Cost Benefit Analysis of Senegal's Rice Value Chains

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Abstract

This paper presents the findings of the CBA of Senegal's rice value chains (looking at rain-fed and irrigated rice specifically). The analysis looks at evaluating the recent Feed the Future (FtF) activities implemented under the PCE (Projet de Croissance Economique) in Senegal.

Overall, the analysis points to two important conclusions:

1. The GoS, other donor partners, and the PCE project significantly improved the productivity of the irrigated rice VC over the last five years. From an economic point of view, the benefits of domestic rice production currently outweigh the costs, even with GoS subsidies and donor support.
2. The ERR is only one percent above the discount rate of 12%, emphasizing the importance of a well-defined exit strategy for both the GoS and international donors. The removal of subsidies or the inability of the budget to sustain such significant fiscal outflows may result in adverse effects throughout the VC.

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Key words: cost-benefit analysis, investment appraisal, stakeholder analysis, dairy value chain, marketing, Senegal.
JEL: D13, D31, D61, D62, E23, H42

List of Acronyms

CBA	Cost-benefit Analysis
CET	Common External Tariff
CNCAS	Caisse Nationale de Crédit Agricole du Sénégal
ENPV	Economic Net Present Value
FEP	Foreign Exchange Premium
FNPV	Financial Net Present Value
GoS	Government of Senegal
GPS	Global Positioning System
IIA	Integrated Investment Appraisal
ERR	Modified Economic Rate of Return
MIRR	Modified Internal Rate of Return
OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal
PCE	Projet Croissance Économique
PRACAS	Programme de Relance et d'Acceleration de la Cadence de
PSE	Plan for the Emergence of Senegal
SRV	Senegal River Valley
USAID	United States Agency for International Development
VC	Value Chain

Executive Summary

USAID has been supporting development of agriculture and improvements in food security in many countries in sub-Saharan Africa through technical assistance under its Feed the Future (FtF) program. In an effort to evaluate these programs USAID has recently begun a process of conducting cost benefit analysis (CBA) of the various activities currently in process or already completed. In order to support this process, USAID Washington requested IDG under its LEAP (Learning Evaluation and Analysis Project) II to conduct several of these CBA activities. The first of these tasks is the subject of this report to conduct a CBA of USAID/Senegal's rice value chains (looking at rain-fed and irrigated rice specifically). The analysis looks at evaluating the recent FtF activities implemented under the PCE (Projet de Croissance Economique) in Senegal.

USAID Senegal Economic Growth Project (PCE) falls within a larger portfolio of U.S. Government interventions in Senegal to improve food security, under the Feed the Future initiative. The project commenced in 2010 and was completed in 2015. The PCE project was implemented in line with Government of Senegal (GoS) development strategies toward achieving the food security of small farmers and national self-sufficiency in rice production. The major objective of the PCE project to improve productivity and quality of local rice production was successfully achieved. The following study presents results of ex-post cost-benefit analysis of the PCE project support to rain-fed and irrigated rice value chains that was conducted in 2015.

The PCE project provided a wide range of interventions along the rice value chains (VC) aimed at enhancing productivity. In the irrigated rice VC the paddy yields on average increased from five MT/ha to six MT/ha. In addition, improved quality of paddy and strong contractual frameworks created by the PCE project resulted in an increase of 25 percent in price of paddy. In the rain-fed rice VC the project managed to double the yields of paddy from one MT/ha to two MT/ha resulting in greatly improved food security for paddy producing households.

As a result of PCE activities in the irrigated rice VC annual income of paddy-producing households has more than tripled from US$ 108.3 to US$ 388.6. In the rain-fed rice VC annual income increased from US$ 59.0 to US$ 221.9. Certified seeds producers and processing industries also benefit as a result of USAID investments.

Table 1. Summary Impact Figures

Value Chain	ENPV*	ERR**
Irrigated Rice	US$ 50.68 mill	25%
Rain-fed Rice	US$ 3.27 mill	18%
TOTAL	**US$ 53.95 mill**	**24%**

*ENPV-Economic Net Present Value
**Economic Rate of Return

The financial gains to certified seed producers, paddy producers, and millers over the 20 year evaluation period would reach US$ 88.49 million expressed in 2010 dollars. The USAID investments in the rice VCs have reached US$ 12.55 million in 2010 dollars. In addition, the estimated cost of GoS subsidies amounted to US$ 22.00 million. As seen in the table above, the Economic Net Present Value (ENPV) of the PCE project is US$ 53.95 mill. The Economic Rate of Return is 24 percent.

The analysis makes four key recommendations:

1. Senegal's rice-production sector exhibits multiple distortions that are the result of significant support extended by the donor community and the GoS. The long-term positive impact of the PCE project therefore requires that donors and government alike develop a clear exit strategy, whereby farmers are gradually encouraged to pursue agricultural activities with limited or no assistance from the GoS and other donors including USAID.
2. The wide promotion of rice cultivation and consumption may impose significant health risks particularly in the low income rain-fed regions. During interviews, farmers repeatedly and proudly stated that they now are consuming only rice throughout a day (breakfast, lunch and dinner). Such poor nutrition will negatively affect the health conditions of the farmers. Donors and the GoS should promote diversification of cultivation to include other staple crops in addition to educating the population on nutrition and the importance of a diverse diet through media and other channels.
3. Availability of certified seeds still remains a risk factor for the long-run economic returns of PCE project interventions. It is recommended to closely monitor factors affecting availability of certified seeds and continue improving domestic seed production during the Naatal Mbaay project.
4. The analysis revealed that many issues resulting in low quality local rice production in the Senegal River Value were effectively addressed by the PCE project. Therefore new assistance should also focus on addressing existing infrastructure gaps, such as poor conditions of milling infrastructure. In rain-fed rice producing areas the focus should also be on market creation, diversification of production to improve dietary habits, and access to micro credit.

Introduction

Project Description

The following study presents an ex-post cost-benefit analysis (CBA) of the USAID Senegal Economic Growth Project (Projet Croissance Économique—PCE). The analysis covered irrigated and rain-fed rice cultivation systems. It did not include the maize, sorghum and millet value chains (VCs) that were also supported by the project.

The USAID PCE project falls within a larger portfolio of U.S. Government interventions in Senegal to improve food security, under the *Feed the Future* initiative. The PCE activities were completed in April 2015, and are currently being scaled up under the Naatal Mbay project.

The PCE project was implemented in line with Government of Senegal (GoS) development strategies, including the Programme de Relance et d'Accélération de la Cadence de l'Agriculture Sénégalaise (PRACAS) and the Plan Sénégal Emergent (PSE), which aim to achieve the food security of small farmers and national self-sufficiency in rice production.

The data and information required for the CBA was collected through a literature review and in interviews with PCE staff and various stakeholders. A list of the stakeholders interviewed is provided in Annex A.

Description of Interventions

The PCE project entailed a wide range of interventions aimed at enhancing the productivity of the identified rice VCs, addressing key weaknesses such as limited access to inputs, outdated cultivation practices, poor quality paddy, and low consumer recognition of marketed output. Project interventions were designed to create a mutually beneficial partnership between various stakeholders in the rice VCs, with an emphasis on production and marketing.

Because the project is complete, the CBA does not analyze the structure or feasibility of individual interventions. Rather, the analysis compares packages of PCE interventions (costs) with corresponding packages of benefits—a methodology that is consistent with the VC approach used in the PCE project.

The VC approach considers an outcome to be the result of multiple investments. Thus, while the returns on an individual intervention may be negative, that intervention may nonetheless be essential to realizing the benefits of other investments. For instance, agricultural training will not in itself result in higher yields if farmers lack access to required inputs. Similarly, access to inputs requires access to credit, and market linkages to ensure the sale of increased output.

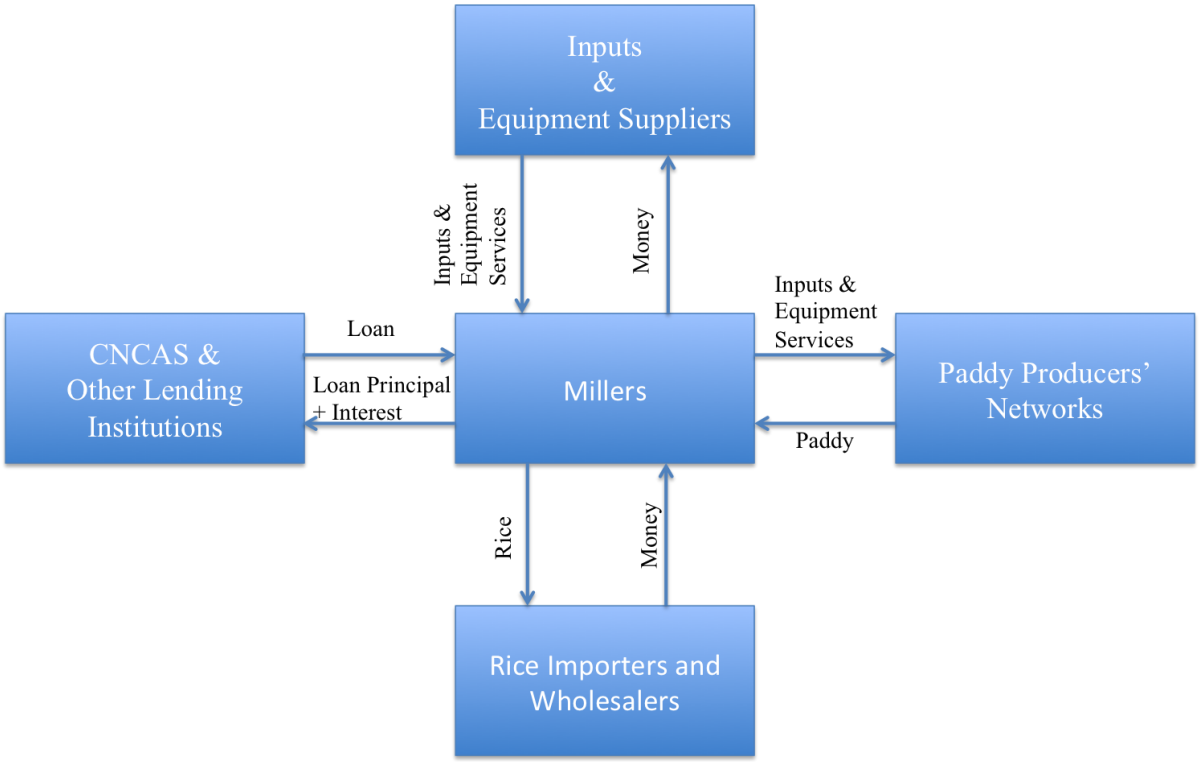
Irrigated Rice Cultivation System

The irrigated rice cultivation system is entirely market-oriented, in contrast to rain-fed subsistence-level production. A major bottleneck to improvements in Senegal's irrigated-rice sector has been farmers' limited access to certified seeds. PCE interventions in the irrigated rice cultivation system therefore focused on this issue, as well as on the development of innovative contractual frameworks, which have had a significant impact on production and

farmer incomes. The following are the interventions introduced through the PCE project:

