that buyers come to them	542	600	11%
# farmers taking their crop to the buyer	293	306	4%
average cost to transport crop to buyer	1.03	1.27	23%
total revenues from main crop	387,000	564,400	46%

Important results from these two tables include:

- Farmers report that buyers are coming to them to buy has increased by 11 percent, representing a significant savings to farmers in both time and transport costs.
- Roughly the same number of farmers also report they are taking crops to buyers, implying a more diverse range of buyers when combined with the increased number of buyers coming to the aldeia.
- The average transport cost is higher, but the important factor is that farmers are able to shift from (free) foot and horse transport to (more expensive) motorized transport which is generally a benefit and indicates more efficient transport and bigger volumes.
- All these factors contribute to the 46 percent increase in revenues (and the overall positive satisfaction with the projects, below). Moreover, this dramatic increase is calculated only from the farmers' most important crop and does not include any benefits from other production and sales that might have occurred.⁸

New Economic Activities

Finally, the enumerators asked respondents if they had begun any new economic activities since the PNDS road or bridge was built, and nearly 60 percent of all those surveyed said they had added the following activities:

Table 6. New Economic Activities

	men	women	total	%
sell things in the market	116	108	224	33%
Other: (3 teachers, 2 civil servants, tais weavers & sellers, sellers of vegetables & animals)	60	42	101	15%
sell coffee	49	44	93	14%
opened a kiosk or shop	18	29	47	7%
make snacks, bread or other items to sell	7	15	22	3%
No new activity	52	98	150	22%
	302	336	*638	

**total number who responded to the question*

Respondents who reported new economic activities were also asked if the road or bridge had any impact on their business activities. The responses of the 426 who answered positively are included in Table 7 (more than one response could be selected, so percentages total more than 100%).

⁸ It is not possible to directly attribute all the increased income to the infrastructure, as increased production and sales could have been pushed by other factors, including weather. However, some degree of causality is likely and there is a strong correlation.

Table 7. Impact of the PNDS Road or Bridge on My Business

	#	%
better access to market	211	49%
easier to get supplies	202	47%
larger volumes can be transported	127	30%
buyers come to me	104	24%
transport is cheaper	71	17%



Two of the assessed PNDS bridges: on the left in Suco Fatumasi (Liquiçá), on the right in Suco Batumano (Ermera)

Beneficiary Satisfaction

Beneficiaries are generally happy with roads and bridges, with only six percent of overall respondents dissatisfied with the project results. Dissatisfaction was concentrated in two projects which had six or more dissatisfied beneficiaries each, and the rest were scattered among the other projects. Overall, women were somewhat happier with the roads and bridges infrastructure projects than men.

Table 8. Beneficiary Satisfaction with PNDS Roads and Bridges

	Men	%	Women	%	Total	%
very satisfied	9	3%	10	3%	19	3%
satisfied	217	66%	342	91%	559	79%
neither satisfied nor dissatisfied	70	21%	15	4%	85	12%
dissatisfied	34	10%	8	2%	42	6%
very dissatisfied	0	0%	1	0%	1	0%
	330	100%	376	100%	706	100%

Table 9. Reasons for Satisfaction and Dissatisfaction with PNDS Roads and Bridges

Reason Dissatisfied	#	%	Reason Satisfied	#	%
condition is poor	33	77%	condition is good	519	90%
doesn't save time	5	2%	saves me time	317	55%
doesn't help me save/earn money	6	14%	helps me save/earn more money	285	49%
too expensive to build	0	0%	not too expensive to build	201	35%
other projects more important	1	2%	most important project	27	5%
other	5	12%	other	9	2%
total dissatisfied or very dissatisfied*	43		total satisfied or very satisfied*	578	

**respondents could give more than one answer*

The primary reason beneficiaries were unhappy with the project is because they felt it was in poor or bad condition (77 percent of those unhappy), as noted in Table 9. The small number of unhappy respondents makes it difficult to compare the views of men and women, but they were roughly similar. Those respondents who were generally satisfied with the road or bridge project overwhelmingly reported they thought it was in good condition, and about half thought it saved them time *and* helped them either save money or earn money. How did men and women evaluate the satisfactory criteria? Satisfaction on all the elements was very similar with one exception: women were more impressed by the fact that it helped them earn more money (52 percent compared to 45 percent for men).

Disabilities

Finally, the enumerators asked respondents if any household members had a disability, and if yes, if they benefited from the road or bridge project. Five percent of respondents reported a disability in their household, which is just one-third the WHO's global estimate of 15 percent of the general population, but greater than the 3.2 percent reported in the 2015 Census. From those who reported benefiting from the road or bridge project, the most important benefits cited were improved access to health services (41 percent), and increased household income (30 percent).

Table 10. Disabilities

	#	%
Households with a disabled person	37	5%
<i>Reported benefiting from:</i>		
improved access to health services	15	41%
increased household income	11	30%
improved access to education services	6	16%
don't know	4	1%
no benefit	10	1%

Summary for Roads and Bridges

The most conservative assumptions yield a rate of return of 25 percent, well above the 12 percent benchmark rate, and indicate that rural roads and bridges are a valuable investment for Timorese. In addition, survey results indicate improved access to markets and buyers, and an overall increase in incomes. Respondents find infrastructure makes it easier to get supplies, increased the volumes they can transport, and nearly 60 percent have expanded economic activities since the infrastructure investment. Households with disabled members report they benefitted from improved access to health services and increased incomes.

Economic Impacts of PNDIS Irrigation



*Channel in the irrigation system
in Suco Usi-Taco, Oecusse*

Thirteen completed irrigation projects were listed in PNDIS' MIS for the target municipalities, with a total investment of \$424,536. All 13 projects were surveyed for the study. The MIS counts 1,433 beneficiary households for these projects, or an average of just over 110 households per irrigation project. Based on field experience, 30-50 households might benefit from an irrigation project, or roughly 400-650 households for the thirteen projects. Five hundred was selected as a conservative but realistic number of total beneficiaries.⁹

One hundred twenty-nine respondents (75 men and 54 women) were surveyed on their agricultural production and sales before and

after the irrigation project to assess the impact. The analysis starts with the rate of return based on farmers' total production of padi, maize and top four vegetable crops before and after the investment in irrigation. These are followed by survey results on livestock and fishponds, and finally by the summary data on revenues before and after for all types of production.

Rate of Return

Two cases are compared below: the results for the impact on crops only, and the combined results for crops, livestock and fishponds.

Table 11. Rates of Return on Irrigation

evaluation criteria	Conservative Assumptions
crops only	35%
crops, livestock & fish ponds	36%

First, the increased value of crops from irrigation-linked production was developed from the survey data (see the section below for detailed analysis) and applied to the adjusted beneficiary households (500), with a resulting EIRR of 35 percent -- well above the benchmark 12 percent. This was thought likely to underestimate the true rate of return because it does not include the increased sales from livestock and fishponds which are often linked to irrigation systems. However, the results indicate changes in livestock and fish consumption rather than financial returns are more likely at this stage, and the differences did not contribute significantly to the rate of return. If the minimum 12 percent benchmark is applied, irrigation projects overall clearly exceed the minimum for all scenarios and are worthwhile investments.

⁹ This method of estimating beneficiaries was thought to be more realistic than simply halving the number in the MIS, as was used for roads and bridges, and for clean water systems.

Irrigation-linked Production

This and the following section focus on the detailed production and revenue changes that have occurred since the irrigation projects were completed.

Table 12. Production and Sale of Padi Before & After PNDS Irrigation

harvest unit	Before PNDS Irrigation				After PNDS Irrigation				% increase production	% increase sales vol
	# farmers	# harvested	# sold	portion sold	# farmers	# harvested	# sold	portion sold		
Sack (<i>Karong</i>)	86	2028	271	13%	97	2,895	353	12%	43%	30%
Kilogram	0	0	0		1	1,500	-	0%		
Large Sack (<i>Karong Jumbo</i>)	5	9	0	0%	5	10	-	0%	11%	
Bucket Containers (<i>Balde</i>)	4	242	50	21%	5	412	100	24%	70%	100%

Survey techniques used in the 2018 survey were revised to gain greater accuracy on both volumes and revenues, which is not perfect but it's believed to be more accurate than the 2016 survey results. Table 12 above follows the production unit reported by farmers¹⁰ and does not attempt to equate kilograms to these units. While production increased across all units, the *karong*, or sack, remains the most common unit (91 percent of farmers measured their production in *karong*) and experienced a significant increase in production – 43 percent. Farmers reported selling almost the same portion of production (from 13 to 12 percent), but the total volume of sales increased sharply for these producers, who now report selling 30 percent more by volume. This indicates that padi saved for home consumption also increased in a roughly equal or slightly higher amount – a big increase in home consumption, a benefit that is not included in the EIRR calculation. Farmers measuring output in *Karong Jumbo* increased production by 11 percent – all for home consumption – but the base volume was modest. Finally, while farmers measuring their production in *balde*, or bucket containers,¹¹ doubled their sales volume, there were only four of these farmers and they started from a very small base.

Table 13. Production and Sale of Maize Before & After PNDS Irrigation

harvest unit	Before PNDS Irrigation				After PNDS Irrigation				% change in production
	# farmers	# harvested	# sold	% sold	# farmers	# harvested	# sold	% sold	
Karong	39	462	90	19%	30	440	87	20%	-5%
Futun	17	203	2	1%	22	606	330	54%	199%
Bidon	9	18	2	11%	8	14	3	21%	-22%

The change in production and sale of maize is an interesting contrast to padi. After irrigation was introduced, production of maize might have declined slightly in volume, but farmers made this

¹⁰ Facilitators and enumerators all agreed that farmers had good mental estimates of total harvest in their unit of choice and would be able to report the number of harvest units sold, even if the end unit of sale was different. They also agreed that each farmer would reliably know how many sales units were contained in each harvest unit. For example, a farmer would know how many *karong* of padi he produced, how many of those were sold, and how many sales units measured in cans are contained in each *karong*. This data combined with the farmer-reported price per sales unit was later used to generate revenue data.

