DOCUMENT OF THE INTER-AMERICAN DEVELOPMENT BANK

SURINAME

SUSTAINABLE AGRICULTURAL PRODUCTIVITY PROGRAM

(SU-L1052)

MONITORING AND EVALUATION PLAN

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ABBREVIATIONS	
ABS	Central Bureau of Statistics (*from its Dutch acronym*)
ADRON	Anne van Dijk Rice Research Center in Nickerie
AOP	Annual Operations Plan
DAS	Division of Agricultural Statistics
DD	Difference in difference
EA	Executing Agency
I&D	Irrigation and drainage
LVV	Ministry of Agriculture, Forestry and Fisheries (*from its Dutch acronym*)
OWMCP	Overliggend Waterschap Multi-purpose Corantijn Project
O&M	Operation and maintenance
PEP	Project Execution Plan
PEU	Project Execution Unit
PMR	Program Monitoring Report
PP	Procurement Plan
RM	Results Matrix
TA	Treatment Area
WB	Water Board

I. Introduction

1.1. This document presents the monitoring and evaluation (M&E) plan of the Sustainable Agricultural Productivity Program (SU-L1052). The objective of the program is to increase agricultural productivity in Suriname through investments in infrastructure and management of irrigation and drainage (I&D) systems, and by improving the quality of available agriculture statistics. The program's specific outcomes are (i) increased agricultural productivity in I&D areas; (ii) improved water management within I&D areas; (iii) operating Water Boards (WB) effectively contributing to operation and maintenance (O&M) of I&D infrastructure; and (iv) improved agricultural statistics and information systems. The Program consists of two components:

1.2. **Component 1. Irrigation and Drainage (US$26.5 million)**. The component aims to improve the functioning and management of I&D systems in Suriname, particularly in Nickerie District, by addressing current failings in infrastructure and transferring key management and maintenance responsibilities to farmers organized in WB. This component is expected to contribute to increase productivity among producers of irrigated areas and at the same time reduce government expenditure. The program will finance: (i) irrigation and drainage infrastructure works, including the rehabilitation of current structures (primary and secondary structures, including those within Water Boards), selected to benefit small- and medium-size farmers; (ii) support for developing and strengthening WB capacity to take over the O&M of I&D systems; (iii) co-finance during the first three years the costs of O&M costs of eligible Water Boards; (iv) incentive for technology adoption by Water Board farmers, including land levelling, pesticide and fertilizer management training; (v) capacity building in I&D management at the National level and in the Nickerie District; (vi) hydrometric stations; (vii) a communication strategy to convey the relevant aspects of the Program to the beneficiaries and other stakeholders; (viii) equipment for water resource management; and (ix) a study on the environmental characterization of the Nani swamp and a hydrological model of the water basin related to the Nickerie irrigation district. This component will include measures to improve the water resource sustainable management for its different uses (irrigation, environmental and human), particularly by taking into account climate change impacts (i.e., in regard to water supply and demand) and considering adaptation measures.

1.3. **Component 2. Agricultural Statistics and Information (US$1.6 million)**. The objective of this component is to improve Suriname's agricultural information system (AIS) by improving the quality and availability of data and by strengthening the Division of Agricultural Statistics (DAS) of the LVV's operational capacity and analytical capabilities. It is expected that this component will increase the relevance and therefore the use of agricultural statistics in public policy and private investment decisions as well as by the academia. This component will finance: (i) the 2020 agricultural census; (ii) two probabilistic-sample surveys; and (iii) institutional strengthening activities.

1.4. **The M&E plan** presented in this document seeks to ensure the achievement of results and compliance with the targets set in the Results Matrix (RM) and is divided into the Monitoring Plan and Evaluation Plan. The Monitoring Plan (section II) lays out the monitoring responsibilities, tools and reports; output indicators, together with their baselines and targets; data sources; arrangements for the monitoring of results; the cost structure of the Program; and timeline and budget for monitoring activities. The Evaluation Plan (section III) presents the ex-post impact evaluation strategy, which includes the logic of the intervention, impact and outcome indicators, evaluation

methodology, sampling strategy, data collection strategy, timeline of activities and budget.

II. Monitoring

a. Responsibility of monitoring

2.1. The borrower will be the Republic of Suriname, and the Executing Agency (EA) will be the Ministry of Agriculture, Animal Husbandry and Fisheries (LVV) which will act through a project executing unit (PEU) specifically established for the execution of this program. The PEU will coordinate its activities with LVV's Planning and Development Department, the Agriculture Department, the Administrative Services Department, the Division of Agricultural Statistics, and other. In addition, the PEU will effectively contribute with LVV in the inter-institutional coordination responsibilities associated to the present Loan. In particular, the PEU will coordinate with other stakeholder institutions participating in the Program including the Ministry of Public Works, the Ministry of Regional Development, Overliggend Waterschap Multi-purpose Corantijn Project (OWMCP), and individual Water Boards under Component 1 of the Program; and the Central Bureau of Statistics (ABS) of Suriname, among others, for the execution of Component 2.

2.2. As EA of the program, the LVV will be responsible for the monitoring of the program through the PEU. The PEU will be financed by the program and will be composed of a Project Coordinator; two Technical Coordinators, one for each component, with the Technical Coordinator for Component 1 based in Nickerie; one Financial Management Specialist; one Procurement Specialist; one Planning, Monitoring and Evaluation Specialist; one Environmental and Social Specialist; and one Public Communications Consultant.

b. Monitoring tools and reporting

2.3. The main tools and reports for the monitoring of the program are: (i) the Monitoring system; (ii) the monitoring of program management tools: Project Execution Plan (PEP), Annual Operations Plans (AOP), Procurement Plans (PP), Risk Matrix, and Results Matrix (RM); (iii) semi-annual progress reports and the Program Monitoring Reports (PMR); and (iv) mid-term and final program evaluations.

2.4. **The monitoring system** will consist of the following instruments: (i) the Loan Contract; (ii) the initial report; (iii) the Results Matrix (RM); (iv) the PEP; (v) the current AOP; (vi) the PP and the financial monitoring plan; (vii) the semi-annual progress reports; (viii) the PMR; (ix) the risk management analysis; (x) the monitoring and supervision missions; (xi) the administration missions; (xii) the aide memoires or reports resulting from the administration, supervision, and any other relevant missions; (xiii) the latest audited financial statements of the program; and (xiv) the technical supervision reports prepared by the LVV at the request of the Bank.

2.5. **Monitoring of program management tools.** Monitoring will be based on the program's management tools: PEP, AOP, PP, risk matrix, RM, financial plans, audited financial statements, and semi-annual progress reports. The goal is to facilitate the accomplishment of the chronogram, budget, risk mitigation plans, and decision making to optimize the management of the Program. It is recommended that the integrated tool provided by the Bank be used.

2.6. **Semi-annual progress reports and PMR.** The preparation of the semi-annual progress report by the PEU and their approval by the Bank is a contractual condition of the loan. The objective of the semi-annual progress reports is to report on the progress achieved and to detect any deviations between programming and execution so as to identify the actions necessary to meet the targets and budget of the Program. Semi-annual progress reports incorporate the PMR as the tool to report on the Program's execution and results. The semi-annual PRs including the PEP will be presented within 60 days after the end of June and December of each year during the disbursement period.