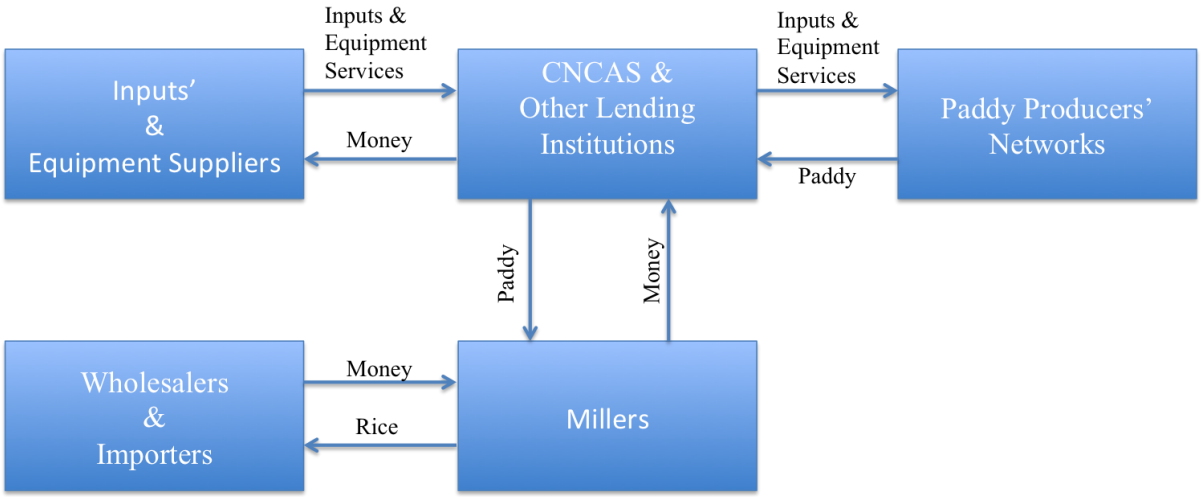
1. Seed-cultivation demonstration sites
   The establishment of seed-cultivation demonstration sites significantly increased farmer access to good quality seeds, securing higher yields.
2. Rehabilitation and capacity expansion of seed laboratories and seed-sorting centers
   Rehabilitation of the previously non-operational Richard Toll seed-certification laboratory, staff training, and expansion of seed-sorting capacity with the addition of new equipment has enabled seed producers to obtain much-needed certification.
3. Introduction of aromatic rice varieties
   Urban-consumer preference for aromatic rice varieties has been almost entirely satisfied by imports, with locally produced rice consumed mainly in rural areas. The project introduced new, aromatic varieties, which are currently produced by about 12% of PCE beneficiaries, who sell their entire output of aromatic rice to wholesalers.
4. Training programs across the value chain
   The project aimed to access as great a number of farmers as possible, working with farmer networks rather than small individual farmers. Best-practice training programs reached 6,906 individual farmers, cultivating about 34,530 ha of land. The project also included capacity-building programs for medium and large milling companies, seed-sorting centers, agribusiness companies, and seed-certification laboratories.
5. Establishing strong contractual frameworks between VC actors
   The establishment of strong contractual frameworks is a major achievement of the PCE project, providing farmers with access to much-needed credit, as well as ensuring the marketability of output. Figures 1 and 2 present the two types of contractual frameworks utilized by the project.

Figure 1. Type 1 contractual framework established by the PCE project.



Millers are at the center of the first type of contractual framework. Under this framework, millers borrow from the Caisse Nationale de Crédit Agricole du Sénégal (CNCAS) or other lending institution in order to provide farmers with all required inputs, including the rent of tractors for land preparation and harvesting.[1] Farmers repay the millers in paddy, covering the loan principal plus interest accrued over nine months at a nominal annual interest rate of 7.5%. The millers process the paddy and sell the rice to wholesalers and rice importers,[2] repaying the lending institution with the proceeds.

Figure 2. Type 2 contractual framework established by the PCE project.



Under the second type of contractual framework, CNCAS contract input and equipment service providers on behalf of farmers' networks. CNCAS also enters into contractual arrangements with the millers to sell paddy received from the farmers. Millers process the paddy and sell the rice to wholesalers and importers.

6. Access to basic equipment and Global Positioning System (GPS) technologies

The project directly provided farmers with basic equipment, or improved farmer groups' access to equipment through linkages with equipment suppliers. Farmer groups were also trained in the use of GPS technologies to measure the surface under cultivation. Both of these activities enable the more efficient use of production inputs, contributing to improved yields.

7. Access to finance and insurance, including a rain index-based program

The contractual frameworks have greatly facilitated farmer access to credit, such that almost every PCE beneficiary now has access to CNCAS micro-credit facilities.

Rain-fed Rice Cultivation System

In contrast to PCE interventions in the irrigated rice cultivation system, interventions in the rain-fed rice cultivation system focused on expanding production through increased yields. The production of rain-fed rice is labor-intensive and generally dominated by female subsistence farmers, in contrast to the market-orientated production of irrigated rice. Rain-fed rice is grown mainly on the plains, with limited or no access to inputs. Male heads-of-

[1] No cash is given to farmers. Credit is provided in the form of inputs and contracts with equipment service providers.

[2] The government of Senegal requires the country's nine registered rice importers to purchase a certain quantity of locally-produced rice products.

household generally use commercial inputs or inputs available at the household level, such as equipment and plowing power, to produce other commodities in the uplands.

Current yields of areas under rain-fed rice cultivation average around one MT/ha, with an average surface of just 0.25 ha per family allocated to rice—sufficient to cover family needs for four to six months. Imported rice purchased from rural outlets or the nearest urban area meets family needs for the remainder of the year.

A key bottleneck in the rain-fed cultivation system is low productivity, which the PCE project tackled with a number of interventions, including:

1. Seed cultivation demonstration sites
2. Rehabilitation of seed laboratories and seed sorting centers
3. Training on best practice in rice cultivation
4. Support for producers of small equipment

Methodology and Model Description

Methodology

The Integrated Investment Appraisal (IIA) model offers a means of evaluating both the financial and the socio-economic effectiveness of an investment project, estimating its impact from various perspectives. IIA is the only single-model approach to quantify the impact of every project related transaction, from the private investor to tax revenues, fiscal expenditure, consumers, and the environment. The methodology is used in project evaluation by major development banks, donor agencies, and public investment units.

Alternative forms of impact analysis entail discrete financial analyses and assessments of economic impact, which are often carried out by independent analysts at different stages of project development, and which therefore rarely provide an opportunity for experts to adjust and improve project design.

The IIA of USAID's PCE project begins with an evaluation of the profitability of the investment (Financial module). This analysis is conducted on an incremental basis, to determine the net incremental impact of the project on various stakeholders, including project beneficiaries, and to test the project's financial sustainability. The socio-economic assessment (Economic module) builds on the Financial module, greatly reducing the time and resources normally required for such studies. The Economic module is based on the principles of applied welfare economics,[3] according to which socio-economic benefits are assigned monetary values and assessed using typical investment project efficiency indicators, such as Economic Net Present Value (ENPV), analogous to Financial Net Present Value (FNPV), and Economic Rate of Return (ERR), analogous to Internal Rate of Return (IRR).

Model Description

The analysis covers a 20-year period from 2010 to 2030, comparing annual "with-project" and "without-project" scenarios on an incremental basis. The base year is 2010, and the real financial and economic discount rates are set at 12 percent. The model first derives nominal cash flows, which are then discounted according to price indexes (World Bank inflation and exchange rate data) to derive statements of real cash flows.

The farm models were constructed on a per-hectare basis, for two reasons. First, paddy production costs are usually expressed on a per-hectare basis. Second, field visits revealed no significant cost savings for farmers with large (20 ha) landholdings compared to smallholders (5 ha).

The excel model is structured as a dynamic VC analysis model, where a change in a parameter affects complete list of the relevant stakeholders. For instance a drop in yields of certified seeds will not only negatively affect returns to seed producers, but also will reduce availability of seeds in the VC and therefore proportionally reduce paddy yields. Reduction in paddy yields in turn will negatively affect capacity utilization of milling companies and result on reduced profits. The GoS will need to import more rice to satisfy domestic demand and therefore will gain import duties. These fiscal gains will be partially outweighed by foreign

[3] See "Three Basic Postulates for Applied Welfare Economics", A. Harberger, 1971.

exchange premium losses. In a same manner a change in the price of paddy, seeds, fertilizers and other inputs and outputs of production will affect all the relevant stakeholders.