¹¹ These can vary widely in volume, depending on the region. These irregular volumes are one of the main reasons the survey design was adjusted.

decision to shift into more desirable padi, and as seen below in Table 14, the much more valuable production of vegetables.

Table 14. Production of Vegetables Before & After PNDS Irrigation

	Before	After	% increase
# farmers growing 1st crop	54	81	50%
# farmers growing 2nd crop	48	78	63%
# farmers growing 3rd crop	28	61	118%
# farmers growing 4th crop	21	44	110%

Farmers were asked to identify their four biggest or best vegetable crops both before and after the completion of the PNDS irrigation system.¹² The farmer survey revealed a full range of vegetables are being grown, and the number of farmers growing vegetables has increased sharply (see Table 15), rising from an increase of 50 percent more farmers growing a first crop to more than doubling the number raising third and fourth crops. This type of expansion of activities is key to increasing agricultural incomes.

The survey included questions about all types of livestock raised both before and after the irrigation project, with the results in Table 15 below.

Table 15. Production of Livestock Before & After PNDS Irrigation – All Farmers

	Before				After				% change raised	% change sold
	# raised	# died	# customary obligation	# sold	# raised	# died	# customary obligation	# sold		
buffalo	136	39	16	20	142	41	16	14	4%	-30%
cattle	234	46	32	23	300	49	42	30	28%	30%
pigs	391	106	59	53	513	166	91	62	31%	17%
goats	227	92	34	19	253	135	38	27	11%	42%
chickens	970	332	45	149	1120	288	30	179	15%	20%
ducks	2	0	0	0	4	1	0	0	100%	

Several useful observations are obtained from the overall livestock survey data.

- The clearest conclusion from Table 15 is that very few farmers in the sample raise ducks.
- Farmers increased the total number of each type of livestock they raised during 2017. The reason for this is unclear, and besides having access to irrigation water, a good year without an El Nino drought could be an important factor as farmers rebuilt their stocks of animals lost during the drought.
- There was a substitution of cattle sales for buffalo sales. While the number of cattle raised increased and buffalo stayed roughly the same, farmers increased cattle sales and reduced buffalo sales by nearly a third. The reasons for this are unknown, although one possibility is that losses of buffalo and cattle differed during the drought and resulted in varying replacement strategies.

A more interesting question for this analysis is how did results compare for farmers who used PNDS irrigation water for their livestock (85 farmers, or 69 percent of the 124 farmers raising livestock

¹² The composition of crops often varied before and after.

reported using their irrigation water for livestock.) The results for these farmers are contained in Table 16 below.

Table 16. Production of Livestock Before & After PNDS Irrigation – ONLY farmers who used PNDS irrigation water for livestock

	Before		After		% change raised	% change sold
	# raised	# sold	# raised	# sold		
buffalo	104	15	98	13	-6%	-13%
cattle	180	16	232	27	29%	69%
pigs	243	27	294	37	21%	37%
goats	166	16	194	23	17%	44%
chickens	692	94	797	130	15%	38%
ducks	2	0	4	0	100%	

There are some similarities and some differences between the farmers who did and did not use PNDS water for their animals.

- Farmers who used PNDS irrigation water are still raising and selling fewer buffalo, but by a much smaller margin than their non-PNDS-using counterparts. That is, they reduced sales, but not by as much as their counterparts.
- Farmers who used PNDS irrigation water increased cattle raising activity by about the same proportion as their counterparts (29 compared to 28 percent, respectively), but they sharply increased their sales of cattle (69 compared to 30 percent).
- Farmers who used PNDS irrigation water increased all types of livestock production and sales by a greater proportion than their non-PNDS water-using counterparts.



*Three irrigation projects of which the economic impact was assessed.
Left to right: Suco Lacro (Ermera), Suco Cowa (Bobonaro), Suco Tiarlelo (Ermera)*

The last component of the survey was fishponds, which are a much smaller but increasing part of the agriculture portfolio for farmers in Timor-Leste. Survey results are shown in Table 17.

Table 17. Fishpond Production Before & After PNDS Irrigation

	before	after
# fishponds using PNDS water	0	11
# fishponds using non-PNDS water	6	5
total number	6	16

While the fishponds are currently producing very small revenues as shown later in Table 18, it is clear that PNDS irrigation projects have leveraged construction of fishponds and are responsible for increased household consumption of fish protein – a good thing. It will be interesting to see whether this also generates sales and income in the future.

Irrigation-linked Revenues

Based on detailed production and sales data obtained from farmers, the following revenue data were calculated for crops, livestock and fishponds.

Table 18. Value of Sales Before and After PNDS Irrigation

	Before	After	% increase
padi sales	\$ 5,664	\$ 6,655	17%
maize sales	\$ 1,073	\$ 2,324	117%
vegetable sales	\$ 23,119	\$ 85,698	271%
<i>subtotal</i>	<i>\$ 29,856</i>	<i>\$ 94,677</i>	<i>217%</i>
livestock	\$ 37,663	\$ 39,070	4%
fishponds	\$ 45	\$ 250	456%
Total	\$ 67,564	\$ 133,997	98%

Beneficiary Satisfaction

With such a sizeable increase in incomes, it is not surprising that only 10 percent of beneficiaries were dissatisfied with the irrigation projects.

Table 19. Beneficiary Satisfaction with Irrigation

	Men	%	Women	%	Total	%
very satisfied	10	13%	4	7%	14	11%
satisfied	58	77%	42	78%	100	78%
neither satisfied nor dissatisfied	1	1%	1	2%	2	2%
dissatisfied	6	8%	6	11%	12	9%
very dissatisfied	0	0%	1	2%	1	1%
	75	100%	54	100%	129	100%

Those dissatisfied with the project were unhappy with the condition of the project, lack of maintenance and frequent breaks, and insufficient water supply. Nearly all the farmers who were happy with the project agreed that irrigation was the biggest need and were happy with the condition of the project, with strong support for all the reasons suggested.

Table 20. Reasons for Satisfaction and Dissatisfaction with PNDS Irrigation

Reason Dissatisfied (n=13) (can choose more than one)			Reason Satisfied (n=114) (can choose more than one)		
	Total	%		Total	%
condition of the project is bad	10	77%	condition of the project is good	106	93%
not the most important need	0	0%	most important need	98	86%
doesn't provide more water	8	62%	can always get water	63	55%
water is too expensive	0	0%	division of water more even	39	34%
too expensive to build	0	0%	not too expensive to build	38	33%
no maintenance, often breaks	5	38%	can plant wider variety of crops	36	32%
no buyers for production	0	0%	more harvest per year	28	25%
other	0	0%	can solve pest problems	12	11%
			other (fields protected from river)	2	2%

Disabilities

The occurrence of disabilities among beneficiary households for irrigation was low, just 8 out of 129 surveyed households, or six percent – higher than the 3.2 percent reported in the 2015 Census. Less than half thought the disabled did not benefit in any way from the irrigation project, while the remainder thought they benefited from higher incomes, either in general, spent on food or on medical services.

Table 21. Benefits of the PNDS Irrigation Project for the Disabled

	#	%
do not benefit	3	38%
more income	2	25%
more income for medical services	2	25%
more income for better food	2	25%
don't know	0	0%

Summary for Irrigation

Farmers used irrigation systems **to change the composition of padi, maize and vegetables** they planted, increased the amount of padi they saved for home consumption and increased the production and sale of high-valued vegetables, with a resulting most-conservative **rate of return of 36 percent**. Findings also showed that PNDS irrigation projects have leveraged construction of fishponds and are responsible for increased household consumption of fish protein.

Economic Impacts of PNDS Clean Water Systems

A total of eighty completed clean water systems were identified in the PNDS MIS in the sample locations. Clean water projects are the largest category of investments selected by communities throughout PNDS (35 percent of all projects). The total investment in the 80 PNDS water projects in the sample was \$1,941,477 (49 percent of the total sample project investment).

The enumerators found that six out of the eighty clean water systems were no longer functioning, although they had in the past. These are identified in Table 22 below. Three of the cases cite lack of money for repairs, indicating that O&M was not, or not adequately, supported through user contributions. There is no clear reason why half of the cases occurred in Bazartete, but further exploration by the PNDS Support Team might yield some useful insights.

Table 22. Broken Water Systems

project survey #	Municipality	Administrative Post	Suco	Reason not working
0429	Bobonaro	Lolotoe	Lupal	Broken and no money to repair
0535	Covalima	Zumalai	Tashilin	Broken and no money to repair
0945	Liquica	Bazartete	Lauhata	Broken and community won't repair
0948	Liquica	Bazartete	Maumeta	Damaged by another village
0960	Liquica	Bazartete	Ulmera	Pump broken and no money to repair
1132	Manufahi	Alas	Dotic	Pipe burned

In total 1,015 respondents (336 men, 679 women) were interviewed from 74 active projects, plus an additional 93 respondents were identified from non-working projects but their genders were not recorded. A total of 1,108 surveys represented 5,185 beneficiary households for the 80 projects.¹³ The survey asked beneficiaries detailed questions about the time required (before and after) to collect water and household consumption of water. Additional sections of the surveys included questions about the economic impacts of access to water, focusing on a) how they used PNDS water resources, and b) how they utilized time saved by no longer carrying water.

Rate of Return

While the time saved carrying water is substantial throughout Timor-Leste, it does not tell us how households are using their new water resources or time savings to increase their incomes or family welfare. For this reason, the survey included a section of detailed questions on before and after agricultural, livestock and fishpond production and sales and their linkage to water resources, as well as other economic activities. When these activities are included in the value stream under the most conservative assumptions, the rate of return doubles from its already-significant 22 to 66 percent.

Table 23. Rate of Return on Clean Water Systems

	Conservative Assumptions
value of time saved only	22%
time saved plus ag & livestock	66%

¹³ Half the number listed in the PNDS MIS.