2.7. The semi-annual PR will focus on fulfillment of output indicators and progress towards achieving outcomes in the Results Matrix during the reporting period. It should also inform on any changes to the Results Matrix; the factors that have affected execution and their causes; any updates to the risk management matrix and their mitigation plans; the main lessons learned, and the challenges foreseen for the next execution period. Annexes that must be included in the semi-annual progress reports are: PMR, RM, risk matrix, PEP, AOP, PP, cash flow and disbursement programming, audited financial statements, and reports on the use of counterpart resources.

2.8. **Mid-term and final evaluations.** The PEU will submit to the Bank a mid-term independent evaluation report within 90 days after the date on which 50% of the loan proceeds have been committed or after 50% of the disbursement period has, whichever event occurs first. The objective of this evaluation will be to determine whether execution is satisfactory and whether the program's strategy is generating the desired impact, or whether any adjustments are needed. For each component, the evaluation will highlight the key issues that are being faced and which require responses from the PEU. It will also provide a set of preliminary insights about the program's design, implementation, and management.

2.9. **A final independent evaluation** will be carried out 90 days before the date of the final disbursement, or any extension thereof, to determine whether it has reached its objectives. The evaluation team will report the results of the program's evaluation as well as identify the lessons learned through the program, particularly its key successes and failures. The team will also assess the sustainability of the program's results and propose a set of recommendations to the various program's stakeholders to reinforce it.

c. Arrangements for the monitoring of results

2.10. The Bank and the EA have agreed on the use of the RM and the activities defined in the PMR as the main instruments for the monitoring of the Program.

2.11. The Bank's team will perform semi-annual technical missions to the EA to review the progress of activities and to make the necessary adjustments that derive from their execution. The team will also conduct annual fiduciary supervision missions. In addition, there will be operational and financial external audits to validate the use of financing resources and of the operational internal controls implemented by the EA. The information collected will be analyzed each semester and the progress and monitoring report will be conducted annually.

2.12. The Executing Agency will present to the Bank semi-annual progress reports during execution no later than 60 days after the end of each six-month period. The reports will analyze the problems faced and the corrective measures used to address them, indicating the physical and financial progress of the program on the basis of the activities and the indicators included in the RM, AOP and PP. These reports will include at a minimum, the following: (i) executive summary, analyzing the program's

physical and financial execution; (ii) monitoring report; (iii) updated PEP and AOP; (iv) risk matrix update; (v) Environmental and Social Management Report (ESMR); and (v) PP. The reports corresponding to the second semester of year of execution will also include the AOP of the following calendar year, a disbursement forecast, an updated PP, and the status and maintenance plan of the works executed by the program.

d. Data collection and instruments

2.13. The PEU will be responsible for preparing, compiling and consolidating all the information for the monitoring system and execution of the program, and it shall present said information to the Bank in the formats and with the frequency required as established in this Plan, in the Loan Contract and the Program's Operations Manual.

e. Indicators for the monitoring of the Program

2.14. **Results Matrix (RM).** The Program has a Results Matrix (POD, Annex II) that has been agreed upon with the LVV. The RM contains a nuanced list of the Program's output and outcome indicators, including their yearly intermediate and final targets.

2.15. The program will contribute to increase productivity of the agricultural sector in general and especially of the beneficiary farmers of the I&D system in Nickerie. The main expected results for Component I are: Reduced costs of operating I&D infrastructure, reduced flooding risk, formalized Water Boards, Water Boards contributing to the payment of O&M costs, improved use of natural capital (water), increased participation of women in Water Boards, and improved efficiency of the I&D system. For component II: Improved evidence-based policy making; and increased information availability.

2.16. Table 1 presents the Program's output indicators—impact and outcome indicators will be presented in section III below.

Table 1. Output indicators

Product	Means of verification	Responsible
Component 1. Irrigation and Drainage		
1.1 Primary I&D infrastructure rehabilitated	LVV reports	LVV
1.2 New I&D infrastructure built	LVV reports	LVV
1.3 I&D action plans formulated	LVV reports (one national, three district plans)	LVV
1.4 Water Board infrastructure rehabilitated	LVV reports	LVV
1.5 Water Boards equipped and trained	LVV reports	LVV
1.6 Annual communication campaigns implemented	LVV reports	LVV
1.7 Cost of O&M plans for WB co-financed	LVV reports	LVV
1.8 Incentives for land leveling provided	LVV reports 10% of total farmers in WBs	LVV
1.9 Annual I&D management and coordination program implemented	Annual programs approved by DIDCWG	LVV
1.10 Irrigation calendarization proposal formulated and presented to users	LVV reports. Three pilots and then the rest.	LVV
1.11 Hydrometric training for OWMCP	LVV reports	LVV

Product	Means of verification	Responsible
Component 1. Irrigation and Drainage		
1.12 OWMCP's hydrological flow measurement and model developed	LVV reports	LVV
1.13 Hydrological and weather network installed	LVV reports. 10 hydrometric and 15 telemetric weather stations, 10 telemetric water level recorders	LVV
1.14 Operational Decision Support System developed and delivered	LVV reports	LVV
1.16 Water users trained on sustainable use of water and inputs	LVV reports	LVV
1.17 Sustainable and integrated Water Resource Management Program developed	LVV reports	LVV
1.18 Ecological assessment of the Nanni Swamp	LVV reports	LVV
1.19 Pesticide survey and sediment quality study	LVV reports	LVV
1.20 Water quality monitoring system established	LVV reports	LVV
1.21 Gender Action Plan implemented	LVV reports	LVV
Component 2. Agricultural Information and Statistics		
2.1 Agricultural census implemented	Census data bases completed. From survey report by LVV	LVV
2.2 Post-census survey implemented	Survey report by LVV	LVV
2.3 Surveys with probabilistic sample developed	Section 4 of the CAQ informs on the method of data capture and the publication of sampling errors and metadata for main variables.	LVV
2.4 LVV staff trained in statistical and census methods	CAQ. Dimension 2. Staff training.	LVV
2.5 LVV/DAS equipped	Semi-annual progress reports from PEU	LVV

f. Program's costs

2.17. The Program's costs structure, established in the PEP, presents the cost of each output necessary for the execution of the Program's components. The AOP disaggregates the outputs in activities and adds the timeline necessary to achieve said outputs as per the technical estimates and considering the average times established by the Bank's hiring and procurement policies. This way, costs are budgeted on a yearly basis for each of the Program's outputs. That information will be used to complement the costs structure of the PMR's baseline. Project costs, as established in the PEP, are disaggregated by output (Table 2) and by year (Table 3).