Irrigated Rice Production

The availability of certified seeds is a key risk factor in paddy production in Senegal. The PCE project's work with seed-producer networks therefore aims to ensure the quality and quantity of this input, which is critical to the main project beneficiaries—paddy producers.
The CBA model starts with an analysis of seed production, comparing the profitability of certified-seed production in the "without-project" and "with-project" scenarios. A similar analysis is undertaken for paddy producers.

The baseline analysis assumes that the quantity of certified seed production is sufficient to satisfy demand from paddy producers affected by the PCE project. If seed production falls (a scenario tested by sensitivity analysis), the total PCE-participant farmers' surface under paddy will fall proportionally.

A feasibility analysis of medium-size millers[4]—representative beneficiaries of the PCE project—indicates that increased paddy production increased millers' profitability. However, the high transport cost of raw materials meant that an increase in available paddy led to the opening of small-capacity milling units close to farmers. That is to say, the PCE did not have much direct influence on the operations of medium-size millers; rather, the increased availability of raw materials resulted in higher profits for the millers. Figure 3 presents the logical linkage of the excel model connecting the three stakeholders across the value chain.

Figure 3. Connectivity of the Model in Irrigated Rice VC.

1. Quantity of Seeds Produced = Demand from Paddy Producers
2. Incremental Quantity of Paddy Production / Capacity of Milling Unit = Number of New Entrants

Rain-fed Rice Production

The farm model constructed for rain-fed rice producers is based on a cultivated surface of 1.0 ha, although the most common plot size allocated to rice production is 0.25 ha. The analysis is conducted on an incremental basis, with the opportunity cost of family labor used to calculate production costs and to estimate FNPV and MIRR.

[4] A medium-size miller comprises two to four small milling units.

Financial Analysis

The primary data for analysis was collected from field trips conducted in October 2015. This data was compared with that collected for an ex-ante analysis of the PCE project conducted in 2012, and was further analyzed and adjusted on the basis of consultations with agricultural experts and implementers of the PCE project, as well as a literature review. A set of farm budgets for each rice production system was prepared and analyzed, to derive a standard farm budget (see Annex B). The CBA could then be carried out using mean values, excluding statistical outliers.

A summary of the incremental financial analysis of the PCE project is presented in Table 2.

Table 2. Incremental Financial Analysis.

PCE Beneficiaries	FNPV/Ha	MIRR	Total FNPV (US$ mill)
Before Financing			
Certified Seed Producers	2,657	32%	**2.71**
Paddy Producers (Irrigated Rice)	1,771	30%	**75.83**
Paddy Producers (Rain-fed Rice)	1,193	35%[5]	**9.16**
After Financing			
Certified Seed Producers	2,920	45%	**2.98**
Paddy Producers (Irrigated Rice)	2,000	37%	**85.65**
Paddy Producers (Rain-fed Rice)[6]	1,193	35%	**9.16**
Millers			
Medium Millers	11,130	17%	**0.51**
Large Millers	35,019	NA	**0.28**
Total After Financing:			**98.57**
Total Before Financing:			**88.49**

[5] Note: Financial "without-project" IRR is 19 percent and "with-project" IRR is 26 percent. An incremental IRR of 35 percent appears high. However farmers reported a 100 percent increase in paddy yields as a result of the use of certified seeds alone.

[6] The PCE project did not have any activities to improve access to finance for rain-fed paddy producers. The returns to the paddy producers are therefore the same before and after financing.

The financial impacts of the PCE interventions are positive, with the improved profitability of farming activities resulting in increased income at the farm level. It should be noted that the "without-project" financial cash flows for seed and paddy producers were also positive. The IRR before financing for irrigated certified seeds and paddy producers in the "without-project" scenario is estimated at 27 and 14 percent, respectively.

In the irrigated rice VC, the incremental IRRs for certified seeds and for paddy producers before financing are estimated at 32 and 30 percent, respectively. The after-financing financial rates of returns are 45 and 37 percent, respectively. The FNPV of the PCE project including the GoS subsidy on loans is US$ 98.57 million, while the FNPV without financing would be US$ 88.49 million. The PV of financial gains to farmers from access to subsidized loans is estimated at US$ 10.08 million.[7]

It should be noted that access to subsidized loans results in positive financial returns for PCE seed and paddy-cultivation activities.[8] The project has improved access to micro credit through the creation of market linkages and contractual arrangements. However, the contribution of the GoS as a loan provider should not be undervalued. The total value of the loan subsidy (as a fiscal outflow) is presented below in the section on stakeholder analysis.

Benefits of the Interventions in the Irrigated Rice VC

Benefits to Certified-Seed Producers

The main downstream benefit of PCE interventions at the seed-production level has been the increased availability of certified seeds. As noted above, insufficient seed supply remains one of the key challenges to rice production in Senegal, although the situation has steadily improved. Limited access to certified seeds could potentially jeopardize higher yields of paddy, and the financial and economic returns of PCE investments. The PCE project has therefore aimed to create a strong linkage between seed producer and paddy producer networks.

A shift toward dry-season production resulted in increased seed-producer yields, from an average of five MT/ha to six MT/ha. In addition, investments in seed laboratories and seed-sorting centers resulted in increased seed production, rising from 75 percent per hectare to 85 percent. Improved yields mean farmers now obtain 5.1 MT of certified seeds per hectare, compared to just 3.75 MT per hectare prior to the PCE project, while efficiency gains have raised seed producers' profitability from 532.0 thousand CFA/ha (US$ 925.2/ha) to 743.2 thousand CFA/ha (US$ 1,292.5/ha).[9]

The incremental FNPV to seed producers is estimated at US$ 2.98 million, with an incremental IRR of 45 percent. As such, the PCE project improved the profitability of certified-seed production and, more importantly, improved paddy producers' access to certified seeds.

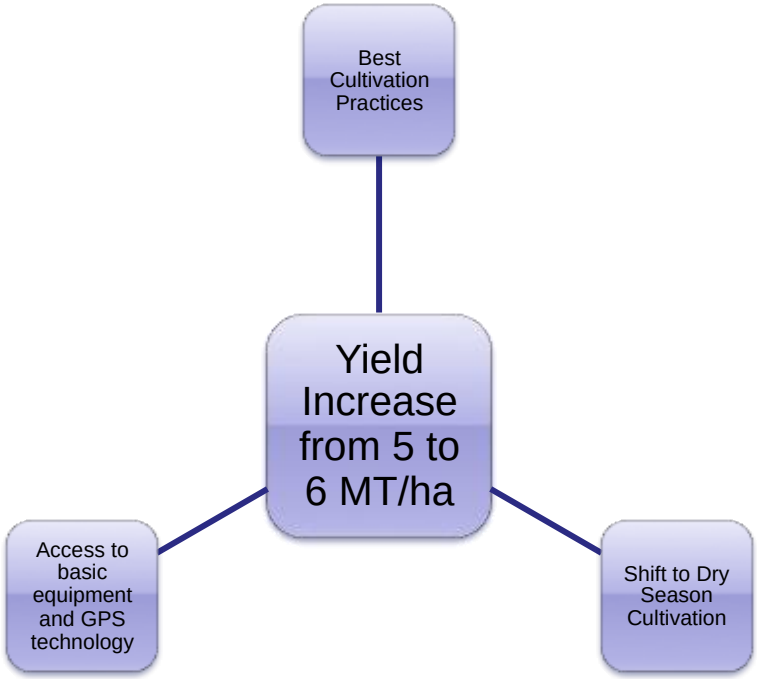
[7] The difference between FNPV before and after financing.
[8] Access to micro-finance in the rain-fed rice production VC remains very limited.
[9] See Annex C for seed producers' farm budget. Numbers are presented as of 2015.

Benefits to Paddy Producers

PCE project interventions resulted in a dramatic rise in participating paddy farmers' net incomes, boosting per-hectare profitability from US$ 108.3 per ha to US$ 388.6 per ha—a 259 percent increase. The incremental FNPV for beneficiary households is estimated at US$ 85.65 million, with an IRR of 37 percent. The improved profitability of rice production stems from three interlinked PCE activities:

1. Adoption of best practice in rice cultivation, including access to certified seeds, basic equipment, and GPS technologies, has boosted paddy yields. In addition, innovative contractual frameworks improved access to finance while reassuring farmers of their ability to sell on higher volumes of produce. This in turn created an incentive for farmers to shift resources from rainy- to higher-yield dry-season production. PCE project beneficiaries currently achieve an average yield of six MT/ha of paddy, compared to five MT/ha in the "without-project" scenario. This increase in paddy yield is one of the main benefits of the PCE project—and therefore a risk factor in achieving the identified benefits of USAID's investment. The increase in paddy yield was confirmed in interviews with beneficiary farmers, representatives of processing industries, agricultural experts and government officials responsible for monitoring PCE project implementation.

Figure 4. Interventions Produced Increase in Paddy Yields.