Based on the responses summarized in Table 24, access to water remains a significant challenge for households in rural Timor-Leste. If we apply the average of the 1,108 responses from the surveys to 5,185 beneficiary households (half the number listed in the MIS) in the sample for clean water projects, more than eight hundred households in the sample areas are now saving *three or more hours every day* by accessing clean water in their aldeia, and more than 40 percent of all beneficiaries are saving an hour or more. Note this includes the six non-operational projects saving zero time daily.

Jerrycans waiting to be filled at a water point in Suco Fadabloco, Aileu

Table 24. Time Saved not Carrying Water

	# Respondents	% Respondents	Half of MIS Beneficiary Households
Households saving up to 1 hour each day	635	57%	2,971
Households saving 1 up to 2 hours each day	200	18%	936
Households saving 2 up to 3 hours each day	100	9%	468
Households saving 3 up to 4 hours each day	60	5%	281
Households saving 4 or more hours each day	113	10%	529
Total	1,108		5,185

Water Consumption

Changes in water consumption were expected to be difficult to quantify for several reasons discovered as part of the 2016 Economic Impact Study. The survey results from the 2016 study indicated that about a quarter of respondents reported consuming *less water* than before the clean water project, yet they were satisfied with the project. Moreover, numerous studies have confirmed that water consumption typically increases after the installation of piped water systems. What was discovered then and explicitly confirmed with this survey is that beneficiaries knew how much water they carried and used every day from a distant water source because it was typically carried in a fixed number of plastic *jerrigan* or similar containers. However, once a water distribution point is built near their house, 58 percent reported bathing and washing clothes at the distribution point and carrying a limited amount of water back to the house for household consumption. They didn't know



Washing clothes at the water point saves households carrying water to their homes

how much water they are actually using, but they are *carrying* less water home. Based on this information, a question was added to the survey asking respondents if they thought they were using more, the same amount, or less water than before the project. 60 percent of all respondents said they were using more water, and another 31 percent said they were using about the same.

Use of Water



A woman in Suco Faturasa, Aileu, grows vegetables with water from a nearby public tap

An additional set of questions concerns respondents' use of PNDS water to generate revenues by using water and/or extra time in gardens and caring for livestock and fishponds. Some of these activities use PNDS water to improve their livelihoods, for example watering animals using PNDS water and using PNDS water to grow and sell vegetables, thus providing a direct contribution. For other increases in production, PNDS water could be viewed as an indirect contribution, in that substantial time savings from no longer having to carry water long distances could be used to increase production in respondents' gardens, caring for their animals, or building and

cultivating fishponds. Alternatively, extra time could be used in non-agricultural economic activities, for example, making and selling snacks or selling goods in the market.

Survey responses show that the size of gardens did not change much before and after the installation – they increased by an average of only three percent. But 45 percent of respondents indicated they are using PNDS water in at least part of their gardens, and a comparison of revenue changes between those who do use PNDS water in their gardens and those who do not reveal some differences.

Overall, everyone did better the year after the PNDS clean water project. The reasons for this are unclear – it could be due to recovery after a drought, more effective use of household labor resources with the time saved from carrying water, or a direct benefit of access to piped water. The first distinction is that revenues from gardens of those who now use PNDS water averages over \$900 per household,¹⁴ while those who do not use PNDS water in their gardens have an average revenue more than double that amount – nearly \$2000. The second distinction is that those with the smaller annual revenues from their gardens have seen that increase more quickly than those who do not use PNDS in any part of their garden – that makes sense and is an important positive impact of the projects.

Table 25. Changes in Garden Revenues

	#	before	after	change	% change
use PNDS water	207	\$ 157,180	\$ 194,673	\$ 37,493	24%
don't use PNDS water	255	\$ 449,803	\$ 504,305	\$ 54,502	12%
	462				

¹⁴ Home consumption levels are unknown.

A larger number of respondents (57 percent) are using the water investments to care for livestock and there are also distinct differences between those who do and do not use PNDS water for their animals. The tables below compare the number of animals raised before and after the clean water project, along with the changes in revenues.

Everybody reduced the number of buffalo they raised, and increased investments in all other types of livestock. However, those who did not access PNDS water for livestock had smaller proportionate increases for every other type of animal. The data on revenue changes adds to the picture. Those not using PNDS water sold their buffalos – revenues jumped more than four-fold while the numbers declined.



Goats raised with water from a PNDS clean water system in Suco Euquisi, Lautem

Table 26. Number of Livestock Raised

	no PNDS water (n = 469)				PNDS water (n = 638)			
	before	after	change	% change	before	after	change	% change
buffalo	216	202	-14	-6%	296	266	-30	-10%
cattle	610	678	68	11%	1020	1229	209	20%
pigs	887	1149	262	30%	1592	2293	701	44%
goats	393	462	69	18%	581	890	309	53%
chickens	1861	2301	440	24%	3870	5243	1373	35%
ducks	12	18	6	50%	37	64	27	73%

Table 27. Livestock Revenues

	no PNDS water (n = 469)		PNDS water (n = 638)	
	change	% change	change	% change
buffalo	\$ 7,750	456%	\$ 1,300	20%
cattle	\$ 7,070	59%	\$ 37,150	107%
pigs	\$ 4,403	53%	\$ 16,770	68%
goats	\$ 1,317	150%	\$ 1,650	76%
chickens	\$ 122	14%	\$ 3,402	89%
ducks	\$ -		\$ -	0%
total	\$ 20,662	87%	\$ 60,272	84%

The results for livestock differ somewhat from those for gardens. As with garden revenues, everyone (on average) earned more money from livestock the year after the PNDS clean water project – also for unclear reasons. However, the data show that households who used PNDS water to care for livestock increased their revenues by an average of \$94, while households who did not enjoyed an average increase of only \$44 – the reverse of the results for gardens.

Table 28. Fishponds

# before	# after	increase	%
7	22	15	214%



There were few fishponds among the respondents, but the number has tripled since the PNDS water systems were built. While none reported using PNDS water in these and none were selling the fish produced, household consumption has increased. Fishponds are likely improving household consumption of protein, but they do not yet play a role in increasing incomes.

Excess water at a public tap is used for fishponds in Suco Loi-Huno, Viqueque

The summary table below presents the outline of key relationships between clean water investments and responses in garden and livestock cultivation. Households with larger livestock sales have used PNDS water to increase their average revenue at a rate greater than households who do not use PNDS water for livestock. On the other hand, households who use PNDS water for at least part of their garden have smaller incomes from their gardens and the increase they have seen is smaller than for those who do not use PNDS water.

Table 29. Summary of Average Revenue and Changes

	garden revenues after	average change	livestock revenues after	average change
use PNDS water	\$ 940	\$ 181	\$ 207	\$ 94
don't use PNDS water	\$ 1,977	\$ 213	\$ 95	\$ 44

New Economic Activities

Survey respondents were also asked about new economic activities they were undertaking since the PNDS water system was completed – an indicator of indirect economic benefits from improved access to water. About half the respondents said their economic activities had not changed since the PNDS water system was completed, while the other half reported they had new activities.¹⁵ Those who reported “Other” activities include four people now working as teachers, two are working for the government, numerous producers of tais, and a carpenter, a rice & maize milling operator, a wage worker, a trader, and a large number of people reported informally selling their vegetables within their community.

Table 30. Summary of New Economic Activities

<i>(respondents could select more than one response)</i>	men	women	total	%
I sell goods in the market	98	132	230	23%
I opened a kiosk	32	76	108	11%
I cultivate coffee	52	47	99	10%
I make cakes, snacks or other food, and sell them	7	40	47	5%
Other	28	41	69	7%
My activities are the same as before the PNDS water	160	411	571	56%

¹⁵ Respondents could choose all relevant activities, and as a result the total responses are slightly larger than the number of respondents.

Taken together, these indicators show that communities are eager to increase incomes and are creative in using all resources available to them. This supports the high rate of return on PNDS clean water projects.

Beneficiary Satisfaction

Patterns of beneficiary satisfaction on working clean water projects are similar for men and women. Overall, 87 percent of all beneficiaries are satisfied or very satisfied with the clean water projects, while just seven percent are dissatisfied or very dissatisfied (see Table 31).

Table 31. Beneficiary Satisfaction for Working Clean Water Projects

	Men	%	Women	%	Total	%
very satisfied	35	10%	42	6%	77	8%
satisfied	264	79%	545	80%	809	80%
neither satisfied nor						
dissatisfied	19	6%	44	6%	63	6%
dissatisfied	15	4%	45	7%	60	6%
very dissatisfied	3	1%	3	0%	6	1%
	336	100%	679	100%	1015	100%

This data covers respondents for working water systems. If we include the six non-working water projects in the data with 93 respondents,¹⁶ and assuming these would all be unhappy customers, the numbers shift as in Table 32. When these are included, the overall level of satisfaction is still relatively high at 80 percent.

Table 32. Beneficiary Satisfaction for ALL Clean Water Projects

	total	%
Very satisfied or satisfied	886	80%
Neither satisfied nor dissatisfied	63	6%
Very dissatisfied or dissatisfied	159	14%
Totals	1108	100%

The reasons for unhappiness with the water projects are that the system doesn't work well and there is not enough water to meet needs. The reasons beneficiaries are happy with the system covers all possible responses.

Table 33. Reasons for Satisfaction and Dissatisfaction with PNDS Clean Water Projects

Reasons Dissatisfied	#	%	Reasons Satisfied	#	%
Not enough for my family	50	5%	I have access to water	686	68%
Not an important need	0	0%	most important need in our aldeia	655	65%
Doesn't work well	32	3%	The water system works well	577	57%
Not enough for the aldeia	50	5%	Everyone has access to water	535	53%
			It saves me time	500	49%
Water is expensive	0	0%	It was not too expensive to build	128	13%
			Quality of the water is better	316	31%
			It helps me earn extra money	175	17%

¹⁶ The surveys averaged 15 respondents per project, so 93 respondents for six non-working projects is consistent with the average.