Table 2. Program's costs structure

Component 1							
Output	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Total**
1.1 Primary I&D infrastructure rehabilitated	202,530	1,957,792	1,890,282	1,237,684	1,237,684	-	6,525,972
1.2 New I&D infrastructure built	285,000	2,085,000	1,990,000	1,295,000	1,295,000	-	6,950,000
1.3 I&D action plans formulated	6,360	5,460	9,460	7,400	7,940	5,380	42,000
1.4 Water Board infrastructure rehabilitated	191,100	2,197,069	3,136,354	3,072,654	2,069,669	-	10,666,846
1.5 Water Boards strengthened	95,996	15,096	13,296	13,296	13,296	-	150,980
1.6 Annual communication campaigns implemented	8,600	8,600	8,600	8,600	4,300	4,300	43,000
1.7 Cost of O&M plans for WB co-financed	110,000	110,000	110,000	110,000	55,000	55,000	550,000
1.8 Incentives for technology adoption provided	-	18,000	54,354	54,555	104,354	3,750	235,012
1.9 I&D management and coordinating capacity strengthened	-	-	720	720	900	1,260	3,600
1.10 Irrigation calendarization proposal formulated and presented to users	-	-	11,560	9,310	8,457	1,707	31,033
1.11 Hydrometric training for OWMCP	3,200	30,000	9,933	30,000	6,200	2,667	82,000
1.12 OWMCP's hydrological flow measurement and model developed	-	-	-	29,840	5,120	19,840	54,800
1.13 Hydrological and weather network installed	-	100,000	200,000	79,000	50,000	50,000	479,000
1.14 Operational Decision Support System developed and delivered	-	50,000	50,000	50,000	25,000	25,000	200,000
1.15 Water users trained on sustainable use of water and inputs	-	-	15,000	15,000	-	-	30,000
1.16 Sustainable and integrated Water Resource Management Program developed	15,000	18,000	15,000	15,000	15,000	12,000	90,000
1.17 Ecological assessment of the Nanni Swamp	40,000	-	-	-	-	-	40,000
1.18 Pesticide survey and sediment quality study	200,000	-	-	-	-	-	200,000
1.19 Water quality monitoring system established	100,000	-	-	-	-	-	100,000
1.20 Gender Action Plan implemented	15,000	9,000	8,000	4,000	4,000	-	40,000
Subtotal	**1,272,786**	**6,604,017**	**7,522,558**	**6,032,059**	**4,901,920**	**180,903**	**26,514,243**
Component 2							
PRODUCT	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Total**
2.1 Agricultural census implemented	-	148,056	580,834	277,500	20,000	-	1,026,390
2.2 Post-census survey implemented	-	-	26,700	-	-	-	26,700
2.3 Surveys with probabilistic sample developed	-	-	-	8,400	33,600		42,000
2.4 LVV staff trained in statistical and census methods	9,900	9,900	13,200	-	-	-	33,000
2.5 LVV/DAS strengthened with adequate equipment	600	543,958	1,200	1,200	1,200	1,200	549,358
Subtotal	**10,500**	**701,914**	**621,934**	**287,100**	**54,800**	**1,200**	**1,677,448**
TOTAL	**1,283,286**	**7,305,930**	**8,144,492**	**6,319,159**	**4,956,720**	**182,103**	**28,191,691**

Table 3. Disbursement forecast

	2019	2020	2021	2022	2023	2024	TOTAL
TOTAL IDB (US$ 000)	1,500	7,500	7,500	6,000	6,000	1,500	**30,000**
%	5	25	25	20	20	5	**100**

g. Budget of monitoring activities

2.18. The Program's monitoring activities have been budgeted as part of the Administration and Evaluation activities in the PEP, which include management expenses (staff and operational costs of the PEU), intermediate and final evaluations, and external audits. Table 4 presents the budget and timeline for these activities.

Table 4. Budget and timeline of monitoring activities

Activities	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Cost (US$)	Source of financing
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Monitoring																									—	Pgm budget
Mid-term evaluation																									25,000	Pgm budget
Final evaluation																									35,000	Pgm budget
Baseline for impact evaluation																									95,000	Pgm budget
Follow-up survey for impact evaluation																									75,000	Pgm budget
Impact evaluation																									20,000	Pgm budget
Semi-annual reports																									—	IDB
Inspection visits																									—	IDB
Administration missions																									—	IDB
External audit																									120,000	Pgm budget
TOTAL																									**370,000**	

III. Evaluation

A. Logic of Intervention and Main Hypotheses

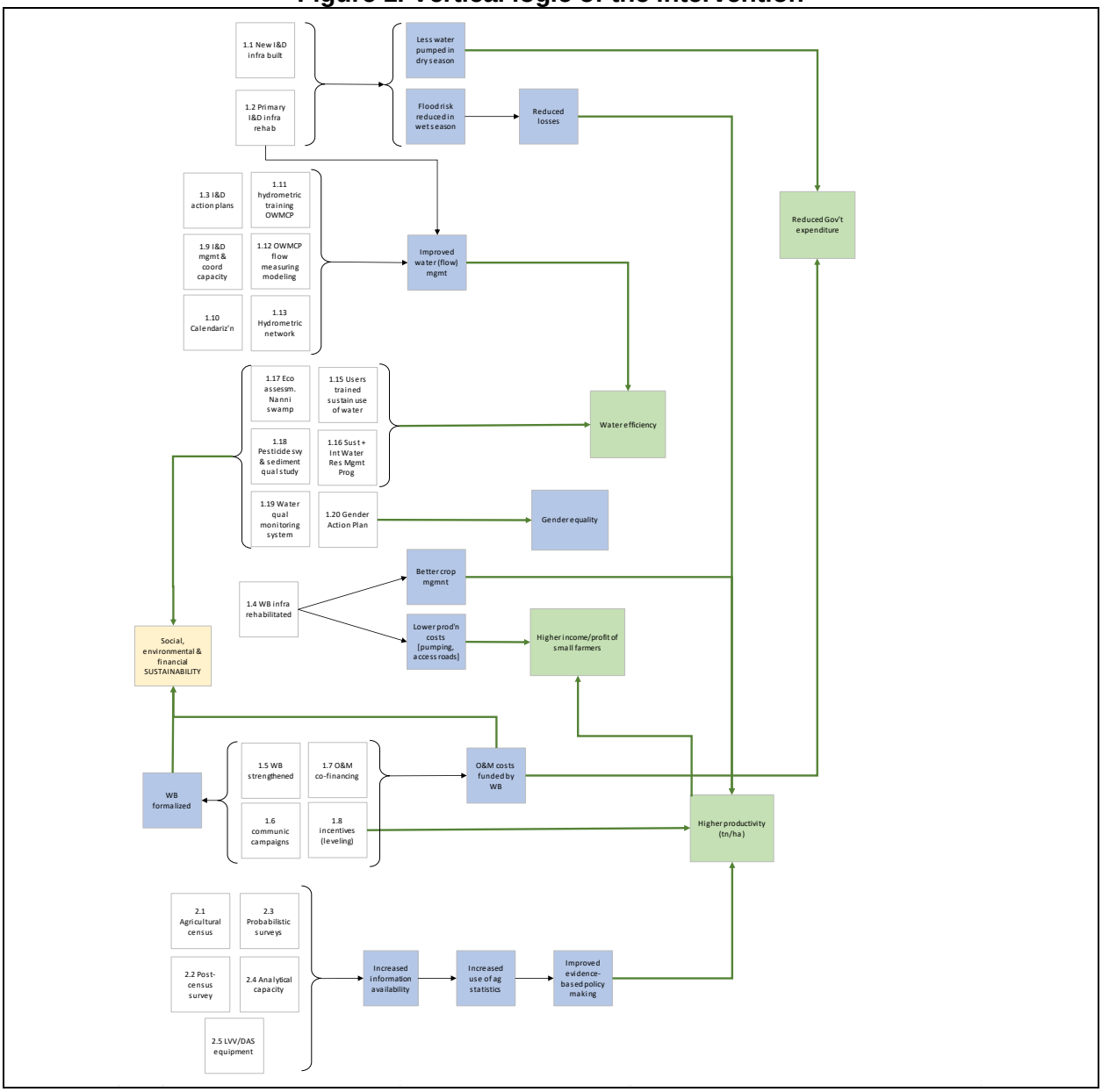
3.1. The Sustainable Agricultural Productivity Program (SU-L1052) consists of two components: (i) irrigation and drainage; and (ii) agricultural statistics and information. Through these components, the program seeks to increase agricultural productivity in Suriname. Specifically, the program expects to increase agricultural productivity in I&D areas of the Nickerie district, improve water management within those areas, make operating WB effectively contribute to O&M of I&D infrastructure, and improve agricultural statistics and information systems. The theory of change of the program is presented in Figure 1, which includes the main causal effects expected from the program's outputs.