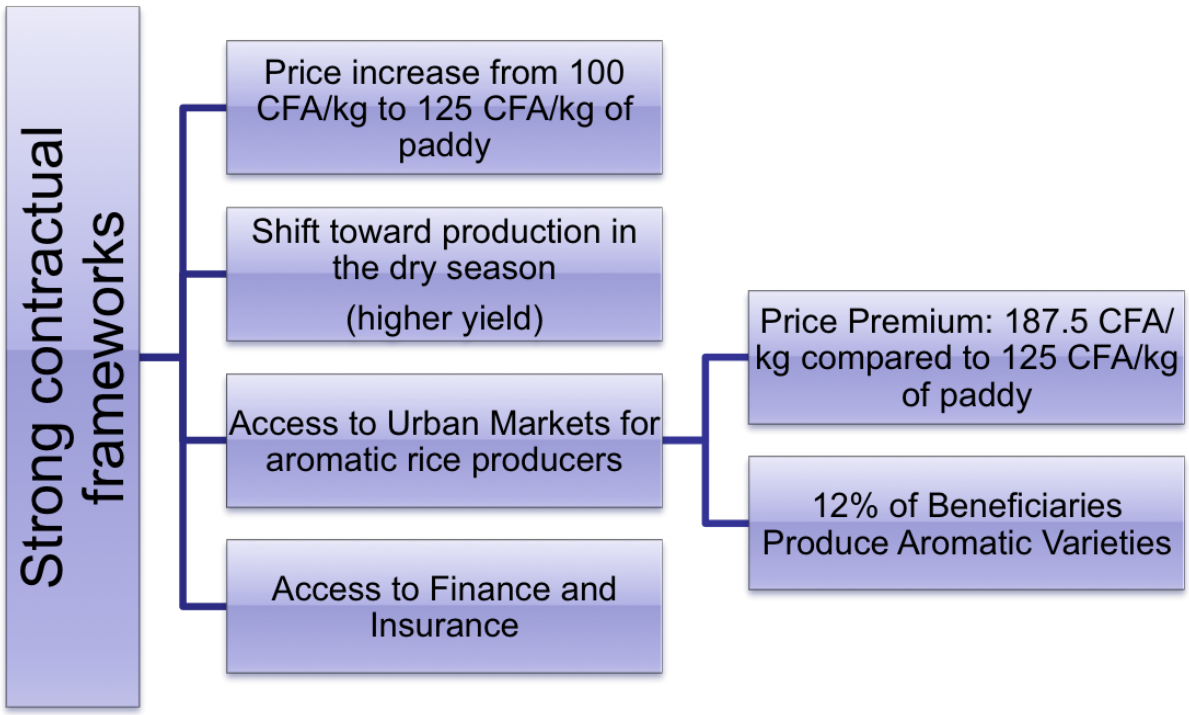


2. In addition to boosting the quantity of rice produced, the adoption of best practices, combined with access to certified seeds, has resulted in a significant increase in the quality of paddy produced. In this regard, the new contractual frameworks also played a part, dictating a 25 percent price premium on paddy procured at the farm-gate. The price of paddy increased from 100.0 CFA/kg to 125.0 CFA/kg.

3. The PCE project encouraged local farmers to produce aromatic rice. At the same time, a PCE-backed marketing campaign helped direct strong urban demand from imported to domestically grown produce. Aromatic paddy now trades at 187.5 CFA/kg, although the price premium over non-aromatic varieties is unlikely to be sustained over the long run. The analysis therefore assumes a long-run farm-gate price for aromatic paddy of CFA 150/kg. Currently only about 12 percent of PCE beneficiaries produce aromatic paddy varieties.

The creation of new contractual frameworks is a central component of PCE activities in the Senegal River Valley. Figure 5 provides an overview of the impact of the contractual frameworks on project beneficiaries.

Figure 5. Interventions Leading to Increase in Paddy Yields.



It is important to note that no single PCE project intervention produced a positive change in the VC. Rather, the project successfully addressed multiple shortcomings, resulting in the range of positive impacts discussed.

Benefits to Millers

The PCE project entailed a limited number of activities directly targeting rice millers. However, PCE interventions in the VC have increased the profitability of eight large millers' operations, in two key ways. First, large milling companies were able to reduce the cost of transporting raw materials, as a result of construction of warehouses, and contractual arrangements established under the PCE project (see Figure 1). Through these contracts, milling companies secured sufficient financing to fill warehouses with paddy rather than collecting from individual farm gates. This reduced transport costs by approximately 30

percent, from 7,000 CFA/MT to 5,000 CFA/MT. The warehouses were built by the Spanish Agency for International Development Cooperation, whose contribution to the success of this project activity must also be acknowledged.

Second, the improved quality of paddy allowed big milling companies to increase paddy processing efficiency from 57 percent to 63 percent. This represents gains of some US$ 0.28 million in real terms—gains passed from the milling companies to paddy producers, as reflected by the 25 percent increase in the farm-gate price of paddy.[10]

The PCE project entailed no incremental costs for large millers, so a feasibility analysis to reveal the incremental impact of project activities on these beneficiaries was not carried out. Project benefits to large millers were calculated according to the total installed capacity of the eight large milling companies affected by the PCE project.

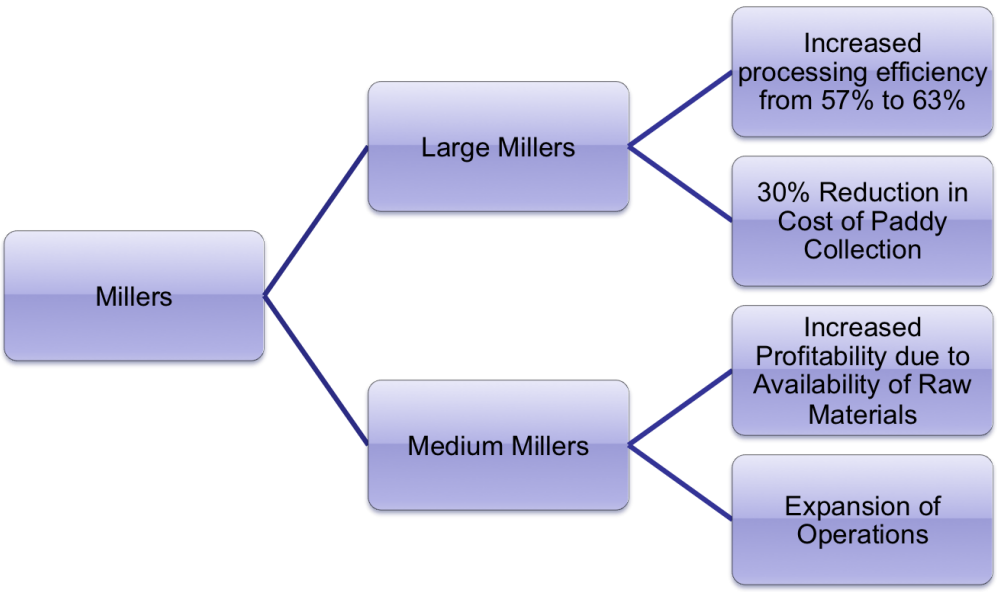
The PCE project also indirectly affected operations of other milling companies, dominantly medium size mills, which did not have access to warehouses constructed by the Spanish Agency for International Development Cooperation. The main risk factor facing milling companies is limited availability of raw materials, while insufficient warehouse capacity contributes to the high cost of transporting raw materials. The most common business model adopted by private milling companies in the Senegal River Valley (SRV) entails the opening of a limited number of medium size milling units close to paddy producers. Although the PCE project did not directly affect these medium-size milling companies, the increased availability of paddy stimulated many small millers in the region to expand their operations.

The incremental increase in paddy production has been used to estimate the number of new milling units likely to enter the market.[11] Assuming that each new milling unit will operate at 70 percent (3.5 MT/day) capacity, the FNPV of these entrants is estimated at 11,130 US$/year/unit, with an MIRR of 18 percent. Accordingly, the incremental increase in paddy production accruing to PCE beneficiaries is absorbed by 57 milling units of five MT/day-capacity. The benefits to milling companies are presented in Figure 6.

[10] The value of the efficiency gains represents an 18.82 percent increase in the farm-gate price of paddy. There is a very strong correlation between improved milling efficiency and a 25 percent increase in the farm-gate price of paddy.

[11] A milling company may own a number of small milling units, the typical capacity of each of which is 5MT/day.

Figure 6. Benefits of Large and Medium Milling Companies.



Benefits of Interventions in Rain-fed Rice Production

Rice is a one of the main food crops in southern Senegal, generally cultivated by female subsistence farmers working small, lowland plots. Production is entirely by hand; plowing power (oxen and tractors) and other equipment are utilized by male farmers for the cultivation of other commodities on the uplands. A lack of access to plowing power and very low yields mean that female farmers have limited incentive to commit more than 0.5 ha of surface area to rice cultivation. Under the PCE project, however, paddy yields doubled from an average of 1.0 MT/ha to 2.0 MT/ha, as a result of best-practice training and increased access to certified seeds.