Disabilities

Respondents reported that 50 households had a member with a disability, or 5 percent of the total surveyed. It is interesting to note that respondents do not report increased income as benefitting their disabled members. It is not clear whether they don't link increases in income to the PNDS water project even though they were clearly reported in the earlier part of the survey, or if they don't see this as a benefit to the disabled. This clearly contrasts with the results from roads and bridges respondents.

Table 34. Benefits of PNDS Clean Water for the Disabled

	#	%
Yes, benefitted from PNDS water	41	82%
Improved health	32	64%
Easier to care for	9	18%
Household income increased	0	0%
Don't Know	0	0%

Summary for Clean Water Systems

Time savings resulting from access to piped water is very large in Timor-Leste: 24 percent of respondents claimed that they now save more than two hours per day not carrying water, and beneficiary **households use both the time and often the water from the projects to increase their incomes**. The most conservative estimate of the value of only time saved generated a **rate of return of 22 percent**, which jumped to **66 percent** when the value of direct and indirect uses of water were included. In addition, 5 percent of respondents reported that a person with a disability lives in their home. Of these, 82 percent said that they benefitted from PNDS water, with 64 percent reporting improved health as one of the benefits.

Economic Impact of Markets

A small number of local markets has been built through PNDS – a total of only eight – and five of these were included in the survey sample. While this is too small a number to obtain a valid rate of return, the project team wanted to look at their performance to date and see if there were any lessons to be learned from their short period of implementation. A total of \$139,881 has been invested in the target sample markets, compared to the \$183,887 in all PNDS markets. The MIS reports the sample markets have 4,805 beneficiaries.



The mini-market in Vemassee, Baucau

Of the five projects included in the sample, only three of the markets were active; two locations had ceased operating. Markets fail because of inadequate demand or insufficient supply, and even if these are satisfied, a market can fail to be viable because of poor location or poor management. It would be very useful to do a more detailed set of interviews at these locations to obtain a deeper understanding of the underlying reasons for success or failure of the individual markets.

Surveys were administered to both buyers and sellers at the three operating markets.

Buyers

Twenty-one buyers (3 male, 18 female) were interviewed at the three markets about their buying habits and transport costs before and after the PNDS market was completed.

About the same number accessed the PNDS market on foot as they did the previous market. Those who used transport before and after the PNDS market save more than half the cost of transport, and it takes less time to get there. All of these are neutral or positive results.

Table 35. Market Usage and Transport

	total #	# using transport	transport cost	time to mkt
PNDS weekly visits	21	9	\$ 0.44	19
Other market weekly	5	5	\$ 1.45	44
Other market monthly	1	1	\$ 1.45	44
Market before PNDS	21	8	\$ 1.19	28

More than two-thirds of the buyers meet all their market needs through the weekly PNDS market, while six of the buyers at the PNDS market supplemented their regular shopping by visiting another market either weekly or semi-monthly. The PNDS market is closer than both the other market and the market used before the PNDS market opened – it takes an average 19 minutes for buyers to reach the PNDS market and 44 minutes to reach the other market, compared to 28 minutes to reach the pre-PNDS market.

One reason for shopping at an additional market might be that the other market has goods that are lacking in the local market, and responses on purchases were compared. Table 36 below shows that consumers are purchasing the same types of goods in both markets, although there might be differences in quality and/or variety of goods that are not captured here. These three PNDS markets appear to have a full range of products, which likely contributes to their success.

Table 36. What do you Buy at the Market?

	veg	fruit	meat	eggs	packaged food	sembako*	household items	clothing & shoes	plastic goods	pots pans utensils
PNDS mkt	18	10	1	1	9	8	18	3	7	1
Other mkt	4	3	0	0	0	2	3	1	2	1

*sembako is a category of basic goods such as rice/cassava, sugar, cooking oil, corn, and salt.

Buyers' Satisfaction



Mini-market in Suco Lela-Ufe, Oecusse

Only one respondent out of the limited number of 21 buyers surveyed was unhappy with the market, which is generally a good result. This person thought the market was in poor condition, although 76 percent of respondents thought the condition of their market was good. In exploring the reasons for success and failure of markets, both the management and financing of operations & maintenance should be considered.

Table 37. Buyer Satisfaction

	Men	%	Women	%	Total	%
very satisfied	0	0%	3	14%	3	14%
satisfied	3	14%	14	67%	17	81%
neither satisfied nor dissatisfied	0	0%	0	0%	0	0%
dissatisfied	0	0%	1	5%	1	5%
very dissatisfied	0	0%	0	0%	0	0%
total	3	14%	18	86%	21	100%

Table 38. Buyers' Reasons

Reason Dissatisfied	#	%	Reason Satisfied	#	%
can't buy what I need	0	0%	can buy what I need	18	86%
not the most important project	0	0%	most important need	17	81%
condition of the market is bad	1	5%	condition of the market is good	16	76%
doesn't save any time	1	5%	saves me time	12	57%
it was too expensive	0	0%	not too expensive	9	43%
doesn't save any money	0	0%	saves me money	6	29%
other	0	0%	other	0	0%

Sellers

The general picture of sellers obtained from the data is that the PNDS markets attract local sellers and those from outside the suco, and the sellers are mixed men and women. The men are younger and sell in multiple markets, bringing goods they buy from traders to the markets by transport. The women sellers are older (on average) and are more likely to sell products produced by their household, extended family or neighbors. Women also sell in multiple markets.

Table 39. Seller Demographics

	#	average age	live outside suco
male	6	27	5
female	14	45	6
total	20	40	11

Twenty sellers (6 men, 14 women) were interviewed at the three markets about their selling activities and transport costs before and after the PNDS market was completed. Male sellers tend to be substantially younger than their female counterparts, 27 vs. 45 years old. Eleven of the 20 sellers (more than half the total) live outside the suco where the PNDS market is located, including five of the six male sellers. Four of those men also sell in another market. From this limited data, it appears that younger men are taking up trading, and are likely to sell in multiple markets.

About half the sellers live nearby and traveled to the PNDS market on foot – their average travel time is just 18 minutes, including three sellers who live outside the suco. Sellers who used transport paid an average \$1.45 and traveled over an hour to get to the PNDS market.

Table 40. Transport to PNDS Market

	#	avg cost	avg time	live outside Suco
non-motorized	9	\$ -	18	3
motorized	11	\$ 1.45	73	8
total	20			11

About half of the vendors sell goods they, their family or neighbors produce. More interesting, nearly all of the male sellers sell goods sourced from traders. If one objective of building markets is to develop the local economy by selling local produce, women sellers should be encouraged.

Table 41. Source of Goods Sold

men	women	total	source
6	7	13	trader
0	9	9	grown by my household
1	4	5	neighbors
0	1	1	from family not my household
0	0	0	other

Twelve of the vendors also sell at another, non-PNDS market. Four of the sellers walk to the other market – a bit further than the PNDS market, at an average 31 minutes travel – and eight use transport for well over 1.5 hours.

Table 42. Transport to Other Market

	#	avg cost	avg time
non-motorized	4	\$ -	31
motorized	8	\$ 2.56	102
total	12		

Sixteen of the sellers sold in another market before the PNDS market began operating, with four sellers starting activity when the PNDS market was built. Sellers were asked to identify an average range of revenues from each market session, and they did this for the PNDS market, the other market they currently sell in, and their market sales before the PNDS market. Sellers were also asked about their cost of goods to gain some insight on their profitability, but these are unlikely to be reliable and about half responded that they didn't know. The results are shown below in Table 43 and indicate average revenues might be slightly higher in the other market than in the PNDS market. There are several possible explanations for this, including being a result of self-selection by the better sellers, or the PNDS market might be a smaller scale with lower revenues. Average revenues before the PNDS market are concentrated at the lower end of the scale, indicating the 16 sellers who have moved into the PNDS market are earning at least the same or possibly more money.

Table 43. Revenues and Costs

PNDS Market Sellers				Other Market Sellers			Sellers before PNDS		
revenues	%	cost of goods		revenues	%	cost of goods	revenues	%	cost of goods
<\$5	0	0%	1	0	0%	0	0	0%	0
\$5-\$10	5	25%	3	2	17%	2	5	42%	3
\$10-\$20	6	30%	1	4	33%	1	3	25%	2
\$20-\$50	2	10%	3	1	8%	2	3	25%	2
\$50-\$100	6	30%	0	5	42%	1	4	33%	1
>\$100	1	5%	1	0	0%	0	1	8%	1
Don't know	0	0%	11	0	0%	6	0	0%	7
Total sellers	20			12			16		

Sellers' Satisfaction

Overall, sellers are happy with the PNDS markets and none of the surveyed sellers reported being dissatisfied. The reasons they gave in Table 45 indicate the most common responses came from "There are always buyers," (80 percent), "It helps me make money," (75 percent) and "The condition of the market is good," (70 percent).

Table 44. Sellers' Satisfaction with PNDS Markets

	Men	%	Women	%	Total	%
very satisfied	1	5%	0	0%	1	5%
satisfied	5	25%	13	65%	18	90%
neither satisfied nor dissatisfied	0	0%	1	5%	1	5%
dissatisfied	0	0%	0	0%	0	0%
very dissatisfied	0	0%	0	0%	0	0%
	6		14		20	100%

Table 45. Sellers' Reasons

Reason Dissatisfied			Reason Satisfied		
	#	%		#	%
not enough buyers	0	0%	there are always buyers	16	80%
doesn't help me make money	0	0%	it helps me make money	15	75%
condition of the market is bad	0	0%	condition of the market is good	14	70%
it doesn't save time	0	0%	it saves time	11	55%
other projects were more important	0	0%	most important need in aldeia	11	55%
too expensive to sell there	0	0%	not too expensive to sell there	9	45%
<i>(respondents could choose more than one response)</i>			Total respondents	20	

Summary for Markets

Out of the five projects included in the sample, surveyors found only three were operational, although the buyers and sellers surveyed at these markets were generally satisfied with the project outcomes. The general picture of sellers is that the PNDS markets attract local sellers and those from outside the suco, and the sellers are mixed men and women. The men are younger and sell in multiple markets, bringing goods they buy from traders. The women sellers are older (on average) and are more likely to sell products produced by their household, extended family or neighbors. Markets are vulnerable to inadequate demand or supply, poor location, and/or weak management, and it is recommended that a simple but more detailed interview process be undertaken at all eight project locations to identify the key success or failure points and to develop a set of operational guidelines for market development.