3.2. Component 1 will finance interventions at the district (and national) level, at the waterboard level, and at the farmer level. At the district level, new I&D infrastructure will be built (see Map 1), thereby completing the I&D system that was envisioned in the Multiprupose Corantijn Project of the 1980s. These works will have two effects: first, during the dry season, when water gets pumped from the Wakay station (60km upstream the Corantijn river) all along the Corantijn canal to the agricultural areas of northern Nickerie, the construction of the Nanni weir will collect the pumped water and distribute it into the irrigation areas without allowing it to spill into the Nanni swamp—currently, the Corantijn canal is not directly connected to the I&D infrastructure in the irrigation areas and so most of the pumped water ends up in the lower-lying swamp and cannot reach the irrigation areas until the water level at the swamp equals the level at the irrigation canals. Hence, the Nanni weir will reduce water pumping costs substantially—and contribute to making the water cycle at the Nanni swamp closer to what it was before human intervention. Second, the construction of the Maratakka spillway to the East will allow, during the wet season, to spill excess water from the swamp into the Maratakka river, thus reducing the risk of floods in the productive areas North of the swamp.

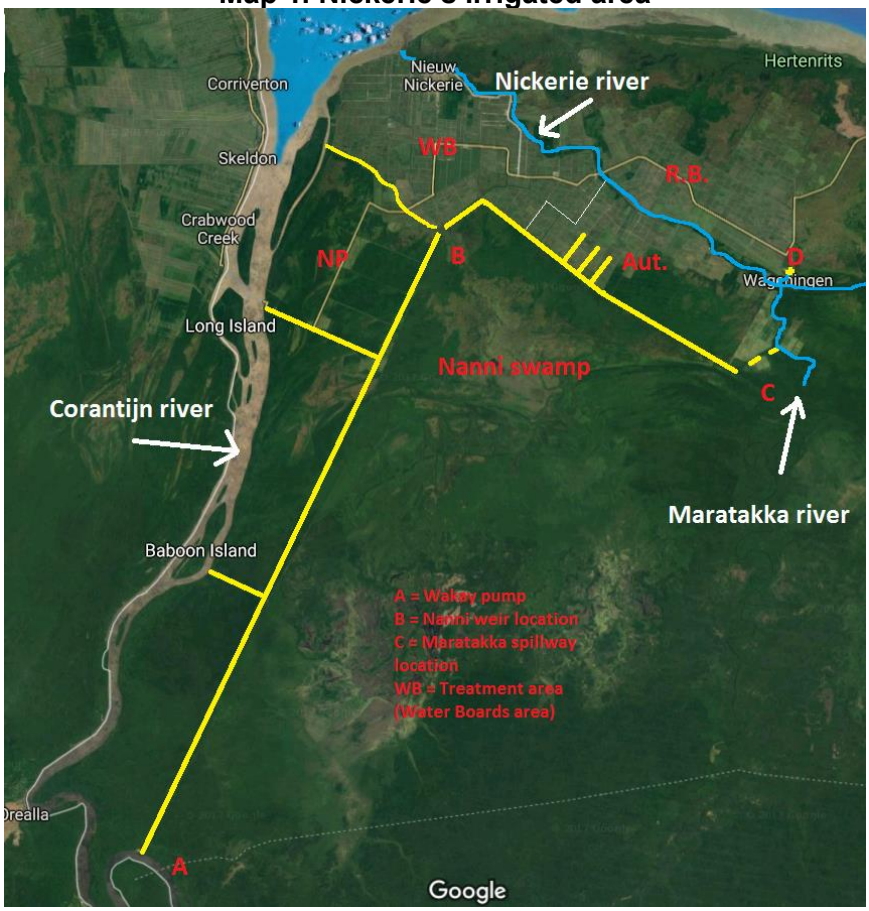
3.3. The I&D component will also rehabilitate existing primary infrastructure—canals, spillways, sluices, gates, etc—which will further reduce flood risk during the wet season and, throughout the year, will improve water flow (the entire system will have an increased capacity) and give water authorities[1] control over the water flow—including giving them the ability to retain the water in the primary irrigation canals and to keep individual polders from accessing water (for instance, to enforce staggered sowing times (a "calendarization") to avoid times of excessive water demand).

[1] Currently, the Ministry of Agriculture, Forestry and Fisheries (LVV) is in charge of controlling the distribution of water among all the polders in the Nickerie district; however, this responsibility is expected to be handed over to the OWMCP. The OWMCP is already in charge of pumping the water from upstream Corantijn river.

Figure 1. Vertical logic of the intervention



Map 1. Nickerie's irrigated area



3.4. In addition to this infrastructure work, the component will also invest in the water authorities' capacity to manage water flows—modeling, measurement, and monitoring of water flows; and management of irrigation and drainage, including action plans (also at the national level) and the proposal of a calendarization of agricultural activities across water users. An increased water management capacity is expected to result in a more efficient use of water in the Nickerie agricultural district as a whole.

3.5. The component will also work at the polder/waterboard level. On the one hand, it will rehabilitate secondary infrastructure—I&D canals, sluices, culverts, access roads, etc—in the six polders that have not been recently rehabilitated. This will allow farmers in those polders to better manage their crops, which is expected to result in increased yields and lower production costs (e.g., due to less water pumping from the primary irrigation canals into their fields as well as easier access to them), thereby increasing their agricultural profits. Also, the component will make investments to strengthen and formalize waterboards, including improving their capacity to collect fees to cover the O&M expenses of the polder's secondary I&D infrastructure, which is expected to contribute to the financial sustainability of the system. The component will also invest in the implementation of a gender action plan, to increase the role of women in agricultural decisions and in the waterboards, and in developing a sustainable and integrated water resource management program, thereby increasing the social and environmental sustainability of the program's outcomes and impacts.

3.6. Finally, at the farmer level, component 1 will train small- and medium-scale rice producers on the sustainable use of water and other inputs such as fertilizers and

pesticides. This is expected to contribute to a higher level of water efficiency in the district and, more generally, to the environmental sustainability of the program. The component will also finance a scheme to incentivize small- and medium-scale rice producers to pay the fees for the O&M of the I&D infrastructure of their polder. The incentive scheme will be two-pronged. First, the payment of the O&M fees will be gradual, with the program financing the part that initially is not paid by water users. Second, producers will be given the opportunity to level their rice fields at a subsidized price, provided that they have paid all their dues. Besides giving financial sustainability to the I&D system, the incentive mechanism—land leveling, specifically—is expected to bring about increases in yields of approximately 10% and reductions in the use of water and other inputs.