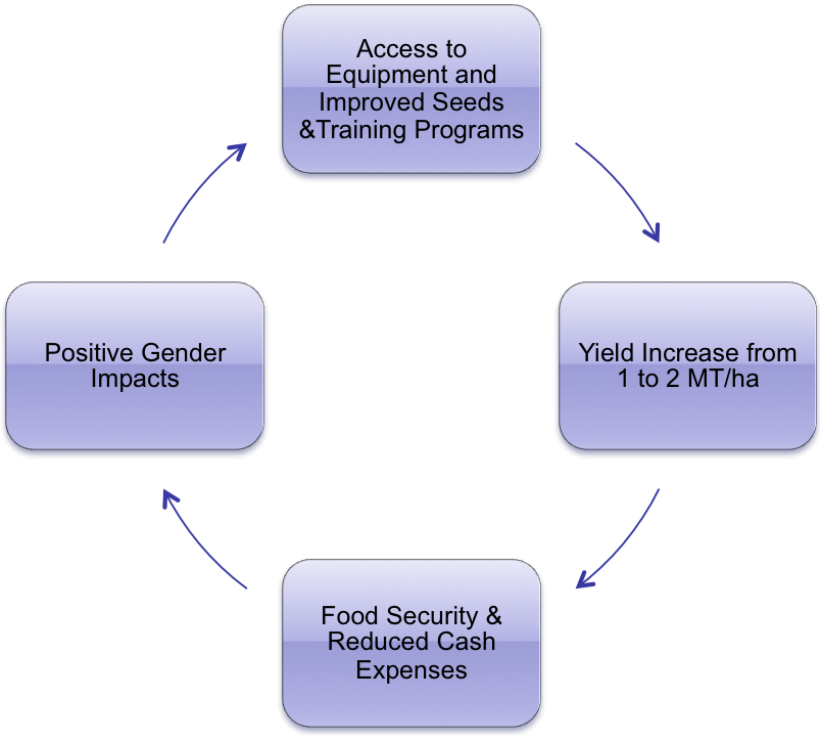
It is important to note that the financial value of paddy to subsistence farmers is higher than the market price of 125.0 CFA/kg, because of the much higher cost of rice sold at local outlets. The average subsistence farmer's annual production of one MT/ha is sufficient to cover only about 40 to 60 percent of household requirements. The remainder must be purchased. But while a paddy price of 125.0 CFA/kg is equivalent to 250.0 CFA/kg of rice at the household level,[12] the minimum retail price of imported rice is 260.0 CFA/kg, in addition to the cost of transport to and from retail outlets. A conservative estimate of the financial value of the incremental paddy yield is 130.0 CFA/kg.[13]

Increased paddy yields mean less cash is spent on rice, as well as contributing to higher food security at the household level. Increased yields are also leading to a gradual appreciation of the importance of rice production among male heads-of-households, greater numbers of whom are now cultivating paddy in the uplands of southern Senegal. At the same time, the higher yields achieved by female farmers have helped to improve the status of women, as well as incentivizing men to allocate some basic equipment and plowing power toward the

[12] The paddy-to-rice transformation coefficient is set at 0.5.
[13] Equivalent to 260.0 CFA/kg of rice, exclusive of transportation costs, where the cost of family labor to beat paddy offsets transportation costs.

cultivation of paddy. A number of female farmers interviewed said they had increased the area of land cultivated to about one ha, once their husbands agreed to invest in additional oxen for plowing. The increase in rain-fed paddy producer incomes is estimated at US$ 163.1 per ha (see Annex D for an indicative farm budget). The FNPV is estimated at US$ 1,193.2 per ha. Given an average of 0.25 ha/household allocated to rice cultivation, FNPV is US$ 298.3/household.

Figure 7. Benefits to the Rain-fed Cultivation System.



Incremental Costs in the Irrigated Rice VC

Table 3. Summary of Incremental Costs.

	US$/ha	CFA/Ha	% of Incremental Yield/Ha
Certified Seed Producers	315.2	181,260.0	46
Paddy Producers (Irrigated Rice)	185.8	106,815.0	40
Paddy Producers (Rain-fed Rice)	62.9	36,200.0	28
Millers	-	-	-

Incremental Costs to Seed Producers

Incremental costs to seed producers in the irrigated rice VC are associated with the shift toward dry-season cultivation. These costs include:

1. Increased cost of irrigation—that is, the higher cost of fuel to run irrigation pumps and higher OMVS (Senegal River Basin Development) fees. The fuel requirement increased on average from 80 lt/ha to 150 lt/ha. The incremental cost of OMVS fees in the dry season is 4,000 CFA. The total incremental cost of irrigation is therefore 52,300.0 CFA/ha or 13 percent of the value of incremental paddy and seed production.[14]
2. The incremental cost of harvesting is 20 percent of the value of incremental paddy and seed production, or 78,500 CFA/ha.
3. Increased paddy and certified-seed production increases the cost of packaging and certification labeling (variable cost). The total increase in packaging costs is 15,300 CFA/kg or four percent of the value of incremental paddy and seed production.
4. The incremental cost of seed-sorting services is 27,000 CFA/ha, equivalent to seven percent of the value of incremental paddy and seed production.

The total incremental cost to certified-seed producers is estimated at 46 percent of the value of incremental paddy and seed production.

Incremental Costs to Paddy Producers

The farm budgets provide a detailed breakdown of costs at the farm level (see Annexes B-D). The adoption of best cultivation practices does not imply an increase in expenditures associated with the cost of land preparation, on-farm labor, or the purchase of fertilizers and other inputs. However, there is an increase in a number of other expenditures.[15]

1. Increased cost of irrigation. As noted above, the shift toward dry-season production results in an increase in the cost of fuel to run irrigation pumps and higher OMVS fees. Fuel requirements increased on average from 80 lt/ha to 139.5 lt/ha, equivalent to 41,055 CFA/ha. OMVS fees in the dry season are 11,000 CFA compared to 7,000 CFA/ha in the rainy season. The total incremental cost of irrigation is therefore 45,055 CFA/ha or about 17 percent of the value of incremental paddy yields.[16]
2. A shortage of harvesting equipment means that service providers charge monopoly rents, calculated on the basis of production. The current practice is to charge 20 percent of paddy yield for harvesting services—an incremental cost of 53,600 CFA/ha.
3. Higher yields produce an additional 12 sacks/ha, equivalent to 3,360 CFA/ha. The cost of transporting paddy sacks to millers averages 400 CFA per sack. The incremental cost of packaging and transportation is 8,160 CFA/ha, equivalent to three percent of the value of incremental paddy yields.

[14] The value of incremental paddy yield is 1,000 kg * 0.85 * 300 CFA/kg + 1,000 kg * 0.15 * 125 CFA/kg = 392,500 CFA.

[15] Since the major benefits of PCE investments stem from price and yield increases, the detailed comparison of incremental costs and benefits of the yield increase is required to determine if the shift toward dry-season production is financially viable.

[16] The average increase in yields from 5 MT/ha to 6 MT/ha is equivalent to 268,000 CFA/ha in incremental revenues.

The aggregate incremental cost of paddy production is therefore estimated at 40 percent of the value of the increase in paddy yields. The main financial benefits to rice farmers stem from a 25 percent price premium on non-aromatic varieties and a 50 percent price premium on aromatic varieties.

Incremental Costs to Millers in the Irrigated Rice VC

There are no incremental costs to large millers in the irrigated rice VC; indeed, large millers gain from transportation cost savings and improved paddy transformation efficiency. The financial gains associated with improved paddy transformation efficiency are however pushed downstream to the paddy producers. The analysis assumes that increased availability of paddy will provide an incentive for new, medium-size mills to enter the market. These small mills are treated as Greenfield operations.

A feasibility analysis of small mills has revealed that the elasticity of variable milling costs to the capacity utilization rate is equal to 1.1. Therefore, at a certain point an increase in the capacity utilization rate will result in a decrease in the per kg average cost of milling. At a rate of 70 percent capacity utilization, the cost of milling is estimated to be 30.7 CFA/kg, implying a profit margin of three CFA/kg of paddy processed.[17]

It should be noted that the average milling cost of paddy processed would continue to fall until the marginal variable cost is equal to average costs. An increase in the capacity utilization rate therefore has a significant impact on the profitability of small mills, if the price is based on long-run average total costs.

Small mills are usually placed in an optimal location between farmers and rice-selling points to minimize transportation costs. The break-even rate of capacity utilization with a 12 percent real rate of return is estimated at 66 percent. The analysis assumes a rate of capacity utilization for small mills of 70 percent, which is a rather conservative assumption for the estimation of benefits of the PCE investments. Given that a new mill is profitable operating at 70 percent capacity, additional mills can be expected to enter soon after existing mills earn a rate of return well above 12 percent

Incremental Costs in Rain-fed Rice VC

The adoption of best-practice cultivation techniques requires the use of certified seeds to achieve an increase in paddy yields: no other changes to inputs or labor requirements at the production level are required. Prior to the adoption of best practices, farmers set aside a fraction of paddy produced for use as seeds in the next planting period. Farmers interviewed for this study could not provide an estimate of the quantity of seeds required to plant a hectare of land. The analysis is therefore based on an assumption of 60 kg/ha. If seeds are valued at the price of paddy, the cost of own-produced seeds is 7,800 CFA/ha. Certified seeds currently trade at 300 CFA/kg and are planted at a rate of 80 kg/ha. This implies an incremental cost of 16,200 CFA/ha, or 12.5 percent of the value of incremental paddy production. The availability of financial resources for the purchase of certified seeds from the outset is therefore the main risk factor to the PCE project in the rain-fed rice VC.

[17] The cost of milling per kg of paddy is calculated all-in, not including the cost of paddy, divided by the quantity of paddy milled.

Economic Analysis

The financial analysis outlined above forms the basis for an economic assessment of PCE investments, examining the incremental costs and benefits of project activities in terms of their broader impact on society. However, market prices frequently do not correspond to the actual value of resources produced and consumed by a given activity due to distortions such as taxes and subsidies—the most significant of which are subsidies on agricultural equipment, fertilizers and loans. The analysis presented here therefore uses commodity-specific conversion factors to adjust farm budgets, while net incremental resource flows are scaled according to the land surface affected by the PCE project, capturing total net economic benefit.

USAID investments in the irrigated and the rain-fed rice VCs amounted to US$ 8.58 million and US$ 6.04 million, respectively. The present value of these costs is deducted from the present value of the net benefits to calculate the ENPV of the PCE project.[18] A summary of the economic analysis is presented in Table 3.

Table 4. Incremental Economic Analysis of Irrigated Rice.