Conclusions

The comparative rates of return on the different types of economic projects are summarized in the table below.

**Table 46. Rates of Return for Economic Infrastructure Projects
(Most Conservative Assumptions)**

	Conservative Assumptions
Roads & Bridges: time savings plus increased value of primary crop sales	25%
Irrigation systems: crops, livestock and fishponds	36%
Clean water systems: time savings plus agriculture & livestock	66%

In each of these cases, the most realistic, conservative estimate exceeds the benchmark rate of 12 percent, indicating they are all valuable investments for Timor-Leste.

On the other hand, are the rates of return too high to be credible? This analysis argues there are good reasons to consider these estimates credible. Most calculated rates of return on infrastructure investments are made on marginal improvements, for example, a highway is built that enables commercial vehicles to circumvent crowded towns or cities and increase transport efficiency. However, for many investments included in this sample the investment is moving a community from foot and horse transport – with extremely limited access to markets – to mechanized transport. In economic terms, this is a quantum leap: farming households now have the option of moving from near-subsistence to production for sale. Similar degrees of change were seen in field studies of clean water systems – in some cases, survival previously meant that all adult family members spent three or more hours every day carrying water, and the infrastructure investment now means that one person can meet the family's needs in a few hours each week. Very large returns on investment should not be surprising with this kind of fundamental change in the living environment.

The number of operating markets was too small to estimate a rate of return, but some useful insights were gained. Only eight market projects have been funded under PNDS, and five of those markets were included in the analysis. Only three of the five markets in the sample were found to be operating. Both buyers and sellers in the markets were generally satisfied with the projects – 95 percent of both buyers and sellers said they were satisfied or very satisfied with the markets, although the numbers of each were quite small. Buyers are saving time and transport costs buying a wide variety of goods at these local markets, although some supplement purchases with a periodic visit to a larger market further away. Men and women are selling in the market, with women tending to sell local production and (younger) men selling goods bought from traders.

While these results are generally positive, we don't know why the other two markets ceased operating. Before decisions are made on whether or not to continue to allow investments in market construction, a more detailed evaluation of all eight markets should be completed. The evaluation should consider the following factors:

- is local demand strong enough to attract and support sellers?
- is there a wide enough range of sellers interested in supplying the market?
- how do other markets in the surrounding area compete with the PNDS market?
- what are the logistical challenges of the market? Are local transport resources adequate to meet the needs of buyers and sellers? Is there enough space to accommodate vehicles? Is the location accessible in the rainy season?

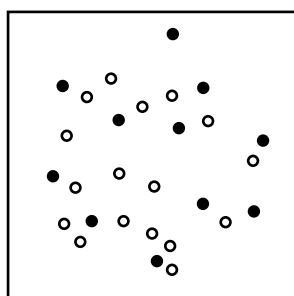
- how is the market managed? Who has responsibility for the market, and how are they accountable to the community? How are environmental factors managed (i.e. water and garbage)? How are repairs and maintenance managed? What financial resources are available for O&M, and how are they managed?

Based on the results of evaluations of the eight market projects, the GoTL can decide if community investments in markets makes sense. Based on the three operating markets surveyed, a set of working guidelines could probably be developed to help PNDS facilitators and communities invest in better working markets that expand opportunities for both buyers and sellers in rural Timor-Leste.

Annex 1. Sampling Methodology

The general methodology for estimating a project's rate of return is to survey a sample of beneficiaries for each project to develop average values for the responses. The sample should be sufficiently large for variations in responses to balance out, and outliers (unexplained very high and very low values) are typically discarded. The averages are then applied to the overall population of project beneficiaries. The process is illustrated in Figure 1 below.

Figure 1. Sampling in one aldeia

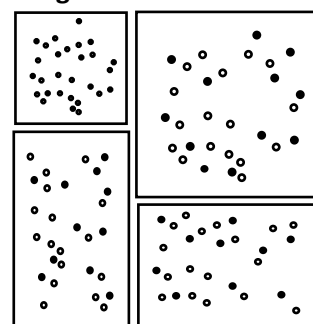


Suppose Figure 1 represents beneficiaries of a clean water project. In the figure, the black dots represent project beneficiaries who were surveyed, and the circles represent those other project users who were not surveyed. All survey responses for all clean water projects (Figure 2) are calculated, averaged, and the averages are applied to all project beneficiaries – both the black dots and the circles – in all the target clean water projects.

A target number of male and female respondents was determined for roads, bridges, irrigation, clean water, market buyers and market sellers. A minimum requirement was set of ten surveys per project, except for irrigation projects which typically have a smaller number of direct beneficiaries – the minimum was set at six.

The survey calculates the value of the projects for beneficiaries today (this year), and based on this value, a stream of benefits is calculated extending ten years into the future – consistent with the typical lifespan of small infrastructure projects¹⁷. Because infrastructure is expected to decline in efficiency over time, the resulting stream of value will also decline; the value stream is generally calculated here to decline by ten percent every year. The actual cost of the projects and the declining ten-year value stream are used to calculate an economic internal rate of return (EIRR). A benchmark EIRR of 12% is typically used for development investments: if a project has an EIRR greater than 12% it is considered good value, and if a project has an EIRR less than 12%, it should be carefully considered. If the EIRR is less than 12%, it is possible for the investment to be justified based on other criteria, for example, other measures of value, benefits to certain disadvantaged groups, redresses inequalities, etc.

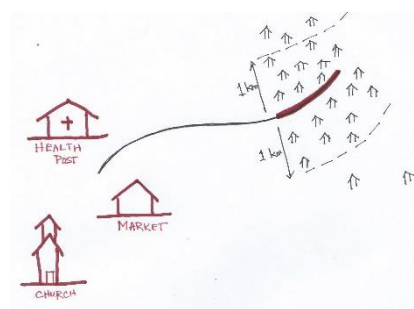
Figure 2. Averaging all target locations



¹⁷ During the 2016 economic impact study, the team found a number of clean water projects in their sample which were a combination of new, gravity-fed projects which incorporated the rehabilitation of barely-working old projects. The Heads of Aldeias reported that the old systems were built by IOM about 10 years ago – confirming the assumption of a 10-year lifespan for gravity-fed clean water projects.

Selection criteria for survey respondents

Roads



Total: 41 projects

Target: All residents who live within 1 kilometer of the new road, and who use it to reach the common destination. Select respondents within the area who live very close, medium distance and far from the road.

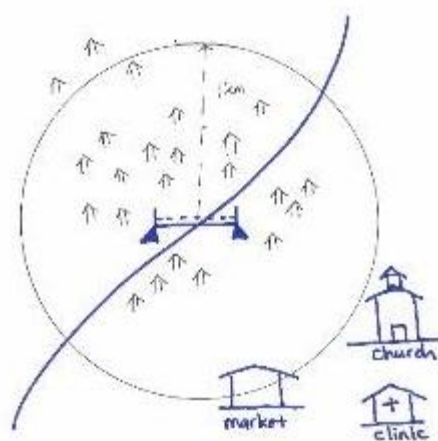
Methodology: meet with the Hamlet Chief and PNDS management team, and ask them to choose a single common destination for all respondents in the aldeia; compare travel times to the common destination before and after the project, during rainy season and dry season.

Bridges

Total: 6 projects

Target: All residents who live within 1 kilometer of the new bridge, and who must use it to reach the common destination. In the illustration, those on the south and east side of the river would not be eligible respondents. Select respondents within the area who live very close, medium distance and far from the bridge.

Methodology: meet with the Aldeia Chief and PNDS management team and ask them to choose a single common destination for all respondents in the aldeia; compare travel times to the common destination before and after the project, during rainy season and dry season.



Clean Water



Total: 80 projects

Target: All residents who use water from the clean water project.

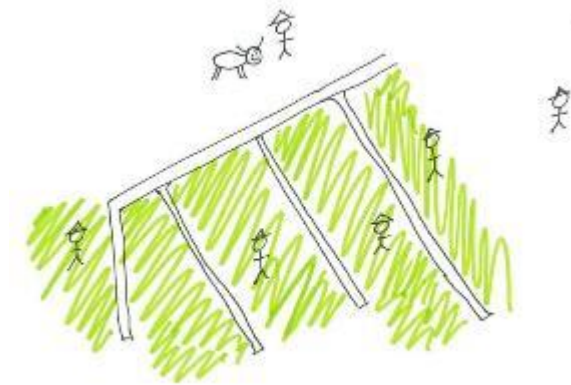
Methodology: Compare the time needed daily to get water before and after the project, in the dry and the rainy seasons.

Irrigation

Total: 13 projects

Target: All farmers who use the water from the project to water fields.

Methodology: Compare agricultural production and sales before and after the project.



Markets

Total: 5 projects

Target: Buyers and Sellers using the PNDS markets on market day

Methodology: For Buyers, understand what they buy in the PNDS market and what they buy in other markets (if any), compare transport time and costs for PNDS and other markets, including previous market. For Sellers, understand what they sell in the PNDS market and in other markets (if any) and the source of goods, compare transport time and costs for PNDS and other markets.