3.7. Component 2, on the other hand, will finance three groups of activities. First, it will finance the preparation, collection, and processing of the 2020 Agricultural Census, which will provide essential, updated information about the sector and will provide a new sample frame from which to draw probabilistic samples for representative surveys. Second, it will finance the preparation, collection and basic processing of two probabilistic-sample surveys on the first and second years after the census. Finally, the component will finance institutional strengthening—training and equipment—of the LVV's Department of Agricultural Statistics. Together, these three interventions will increase the availability (and quality) of agricultural information and statistics in the country, thereby increasing their relevance. Other things being equal, this should lead to an increase in their use by many different actors, including the public sector, who is expected to improve its evidence-based policy making and thereby help increase agricultural productivity.

3.8. As the methodology section will discuss, not all the program's interventions can be evaluated with a methodology capable of identifying their causal effect. For that reason, the impact evaluation will be limited to some of the activities financed in component 1. Specifically, the evaluation will test the hypothesis that well-functioning secondary I&D infrastructure has positive impacts on rice productivity and on profits. Testing this hypothesis is relevant because if water users—rice producers, in this case—realize that maintaining the secondary I&D infrastructure is important for their own profitability—as opposed to thinking that only primary I&D infrastructure and intra-plot investments are important—then they should be more willing to pay for the O&M of that infrastructure, which would contribute to its sustainability. Implicitly, this conjecture assumes that the benefits of maintaining the secondary infrastructure in optimal conditions are larger than the O&M costs, but this needs to be demonstrated. Hence, the evaluation will not only show whether the rehabilitation has positive effects; importantly, it will also measure those effects.

B. Key Outcome and Impact Indicators

3.9. The outcome and impact indicators to be measured as part of the evaluation strategy are presented in Tables 5 and 6. All outcome indicators (Table 5) will be evaluated in a reflexive manner, comparing their values before and after the program. Impact indicators (Table 6), on the other hand, will be evaluated following the methodology described in section D, below.

Table 5. Outcome indicators

Outcome	Indicator	Frequency of measurement	Means of verification
Component 1.			
Pumping cost reduced	Cost of pumping water per season	2018 & 2022	Costs of fuel and oil at the Wakay pump station. OWMCP records
Flooding risk reduced	Days of year that water is above critical level	2018 & 2020	OWMCP reports
Water Boards formalized	Number of Water boards	2018 & 2022	LVV reports
O&M costs funded by WB	Percentage of target O&M cost that is covered by WB members	2018 & 2022	LVV reports
Participation of women in WB increased	% Women members of WB committees	2018 & 2022	
Component 2.			
Evidence-based policy making improved	Average score on the capacity to generate statistics for policy making	2016 & 2022	Country assessment questionnaire (CAQ)
Information availability increased	Census results report published, including main tables	2018 & 2022	LVV report
Gender-specific information availability increased	Index of FAO-recommended gender questions	2018 and 2023	Index measures fraction of FAO-recommended (World Programme for the Census of Agriculture 2020) gender-disaggregated questions (5) that are included in the agricultural census.

Table 6. Impact indicators

Impact	Indicator	Frequency of measurement	Means of verification
Rice productivity per ha	tn/ha	2017 & 2022	LVV Reports & impact evaluation
Small farmers' profits from rice production	$/ha	2018 & 2022	Impact evaluation

C. Existing Knowledge

3.10. Introducing irrigation can have several beneficial effects in the economy, from increases in agricultural productivity and income brought about by production intensification and switching to high-value crops, to increases in employment and wages, to improvements in health and education, and to higher economic growth at the regional or even national level (Hussain, 2007a). In fact, it has been found that investments in irrigation can have a multiplier effect in the economy of up to 6 (Comprehensive Assessment of Water Management in Agriculture, 2007).

3.11. There are several links between irrigation and the economic wellbeing of agricultural producers. Hussain and Hanjra (2004) indicate there are direct and indirect linkages between irrigation and poverty. The former are increases in returns to physical, human, and social capital of the poor, while the latter are the integration to markets of the poor and the improvement of national growth rates. Among the direct linkages, Datar and Del Carpio (2009) cite three main reasons put forth by the literature for why irrigation infrastructure can positively affect agricultural activity: (i) it can stabilize cropping patterns and yields, (ii) it may allow for more crop cycles per year, and (iii) it may allow switching to more profitable crops.

3.12. In the case of the Sustainable Agricultural Productivity Program, only the first mechanism is expected to be at play. Producers in the area of intervention are already producing in two seasons per year, which is the maximum possible for paddy rice. In addition, there are no indications that producers are looking to switch to more profitable crops and all agricultural markets in the area are organized around rice production. Besides, since water is abundant during approximately one half of the year and is readily available through the I&D system, it does not seem to be the limiting factor for switching to other crops.

3.13. Rehabilitating the secondary infrastructure is expected to allow for better crop management, at reduced costs. The first reason is that the rehabilitation will include access roads, which will facilitate access to the fields and allow producers to access their fields more easily and cheaply. And even considering exclusively irrigation and drainage infrastructure, the rehabilitation will allow producers to have better and cheaper control over water coming in and out of their fields. Currently, the condition of the secondary infrastructure does not allow that water flow control and causes producers to do various activities that are inefficient and expensive—such as water pumping and frequent field flushing—, and ultimately to obtain suboptimal yields.

3.14. The rehabilitation and construction of *primary* I&D infrastructure will also contribute to reducing these problems, so it will be very important for this evaluation to tease apart the positive effects of the secondary I&D infrastructure rehabilitation from those of the primary I&D infrastructure rehabilitation and construction.

3.15. The empirical literature indicates that irrigation infrastructure projects can have poverty-reducing effects. In a review of the literature, Hussain (2007a and 2007b) finds

that income can be up to twice as high among agricultural households with access to irrigation than among similar households without irrigation. This seems to emanate from higher agricultural productivity (and income), which also can be more than twice as high among producers with irrigation than among producers without irrigation (World Bank, 2007a). Studies conducted by the Government of Guatemala (2013) show that, in horticulture, irrigation can increase productivity and income by 200% to 400%, and by at least 29% in fruit production.