PCE Beneficiaries	ENPV/Ha	ERR	TOTAL ENPV (US$ m)
Certified Seed Producers	2,636	33%	2.61
Paddy Producers (Irrigated Rice)	1,272	30%	54.49
Medium Millers		19%	0.69
Large Millers		NA	0.24
Total ENPV:			**US$ 58.04**
PV of USAID Investment			US$ 7.36
ENPV USAID PERSPECTIVE:			**US$ 50.68**
EMRR USAID PERSPECTIVE:			**25%**

Because Senegal imports certified seeds, the analysis treats such seeds as an importable commodity. All agricultural inputs are exempt from GoS import duties. The PCE project has increased the domestic supply of certified sees, resulting in foreign exchange savings. The Foreign Exchange Premium (FEP) for Senegal is estimated at 7.46% (Kuo, 2014). The conversion factor for certified seeds is estimated at 1.07. The ENPV of certified-seed production is US$ 2.61 million.

[18] The PV and NPVs are expressed as of 2010, the year the PCE project commenced.

Despite the ambitious target of achieving rice self-sufficiency by 2017, Senegal remains one of the biggest rice importers in Africa, reaching 1.15 million MT in 2014—up 4.55 on the previous year (United States Department of Agriculture). In an attempt to protect the purchasing power of consumers, the GoS has encouraged cheap rice imports by exempting rice from VAT and setting a Common External Tariff (CET) as low as 12.7 percent (SOS, 2015).

The conversion factor for rice is 0.95, while the ENPV of paddy production is US$ 54.49 million, significantly lower than the FNPV of US$ 75.83 million.

Though the impact of the paddy conversion factor on millers' ENPV is limited, because paddy is an input and rice is an output, it still has a significant impact on the difference between FNPV and ENPV. In addition, the GoS collects taxes on fuel used for the transportation of paddy and rice, and on the electricity used in rice production. In addition, import duty and VAT is charged on vehicles required for paddy transportation. Taken together, these taxes reduce the economic value of resources used to produce rice, below their financial values. The ENPV of medium-size millers, for example, is US$ 0.69 mill compared to a FNPV of US$ 0.51 mill.

Total USAID investment in the irrigated rice VC is US$ 8.58 million nominal, which translates to a PV at 12% of US$ 7.36 million, in 2010 prices. The total ENPV of the PCE project in the irrigated rice VC is US$ 58.04 million. From the perspective of USAID, the ENPV of its investment is US$ 50.68 million with an ERR of 25 percent.

Table 5. Incremental Economic Analysis of Rain-fed Rice.

PCE Beneficiaries	ENPV/Ha	ERR	TOTAL ENPV
Paddy Producers (Irrigated Rice)	1,100	34%	8.45 mill
Total ENPV:			**US$ 8.45 mill**
PV of USAID Investment			US$ 5.18 mill
ENPV USAID PERSPECTIVE:			**US$ 3.27 mill**
ERR USAID PERSPECTIVE:			**18.0%**

The ENPV of PCE activities in the rain-fed rice VC from USAID's point of view is US$ 3.27 million, with an ERR of 18.0 percent. The relatively low returns in the rain-fed VC as compared to the irrigated VC can be explained by two factors:

1. Low average land holdings in the rain-fed VC of just 0.25 ha/household limit the effect of improved practice to 7,122 ha of rain-fed surface in 2014-15 compared to 12,088 ha in the irrigated rice VC.
2. A 25 percent increase in the paddy price has a significant impact on returns to interventions in the irrigated rice VC. However, the price of paddy in the rain-fed rice VC is strongly correlated with the price of cheaper imported rice, with or without PCE interventions. Therefore, a 25 percent increase in the paddy price does not affect returns to PCE interventions in the rain-fed rice VC.

Stakeholder Analysis

The social analysis of the project estimates the distribution of income changes caused by the project. This distributive analysis includes the reconciliation of financial, economic, and distributional appraisals, as well as identifying project impacts on principal objectives of the society concerned. There are six stakeholders associated with the PCE project:

1. Certified seed producers
2. Paddy producers
3. Medium-scale millers
4. Large-scale millers
5. Government of Senegal
6. USAID

The financial gains to the first four stakeholders are reported as the corresponding FNPVs in the financial analysis section. In the irrigated rice VC, subsidies and taxes amount to a loss to the GoS with a PV of US$ 21.29 million, the bulk of which is due to a subsidized interest rate. The interest rate subsidy on loans has a PV of US$ 20.39 million. In the rain-fed rice VC, the government bears a loss of US$ 0.70 million, with US$ 0.60 million due to foregone CET on rice imports. However, it should be noted that the foregone CET of 14.28 percent is partially outweighed by a FEP of 7.46 percent.

The cost of USAID investments is nominal at US$ 14.62 million spread over the life of the PCE project. This translates into a PV at 12% of US$ 12.55 million. Table 5 presents the results of the distributive analysis.

Table 6. Distributive Analysis (Present Value at 12%).

Stakeholder	PV of Gains/Losses
Certified Seed Producers	US$ 2.71 mill
Paddy Producers	US$ 84.99 mill
Medium Millers	US$ 0.51 mill
Large Millers	US$ 0.28 mill
Government of Senegal	(US$ 22.00 mill)
USAID	(US$ 12.55 mill)
Total:	***US$ 53.95 mill***

The significant level of government subsidies to stimulate increased domestic production of rice raises concerns about the competitiveness of domestically produced rice versus rice imports. The main subsidies cover fertilizers, agricultural equipment, and loans, none of which is currently used in the rain-fed rice VC. The analysis therefore attempts to establish whether irrigated rice cultivation is economically feasible for Senegal. Economic resource-flow statements were derived for the "with-project" and "without-project" scenarios. The analysis revealed that the ENPV of the "without" scenario is negative US$ 1,138 per ha, with an ERR of negative three percent. The ENPV of the "with-project" scenario is US$ 135, with an ERR of 13 percent. Two important conclusions can be drawn from this analysis:

1. The GoS and donor partners were able to significantly improve the productivity of the irrigated rice VC over the last five years. From an economic point of view, the benefits of domestic rice production currently outweigh the resources spent, including subsidies from the GoS and donor support.
2. The ERR is only one percent above the discount rate of 12 percent, emphasizing the importance of a well-defined exit strategy for both the GoS and international donors. The removal of subsidies or the inability of the budget to sustain such significant fiscal outflows may result in adverse effects throughout the VC.

Sensitivity and Risk Analysis

Irrigated Rice Production

Sensitivity analysis was carried out to test how changes to the main assumptions/parameters of the analysis would affect deterministic returns of PCE interventions. In the irrigated rice VC, sensitivity analysis was conducted on five variables:

1. Change in the paddy yields of certified seed producers
2. Change in the rejection rate of certified seeds
3. Change in the paddy price increase
4. Change in average fuel consumption during the dry season
5. Change in medium-size millers' capacity utilization rate

Table 7. Change in the Yield of Certified Seeds

	Aggregate FNPV (Million USD)			Aggregate ENPV (Million USD)	
	Seed Multiplication	Paddy Production	Med-size Millers	Economy	USAID
	2.98	**85.65**	**0.51**	**58.04**	**50.68**
-20%	0.54	85.65	0.51	55.38	48.01
-15%	1.15	85.65	0.51	56.05	48.68
-10%	1.76	85.65	0.51	56.71	49.35
-5%	2.37	85.65	0.51	57.37	50.01
0%	**2.98**	**85.65**	**0.51**	**58.04**	**50.68**
5%	3.58	85.65	0.51	58.70	51.34
10%	4.18	85.65	0.51	59.36	52.00
15%	4.79	85.65	0.51	60.03	52.66
20%	5.40	85.65	0.51	60.69	53.33

An increase in certified-seed producers' paddy yields positively affects their FNPV, as well as ENPV from the GoS and USAID perspectives. The increase in paddy yield, and therefore in the quantity of certified seeds produced, does not affect paddy producers and millers, since the analysis assumes that the total land surface affected by the PCE project cannot be greater than reported figures, even if supplies of certified seeds increase.[19] However, the opposite scenario is considered a risk factor. If the yield of certified seeds is reduced, it will negatively affect the yields of paddy producers, which in turn will reduce medium-size mills' capacity utilization. Therefore, a decrease in certified seed yields negatively affects all stakeholders.

[19] The PCE project implementer provided data on total land surface covered by the project.

Table 8. Change in the rejection rate of certified seeds

	Aggregate FNPV (Million USD)			Aggregate ENPV (Million USD)	
	Seed Multiplication	Paddy Production	Med-size Millers	Economy	USAID
	2.98	**85.65**	**0.51**	**58.04**	**50.68**
5%	3.84	85.65	0.51	59.11	51.75
10%	3.41	85.65	0.51	58.58	51.22
15%	**2.98**	**85.65**	**0.51**	**58.04**	**50.68**
20%	2.55	85.65	0.51	57.51	50.14
25%	2.11	85.65	0.51	56.97	49.60

The baseline scenario assumes that the counterfactual certified seeds rejection rate of 25 percent due to poor quality of paddy is reduced to 15 percent by the PCE interventions. However, it should be noted that the rejected paddy does not represent a loss for seed producers, since the rejected yield is sold on the market. A reduction in the rejection rate below 15 percent increases financial returns to seed producers and the ENPVs from the GoS and USAID point of view. However, as in the case of certified seed yields, it does not positively affect the FNPVs of paddy producers or millers.

Table 9. Change in the paddy price increase

	Aggregate FNPV (Million USD)			Aggregate ENPV (Million USD)	
	Seed Multiplication	Paddy Production	Med-size Millers	Economy	USAID
	2.98	**85.65**	**0.51**	**58.04**	**50.68**
10%	2.83	54.61	6.48	34.36	26.99
15%	2.88	64.95	4.49	42.25	34.89
20%	2.93	75.30	2.50	50.15	42.78
25%	**2.98**	**85.65**	**0.51**	**58.04**	**50.68**
30%	3.02	95.99	(1.48)	65.93	58.57
35%	3.07	106.34	(3.47)	73.83	66.47
40%	3.12	116.69	(5.45)	81.72	74.36

The contractual arrangements created by the PCE project helped to increase the farm-gate price of paddy by 25 percent. However, if the increase only represents a short-run spike in price, the financial and economic returns to all stakeholders except millers will be negatively affected. Since paddy is an input for millers, a reduction in its price will increase the profitability of their operations. However, given the competitive nature of the market, it is unlikely that the price of paddy would drop unless there was a reduction in the world price of rice.