Annex 2. List of Sampled Projects

Municipality	Administrative Post	Suco	Subsector
Aileu	Remexio	Fahisoi	Clean water
Aileu	Remexio	Fadabloco	Clean water
Aileu	Remexio	Hautoho	Clean water
Aileu	Remexio	Maumeta	Clean water
Aileu	Remexio	Fahisoi	Clean water
Aileu	Remexio	Tulataqueo	Clean water
Aileu	Remexio	Suco Liurai	Road
Aileu	Remexio	Faturasa	Road
Aileu	Remexio	Maumeta	Road
Aileu	Remexio	Hautoho	Road
Aileu	Remexio	Hautoho	Road
Aileu	Remexio	Tulataqueo	Road
Aileu	Remexio	Suco Liurai	Road
Aileu	Remexio	Maumeta	Road
Aileu	Remexio	Tulataqueo	Bridge
Ainaro	Hatu Builico	Nunu-Mogue	Clean water
Ainaro	Hatu Builico	Mau Chiga	Clean water
Ainaro	Hatu Builico	Mulo	Road
Baucau	Vemassee	Vemassee	Market
Baucau	Venilale	Fatulia	Clean water
Baucau	Venilale	Fatulia	Market
Baucau	Venilale	Uatu - Haco	Road
Baucau	Venilale	Uma Ana Ulo	Road
Baucau	Venilale	Uailaha	Irrigation
Baucau	Venilale	Uma Ana Ico	Irrigation
Bobonaro	Balibo	Leohito	Clean water
Bobonaro	Balibo	Batugade	Clean water
Bobonaro	Balibo	Leolima	Road
Bobonaro	Balibo	Batugade	Road
Bobonaro	Balibo	Balibo Vila	Road
Bobonaro	Balibo	Sanirin	Road
Bobonaro	Balibo	Leolima	Road
Bobonaro	Balibo	Sanirin	Irrigation
Bobonaro	Balibo	Cowa	Irrigation
Bobonaro	Bobonaro	Carabau	Market
Bobonaro	Lolotoe	Lebos	Clean water
Bobonaro	Lolotoe	Lupal	Clean water
Bobonaro	Lolotoe	Lupal	Clean water
Bobonaro	Lolotoe	Lebos	Clean water
Bobonaro	Lolotoe	Gildapil	Road
Bobonaro	Lolotoe	Guda	Road
Bobonaro	Lolotoe	Lontas	Road
Bobonaro	Lolotoe	Opa	Road

Municipality	Administrative Post	Suco	Subsector
Bobonaro	Lolotoe	Deudet	Road
Bobonaro	Lolotoe	Deudet	Road
Covalima	Zumalai	Fatuleto	Clean water
Covalima	Zumalai	Tashilin	Clean water
Covalima	Zumalai	Raimea	Clean water
Covalima	Zumalai	Tashilin	Clean water
Covalima	Zumalai	Mape	Clean water
Covalima	Zumalai	Lepo	Clean water
Covalima	Zumalai	Lepo	Clean water
Covalima	Zumalai	Zulo	Clean water
Covalima	Zumalai	Ucecai	Road
Covalima	Zumalai	Lour	Road
Covalima	Zumalai	Fatuleto	Road
Covalima	Zumalai	Lepo	Road
Covalima	Zumalai	Zulo	Irrigation
Ermera	Atsabe	Leimea Leten	Clean water
Ermera	Atsabe	Laclo	Clean water
Ermera	Atsabe	Lasaun	Clean water
Ermera	Atsabe	Obulo	Clean water
Ermera	Atsabe	Tiarlelo	Clean water
Ermera	Atsabe	Atademe_Malabe	Clean water
Ermera	Atsabe	Baboi Criac	Clean water
Ermera	Atsabe	Atara	Clean water
Ermera	Atsabe	Baboi Criac	Clean water
Ermera	Atsabe	Leimea Leten	Clean water
Ermera	Atsabe	Atara	Clean water
Ermera	Atsabe	Atara	Clean water
Ermera	Atsabe	Paramin	Clean water
Ermera	Atsabe	Baboi Leten	Road
Ermera	Atsabe	Lasaun	Road
Ermera	Atsabe	Laubono	Irrigation
Ermera	Atsabe	Tiarlelo	Irrigation
Ermera	Atsabe	Laclo	Irrigation
Ermera	Atsabe	Batumanu	Bridge
Ermera	Atsabe	Batumanu	Bridge
Ermera	Railaco	Tocoluli	Clean water
Ermera	Railaco	Taraco	Clean water
Ermera	Railaco	Matata	Clean water
Ermera	Railaco	Fatuquero	Clean water
Ermera	Railaco	Tocoluli	Clean water
Ermera	Railaco	Lihu	Clean water
Ermera	Railaco	Railaco Criac	Clean water
Ermera	Railaco	Samalete	Clean water
Ermera	Railaco	Railaco Leten	Clean water
Ermera	Railaco	Railaco Criac	Clean water

Municipality	Administrative Post	Suco	Subsector
Ermera	Railaco	Lihu	Clean water
Ermera	Railaco	Tocoluli	Clean water
Ermera	Railaco	Deleco	Road
Lautem	Lautem	Parlamento	Clean water
Lautem	Lautem	Maina II	Clean water
Lautem	Lautem	Baduro	Clean water
Lautem	Lautem	Ililai	Clean water
Lautem	Lautem	Euquisi	Clean water
Lautem	Lautem	Daudere	Clean water
Lautem	Lautem	Ililai	Clean water
Lautem	Lautem	Serelau	Clean water
Lautem	Lautem	Pairara	Clean water
Lautem	Lautem	Baduro	Road
Lautem	Lautem	Euquisi	Irrigation
Liquica	Bazartete	Mota Ulun	Clean water
Liquica	Bazartete	Ulmera	Clean water
Liquica	Bazartete	Tibar	Clean water
Liquica	Bazartete	Lauhata	Clean water
Liquica	Bazartete	Maumeta	Clean water
Liquica	Bazartete	Mota Ulun	Clean water
Liquica	Bazartete	Fahilebo	Clean water
Liquica	Bazartete	Fatumasi	Clean water
Liquica	Bazartete	Maumeta	Clean water
Liquica	Bazartete	Tibar	Road
Liquica	Bazartete	Leorema	Road
Liquica	Bazartete	Fahilebo	Road
Liquica	Bazartete	Mota Ulun	Road
Liquica	Bazartete	Fatumasi	Bridge
Liquica	Bazartete	Metagou	Bridge
Manatuto	Laclo	Lacumesac	Clean water
Manatuto	Laclo	Uma Caduac	Clean water
Manatuto	Laclo	Lacumesac	Clean water
Manatuto	Laclo	Uma Caduac	Clean water
Manatuto	Laclo	Hohorai	Road
Manatuto	Laclo	Uma Naruc	Irrigation
Manatuto	Laclo	Uma Caduac	Irrigation
Manufahi	Alas	Taitudac	Clean water
Manufahi	Alas	Dotik	Clean water
Manufahi	Alas	Dotik	Clean water
Manufahi	Alas	Taitudac	Road
Manufahi	Alas	Uma Berloic	Irrigation
Oecusse	Nitibe	Banafi	Clean water
Oecusse	Nitibe	Banafi	Clean water
Oecusse	Nitibe	Lela-Ufe	Clean water
Oecusse	Nitibe	Lela-Ufe	Market

Municipality	Administrative Post	Suco	Subsector
Oecusse	Nitibe	BeneUfe	Road
Oecusse	Nitibe	Suni-Ufe	Road
Oecusse	Nitibe	Usi-Taco	Irrigation
Viqueque	Viqueque	Uma Uain Craic	Clean water
Viqueque	Viqueque	Maluru	Clean water
Viqueque	Viqueque	Bibileo	Clean water
Viqueque	Viqueque	Caraubalo	Clean water
Viqueque	Viqueque	Maluru	Market
Viqueque	Viqueque	Uma Quic	Road
Viqueque	Viqueque	Caraubalo	Road
Viqueque	Viqueque	Uma Uain Craic	Road
Viqueque	Viqueque	Uai-Mori	Bridge

Annex 3. Stories from the Field

PNDS Clean Water Project

Aldeia Raeudu, Suco Liho, Railaco - Ermera

Completed 2016

Total budget: \$23,327, including \$3,338 for labor

Aldeia Raeudu is located on a hillside about 4 kilometers down a poor-quality side road from Railaco. The community had an old water tank from the Indonesian era high up on the hill, but it was too small for current needs and it required a 1 km walk up the hill to get water and bring it back to homes. The reservoir tank has two sources, both springs from higher up the hill.

Residents spent \$23,327 of PNDS funds to rehabilitate the old holding tank, add an additional tank next to it, build a distribution tank a bit further down the hill nearer to the gardens, and to pipe the water from there



down to four taps in the village for home consumption for 40 beneficiary households.

We spoke with 5 households, and all of them consider the project a big success. Everyone says they save a lot of time by using the new neighborhood taps and not having to hike up the hill to the tank and carry the jerry cans back home. They are happy with the volume and the quality of water, although a few people observed that they used so much more water now that they were worried they might run short. One neighborhood added an enclosure next to the tap (see photo to the left) so people could bathe there instead of carrying the water home.

In addition to using the water for everyday household needs, families are using the water to boost their livelihoods. The most important economic use is to pulp coffee cherries, although expanding garden production for sale has become very important, too.



Brothers Helder and Tiago

Helder teaches at the nearby SMA, while his brother Tiago manages the garden and coffee trees for their combined family of 14. For them, access to water from the tap just across from their house is now much more convenient, and during the EIS they calculated they save a total of 140 minutes per day carrying water. This adds up to 106 working days per year which can now be used for productive activities. But the brothers say the biggest value of the piped water is for pulping coffee cherries. They report that when the cherries are pulped before they are dried, the beans can be sold for \$1.25 per kg. If they are not pulped, no buyer will take them.



Figure 1 One of several traditional meeting houses in Raeudu.

Anna Paula says coffee is the biggest source of income for her, her husband Alexandre and their two children, and the tap near her house means they can pulp the coffee cherries and dry them more efficiently and conveniently. But she has also expanded her garden, and now plants and sells a wider variety and volume of vegetables than she did before. She reports this has become an important income source, but not quite as big as coffee. She sells in the Tuesday market in the aldeia but says that people are now starting to come to the suco to look for vegetables to buy, and that makes her very happy.



Anna Paula at the tap near her house



Victor is planning on planting more sale-able crops around his house.

Victor says their household income has increased substantially. He doesn't have a big garden up the hill, but he has used extra land around his house and near the tap to plant income earners – a big stand of bananas in the front (already harvested and sold), and he has just planted eggplants in the side garden that he plans on selling.