3.16. The empirical literature concentrates on the effects of irrigation vis-à-vis rainfed agriculture; empirical works on the effects of rehabilitating already existing irrigation infrastructure, however, are less common. Datar and Del Carpio (2009) provide an example in the context of a project with important similarities to the Sustainable Agricultural Productivity Program (SU-L1052). They evaluate a large irrigation infrastructure rehabilitation project in the coastal areas of Peru that was implemented during the first half of the 2000s and rehabilitated 313 kilometers of canals, 1,257 structures and 49 wells. Following a spatial regression discontinuity methodology, they find modest but progressive effects on income as well as differentiated crop specialization patterns, wherein poor households increased their production of staple crops while non-poor households increased their production of industrial crops. Using a differences-in-differences approach, Del Carpio, Loayza and Datar (2011) find that the increases in income among poor households come from better employment opportunities at large-scale farms rather than from increases in their own agricultural production. In Bolivia, a recent impact evaluation of the PRONAREC program—which includes both rehabilitation and construction of new irrigation infrastructure—uses timing differences in the roll-out of the program as identification strategy[2] and finds that irrigation increased the value of production of small farmers by 65%-70% and their income by 40% (Lopez and Salazar, 2017). In addition, the program included technical assistance on system management and the evaluation found that producers were significantly more likely to formalize water users' associations and implement irrigation calendarization as a result of the program. This result suggests that the efforts that will be implemented in the Sustainable Agricultural Productivity Program are likely to result in higher levels of WB formalization.

D. Evaluation Methodology

3.17. The Program seeks to increase agricultural productivity in Suriname through investments in infrastructure and management of I&D systems, and by improving the quality of available agriculture statistics. Other impacts from the investments in I&D systems include water use efficiency and profits of small farms. The central objective of the evaluation is to measure these farm-level effects generated by some of the investments in I&D systems.

a. Unit of Analysis, Treatment Group and Identification of Comparison Group

3.18. The Program includes several interventions acting at different levels. The activities of Component 2, for instance, affect the entire country. In Component 1, some activities—such as the main I&D infrastructure rehabilitation and construction or the

[2] The evaluation also uses a propensity score matching technique to "control for self-selection bias at the individual-level" (p. 17).

institutional strengthening of the water authorities—affect the entire irrigated area of Nickerie while others have effects at the polder/Water Board level and still others at the individual farmer level.[3] The characteristics of many of these activities, combined with the particular characteristics of agricultural production in Suriname, make it extremely difficult to identify their causal effects.

3.19. The complexity of assessing the indirect effects of information—such as those expected from Component 2—is well known. To the best of the team's knowledge, there are no impact evaluations of conducting a census or of strengthening a Ministry's analytical capacity.

3.20. The interventions financed under Component 1 present several complexities, too. Many of them affect the entire irrigated area to the left of the Nickerie river. Since rice—and indeed most of all agricultural—production is concentrated in that area, finding a control group is extremely complicated. Within Suriname, rice is only produced in the area of intervention and, to a much smaller extent, along the right bank of the Nickerie river and in the Coronie district. The latter areas differ significantly from the treatment area not only in their size but also in their characteristics: the area on the right bank of the Nickerie relies only on this river's flow and lacks sufficient water to grow rice during the dry season. In Coronie, there is reportedly only one active rice producer.

3.21. Finding within Suriname a comparison group for those interventions that have effects at the level of the entire treatment area is not feasible. On the other hand, and leaving data availability considerations aside, the nature of those interventions—a gradual improvement in I&D infrastructure and management capacity—make it difficult to construct a synthetic control formed by countries that do not make any interventions of that nature during the life of the Program.

3.22. At the farm level, however, things are different. Not all the Program's investments in the I&D system will be the same for all farms in the treatment area (TA), which creates a source of variability that can be exploited for the evaluation. Therefore, the unit of analysis of the evaluation is the farm.

3.23. The investments in the main I&D infrastructure are expected to be gradual but homogeneous across the entire TA. Hence, they will equally affect all farms in the area and are not the focus of this evaluation. In addition, there are other interventions affecting the Nickerie area—the Agricultural Competitiveness Program (SU-L1020) and other infrastructural investments financed by other development agencies. However, all of them are expected to either affect all farmers on the left bank of the Nickerie river uniformly or to not affect them at all.

3.24. The rehabilitation of the secondary I&D infrastructure, however, will not be homogeneous. There are 12 polders in the TA. Five of those polders have already been rehabilitated, another is pending, and only the remaining six will be rehabilitated by the program (see map 2). This creates two groups: farms that belong to those polders that will be rehabilitated and farms that belong to those polders that have already been rehabilitated. In addition, the beneficiary polders will have their I&D infrastructure rehabilitated at different times during the life of the program, allowing the polders that are rehabilitated later to serve as a comparison group for the polders that are rehabilitated earlier.

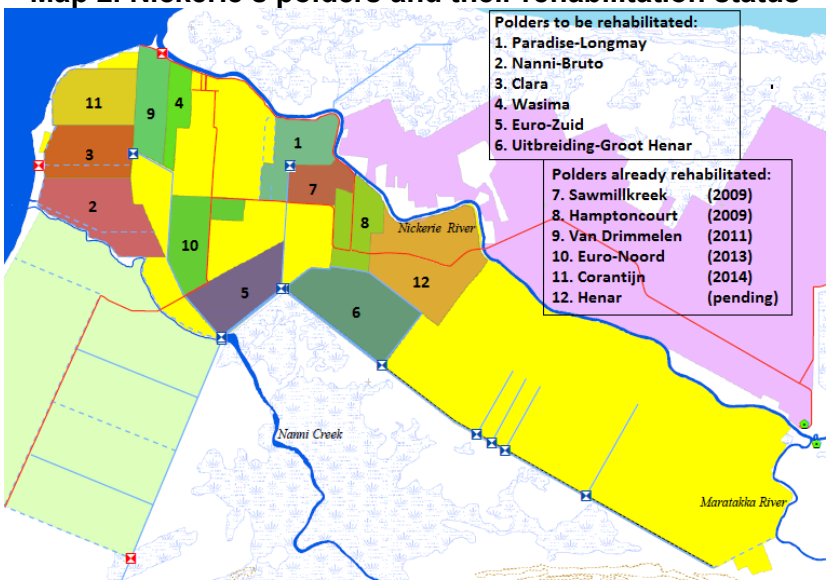
3.25. The Program will also subsidize land leveling as a mechanism to incentivize producers to pay the fees to cover the operation and maintenance of their polder's I&D infrastructure. The subsidy will cover a fraction of the cost of land leveling and will be offered only to those producers that have paid all their dues. Land leveling—

particularly, laser leveling—is known to increase rice yields substantially at the same time that it reduces the use of inputs—mainly water and fertilizer. While these effects are well established in the literature (e.g., Aryal, et al., 2014; IRRI, 2018; Lybbert, et al, 2014; and Mondal and Basu, 2009), the evaluation will verify these effects and test whether the incentive works—i.e., whether offering land leveling subsidies increases farmers' payments of O&M fees. Finally, the program will include training to farmers on agricultural good practices, including efficient use of water and other inputs.[4] Since this training will be offered to all farmers in the treatment area, it presents similar methodological difficulties for evaluation as the main I&D infrastructure works.

b. Research Design

3.26. The empirical strategy is based on the difference-in-differences method, which compares the changes experienced by the treated group during a period before and after the Program with the changes experienced by the control group during the same period.