Table 10. Change in average fuel consumption during the dry season

	Aggregate FNPV (Million USD)			Aggregate ENPV (Million USD)	
	Seed Multiplication	Paddy Production	Med-size Millers	Economy	USAID
	2.98	**85.65**	**0.51**	**58.04**	**50.68**
120	3.28	95.30	0.51	66.10	58.74
130	3.18	92.08	0.51	63.41	56.05
140	3.08	88.86	0.51	60.73	53.36
150	**2.98**	**85.65**	**0.51**	**58.04**	**50.68**
160	2.87	82.43	0.51	55.35	47.99
170	2.77	79.21	0.51	52.67	45.30
180	2.67	75.99	0.51	49.98	42.62
190	2.57	72.77	0.51	47.29	39.93
200	2.47	69.56	0.51	44.61	37.24

Although the shift to dry-season production results in higher yields, it also implies increased fuel consumption. The baseline scenario assumes an increase from 80 lt/ha to 150 lt/ha. An increase in fuel consumption reduces financial and economic returns to all stakeholders except millers.

Table 11. Change in medium-size millers' capacity utilization rate

	Aggregate FNPV (Million USD)			Aggregate ENPV (Million USD)	
	Seed Multiplication	Paddy Production	Med-size Millers	Economy	USAID
	2.98	**85.65**	**0.51**	**58.04**	**50.68**
60%	2.98	85.65	(0.61)	56.99	49.62
65%	2.98	85.65	(0.02)	57.54	50.18
70%	**2.98**	**85.65**	**0.51**	**58.04**	**50.68**
75%	2.98	85.65	1.00	58.50	51.13
80%	2.98	85.65	1.44	58.91	51.55
85%	2.98	85.65	1.84	59.28	51.92
90%	2.98	85.65	2.18	59.60	52.24

Seed multipliers and paddy producers are not affected by a change in the capacity utilization of medium-size mills. The increased capacity utilization will positively affect millers as well as the ENPV from the GoS and USAID point of view. The ENPVs are positively affected because increased capacity utilization per mill reduces the number of new mills opened and therefore saves resources. High transportation costs associated with the delivery of paddy, however, are likely to prevent a significant increase in the capacity utilization of milling units.

Rain-fed Rice Production

In the rain-fed rice VC, sensitivity analysis was conducted on two variables:

1. Change in paddy yields achieved by the use of certified seeds
2. Impact of certified seed availability

Table 12. Change in paddy yield

	Aggregate FNPV (Million USD)	Aggregate ENPV (Million USD)	
	Paddy Production	Economy	USAID
	9.16	**8.45**	**3.27**
-20%	3.97	3.51	(1.67)
-15%	5.27	4.75	(0.44)
-10%	6.57	5.98	0.80
-5%	7.86	7.22	2.04
0%	**9.16**	**8.45**	**3.27**
5%	10.45	9.69	4.51
10%	11.75	10.93	5.74
15%	13.05	12.16	6.98
20%	14.34	13.40	8.22

A change in yields due to the use of certified seeds has a significant impact on the financial and economic returns to PCE interventions. A 10 percent reduction in yields results in a 75.5 percent decrease in the ENPV from the USAID point of view.

Table 13. Change in availability of certified seeds

	Aggregate FNPV (Million USD)	Aggregate ENPV (Million USD)	
	Paddy Production	Economy	USAID
	9.16	**8.45**	**3.27**
80%	7.33	6.76	1.58
85%	7.78	7.19	2.00
90%	8.24	7.61	2.43
95%	8.70	8.03	2.85
100%	**9.16**	**8.45**	**3.27**

A change in the availability of certified seeds is also a significant risk factor in returns to PCE interventions. In addition, even if certified seeds are available, households may not possess the financial resources to purchase the seeds at the beginning of the planting season, jeopardizing expected returns to the PCE project. Lastly, the distribution of certified seeds to farmers free of charge raises concerns as to the sustainability of certified-seed production in the region.

Conclusions

The PCE project has significantly improved the productivity and profitability of the irrigated and rain-fed rice VCs, with positive financial and economic gains at all levels. However, the key role played by other donors, in addition to significant GoS interventions, means these achievements cannot be exclusively attributed to the PCE project.

Access to subsidized loans has a positive impact on the financial returns to seed multiplication and paddy cultivation activities. The PCE project has improved access to micro credit through the creation of market linkages and contractual arrangements. However the loans themselves are provided by the GoS. The GoS contribution, therefore, should not be undervalued.

The cost of increased paddy production is estimated at 40 percent of incremental yield. The main source of financial benefits to paddy farmers is therefore the 25 percent price premium for non-aromatic rice varieties, and the 50 percent price premium for aromatic rice varieties. The analysis revealed that the ENPV of the "without-project" scenario is negative US$ 1,138 per ha, with an ERR of negative three percent. The ENPV of the "with-project" scenario is US$ 135, with a ERR of 13 percent. Overall, the analysis points to two important conclusions:

3. The GoS, other donor partners, and the PCE project significantly improved the productivity of the irrigated rice VC over the last five years. From an economic point of view, the benefits of domestic rice production currently outweigh the costs, even with GoS subsidies and donor support.
4. The ERR is only one percent above the discount rate of 12%, emphasizing the importance of a well-defined exit strategy for both the GoS and international donors. The removal of subsidies or the inability of the budget to sustain such significant fiscal outflows may result in adverse effects throughout the VC.

However, the following are the key recommendations born by the analysis:

1. Senegal's rice-production sector exhibits multiple distortions that are the result of significant support extended by the donor community and the GoS. The long-term positive impact of the PCE project therefore requires that donors and government alike develop a clear exit strategy, whereby farmers are gradually encouraged to pursue agricultural activities with limited or no assistance from the GoS and other donors including USAID.
2. The wide promotion of rice cultivation and consumption may impose significant health risks particularly in the low income rain-fed regions. During interviews, farmers repeatedly and proudly stated that they now are consuming only rice throughout a day (breakfast, lunch and dinner). Such poor nutrition will negatively affect the health conditions of the farmers. Donors and the GoS should promote diversification of cultivation to include other staple crops in addition to educating the population on nutrition and the importance of a diverse diet through media and other channels.
3. Availability of certified seeds still remains a risk factor for the long-run economic returns of PCE project interventions. It is recommended to closely monitor factors affecting availability of certified seeds and continue improving domestic seed production during the Naatal Mbay project.

4. The analysis revealed that many issues resulting in low quality local rice production in the Senegal River Value were effectively addressed by the PCE project. Therefore new assistance should also focus on addressing existing infrastructure gaps, such as poor conditions of milling infrastructure. In rain-fed rice producing areas the focus should also be on market creation, diversification of production to improve dietary habits, and access to micro credit.

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Annex A – List of Interviewed Stakeholders

Irrigated Rice Production

1. Seed producers
2. Farmers' unions, including female, male and mixed unions
3. Medium-size millers
4. Large millers
    a. VITAL
    b. TERANGA
5. Richard Toll Seed Sorting Center
6. Richard Toll Seeds Certification Laboratories
7. Agribusiness Companies
    a. Thiaytou
    b. CNT – Coumba Nor Thiam
8. ISRA
9. AFRICARICE
10. SAED – Society for the Development and Use of Delta Lands
11. CNCAS
12. DRDR – Regional Directorate of Rural Development

Rain-fed Rice Production

1. Seed producers
2. Farmers' unions, including female, male and mixed unions
3. SODAGRI
4. ISRA
5. SEDAB
6. Producers of small agricultural equipment
7. DRDR
8. PADAER
9. PAPIL

Annex B – Indicative Paddy Producers' Farm Budget (Irrigated Rice)

Item	Quantity	Value per Unit (CFA)	CFA/Ha
Revenues			
Non-aromatic Paddy (Kg/Ha)	5,280	125	660,000
Aromatic Paddy (Kg/Ha)[20]	720	150	108,000
Total Revenues			**768,000**
Costs			
Cost of Inputs			
Certified seeds (Kg/Ha)	120	300	36,000
Herbicide - Propanil (Liter/Ha)	5	3,800	19,000
Herbicide - Weedone (Liter/Ha)	1	4,000	4,000
Herbicide - Londax (gr/Ha)	100	70	7,000
Fertilizer - DAP (Kg/Ha)	100	176.2	17,620
Fertilizer - Urea (Kg/Ha)	300	162.2	48,660
Effective fuel consumption(Liter/Ha)	139.5	690	96,255
Sacks for Paddy (Sacs/Ha)	75	280	21,000
Rental cost of land	1	10,000	10,000
Total cost of Inputs			*258,140*
Cost of Labor			
Land preparation and offset	1	25,000	25,000
Family labor activities	1	15,000	15,000
Harvesting (20% of Yield)	1	153,600	153,600
Total cost of labor			*193,600*
Other Costs			
Maintenance of irrigation channels	1	15,000	15,000
Rental cost of pump	1	30,000	30,000
Rental cost of sprayer	1	2,700	2,700
Transportation	75	400	30,000
OMVS fee	1	11,000	11,000
Small irrigation equipment	1	2,700	2,700
Total other costs			*91,400*
Total Costs			**544,535**
Net Income			**223,465**

[20] About 12 percent of farmers produce aromatic paddy varieties. The farm model per hectare therefore assumes that 12 percent of land surface is allocated to aromatic paddy production. However, a farmer can produce only non-aromatic, only aromatic, or both varieties.