Philomena and Domingo aren't using the water directly for economic activities, but the time they save no longer carrying water means they can spend more time on their small used clothing business. They go for a low-profit, high volume strategy, which means after bringing the clothing home from Dili, they put a low price per piece. They like to sell out fast with low prices and do a higher volume. There's too much competition in the aldeia weekly market, so they sell out of the front of their house – the only clothing seller in town.



Philomena and Domingo spend more time selling clothing from their house.



Luiza makes a profit of about \$2 per day from the time she saves not carrying water.

Luiza also has more time to spend on her profitable sales table in front of her house, where she sells grilled sate and palm wine (she can produce 5 large aqua bottles of palm wine per day and had a covered tub of approximately 25 sticks of sate.) She makes a profit of about \$2 per day.

PNDS Irrigation Project

Aldeia Railuli, Suco Cowa, Balibo - Bobonaro

Completed 2015

Total budget: \$44,000, including \$6,819 for labor

It's mid-June and harvest time in the rice fields of Railuli, located in a valley high outside the town of Balibo on the western border with Indonesia. When we arrived on a sunny afternoon, the community was happy to take a break and talk with us under their shade shelter in the fields. This is a remote frontier village, and while the road is long but fairly good from Balibo, there is no electricity and they are self-sufficient – they live on what they grow. All the families in their aldeia have grown rice in the valley for as long as they can remember, depending on rainfall for their one crop a year. They also have gardens near their homes on the hillside above, which provide them with basic vegetables during the growing season.



Residents of Aldeia Railuli in the middle of the annual rice harvest



The community proposed to use a PNDS grant to build a simple, gravity-fed irrigation system to provide supplemental water to a section of rice fields for 56 families. The aldeia has three separate areas of rice fields, and this system is intended to supply water to the largest common area – two smaller sections to the east and the west don't yet have access to supplemental water. The water comes from a spring in the hills behind the aldeia and flows steadily. Project funds were used to build a simple system of regulated channels to deliver the water

to their rice fields below. This is their third harvest with the irrigation system.





Mr. Juanico Da Cruz, the Aldeia Chief of Railuli

Mr Joanico Da Cruz, the Aldeia Chief, explained that since the system is gravity fed, the amount of water each family enjoys on their land depends on how high in the system their land is located. Rice fields located higher up get larger amounts of water than those located at the far end of the system. While yields have improved significantly for everybody, families harvest between 50-100 bags (approx. 50 kg each bag) of unhusked padi from their plots, with the yield being fairly reliable but dependent on their access to water within the system. The gathered community members estimated the yield before project was roughly 30-35 bags each when they all relied solely on rainfall, and that could vary widely with the climate (Timor is highly vulnerable to the effects of the Southern Oscillation, or El Niño cycles).¹⁸ Despite the variations in yield, all community members report they are satisfied with the project.¹⁹

Based on the EIS survey results (11 households were included in the survey), farming families in Railaco are now selling a limited amount of vegetables – just \$42 worth compared to none before irrigation – but still keep all padi and maize production for home consumption. However, production of padi has increased by 34 percent among the respondents while maize production has decreased by 80 percent. Padi appears to be the more important crop, and with irrigation they are now able to shift from maize to padi production.

Now that the community has (almost) three harvests with the irrigation system they built, what are their current issues? First, they had not anticipated the wide variation in water delivery in different parts of the system, and while the irrigation has more than doubled yields in the higher areas, the lower areas haven't benefited as much (yield increase lower down is estimated at around 40%). They estimate the current flow of water is sufficient to fully meet the needs of only about 30 out of 56 farmers in this section. In addition, there are two smaller sections of rice fields to the east and west which still rely on rainfall every year. The Aldeia Chief and others in the community think a small check dam above the village would solve their issues. Building a small reservoir would enable them to build a stock of water from their small-but-regular source, and they could manage it for the benefit of all farmers in the aldeia. Based on their calculations, in addition to fully covering the needs of the 56 families in the main section, there should be enough to extend irrigation to the two, smaller sections, as well. This might be enough to move them beyond subsistence and enable them to sell their surplus, a big step up for them. But they don't have the resources to do this on their own.



¹⁸ Timor-Leste experienced one of the most severe El Niño droughts in history during 2015-2016, so the aldeia's construction of this irrigation system was well-timed.

¹⁹ This is consistent with the results of the EIS survey, where 11 randomly sampled beneficiaries all reported they were satisfied with the project.

PNDS Irrigation Project

Aldeia Subaleco, Suco Sanirin, Balibo - Bobonaro

Completed 2015

Total budget: \$44,000, including \$9,366 for labor

We visited in the morning to talk with Mr. Jacob Soares and Ms. Cecilia Pereira, representing two households who participate in the irrigation project. Both had said in the survey they were very satisfied with irrigation project they had built with the PNDS grant, so we went to find out why.

There are more than 50 families in this aldeia, and all participate in the irrigation scheme. Before PNDS they had no irrigation and got one crop per year mainly from rainfall. There is a stream nearby, and for the few people who were close to that and could use the water, they did OK. Others were rainfall only, and their production was very unpredictable.

They had an old water tank above the aldeia from the Indonesian period, but it was blocked up and hadn't worked for years. The PNDS project enabled them to completely rehabilitate the old water tank plus add a channel and distribution system to bring it down to the fields in the aldeia. All of the families get 3 crops per year now, even the ones at the end of the system. Long beans, bitter gourd and tomatoes are the main crops and they sell mainly in the Dili market a couple of hours away.

Ten households participated in the EIS survey, and they reported they increased their income by more than \$25,000 per year because of the irrigation project – all of this comes from vegetable sales. They also increased their maize production by 21 percent, all of which is not sold but kept for home consumption. The group of about a dozen people who met with us at Jacob's house all agreed they were earning more money now.



Cecilia took us to see her gardens behind her house where she typically grows bitter gourd and tomatoes (left). Almost all the tomato crop has been sold, and she still has more bitter gourd to sell over the next month. She says the irrigation project has provided big benefits to her family.

Cecilia shows us her bitter gourds she will sell over the next few weeks.

Jacob has a large garden behind his house where his family is growing tomatoes right now for sale (right). This year he added a planting of padi to see how it does and has been encouraged. It's just being harvested now (below, right). He'll still be able to plant three vegetable crops plus the padi, which he thinks this will probably be enough padi for his family for the year. But he doesn't yet have a place to store it. They are just figuring this out, and everybody in the aldeia is watching his result before they try it themselves.



Tomatoes are ripening in the garden behind Jacob's house.



Jacob looking over his first crop of padi.

How have they spent their increased family income? Everyone gathered in his front yard to talk with us agreed that school fees, house repairs and contributions to traditional / customary events are important. Several families have built new houses in the aldeia (below). They also have more money to spend on health services outside the regular Postu Saúde.

They all agreed debt had declined in the aldeia since the project was completed. Jacob noted that he used credit regularly, it was an important part of his production cycle. The NGO they borrow from requires collateral or a demonstrated ability to pay, and the irrigation system is their ticket to participation.

They buy seed from farm stores either in Dili or Maliana. He got padi seed from family in Maliana. Some households use a pesticide for tomato worms, and they got advice from the farm shop on how to deal with them. They also report they read the instructions in the package very carefully. The product was useful.



A new house being finished in the aldeia. Several families have built new homes since the irrigation project was completed.

PNDS Clean Water Project

Aldeia Anarua, Suco Daudere, Lautem - Lautem

Completed 2016

Total budget: \$17,200, including \$1,584 for labor

Anarua is located on the north coast of Lautem, in a valley extending south from the coast and with a good river flowing through it to the coast. There is a large plateau alongside the river that looks like prime agricultural land, but is currently unused except for grazing cattle. The main coast road is about 12 km away. The PNDS EIS team visited the aldeia together with the PNDS social facilitator in June 2018.



The valley floor along the river in Anarua

The PNDS project is a water system which uses a pump to bring water from a deep well up into a holding tank, and five taps distributed around the aldeia.

The team met first with Mr. Aderito Morais, the Aldeia Chief. The well and pump controls are located just off the main road in the aldeia and near his house, and are

fenced and protected from rain by roofed structures (see photo). The holding tank is located higher up in the village for distribution by gravity. We learned that there are 310 households in the aldeia (population 629). The five taps were intended to serve 10+ families each, which means that a good number of families in the aldeia do not yet have access to piped water.



The covered well and pump, and the electrical control box.

We talked with two families in the aldeia who now use the PNDS system every day.

Mrs. Terezinha De Carvalho and her husband, Mr. Armindo Horacio, live not far from one of the taps. She is a housewife, and he is a teacher in the local school. Before the PNDS water system, they walked to the river to get water. Everyone in the family participated in this task, but it wasn't too far and a round trip took about 1 hour, typically twice a day. Terezinha explained how she would carry two 5-liter jerry cans

on her head and one in each hand, twice a day, for a total of 40 liters a day for her family of four. Now she uses a hose from the tap next door to fill the jerry cans in her yard. This water is sufficient for all her household needs, plus she waters her 5 goats with it as well.

She also explained that every family pays \$2 per month to use the water system – this covers maintenance costs and any repairs that might be needed (none yet). What is the next priority? She thought an public sanitation facility, and expanding the system would be good to include those who don't have access.



Mr. Aderito Morais, the Xefe Aldeia



Mrs. Terezinha De Carvalho and her husband, Mr. Armindo Horacio, a school teacher.



Her husband thought the next priority should be restoring the irrigation system, but he doesn't know how to achieve this. In 2006 (?), they suffered a very bad flood in the area which made their irrigation system inoperable. There are 360 hectares of rice fields in their valley (see photo) with more than 230 owners, and not having a working irrigation system has seriously hurt all their incomes. The Ministry of Agriculture has been to assess it, but they only did a survey and nothing more. They tried to figure out a way to do it with this grant, but the cost would have been much more than the budget allowed.