Map 2. Nickerie's polders and their rehabilitation status



3.27. The program is expected to impact an outcome *Y* (agricultural productivity, for example) in farms that belong to the polders that will have their I&D infrastructure rehabilitated. We define group "*b*" as the farms benefited by the project ("treatment" group) and group "*c*" as a group of comparison farms ("control" group). At the beginning of the project, both groups have an average value of Y_1 of the impact variable, i.e., Y_{1b} and Y_{1c} for the treatment and control groups, respectively. At the end of the project, the impact variable is measured again in both groups, i.e., Y_{2b} and Y_{2c}. The attributable impact of the project, ΔY, is estimated by:

$$\Delta Y = (Y_{2b} - Y_{1b}) - (Y_{2c} - Y_{1c})$$

3.28. The average gain in the control group $(Y_{2c} - Y_{1c})$ is subtracted from the average gain in the treatment group $(Y_{2b} - Y_{1b})$—what is known as the double difference (DD). This procedure removes biases in second-period comparisons between the treatment and control group that could result from permanent differences between those groups, as well as biases from comparisons over time within the treatment group that could be the result of unobserved factors different from the Program.

3.29. Although the DD can be estimated directly by subtracting average values, it is desirable to incorporate control variables in the estimation, as it increases the precision of the DD estimates. To do that, the following regression approach is proposed:

$$Y_{it} = b_0 + b_1 * P_i + b_2 * T + b_3 * (P_i * T) + d * X_{it} + u_{it}$$

3.30. where Y_{it} is the outcome of interest for farm i at time $t = \{1,2\}$, T is a dummy variable for the second period and P_i is a dummy variable that equals 1 if farm i belongs to the treatment group. The time-period dummy, T, captures aggregate factors that would cause changes in Y_{it} even in the absence of an intervention. The coefficient of interest, b_3, multiplies the interaction term, $(P_i * t)$, which is a dummy variable that equals 1 for observations corresponding to farms in the treatment group in the second period. X_{it} is a vector of control variables that are correlated with the outcome of interest but not with the error term u_{it}.

3.31. Coefficients b_1, b_2, and b_3 are crucial in the model. b_1 measures the average difference in the outcome Y between treated and control farms at $t = 1$ (before the program); b_2 measures the average change in the outcome variable between the two observed times; and b_3 measures the DD—in other words, b_3 measures the impact of the Program on the outcome variable. Formally, estimates of this model are:

$$\hat{b}_0 = (Y|t = 0, P = 0)$$
$$\hat{b}_1 = (Y|t = 0, P = 1) - (Y|t = 0, P = 0)$$
$$\hat{b}_2 = (Y|t = 1, P = 0) - (Y|t = 0, P = 0)$$
$$\hat{b}_3 = [(Y|t = 1, P = 1) - (Y|t = 0, P = 1)] - [(Y|t = 1, P = 0) - (Y|t = 0, P = 0)]$$

3.32. To be valid, the methodology proposed requires that we observe each farm twice—before and after the program—, regardless of whether it belongs to the treatment or the control group. In addition, although the farms in the control group are not required to be elements randomly drawn from the same distribution as farms in the treatment group—which would make the average values of their outcome and control variables equal—any initial difference in the outcome variable between the treatment and control farms has to be constant over time. That is, the time trend of the outcome variable before the program must be the same for treatment and control farms. Testing this requirement of the model necessitates having at least two time-observations for both groups *before* the program, which unfortunately will not be feasible in this case.

c. Comparability between the Treatment and Comparison Groups

3.33. The success of an impact evaluation relies heavily on having a valid control group, that is, a group of units of analysis (farms in this case) that is comparable to the treatment group before the program but will not be affected by it.

3.34. In the case of the rehabilitation of secondary I&D infrastructure, beneficiary polders have similar characteristics to the other polders, except that the latter had its secondary infrastructure rehabilitated between 2009 and 2014. This implies that farms

in the latter polders have already been "treated" (their secondary I&D infrastructure was rehabilitated), which challenges their validity as a control group, since there could be unobserved reasons that explain why those polders were rehabilitated before and those reasons may be correlated with the productivity of their farms. In addition, the rehabilitation could have set the farms in those polders on a different productive path, so that the trends of the outcome variables—productivity, water efficiency, and profits—differ between the farms in the already-rehabilitated polders and the farms in this program's beneficiary polders. As discussed above, this (potential) difference in trends invalidates the use of the DD methodology.

3.35. However, the different timing of the rehabilitation can be used to generate a valid control group. Two polders will have their secondary infrastructure rehabilitated each year during years 2, 3, and 4 of the execution of the program. Farms in the first two polders to be rehabilitated will constitute the treatment group and farms in the last two polders will constitute the control group. This way, the control group will not have benefited from any previous rehabilitation and we will be able to observe the impacts of the rehabilitation on the treatment group. One drawback of this method is that it does not allow us to evaluate the long-run impact of the rehabilitation, since the control group is valid only during the two years between the time the first polders receive the rehabilitation and the time the control group also starts receiving the rehabilitation.

3.36. As discussed, the program will also finance subsidies to pay for land leveling. It is estimated that the amount allocated to this activity will be sufficient to finance most of the cost of leveling approximately 500 hectares of land, which covers only a small fraction (approximately 3%) of all the treatment area. Since these subsidies are meant to serve as an incentive for farmers to pay for the O&M of the secondary I&D infrastructure of their polder, the subsidies will be randomly assigned as of the third year of the program among farmers who have paid all their O&M fees during the previous years. For the subsidies to have their incentive effect, their existence and allocation mechanism will be announced as of the first year of the program.

3.37. The random allocation of the subsidies resolves the issue of comparability between the treatment and control groups—the latter will be formed by those eligible farmers that do not receive the subsidy. There is still, however, a potential issue of selection: only the subset of farmers that have paid their O&M fees will belong to either the treatment or control group. This issue challenges the external validity of the estimates of the impact of land leveling on productivity and other outcomes.

3.38. To estimate the incentive effect of the land-leveling subsidies on the payment of O&M fees, the subsidies will only be announced and offered among the farmers in the six polders to be rehabilitated during the program (only one plot per farmer, of a maximum extension of 5 ha, will be subsidized). This way, the difference in the rates of compliance in payment of the O&M fees between the polders rehabilitated by the Program and the polders previously rehabilitated will measure the incentive effect of the subsidies. Offering the subsidy only to farmers in the polders to be rehabilitated under the Program is fair considering that the remaining polders have enjoyed the benefits of the rehabilitation for a number of years.

E. Sampling Strategy, Power Calculations, Data Collection and Other Technical Aspects of the Evaluation

a. Sampling Strategy

3.39. The sample design sought coverage and representativeness of farms in the polders to be benefitted by the rehabilitation of their secondary I&D infrastructure. The local office of the LVV in Nickerie has a list of all the farms in each of the 12 polders, which effectively provides a list of the population of interest from which to draw elements to form the sample. At this point it is still not known which polders will receive the rehabilitation first. Hence, it is important that the baseline survey collects information from all of the six polders that will receive the rehabilitation. For that reason, a random sample will be obtained from each polder. Since the area of interest is relatively small and accessible, geographic convenience is not a consideration to determine the sample.