Annex C – Indicative Seed Producers' Farm Budget

Item	Quantity	Value per Unit (CFA)	CFA/Ha
Revenues			
Certified seeds (Kg/Ha)	5,100	300	1,530,000
Paddy (Kg/Ha)	900	125	112,500
Total Revenues			**1,642,500**
Costs			
Cost of Inputs			
Foundation seeds (Kg/Ha)	120	400	48,000
Herbicide - Propanil (Liter/Ha)	5	3,800	19,000
Herbicide - Weedone (Liter/Ha)	1	4,000	4,000
Herbicide - Londax (gr/Ha)	100	70	7,000
Fertilizer - DAP (Kg/Ha)	100	176.2	17,620
Fertilizer - Urea (Kg/Ha)	300	162.2	48,660
Fuel consumption with project	150	690	103,500
(Liter/Ha)	75	280	21,000
Sacks for Paddy (Sacs/Ha)	1	10,000	10,000
Rental cost of land			
			277,280
Total cost of Inputs			
Cost of Labor	1	25,000	25,000
Land preparation and offset	1	15,000	15,000
Family labor activities	1	328,500	328,500
Harvesting (20% of Yield)			
			368,500
Total cost of labor			
Other Costs	1	15,000	15,000
Maintenance of irrigation channels	1	30,000	30,000
Rental cost of pump	1	2,700	2,700
Rental cost of sprayer	1	11,000	11,000
OMVS fee	1	2,700	2,700
Small irrigation equipment			
			61,400
Total other costs			
Cost of Certification	128	350	44,800
Sacks for certified seeds	128	100	12,800
Cost of certification labels (CFA/Sac)	75	400	30,000
Transportation (Farm-Sorting Center)	1	1,000	1,000
Sample treatment (CFA/Ha)	5.1	20,000	102,000
Seed sorting services (CFA/Ton)			
			190,600

Item	Quantity	Value per Unit (CFA)	CFA/Ha
Total cost of certification			
Total Costs			**899,280**
Net Income			**743,220**

Annex D – Indicative Paddy Producers' Farm Budget (Rain-fed Rice)

Item	Quantity	Value per Unit (CFA)	CFA/Ha
Value of In-house Consumption			
Paddy (Kg/Ha)	2,000	130	260,000
Total Value			**260,000**
Costs			
Cost of Inputs			
Certified seeds (Kg/Ha)	80	300	24,000
Herbicide - Propanil (Liter/Ha)	5	3,800	19,000
Herbicide - Weedone (Liter/Ha)	1	4,000	4,000
Herbicide - Londax (gr/Ha)	100	70	7,000
Fertilizer - DAP (Kg/Ha)	-	-	-
Fertilizer - Urea (Kg/Ha)	-	-	-
Rental cost of land	1	10,000	10,000
Total cost of Inputs			*64,000*
Cost of Labor			
Labor days	20	420	8,400
Plowing	1	20,000	20,000
Harvesting	1	40,000	40,000
Total cost of labor			*68,400*
Total Costs			**132,400**
Net Value			**127,600**

Annex E – List of Commodity-Specific Conversion Factors

Seeds (Importable Input)	1.06
Seeds (Importable Output)	1.08
Rice (Importable Output)	0.95
DAP (Importable Input)	2.03
Propanil (Importable Input)	1.06
Urea (Importable Input)	2.03
Londax (Importable Input)	1.06
Weedone (Importable Input)	1.06
Fuel (Importable Input)	0.81
Sacks (Importable Input)	1.06
Agricultural Equipment (Importable Input)	1.06
Land Preparation and Offset (Tractor-based)	1.84
Vehicle (Importable Input)	0.77
CF for Transportation	0.87
CF for Labor	1.00
Total Investment Costs for Millers	0.90
CF for Electricity	0.88
Rental Cost	1
CF for Labeling	1
CF for Sample Treatment	1
CF for Governmental Interest Rate Subsidy	0

Annex F – Sources of Assumptions

Input sources of the irrigated model

General Inputs	
Item	**Source**
Annual growth in the paddy yield, without project (F82)	Assumption
Prices (F84 to F98)	Interviews with stakeholders (farmers, traders, millers, Min. of Agriculture)
Input Requirements (F100 to F108)	Interviews with stakeholders (in accordance with technology promoted by the project)
Cost of Labor (F110)	Interviews with farmers
Other Costs/ Cost of Certification (F112 to F115)	Interviews with stakeholders (farmers, private service providers, seed sorting centers)
Other Costs/Land preparation and Harvesting fee (F116 & F117)	Interviews with farmers
Other Costs/Transportation (F118 to F120)	Interviews with farmers and millers (In many instances millers will hire service provides to transport paddy and rice. Interviews with 6 milling companies reveal that the cost is uniform).
Other Costs/OMVS fee (F121 to F122)	Interviews with farmers, MinAgri, and various publications
Other Costs (F123 to F126)	Interviews with farmers
Certified Seed Multiplication (Without project)	
Paddy yield of seed producers (F132)	M&E data of the project. During interviews farmers were actually reporting lower yield of 4 MT/ha.
Seed acceptance rate (F133)	Interviews with farmers. Farmers were reporting 70% seed acceptance rate, a more conservative estimate of 75% was used
Seed rejection rate (F134)	Difference between 100% and the seed acceptance rate
Sacks for paddy (F136)	Function of yield
Sacks for certified seeds (F138)	Function of yield and seed acceptance rate
Certified Seed Multiplication (With project)	
Production (F141 to F148)	M&E data of the project, interviews with stakeholders
Sacks for paddy (F150)	Function of yield
Sacks for certified seeds (F152)	Function of yield and seed acceptance rate
Paddy Production (without Project)	

Production (F158 to F167)	Interviews with stakeholders and agricultural experts, including MinAgri
Effective fuel consumption (F169)	Function of dry and rainy season fuel consumption
Sacks for paddy (Row 170)	Function of yield
Paddy Production (with Project)	
Production (F173 to F183)	M&E data of the project, interviews with stakeholders
Effective fuel consumption (F185)	Function of dry and rainy season fuel consumption
Sacks for paddy (F186)	Function of yield
Medium Size Millers	
All parameters (F189 to F218)	Interviews with Millers (10 millers were interviewed)
Financing	
All parameters (F220 to F223)	Interviews with lending institutions, farmers, MinAgri
Macroeconomic Indicators	
US Inflation (F225)	IMF
Price Index US (F226)	Function of US Inflation
Senegal Inflation Rate (F227)	IMF[21]
Price Index – Senegal (F228)	Function of Senegal Inflation
Relative Price Index (F229)	Function of US and Senegal price index
Official exchange rate, annual average (F230)	WB (http://data.worldbank.org/indicator/PA.NUS.FCRF)
Real exchange rate (F231)	Base year 2015
Change in real exchange rate (F232)	Estimated based on the annual official exchange rates and real exchange rate
Nominal exchange rate (F233)	Function of real exchange rate and relative price index
VAT (F234)	Various sources

[21] http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/weorept.aspx?pr.x=36&pr.y=7&sy=2013&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&c=722&s=PCPIPCH&grp=0&a=

Discount Rate (F235)	USAID guidelines
EOCK (F236)	USAID guidelines
FEP (F237)	Kuo, C. Y., Salci, S., & Jenkins, G. P. (2014). Measuring the Foreign Exchange Premium and the Premium for Non-Tradable Outlays for 20 Countries in Africa. South African Journal of Economics.

Input sources of the rain-fed model

General Inputs	
Inputs	**Source**
Inputs Requirements (F55 to F57)	Interviews with stakeholders (in accordance with technology promoted by the project)
Prices (F59 to F64)	Interviews with stakeholders (farmers, traders, millers, Min. of Agriculture)
Cost of labor (F65)	Interviews with farmers
Number of labor days required (F67)	Interviews with farmers
Without Project	
Production (F71 to F76)	M&E data of the project, interviews with stakeholders
Input requirements (F78 to F80)	Interviews with farmers M&E data of the project
Price of seeds (F82)	Interviews with farmers
Cost of labor (F84 & 85)	Interviews with farmers
With Project	
Production (Cell F89 to F94)	M&E data of the project, interviews with stakeholders
Certified seeds (F96)	Interviews with farmers
Availability of certified seeds (F97)	Assumption
Price of certified seeds (F101)	Interviews with farmers
Cost of labor (F103 & F104)	Interviews with farmers

Macroeconomic Indicators	
US Inflation (Cell F108)	IMF
Price Index US (F109)	Function of US Inflation
Senegal Inflation Rate (F110)	IMF[22]
Price Index – Senegal (F111)	Function of Senegal Inflation
Relative Price Index (F112)	Function of US and Senegal price index
Official exchange rate, annual average (F113)	WB (http://data.worldbank.org/indicator/PA.NUS.FCRF)
Real exchange rate (F114)	Base year 2015
Change in real exchange rate (F115)	Estimated based on the annual official exchange rates and real exchange rate
Nominal exchange rate (Row 116)	Function of real exchange rate
VAT (F117)	Various sources
Discount Rate (F118)	USAID guidelines
EOCK (F119)	USAID guidelines
FEP (F120)	Kuo, C. Y., Salci, S., & Jenkins, G. P. (2014). Measuring the Foreign Exchange Premium and the Premium for Non-Tradable Outlays for 20 Countries in Africa. South African Journal of Economics.

[22] http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/weorept.aspx?pr.x=36&pr.y=7&sy=2013&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&c=722&s=PCPIPCH&grp=0&a=