The team next walked the house of Mrs. Jacinta Ribeiro who relies on the system to provide water for her large family. She has 10 children²⁰, the oldest in middle school, and keeping them all clean and fed and clothed requires a LOT of water. She, too, used to go to the river to collect her water, and it was always a real challenge with so many small ones in tow – she couldn't bring back a full load of 20 liters, and the children were too small to carry water. She uses the tap for all her household water needs, and also waters her pigs and chickens – she still takes the goats down to the river for water and bathing. She thought the next priority project should be a public sanitation facility.



Mrs. Jacinta Ribeiro and her cousin who lives nearby.

²⁰ Her oldest child is in middle school. She then had four (4!) sets of twins (boy & girl each set), and her last child (she hopes) is a boy.

PNDS Clean Water Project

Aldeia Vaniria, Euquisi, Lautem - Lautem

Completed 2016

Total budget: \$19,081, including \$900 for labor

Vaniria is high up on a ridge on the north coast of Lospalos, at least 10+ kilometers from Lautem. The road near the coast is asphalted and in reasonably good condition, and the middle section is relatively new in the past couple of years and widely graded. The highest section of the road is rugged. The PNDS team including the PNDS social facilitator visited the aldeia in June 2018.

Agriculture is the main activity along this ridge, with a lot of fruit trees evident, plus a good number of sheep. It's unclear where their main market is located, but for the sheep it is probably Lautem and Dili.

We met with the Aldeia Chief of Vaniria, Mr. Americo Da Costa together with his wife and family at their home alongside the road. Before the PNDS water project, everyone went down to the stream flowing from the spring to collect water. This is far, far down a near vertical slope about 3 km from the Aldeia Chief's house. Most families reported that all family members helped with this task, plus they used a pony to help carry 80 liters of water back up the ridge daily. The grant was split with another aldeia (they built irrigation). He explained that the village got electricity about a year before the PNDS grant became available, and this allowed them to install a pump to get the water from their spring up the hill to the storage tank. There are 100 households in this aldeia, and 27 do not yet have easy access to water.



Aldeia Vaniria's 16,000 liter water tank, and the spare tank. The roof of the Posto Saúde is seen down below.



The feeder tank for the Health Post

After talking with the Aldeia Chief, we went up to the top of the village where the tank was installed. It is a 16,000 liter metal tank, fabricated in Baucau, hauled to the village in pieces, and assembled there on a purpose-built raised concrete pad. They purchased a second tank as a back up, and this sits on a rack nearby. The pump was purchased in Dili – the social facilitator, Eugenio, went with the team to Dili and they bought it, and it was brought back to the village and installed. From the main tank, there is a feeder line to a smaller tank which is used by the Health Post that had been built near it, along with the family who contributed the land.

The system has 16 taps on a gravity system, and serves the families in the top part of the next (lower) aldeia, too. The team that manages the water turns it on 3 days each week. Families in the lower part of the system have one day per week – morning to afternoon – and the main upper part of the aldeia gets 2 days. The management team was fully integrated into the local customary system so there are no conflicts over individual control of the water.

We talked with Mrs. Justina Dos Santos, whose house sits about 10 meters from the water tank. Before the water system was built, she and her family used to go down to the stream to get water. They used their pony to haul 80 liters a day back up the hill for the six members of her family. She uses the water for her animals – a cow, some pigs and chickens. What would she say is the next priority for the village? No question, a public sanitation facility.



Mrs. Justina Dos Santos pointing down the steep hill where she used to get water daily.



A village water tap

Following the road back down the hill, we saw a number of water taps in good condition. We stopped in front of Mrs. Angelina Dos Santos' house to ask her about the water system. She lived near the end of the water line and gets water one day per week. Before the water project, she and her family spent 4-5 hours every day going down the hillside with two ponies to collect water. There was usually water in the stream, but when it was too dry to collect easily they would go upstream closer to the spring source. She was very happy to have the tap on the land two lots down from her house, but would like to see more water points. She now has 50-60 5-liter jerry cans that she fills weekly, and uses the water for all household needs, and uses it to water

her animals. Up to now, the water from the spring has been enough to supply her household and the village. She now spends her extra time farming – tending her fruit trees and selling the produce at a stall along the road in front of her house.



Mr. Germano Da Costa filling water containers in front of his home

We went back up the road a bit to find the tap she uses, and found it in front of the house of Mr. Germano Da Costa. He had brought out all his jerry cans to fill that morning, and had just started when we walked in. The tap was on the side of the road, and he had brought the hose from the tap up into his yard to fill the containers. He has seven people in his household, and while they can manage most needs from the one day's water, they still bathe down the hill at the stream to save water. Suggestion for the next project? Add another tank to increase the stock of water.



Mrs. Angelina Dos Santos at her kiosk in front of her house

PNDS Clean Water Project & Road Project

Aldeia Irapana, Baduro, Lautem - Lautem

Completed 2016

Total budget: \$17,200 (water) and \$26,800 (road), including \$6,717 for labor

Irapana is high up on a ridge on the north coast of Lospalos, probably 10+ kilometers from Lautem. The road near the coast is asphalted and in reasonably good condition, and the middle section is older, and the highest section of the road is pretty rough – but ok for truck access.

The PNDS EIS team visited Irapana together with the PNDS social facilitator in June 2018. We met with the Aldeia Chief for Irapala, Mr. Benedito Da Cruz at the aldeia meeting house next door to his home. The new road passed by the meeting house. We were later joined by Mrs. Sabina Pereira and her daughter (to discuss water) and Mr. Gil Correa (to discuss the road).

Agriculture is the main activity in this area, with a wide range of fruits and vegetables grown. The main retail markets for their output are Lautem and the big Saturday Lospalos market, with Lospalos absorbing most of the production.

The PNDS social facilitator informed us that the residents of all the sucos in this area were moved down to Lautem during the Indonesian era. They moved back up to their agricultural areas after the referendum in 1999, although a number of people have remained down in Lautem on the coast, as they had shifted to fishing for a livelihood.

There are 309 households and 1,480 residents in the 5 aldeias in Suco Baduro. There are 63 households in Irapala who use the road and water projects. 3 additional aldeias also use the road, leaving just one aldeia that doesn't benefit. Everyone agreed that the 5th aldeia is very remote – no easy road access – and not many people go there. The PNDS facilitator joked that he was the only visitor they ever had, and the Aldeia Chief laughed and agreed.

The road was a simple graded road about 1 km long, with just a short section with concrete culverts on each side. We thought the road was not in very good condition, but the Chief said this was a result of the recent rains, and that the O&M team repaired it monthly. The short section with the concrete culverts was in visibly better condition than the other sections of the road.

The total PNDS grant for \$44,000 was divided between two projects in this aldeia (\$17,000 for the road, and \$27,000 for the water system), which the facilitator said was not uncommon in this municipality. The idea is that they can squeeze the budget and get two useful projects instead of just one, and the needs in these remote areas are great. The lack of good water drainage along most of the road is a result of squeezing the budget – they built what they had the budget to build.

To build the projects back in 2015-16, local labor was organized into four teams of about 20 each and they took turns. This ensured the fair distribution of the funds for wages for the two projects (about \$6,700).

ROAD

Mr. Gil Correa talked with us about the impact of the road project on his livelihood. (He was also a member of the project management team and heads up the road repair team.)

Before the road was built, he would harvest his garden and pack the produce into about 10 (max 12) sacks on Friday. On Friday evening he would carry them from the garden up to the main road and wait for the truck to Lospalos. He loaded his goods onto the truck and took them to the market in Lospalos, and sold it all between 2 and 5 a.m. He would then climb back on a truck for the long return trip, arriving home Saturday afternoon. He estimates he made 20-30 market trips per season, earning an average of \$20 each week, and up to \$30 during the peak of the harvest. He paid for transport to and from the market. The land is his family's garden plot, which hasn't changed. Before the road, he didn't plant all the land because he couldn't manage the sales of all the output. He said the pigs ate pretty well from the excess production.



Mr. Benedito Da Cruz (left), the Aldeia Chief, and Mr. Gil Correa (right) show us the road the aldeia built with the PNDS grant.

With the road, trucks can now access the garden areas of the village. He works with 2-3 other farmers, and they jointly call a truck to come and buy their produce – still sold at the Lospalos Saturday market. They all sell their product to the owner of the truck, and he manages the onward sales – a process they are all happy with. He now plants the whole garden, the pigs don't eat as well, and he makes up to \$100 per week from sales.



Mrs. Sabina Pereira and the aldeia team at the PNDS water tank

How does he know he's getting a fair price for his goods? They have a good working relationship with the buyer, and there is also an agreement in the aldeia that all farmers get the same price. If not, they don't sell. This arrangement seems to be working for them and enforces some discipline on the buyers who come into the aldeia.

What would he like to see for the next project? He thinks there are two main needs: improving the road with drainage canals so it doesn't deteriorate, and fencing for the school and health center so goats and other animals can't wander in all the time.

WATER

The community built a 20,000+ liter tank in the middle of the housing area (next to the road), with two taps. There is a large concrete area for washing clothes.

Sabina Pereirra talked with us about the impact of the water system. Before the PNDS system, the water source was 1.5-2 km away, and a round trip took 2 hours. The whole household was responsible for getting water every day. Typically, they would get up very early and everyone (including the kids) would carry the jerry cans to the source, fill up, and then carry them back. She carried a large bucket of about 10 liters on her head, plus one 5-liter jerry can. Her daughter (age about 12) joined the discussion and said kids carried a smaller jerry can each. Then she would bathe and feed the kids, and send them off to school. The whole process was repeated in the afternoon when they came home from school. In total, the 9 members of the household used about 80 liters of water a day.



Girls doing laundry at the water tank

Now they have the same routine – get water in the morning before school and in the afternoon – but they use a lot more water, maybe 100-120 liters a day, and spend a lot less time getting it. The daughter chimed in that they used to always be careful to measure out the water for every task, so much for bathing, so much for washing the dishes, and her mother was a real hawk. But now they just use as much as they want because it is quick and easy to get more from the tap – all agreed this felt like a luxury.

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