3.40. Farms in the polders whose infrastructure was rehabilitated before the program also offer valuable information to assess the incentivizing effect of the land-leveling subsidies as well as to assess whether the rehabilitation of the *primary* infrastructure has an additive or multiplicative effect relative to the rehabilitation of the secondary infrastructure. The sample for this group of polders, however, does not need to be representative of each polder, only of the group as a whole.

b. Power Calculations

3.41. Statistical power calculations were performed to establish the number of farms needed in the treatment and comparison groups. Disaggregated data on rice production in Nickerie are scant. The Anne van Dijk Rice Research Center in Nickerie (ADRON) reports that average yields have been increasing, reaching 4.9tn/ha in 2015. This figure is consistent with the anecdotal information that the project team received from local authorities. A recent survey financed by the Bank, the 2016/2017 Suriname Survey of Living Conditions, collected information on agricultural production. Unfortunately, the data reported on volume of production and area cultivated are imprecise. From the 68 households that reported to have cultivated rice, only 52 reported both area cultivated and volume of production. Of those 52, only 13 have a yield that is between 2.5tn/ha and 7.5tn/ha (with the 25th percentile at 0.75tn/ha and the 75th percentile at 18.3 tn/ha). Taking only those 13 observations as a basis, a mean yield of 5.01tn/ha and a standard deviation of 1.65tn/ha were calculated. These figures are used to calculate the sample size of the baseline and follow-up surveys.

3.42. In addition to rice yields, the program seeks to contribute to two other impacts—water efficiency and farmer profits. However, information on these variables is even more scarce. For that reason, power calculations are based solely on the need to detect the impacts that are expected on rice yields.

3.43. In this regard, it is anticipated that the program will increase rice yields by 12% (an increase from 5.01tn/ha to 5.61tn/ha). However, it is likely that this increase will be due to the combination of two factors: the rehabilitation of the primary infrastructure and the rehabilitation of the secondary infrastructure. As discussed above, our methodology only allows us to identify the impact of the latter factor. Hence, the sample size calculations will consider a range of minimum detectable effects (MDE) between 6% (half of the effect) and 12%.

3.44. The following equation[5] is used to estimate the sample size required to identify a minimum detectable effect (MDE) of size D with a 95% confidence level, a statistical power of 90%, and assuming that the sample is equally split between treatment and control groups:

[5] World Bank (2007b), referenced in Winters, Salazar and Maffioli (2010).

$$N = \frac{4\sigma^2\left(Z_\alpha + Z_\beta\right)^2}{D^2}$$

where
Z_α is the critical value of a 95% confidence interval (1.96);
Z_β is the critical value of the 90% statistical power (1.28);
σ is the standard deviation; and
N is the sample size.

3.45. Table 7 presents the sample size calculations based on this formula and the assumptions described above.

Table 7. Sample size calculations

	MDE		
	6%	**9%**	**12%**
Productivity (tn/ha)	5.31	5.46	5.62
Sample size	1,263	561	316

3.46. Since we cannot presume that the entire expected increase in yields (12%) will be due to the rehabilitation of secondary infrastructure, a more conservative increase of 6% is assumed. This implies a sample size of 1,264 farms to be interviewed. This number still needs to be adjusted for non-response rates—due to refusals and attrition in the follow-up survey. According to the CIA's World Factbook, Suriname has a low but positive net migration rate of 0.6 migrants per 1,000 population. However, there are indications that there is internal migration from rural areas to Paramaribo. To prevent this from affecting the evaluation, a 20% non-response rate is assumed, yielding a sample size of 1,520 farms (rounding up).

3.47. The formula assumed an even distribution of the sample between treated and control farms, implying 760 treated farms and 760 control farms. As discussed above, the treatment group will be formed by the first two (and the control group by the last two) polders to get their secondary infrastructure rehabilitated. That implies a sample of **380 farms per polder**. Since it is not yet known which of the six polders will have their infrastructure rehabilitated first and which last, the baseline survey will have to be collected in all six polders (unless the beneficiary and control polders are defined before the baseline is collected). Finally, the survey will also be collected in two of the polders (randomly chosen) whose secondary infrastructure was rehabilitated before the program.

3.48. These sample sizes obtained from the foregoing calculations are infeasible because the number of farmers some polders is smaller (see Table 8). In those cases, all farms in the polder will be surveyed.

c. Data Collection

3.49. The project's impacts will materialize over the project's six years and will become most apparent in each polder at the end of the rehabilitation of the secondary infrastructure. As a result, there will be two survey rounds: a baseline survey, to be collected in 2019,

and one follow-up (or end line) survey, to be administered after the first two polders have had their secondary infrastructure rehabilitated. Both rounds of surveys will be collected in the same calendar months to collect information from the same agricultural cycle and avoid seasonality effects. Specifically, both survey rounds should be collected immediately after the harvest, around April or September.

d. Questionnaires

3.50. The main data collection instrument for this evaluation will be one farm survey with detailed information on relevant socioeconomic characteristics. Since most of the farms are family farms, the survey will contain elements of a household survey. The structure of this survey is presented in Table 9.

Table 8. Area size and number of farms in each polder

	Area (ha)	No. of Farms	Year rehabilitated
Paradise-Longmay	1,244	362	to be rehab
Nanni-Bruto	1,988	131	to be rehab
Clara	1,451	169	to be rehab
Wasima	582	86	to be rehab
Euro-Zuid	1,440	72	to be rehab
Uitbreiding-Groot Henar	2,243	80	to be rehab
Sawmillkreek	481	68	2009
Hamptoncourt	894	227	2009
Van Dirmmelen	850	582	2011
Euro-Noord	1,035	93	2013
Corantijn	747	197	2014
Henar	2,242	105	pending

Table 9. Farm questionnaire measures

Section	Measures
HH – General Characteristics of Household	Demographic and household profiles
CD – General Characteristics of Dwelling	Dwellings construction type, amenities, and ownership
EA – Economic Activities of Household Members	Persons employed, occupation type, location, hours worked, income (fixed and supplementary), total annual earnings
CF – General Characteristics of the Farm	Number, size, location, value and ownership of plots; assets of the farm
FM –Farm Management and Performance	Per plot: Production costs (input use, water use, people employed, machinery use); management practices; number of cycles grown; yields; sales.
HA – Household Assets	Quantity and value of furniture, appliances, electronics, vehicles
WB – Water Board and Polder	Condition of primary and secondary infrastructure; functioning of water board; district-level water management

F. Evaluation Reporting and Budget

3.51. At this point it is not known which of the six polders will have their infrastructure rehabilitated first and which last. Hence, the budget will assume that the survey will be collected in all six polders whose infrastructure will be rehabilitated, plus two additional polders whose infrastructure has already been rehabilitated. This yields a total of 2,104 farms to be surveyed.

3.52. Budget necessary for the evaluation will be US$190,000, as detailed in Table 9. This includes (i) the questionnaire design and pilot survey; (ii) data collection for baseline survey; (iii) data collection for follow-up survey; and (iv) impact evaluation. This cost is included in the Administration Cost of the program. The PEU, specifically the monitoring and evaluation expert, will support the evaluation process. All procedures, results, key findings, challenges and lessons learned will be thoroughly documented as per IDB reporting requirements.

Table 10. Evaluation work plan and budget

Activities	2019				2020				2021				2022				2023				2024				Responsible	Cost (US$)	Source of financing
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Questionaire design and pilot survey																									Consulting firm	$ 20,000	Pgm budget
Data collection for baseline survey																									Consulting firm	$ 75,000	Pgm budget
Data collection for follow-up survey																									Consulting firm	$ 75,000	Pgm budget
Impact evaluation																									Individual consultant	$ 20,000	Pgm budget
TOTAL																										$ 190,000	

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